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The aim of the seminar is to present and discuss the latest results obtained by researchers especially at the Czech Technical University in Prague and at collaborating institutions.

The organizing committee has selected a total of 529 contributions divided into 15 different areas of interest:

• Part A:

– mathematics
– physics
– informatics and automation engineering
– electrical engineering and instrumentation
– materials engineering

• Part B:

– mechanics and thermodynamics
– mechanical engineering
– production systems, technology and technological processes automatisation
– energetics and power engineering
– nuclear engineering
– chemistry
– biomedical engineering
– civil engineering
– architecture, town planning, geodesy and cartography
– transportation, logistics, economy and management

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CONTENTS

1. MATHEMATICS

2. PHYSICS

3. INFORMATICS AND AUTOMATION ENGINEERING

4. ELECTRICAL ENGINEERING AND INSTRUMENTATION

5. MATERIALS ENGINEERING

Section 1

MATHEMATICS

Numerical Solution of the Two-phase Two Moving Boundary Problem Arising in Pulsed Laser Irradiation of CdZnTe

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Many ternary II-VI semiconducting alloys including CdZnTe, which is the subject of our interest, can be considered as pseudobinary in a certain temperature and concentration range. This gives us the possibility to employ the same basic treatment in modeling transport phenomena in these semiconductors as that used in the case of binary systems. Therefore, we consider a binary alloy consisting of components A, B that is irradiated by a laser pulse in the modeling process. We suppose that the dimensions and symmetry of the sample allow us to treat it in one space dimension. Initially, the sample is in the solid state and occupies the one-dimensional domain (interval) [0,D], where D is the thickness of the sample. Due to the laser irradiation the sample begins to melt and evaporate and we suppose that the solid phase occupies the interval [Z(t),D], whereas the interval $[Z_0(t),Z(t)]$ corresponds to the liquid phase. Hence, the functions $Z_0(t)$, Z(t) describe the positions of the liquid/vapor and solid/liquid interfaces, respectively. We assume evaporation into vacuum in our model, which is the common case in most experiments, so that the vapor is assumed to be removed from the surface of the sample immediately. Therefore, only two of the three phases, namely solid and liquid, are treated explicitly in our model and the field balance equations are written on the intervals $[Z_0(t),Z(t)]$ and [Z(t),D] only. The evaporation effects are included in the boundary conditions at the vapor/liquid moving interface so that our model is a two-phase moving boundary problem with two moving interfaces mathematically, one of them representing a part of the boundary of the sample.

We suppose that no chemical reactions occur in the system, and regarding to the large temperature gradients induced by pulsed laser irradiation [1], we neglect the convection in the melt. Similarly as with the classical Stefan problem, we also neglect the density change due to melting and solidification. Therefore, it is sufficient to employ the balance equations of internal energy of the system and the balance equations of mass of the component A in both the explicitly-treated phases.

In formulating the balance equations at the solid/liquid interface Z(t), we employ the theory of discontinuity surfaces. Besides the balance conditions, two additional conditions at the solid/liquid interface have to be formulated, namely the liquidus and solidus curves of the phase diagram, and finally we introduce the Wilson-Frenkel interface response function. The practical implementation of the nonequilibrium phase diagram is performed using the nonequilibrium segregation coefficient k in our model. The relation between k and the equilibrium segregation coefficient k_0 can be expressed, for instance, by the formula derived by Aziz [2].

In formulating the conditions at the liquid/vapor interface, we start with the first necessary equation at the liquid/vapor interface $Z_0(t)$, which is the balance equation of internal energy. Assuming evaporation into vacuum, it can be derived using the common rules

of the discontinuity surface theory (see e.g. [3]). The second necessary equation is the interface response function, which can be obtained by the treatment described in detail in [3].

The initial and boundary conditions are formulated in a common way (see e.g. [4]). The initial positions of the moving phase interfaces are assumed to be at the sample surface, x=0.

In solving the two-phase two moving boundary problem formulated we first employ the Landau transformation to map both the liquid and the solid domain onto fixed space intervals [0,1]. To solve the fixed-domain initial-boundary value problem obtained we employ the Galerkin finite element method.

The iteration algorithm used to solve the nonlinear problem under consideration is based on the successive approximation approach with underrelaxation. Its final purpose is to find the temperature and concentration fields in the sample and the positions and velocities of the phase interfaces such that the interface response conditions are satisfied within accuracy δ in each time step.

There are two points worth commenting. First, the choice of the kinetic conditions as the convergence criteria of our algorithm has not been arbitrary. When solving the classical Stefan-like problems, one iterates on the interface balance equations usually. However, our computational tests have shown that in the model in question here this is a bad choice and that it is not possible to achieve convergence in such a case. On the other hand, our choice leads to an algorithm in which the iteration procedure converges quite rapidly. Second, we have found that even when solving standard benchmark moving boundary problems, the successive approximation method itself does not converge in the iteration procedure even if we start with a very good initial approximation. However, the introduction of (under)relaxation leads to fast convergence. The proper values of the relaxation factors have been determined in a series of numerical experiments.

The applicability of the above model was illustrated on the example of Nd:YAG laser (16 ns FWHM, 266, 355, 532 nm) induced melting, solidification and evaporation of CdZnTe. The initial content of zinc in the CdZnTe pseudo-binary was assumed to be 4% in all calculations. The shape of the laser pulse employed in the computations was obtained by experimental measurements. The main outputs of our calculations were the temperature and concentration fields, and the positions and velocities of the phase interfaces.

It can be concluded that the numerical studies performed improve our understanding and modeling nonequilibrium, short-time scale phase change phenomena in II-VI semiconductors. The model can also help the experimentalist in designing the proper setup of the laser treatment of the materials in question.

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Numerical Analysis of Surface Diffusion by Means of Cahn-Hilliard Equation with Applications in Image Processing

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Phase separation is a physical process at micro scale taking place when a binary alloy in thermal equilibrium is undercooled under a critical temperature. Homogeneous state with single phase becomes unstable and the system will try to reach thermodynamical equilibrium. At this point, phase separation will take place and the solution will separate into regions rich in one component and poor in the other. This process can progress in two different ways: as nucleation (nuclei of on component appear randomly and grow) or as spinodal decomposition (the whole solution nucleates at once, periodic structures appear).

Cahn-Hilliard equation with degenerate mobility is a partial differential equation of fourth order used to model isothermal phase separation in two component system. Cahn-Hilliard theory is based on Ginzburg-Landau free energy functional. Minimizing this functional under the constraint of mass conservation yields the division of the domain into regions rich in one of the components and poor in the other, which are separated by a thin interface. This minimizing is realized by evolving the Cahn-Hilliard equation with degenerate mobility. The role of the mobility function is to enhance diffusion on the interface. Important property of the solution of the Cahn-Hilliard equation is the conservation of mass. Existence of the weak solution has been proved by Yin (1992) in one-dimensional case and by Elliot, Garcke (1996) for dimensions higher than one. As for the uniqueness, no results are known so far.

Vast majority of papers treating this equation numerically deals only with the case, when the mobility function is constant and thus non-degenerate. Finite element method for the degenerate case has been proposed by Barrett, Blowey, Garcke (1999).

In this project, we solve the degenerate Cahn-Hilliard equation by method of lines, discretizing the equation by central finite differences in space and leaving the time variable continuous. The resulting system of ODEs is then solved by Cash-Karp's modification of the Runge-Kutta method, which enables adaptive changes in time step while maintaining the required accuracy. Zero Neumann boundary conditions are treated by reflecting the solution at the boundary.

We have computed a number of numerical experiments and have obtained both the nucleation case as well as the spinodal decomposition case of phase separation. The numerical experiments also demonstrate that the numerical scheme keeps the property of conserving the mass.

Besides the mass conservation property the Cahn-Hilliard equation has another property which makes it very useful also for applications other than the simulation of phase decomposition. If we scale the equation properly (Cahn, Elliott, Novick-Cohen (1996)), the thin interface separating regions rich in one component and poor in the other will move according to a motion law called *surface diffusion*. It is a geometric motion law for curves, which is mass conserving and curve shortening. Here appears the important difference between the constant and degenerate mobility cases. Constant mobility Cahn-Hilliard

equation leads to the so called Mullins-Sekerka problem, where nonintersecting interfaces are coupled. Degenerate mobility case leads to surface diffusion, where such interfaces evolve independently. These properties of surface diffusion can be successfully used for applications in image processing.

Image processing by degenerate Cahn-Hilliard equation

The steps involved in segmentation of an image for further post-processing (for instance, image recognition) can be the following:

1. Acquire gray-scale image (possibly with noise).
2. Apply a segmentation algorithm (for instance simple thresholding) and yield binary image with several objects with possibly distorted or unnecessarily complicated boundaries.
3. Remove the noise and smooth the edges. This process is called *shape recovery*.

The idea how to achieve the point 3. is the following. Noise creates interfaces with high curvature; therefore, if we move them according to some curvature-dependent motion law, the noise disappears quickly while dominant features are preserved. These motions laws can be for example:

- Motion by mean curvature – is not mass conserving, objects shrink and vanish and the original shape is quickly lost.
- Surface diffusion – is mass conserving, operates on two different scales (small scale – noise at the boundaries, large scale – shape of the objects).

Due to its properties, it is apparent that surface diffusion motion law is more suitable for our application.

For approximating the motion by surface diffusion, two approaches are possible:

- Direct approach – we approximate the curve of interest by series of points and simulate the surface diffusion directly.
- Indirect approach – we define the curve of interest as a level set of some higher dimensional function and then use this function as an initial condition for a partial differential equation.

However, there are a number of problems with the direct approach in image processing – the number of interfaces is unknown and most likely large. Therefore, firstly we have to detect them, discretize them and then move them. During the motion some curves may disappear, some may merge and singularities and changes in topology may appear. It is apparent that this approach is computationally difficult. Thus, the indirect approach is preferred – we can use the image obtained from point 2. as the initial condition for the degenerate Cahn-Hilliard equation and the boundaries of objects will automatically evolve according to the surface diffusion motion law.

This proposed algorithm has been verified by numerous computational experiments to yield the desired results, both on artificial as well as natural images.

In the future, we plan to finish the analysis of the numerical scheme and implement the existing software for parallel environment in order to be able to calculate simulations of phase separation and shape recovery with higher resolution and in three dimensions.

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Support of International Education at FNSPE for Students of Mathematical Engineering

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The curricula of graduate and doctoral study at CTU-FNSPE involve as important obligatory part the student work on scientific research projects. The students of Mathematical Engineering are supervised by the collaborators of the Doppler Institute. Longstanding cooperation with renowned foreign universities and institutes has allowed us to continue our successful model: the student project work is led by two supervisors, one from CTU, the other from abroad. Students take active part in collaboration with foreign cotutors, visit the cooperating institutes and coauthor the common publications of obtained results in international journals or present them at international scientific meetings. These facts, to our experience, immensely stimulate their research activity.

In this report the main results are connected with the work of students Petr Ambrož, Peter Baláži, Lubomíra Balková, Jaroslav Hlinka, Ivo Hradecký, Jiří Hrivnák, Petra Kocábová, Petr Novotný, Robert Straka, Milena Svobodová, Ondřej Turek and Jan Zich: papers (with supervisors) appeared in Journal of Physics A, Journal of Mathematical Physics and Czechoslovak Journal of Physics B, further papers will appear in international journals and proceedings of international meetings or have been submitted there. The students learn in this way to communicate their results in written form as well as to present them at international scientific meetings and seminars. The successful students, their supervisors and topics of student projects were:

- L. Balková, J. Hlinka and J. Zich, Ing. Z. Masáková/Prof. J. Patera (Université de Montréal), quasicrystals, aperiodic tilings of the plane.
- M. Svobodová, Doc. Pelantová/Prof. J. Patera (Université de Montréal), fine gradings of Lie algebras o(4,C) and sl(4,C).
- J. Hrivnák and P. Novotný, Prof. J. Tolar/Prof. J. Patera (Université de Montréal), graded contractions of sl(3,C).
- P. Ambrož, Doc. Pelantová/Prof. Chr. Frougny (Université Paris VII), arithmetics on number systems with irrational bases.
- I. Hradecký and O. Lev, Prof. P. Šťovíček/Prof. P. Duclos (Université de Toulon et Var), time-dependent quantum systems.
- M. Kryšková, J. Novotný and S. Vymětal, Prof. I. Jex/Prof. G. Alber (TU Darmstadt), quantum entanglement and quantum coding.
- Peter Baláži, Doc. E. Pelantová/Prof. B. Adamczewski (CNRS Marseille-Luminy), coding methods.

- O. Turek, Doc. E. Pelantová/Prof. V. Berthé (Université de Montpellier), infinite words of beta-integers.

Further informations about the student research and publications can be found at http://www.fjfi.cvut.cz, katedra fyziky.

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Discrete Fracture Network Model of the Contaminant Transport through Rock Massifs Based on the Combined Barycentric Finite Volume – Nonconforming Finite Element Method

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Underground granitoid massifs are intended as possible repositories of dangerous nuclear waste. They are however always disrupted by a system of geological faults, *fractures*. The percolation of groundwater and displacement of contaminants in such massifs takes place mainly in the network created by fractures. The most accurate possibility for modelling water flow and contaminant transport give the so-called *stochastic discrete fracture network models* (see [2] for more details). In these models, the original three-dimensional fractures are approximated by planar polygonal disks whose frequency, size, assigned aperture, and orientation are statistically derived from field measurements. The network of polygonal disks is further decomposed onto e.g. triangular elements and one then simulates, using some numerical method, the flow and transport processes on a triangular mesh in the three-dimensional space. Up to now, only simplified formulations of the finite difference method have been used for the discretization of the flow and transport equations on fracture networks. In [4], the authors have used the mixed-hybrid finite element method to simulate the flow in a fracture network. This method gives much better approximation of the flow field. In this article, we propose an efficient numerical method for the contaminant transport problem.

The contaminant transport equation in a single fracture (i.e. in a two-dimensional polygon) is described by a nonlinear degenerate parabolic convection–reaction–diffusion equation (see [1]) in the form

$$\frac{\partial \beta(c)}{\partial t} - \nabla\cdot(\overline{D}\nabla c) + \nabla\cdot(c\vec{v}) + F(c) = q\,, \tag{1}$$

where c is the unknown concentration of the contaminant, the function β represents time evolution and equilibrium adsorption reaction and is supposed to be continuous and increasing with the growth bounded from below by a positive constant, $\vec{v}$ is the velocity field defining the convection term, $\overline{D}$ is the diffusion–dispersion tensor, the function F represents the changes due to chemical reactions, and q stands for the sources. The equation (1) is nonlinear because of the functions β and F, degenerate since β' may be unbounded, convection dominated, and contains a heterogeneous and anisotropic (nonconstant full matrix) diffusion–dispersion tensor $\overline{D}$.

The finite element methods are naturally suited for the discretization of diffusion terms with general tensors. However, spurious oscillations may appear in the velocity-dominated case. The finite volume methods with upstream weighting techniques do not produce such oscillations. However, there are geometrical restrictions on the mesh for the

discretization of the diffusion term (the magnitude of all angles in the triangulation has to be less than $\pi/2$) and there is no general prescription how to discretize full tensors. Hence a quite intuitive idea is to combine these methods, trying to use the "best of both worlds".

In this contribution, we extend the method proposed in [3] for standard two- or three-dimensional domains onto fracture networks. In the triangular grid of a fracture network, interelement edges shared by three or more triangles occur. This is not possible in two space dimensions. However, assigning the unknowns to the midpoints of these (multiply shared) edges, we still can discretize the diffusion term by means of the piecewise linear nonconforming (Crouzeix-Raviart) finite element method over the triangular grid of the fracture network. Alternatively, we can use the stiffness matrix of the hybridization of the lowest order Raviart-Thomas mixed finite element method. We then construct a dual mesh. We associate one *dual volume* with each edge of the triangulation. We obtain this dual volume by connecting the barycentres of the triangles sharing this edge through the endpoints of this edge. The other terms of the equation (1) are discretized by means of a finite volume scheme on the dual mesh. To avoid spurious oscillations in the velocity dominated case, we check the local Péclet number to set up exactly the necessary amount of upstream weighting. This technique also insures the validity of the discrete maximum principle when the magnitude of all angles in the triangulation is less than $\pi/2$ and when the diffusion-dispersion tensor has a form of the identity matrix. We extend the convergence result of [3] also onto fracture networks.

The fracture networks are generated and discretized onto triangular meshes with the aid of the *Fracture network generator* (see [4]). Then the mixed-hybrid finite element method implemented in the *Fracture flow solver* (see [4]) is used to obtain the flow field $\vec{v}$. Finally, the combined finite volume – finite element scheme implemented in the *Fracture transport solver* is used to simulate the transport. To confirm the theoretical results, model problems with known analytical solution on networks containing only several fractures are tested first. The next step will be the calibration of the introduced model on the granitoid massif of Potůčky, Western Bohemia, in the vicinity of the explorational drill hole Ptp-3.

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Multilevel Solution of Some Problems with Fast Changing Data

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The cost of a numerical solution of a differential equation depends on the time spent by the process of solving and on the amount of memory needed for the data. From this point of view we have considered the use of certain bases in the Galerkin method applied to a second order elliptic partial differential equation with variable coefficients. The time needed for obtaining the numerical solution and its accuracy is strongly determined by the condition number of the matrix of the corresponding discretized problem. Applying Galerkin method to the second order elliptic partial differential equation, we obtain the so called mass and stiffness matrices. The influence of the mass matrix is usually negligible, that is why we examine only the stiffness matrices.

We have applied a hierarchical basis to the Galerkin method for solving the second order partial differential equation of elliptic type with variable coefficients on a bounded region, which was a rectangle. We have given a special attention to the case of the oscillating coefficients. These equations can express behavior of the material with periodically changing properties.

A widely used method for solving partial differential equations is the finite element method. The condition number of the corresponding stiffness matrix is known to grow like $O(n^2)$, where n is the number of unknowns (i.e. number of elements). The motivation for our study, were some properties of wavelet bases. The multilevel system of these functions when applied as a basis in the Galerkin method, results in the optimal condition number, i.e. $O(1)$, of the corresponding stiffness matrix. Nevertheless the wavelet functions are mainly a theoretical tool and they are not suitable for practical computing of large problems in complicated regions. Hence we have studied a hierarchical system of finite element functions. It is well known that the set of hierarchical Lagrange triangular supported elements for the second order elliptic problem leads to the condition number of the stiffness matrix equal to $O(\log(n))$, where n is the number of basis functions.

We have used another basis functions - the hierarchical Lagrange finite element functions on rectangles. The theoretical results showing the value of the corresponding conditioning of the stiffness matrix have not been presented in literature yet. Applying this approach, we have presented that the condition number behaves like $O(\log(n))$. In practical computing, the significant decrease can be obtained after using only several few levels of hierarchy, which resists the theoretical demand of the full hierarchy. We have studied the action of the variable coefficients to the problem [1], [4]. Obviously the conditioning of the stiffness matrix gets worse when the ratio of the supremum of the coefficient values and their infimum grows. A frequency of the coefficients also causes the fluctuation of conditioning. As a result we can conclude that the basis functions with roughly the same supports as the period of the coefficient should not be used.

During the analysis of the properties of multilevel basis, the strengthen CBS constant for two levels of Lagrange finite element functions on rectangles was found. This number has occurred to be less (i.e. better) then that one for the triangular elements. This property could relate with a good conditioning behavior of rectangular supported basis functions, e.g. a tensor product wavelet functions.

Further methods aiming in the decreasing of the condition number of the stiffness matrix corresponding to a hierarchical basis and to a problem with oscillating coefficients has been observed. Among these preconditioning methods, the FSAI algorithm, developed by L. Y. Kolotilina and A. Y. Jeremin, was adopted and adapted. As expected, the condition number of the stiffness matrix obtained from a multilevel basis can be decreased with FSAI algorithm. The bad conditioning caused by varying coefficients can be eliminated to a large extent. The drop is more significant, when more levels of hierarchy are used ([2], [3]).

In order to prove the asymptotical properties and the ability to solve real-life problems, all methods used were tested on the problems which were as large as computers could manage. The computing efficiency of the finite element method and the multilevel methods has been compared.

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Probability Theory of Fuzzy Events and Its Applications

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Probability on fuzzy sets has been evolving since the publication of an innovative paper by L. Zadeh who initiated the studies of probability of fuzzy events. The aim of probability on fuzzy sets is to capture both the vagueness (usually expressed by means of fuzzy set theory) and stochastic uncertainty (usually modeled by probability theory). Novel approaches in the field are based on MV-algebraic probability theory developed by B. Riečan and D. Mundici. It is however worth mentioning that probability on fuzzy sets as a special branch of probability on MV-algebras belongs equally to a much wider context of measure theory on ordered structures such as quantum logics and triangular norm based tribes of fuzzy sets. After all, the terminology and some of the basic definitions such as state, observable or tribe introduced in the MV-algebraic theory originates from both the above mentioned theories.

MV-algebras are many-valued generalizations of classic Boolean algebras. Due to Loomis-Sikorski theorem, σ-complete Boolean algebras can be identified up to an epimorphism with σ–complete Boolean algebras of sets; quite analogously, each σ-complete MV-algebra can be represented as a certain collection of fuzzy sets ([0,1]-valued measurable functions), so called Łukasiewicz tribe. Elements of the Łukasiewicz tribe are measurable fuzzy sets. MV-algebraic probability theory therefore subsumes probability theory on Boolean algebras. A 'probability measure' m on an MV-algebra M is called a state due to a physical analogy. A variant of the well-known and significant result by D. Butnariu and E. P. Klement states that each state m on a σ –complete MV-algebra M is the Lebesgue integral of the fuzzy set with respect to the probability measure defined on a σ–complete Boolean algebra of sets. MV-algebraic counterparts of random variables are observables on M: an observable is an M-valued measure defined on a Boolean algebra. Joint observables have then the similar role as random vectors.

Development of probability theory on any mathematical structure is inevitably connected with constructions and notions such as independence, conditioning, conditional independence etc. These theoretic tools are further studied in articles [1], [2], [3] and [4].

In Kolmogorov probability theory, the random vectors as vector mappings consist simply of random variables as components of the mapping. There is no straightforward formal analogy of this concept in MV-algebraic probability theory: the construction of a joint observable from (one-dimensional) observables resembles rather the construction of a classic product measure. The existence of the joint observable on M is not always guaranteed and usually follows from assumptions about the MV-algebra M. In case of a Łukasiewicz tribe T, the construction of the joint observable is interpreted by means of fuzzy set theory: it was demonstrated in [1] that a value of the joint observable on Łukasiewicz tribe T can be interpreted as a fuzzy relation (parameterized by the product t-norm). This interpretation also provides a technique for a natural composition and definition of (one-dimensional) observables from which the joint observable is composed.

One of the open problems in probability on MV-algebras was a reasonable definition of a conditional probability (state) on an MV-algebra M. The paper [4] contains a solution to this problem. In Kolmogorov probability, the most general definition is that the conditional probability is a certain Radon-Nikodym derivation. Conditioning of events and random

variables are only special cases of this concept. Analogously, the conditional probability on an MV-algebra is also a measurable function which is defined to be a solution of some integral equation. It was further demonstrated that such conditional probability has desirable properties of conditioning. Moreover, the conditional probability on an MV-algebra can be seen as a generalization of the classic Kolmogorov definition.

In [2] and [3] we studied the concepts which more intensely explore properties of the conditional probability such as conditional independence. Conditional independence is closely related to the effective construction of many-dimensional models, i.e. joint observables. Roughly speaking, conditional independence enables the composition of the (joint) distribution of a joint observable from the individual distributions in a similar way as it possible in classic probability, e.g. in case of Markov models, Bayesian networks etc. It was proven in [3] that conditional independence in MV-algebraic probability theory satisfies the same properties (so called semi-graphoid axioms) as conditional independence relation in classic probability theory.

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Information Theory for Possibility Measures

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Information theory covers nowadays a rich variety of mathematical formalizations of uncertainty. In the pioneering work of R. Hartley, so called Hartley measure was defined on a purely set-theoretic basis: Hartley measure is a minimal number of binary digits necessary for the unique representation of a finite set. The result of efforts of his successors was establishing information theory in the probabilistic framework in the classic work of C. Shannon, who defined and studied the most classic information quantities such as Shannon entropy or mutual information. Consequently, the advances in information theory have given rise to the further development in many areas of science, e.g. theory of coding, communication networks or mathematical statistics. It is important that each information quantity can be expressed as the Lebesgue integral of some (measurable) real function with respect to a probability measure.

Probability theory is not the only existing calculus enabling to reason under uncertainty. Namely, so called possibility theory is more eligible when the source of uncertainty is of a different kind than randomness, e.g. vagueness of natural language, or when the probabilistic model can be specified only imprecisely, e.g. giving lower and/or upper bounds for probabilities. Possibility theory originated in the field of artificial intelligence as theory providing both theoretical and practical tools in order to develop models covering also those different types of uncertainty. Mathematically, possibility measure is a set function defined on a Boolean algebra of sets satisfying so called maxitivity condition instead of additivity (or σ-additivity) condition as classic measures in measure and probability theory: the value of a possibility of a union of two sets is defined to be equal to the maximum of the values of the two respective possibilities. The possibility measure is a monotone set function and quite naturally, each possibility measure can be conceived as a convex and compact set of probabilities whose values are lower or equal than the possibilities. Possibility theory is more general than probability theory in many aspects: for example, product possibility measures are constructed on product algebras by means of an arbitrary t-norm T and we call them T-product possibility measures. A t-norm T is commutative, associative and monotone binary operation on [0,1] with the neutral element 1. The t-norms are used in fuzzy logics as interpretations of fuzzy conjunctions. Product probability measures are constructed by means of the product t-norm only and consequently, the product t-norm exactly characterizes the independence of random variables. On the other hand, any t-norm determines completely the interpretation and meaning of independence in possibility theory.

Recent scientific efforts in information theory (mainly of a group centered around G. Klir) initiated a thorough theoretical studies of information quantities for non-probabilistic calculi of uncertainty embracing thus possibility theory, fuzzy set theory and other calculi in a unifying manner. Several information quantities were proposed to be a counterpart of Hartley measure, Shannon entropy or mutual information. Namely, so called nonspecificity quantifies an amount of uncertainty of a possibility measure. The aggregate uncertainty of a possibility measure is defined to be the Shannon entropy of a probability measure maximizing this entropy on the set of the dominated probabilities. Many theoretical aspects

have been however left unclear and unsolved. Not going into details, one of the open problems was connected with a reasonable definition of the mutual information in possibility theory. The principal severity is the more general (t-norm-based) concept of independence and construction of *T*-product measures in possibility theory.

It was proposed in [2] that information theory for possibilities is based on Choquet integration theory rather than on the Lebesgue integral. Choquet integral is defined for a measurable real function with respect to a monotone set function. If this set function is σ-additive, then the Choquet integral coincides with the ordinary Lebesgue integral. The use of Choquet integral is motivated by the fact that the nonspecificity of a possibility measure can be expressed as a certain Choquet integral with respect to the well-known Hartley measure of information. Since any integral can be viewed as an extension of a set function, the nonspecificity can be indeed viewed as a properly defined extension of Hartley measure to possibility theory. In addition, the Choquet integral admits the integration of any measurable function with respect to a possibility measure as possibility measures are monotone set functions.

Further developments in possibilistic information theory consist in a definition and theoretical studies of counterparts of the mutual information and Kullback-Leibler divergence of possibility measures (see [1], [2]). The proposed information quantities (the measure of *T*-dependence and the measure of divergence) are generally applicable to any t-norm-based independence (*T*-product possibility measure). The measure of *T*-dependence exhibits the desirable properties: it is equal to zero iff the possibility measure is the *T*-product possibility measure, that means under the condition of *T*-independence. In all other situations, values of the measure of *T*-dependence indicate the strength of dependence.

The elaborated theory was applied in [1] to the construction of a possibilistic classifier which is a possibilistic analog of a classic Bayesian classifier frequently used in machine learning and artificial intelligence. The classifier in possibility theory is more apt to capture the vague knowledge concerning the domain in question, such as description of certain values of variables only by means of common language (value is ‘small’, ‘high’ etc.) The application of information quantities in any stage of the classification task can significantly speed up the classification by selecting the most discriminative attributes.

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An Adaptation of the Box Method to the Needs of the Electromagnetic Field Computation

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1. Introduction

The presented paper contains a fraction of results of a long-term research in numercal solution of partial differential equations. The most important of author's praviously published papers is "Finite difference, finite element and boundary element formulae as a language of applied physics" (written jointly with Dr. Ing. Nguyen van Nhac) presented in 1990 at the "CP 90" Europhysics confenrence on computational physics in Amsterdam. The presented paper can be looked upon as a continuation of a previous author's paper published in the Proceedings of Workshop 2002, Part B. The time discretization has been explained there; now, we shall keep time as a continuous variable {we shall use the semi-discrete method}. This has already been done in the author's poster presented at Workshop 2002, where the "DYNAST" simulation system has been used (see http://virtual.cvut.cz) .

2.The electromagnetic field

The electromagnetic field is supposed to be quasistationary. Four vector quantities are available for the description of the field: **E, D, B, H.** As a fifth vector quantity, we are introducing the vector potential **A .** For the needs of our presentation, the following simplified definition of **A** is sufficient: $\mathbf{B} = \mathrm{rot}\,\mathbf{A}$, $\mathbf{E} = -\partial\mathbf{A}/\partial t$. The additional condition $\mathrm{div}\mathbf{A} = 0$ is usually imposed upon A for the sake of uniqueness. * We shall now concentrate on the case where $\mu = \mu(x,y,z)$ is independent of time. * N. B. If $\mu = \mu(x,y,z,t)$ is a function of time, then a time discretization is recommended since **B** or **H** is to be calculated at every time-step . The same is valid for the case of a ferromagnetic material with nonlinear dependence $\mathbf{B} = \mu(\|\mathbf{H}\|).\mathbf{H}$.

3. Space discretization

In the xy – plane (or horizontal plane) we shall draw a rectangle {whose sides have the lengths Δx, Δy} with the center at the coordinate origin. The intersections of the sides of the rectangle with coordinate axes are denoted by a, b, c, d. This rectangle will be used for the calculation of the contour integral $\oint \mathbf{H}.d\mathbf{s} = \iint (\mathbf{i} + \sigma\mathbf{E}).\mathbf{n}\, dS = \iint (\mathbf{i} - \sigma\partial\mathbf{A}/\partial t).\mathbf{n}\, dS$ (= the total current) . The vector **i** will be called "the impressed current density" [the impressed current can be generated e. g. by a source situated outside the calculated field and it is then pushed through a conducting loop situated in the field]. Then we shall draw two more rectangles {whose sides have the lengths Δz, Δx}in the zx plane (the first vertical plane) with centers at a, c . We shall draw two more rectangles in the yz plane (the second vertical plane) with centers at b, d . The vertical rectangles will be used for the calculation of contour integrals $\oint \mathbf{A}.d\mathbf{s} = \iint \mathbf{B}.\mathbf{n}\, dS$ (= magnetic flux) . All integrals are then approximated by means of the "tangent formula" or "central point formula" : $\int f(x)\,dx \approx (b-a)\,.\,f(a + (b-a)/2)$. The two-dimensional integrals are calculated in a similar manner. In our case, the space step lengths Δx, Δy, Δz are corresponding to the interval length $b - a$ in the above mentioned formula. If

we are approximating all contour and surface integrals in the above mentioned manner and if we combine all available relations [taking into account $\mathbf{H} = \mathbf{B}/\mu$] we obtain a finite difference formula approximating one component of the vector equation $\mathrm{rot}\,((\mathrm{rot}\,\mathbf{A})/\mu) = -\sigma\partial\mathbf{A}/\partial t + \mathbf{i}$. On the left hand side of the finite difference formula, we get totally twelve terms: eight terms which can be looked upon as a finite difference approximation of the expression $\partial\,(\mathrm{div}_{xy}\,\mathbf{A})/\partial z$, where div_{xy} means "the two-dimensional divergence operator" (for z = const) ; and four terms (each of them containing a finite difference of A_z) which can be looked upon as the finite difference approximation <if μ = const: > of the two-dimensional Laplace's operator (for z = const) or <if $\mu = \mu(x,y,z\}$: > of a two-dimensional linear self-adjoint operator (for z = const).

4. Boundary and interior conditions

The boundary conditions for **A** are only rarely defined in a finite distance from the origin. One of such cases is mentioned in [1], chapter 4, paragraph 4.2, formula (4.16). p. 49; see also the unnumbered formulae between (4.22) and (4.23), p. 51 (A_z is there denoted as "u") . In a general case, only the asymptotic behaviour of **A** is known. We are making the assumption that the magnetic field can be approximated by the field of a dipole situated at the origin. In this case, **A** is behaving <in two-dimensional planar cases: > like r^{-1} or <in three-dimensional cases and in two-dimensional cylindrically symmetrical cases: > like r^{-2} . * Equally important as boundary conditions are the so-called "interior conditions" , e. g. a conducting loop, which is connected to an ideal current source, is situated in the field . In this case, we are substituting the current I of the source in place of $i_z\,\Delta x\,\Delta y$ in the finite-difference formula. On the other hand, if a circuit is attached to the conducting loop, we are treating the current I as an unknown quantity and we have to solve an ordinary differential equation simultaneously with the partial differential equation under consideration . This can be easily done, since the space is discretized and instead of a partial differential equation we have a system of ordinary differential equations. There can be several conducting loops in the field and we can calculate several unknown currents. In this manner, we are investigating the interaction of the field with circuits with concentrated parameters. * N. B. If an external circuit containing an ideal voltage source is given, it is recommendable to choose **E** as the basic quantity.

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Mathematical Modelling of an Aquifer Contamined by Organic Compounds

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Organic compounds belong to the most often encountered contaminants in the groundwater. Many kinds of these contaminants are only weakly soluble in water and behave as Non Aqueous Phase Liquids (NAPL's). These chemicals are often used in the industry, e.g. as industrial solvents like TCE or PCB's, and despite of their low solubilities they usually are highly toxic even in small concentrations and pose the problem for the groundwater quality when they enter the subsurface. Because of their high viscosities and low solubilities their movement is very slow and that is the reason for which the NAPL's usually represent long-time source of the contamination.

Depending on NAPL's density, one can distinguish between the so-called DNAPL's and LNAPL's. DNAPL is a NAPL whose density is higher than the density of water whilst LNAPL is a NAPL whose density is lower than the density of water. When an LNAPL enters the subsurface it percolates down in the direction of gravity through the unsaturated zone until it reaches the water table. Since the LNAPL is lighter than water it spreads along the water table. Unlike the LNAPL, DNAPL infiltrating through the unsaturated zone advances across the water table and continues to percolate down in the direction of gravity through the saturated zone.

Full description of NAPL infiltration through the unsaturated zone requires three phase equations, see [1], which describe movement of the three phases (water, NAPL, and air) in the subsurface. If we are interested only in the dynamics of a DNAPL in the saturated zone, we can use the following set of the two-phase equations in the so-called pressure-saturation formulation, see [2]

$$\frac{\partial \phi \rho_w (1 - S_n)}{\partial t} = div\left(\frac{k_{rw}(S_n)}{\mu_w} \rho_w K \cdot \left(\nabla p_w - \rho_w g \right) \right)$$

$$\frac{\partial \phi \rho_n S_n}{\partial t} = div\left(\frac{k_{rn}(S_n)}{\mu_n} \rho_n K \cdot \left(\nabla p_w + \nabla p_c(S_n) - \rho_n g \right) \right)$$

In these equations ϕ stands for porosity of the porous medium, K is its intrinsic permeability, ρ_w and ρ_n denote densities, μ_w and μ_n are viscosities where the indices w and n refer to the water and NAPL phase respectively. Furthermore, g is the acceleration of gravity, k_{rw} and k_{rn} are the relative permeabilities of the respective phases and p_c is the capillary pressure between the water and NAPL. Finally, the unknowns in these equations are p_w - water pressure and S_n - NAPL saturation. The relative permeabilities k_{rw} and k_{rn} and capillary pressure p_c are non-linear functions of saturation.

There are several possibilities for choosing the relative permeabilities – saturation and capillary pressure – saturation constitutive relationships. Most often models used are Burdine's model for relative permeabilities in conjunction with Brooks-Corey model for capillary pressure or Mualem's model for relative permeabilities in conjuction with Van Genuchten's model for capillary pressure. There also exist some modifications of these standard models which will not be mentioned here.

These equations supplemented by suitable initial and boundary conditions have been numerically solved using the Control Volume Finite Element Method (CVFE) for discretization in space and implicit Euler discretization in time. Stability of the numerical scheme is achieved by upwinding the relative permeability coefficients. As an alternative, the author has proposed an analogous method which employs the Finite Volume Finite Element Method (FVFE) for spatial discretization. Numerical experiments indicate that this modification may attain higher accuracy when compared to the CVFE scheme. Both schemes lead to a system of non-linear algebraic equations which is linearized using modified Newton's method. As a result, this procedure leads to solution of large sparse systems of linear algebraic equations with a non-symetric matrix. These systems are solved using the stabilized biconjugate gradient method with the multigrid preconditioning. The developed codes can use advantage of the adaptive timesteping which is a very essential feature which is necessary to use for simulation of the real-world problems and is very handy even for computations of some simplified problems.

The developed codes have been tested on the McWhorter – Sunada problem which is a simplifed one-dimensional problem with a well-known quasi-analytical solution, see [3] and [4]. Since the developed code is two-dimensional, simulations were carried out using the CVFE and FVFE schemes in a rectangular domain of a long thin stripe shape. Triangular mesh was constructed in such way that the long axis of the stripe is constituted by triangle edges only, and thus direct comparison of the values of NAPL saturation on the stripe axis with the corresponding values of the quasi-analytical solution is possible. Numerical simulations have been repeated with several settings of numerical parameters. The code has been run on different meshes and with several timesteps. These comparisons with the quasi-analytic solution establish experimentally convergence of the numerical solution toward the exact solution in norms of several function spaces.

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MOS FET Mathematical Model Parameter Extraction Sensitivity

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The modern applications require often parameter extraction process which is used to determine the unknown parameters of the mathematical model we use to represent physical relationships. The most common way to extract the unknown model's parameters is to use some form of the modified nonlinear least squares approximation. The method minimalizes the sum of the squares of distances of the measured data and the values of the mathematical model with some startup parameters and leads finally after some assumptions to the problem of solving the set of linear equations (SLE). Only a few realize that the least squares approximation produdes ill conditioned matrices and they are the more ill as the number of parameters we estimate grows. To tell whether the given matrix (and therefore SLE) is ill conditioned or not, matrix norm $\|\mathbf{A}\|$ and the condition [3, 4]

$$\kappa(\mathbf{A}) = \|\mathbf{A}\| \cdot \|\mathbf{A}^{-1}\|$$

is used. If the $\kappa(\mathbf{A}) >> 1$ then we speak about ill conditioned matrix and therefore a little change to any of the input variables causes big change in the result. During the SLE solving we encounter rounding errors and this is a problem since computers we use work only with a finite discrete aritmetics defined by [1].

The statement above means that not every number in computer can be represented precisely. It depends whether we use single or double precision or something completely different for floating point number representation. The given floating point number n is represented as the product of mantissa m and the 2^e, where e is the exponent:

$$n = m \cdot 2^e,$$

where mantissa m is in the normalized form as defined by [1]. The major advantage of single and double precision numbers is that they are directly supported by processors. The problem is that the mantissa length and exponent length are finite and therefore only a given subset of real numbers can be represented. The rounding unit for a single precision is $\varepsilon \doteq 5{,}96 \cdot 10^{-8}$ and $\varepsilon \doteq 1{,}11 \cdot 10^{-16}$ for the double one and that fact yields the precision for 8 and 16 decimal digits. That may be sufficient for certain applications but not for the solving of ill conditioned SLE. To tell whether the precision we use is good or not, often the residue [3] term is used. Residue is defined as

$$\mathbf{r} = \mathbf{A}\mathbf{x} - \mathbf{b},$$

where **A** is the matrix of the SLE, **x** is the solution we have estimated and **b** is the vector of right sides of the SLE. For precise solution **r = 0** but not for the ill conditioned SLEs solved in finite arithmetics. Our goal is to make elements of residue **r** acceptable size i.e. 10^{-6} or less.

The common example to realize the burden of rounding errors may be the finding of roots of a simple quadratic equation where discriminant is nearly zero. When a rounding error occurs

the most misfurtune case would be that the discriminant turns to a negative value due to the rounding error and the whole computation is screwed because of the square root of the negative discriminant. To work around the problem of rounding errors to get the residue **r** to the acceptable size is to use either arithmetic that allows us to specify the mantissa length [2] or to use residual number system (RNS) arithmetics [3].

The former way we offered was to use the aritmetic with a flexible mantissa length. Such aritmetics is offered by the MPFR library [2] – a subset of known GMP [2] – arithmetics without limitation library for C/C++. The biggest problem of that library is only the limited ability for making calculations in parallel. The limited parallelization is being a problem since parameter estimation of many parameters takes a lot of time and the goal is to make the parameter estimation process as fast as we can and also acceptably precise. That's why we don't recommend MPFR for larger parameter extractions.

The latter method was to use the residual number system. We transform the whole SLE to the RNS as described by [3]. We gain a number of SLEs we have to solve only in Z_n therefore an integral set with given moduli n, where n s are prime numbers to ensure that an modular inversion exists. The number of moduli can be 3000 or more. The more moduli we use, the more precise result we get. Of course the moduli that yield singular matrices are discarded. Such set of SLEs can easily be scattered upon a number of computers (and/or threads/processes) and then make a join on the gathered results. The biggest advantage of this method is that it can use regular 32 bit [Intel, PowerPC 7400] or 64 bit [IA 64, PowerPC 950, SPARC] integers represented by processors' registers therefore the calculations are very very fast and native. One minor problem is that RNS does represent division as a multiplication by an inverse in the given moduli group. Such inverse has to be calculated by a modified Euclid algorithmus [3] but it can be done pretty fast as well. Another problem is that we have no equivalents for functions like *sin*, *log*, *exp*, etc. in the RNS but we don't need them for the SLE solving.

We are currently researching a MOS FET parameter extraction and we tried several ways to extract the parameters. We chose to extract the MOS FET since its mathematical model is very complex and has about 30 parameters and we decided to extract 13 out of them giving the rest default value. We've also found that the evaluation of mathematical model can be done very precisely even with standard double precision and then calculate the numeric derivation and step to the SLE solving. The RNS proved to be the most useful since it is even faster than MPFR on a single processor machine with 13 extracted parameters and 1500 measured points of the DC MOS FET characteristic. A single iteration took about 2 minutes with MPFR with 128 bit mantissa while only few seconds with RNS with 3000 moduli used. The results were comparably precise.

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The Modeling of the Architectural Elements by the Rhino Software

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The main goals of the project *The Modeling of the Architectural Elements by the Rhino software* were:

1. Study the theoretical background for the *Rhino* modeling
2. Set the short guide of *Rhino* for the students
3. Model selected architectural elements
4. Prepare a part of the web site http://mat.fsv.cvut.cz/geometrie with the results of the project. All results created in the framework of the project can be found at this page. No demonstrations are presented in this short communication.

Rhino is a NURBS (Non Uniform Rational B-Spline) technology based software for the modeling of 3D objects. *Rhino* combines the accuracy of traditional CAD with the flexibility of spline-based modeling technology, to create objects that are smooth NURBS curves and surfaces rather than line segments or polygon meshes. *Rhino* uses trimmed free-form NURBS surfaces to accurately represent curved shapes, including curved shapes with holes in them. *Rhino* also integrates solids (surfaces joined together at their edges) and surface modeling so that solids can be exploded into surfaces, edited, and then joined back together again. Any combination of curves, surfaces, and solids can be trimmed. Rendering of the graphics can be realized by *Rhino*. For more quality rendering you must apply an external render, the best is Flamengo (the *Rhino* producer, *Robert McNeel and Associates*) or the 3DMax or another suitable software.

Rhino allows a standard manipulation with the basic primitives which is typical for all modellers – a wide palette of objects, Boolean operations, basic object transformations (sweep, loft, extrude, etc). On the other hand, it allows to create complicated 3D scenes as well. The basic information of the software can be found at the web addresses [3], www.rhino3d.com, www.dimensio.cz. There are a great number of addresses where the results of *Rhino* applications can be found, e.g. www.lubovo.misto.cz.

Rhino seams to be a suitable software for the modeling of basic geometric shapes and can be used in teaching geometry. The basic students guide is the first result, see [2]. The first chapter of this small "textbook" deals with NURBS objects. NURBS curves and surfaces are defined and their basic properties are presented. The main chapter describes the basic commands of the software. Besides the Menu bars, Toolbars and Graphics areas it describes the basic editorial modes. The fifth chapter shows the edition of objects – Points, Lines, Polylines. The special commands as *LinePerp* (a normal to a given curve passing through a given point), *LineTan* and *LineTT* (a tangent line to a given curve or two curves) are presented. A wide list of commands concerning curves obtains Conic, Helix, Spiral, Arc, Curve, InterpCrv, Circle, Ellipse. Special part includes polygons. A surface can be created by a "moving" curve. Eight basic commands are described: Revolve, Extrude, Loft, ExtrudeAlong Curve, LoftLoose, LoftNormal, Sweep1 and Swep2. Selected solids are defined by their surfaces, special objects are Box, Cone, Cylinder, Torus, Ellipsoid, Sphere. Basic Boolean operations are described. The last chapter shows the representative examples

of geometrical problems solved by means of *Rhino*. The first example is a transitional surface between a square and a circle (or a box and a cylinder), next examples show three simple applications: a chalice, a spindle band and a spiral baluster.

The second main result is a collection of models of different architectural elements. We have tried to model various capitels and foots of different types of stanchions, balusters, niches, lattices. The next part of the collection obtains various staircases. The collection will be extended in the year 2004. The website [3] also shows the more sophisticated applications in the reconstruction problems, which were created in Dimensio comp.

The application of a suitable software allows to create the spatial imagination of the future architects. This pilot project was focused on the individual work of a group of students. The main part of the results is due to the student of the program Civil Engineering and Architecture Jan Zajíček. He is the author of all demonstrations at the web site [3]. Other activities related to the project were realized by Zdeněk Vacek.

A ClassroomKit of the software was bought in the framework of this project which has been supported by the FRVS agency. A facultative course *Modeling with Rhino* will be available in the next academic year. A thin manuscript based on the report [2] will be prepared during the summer term.

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Many-valued Logics and Their Properties

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Łukasiewicz logic is one of the most important logics in the broad family of many-valued logics. Its corresponding algebraic structures of truth values (MV-algebras) are well-known and deeply studied. Mundici's famous result established an important correspondence between MV-algebras and Abelian lattice ordered groups with strong unit. There is an obvious question if there is a logic, whose corresponding algebras of truth values are in the analogous correspondence with lattice ordered rings.

There are several papers by Montagna dealing with so-called product MV-algebras. A product MV-algebra (PMV-algebra for short) is an MV-algebra enriched by a product operation in such a way that the resulting structures correspond to the lattice ordered rings of functions with strong unit. Montagna proved the subdirect representation theorem for PMV-algebras and established a correspondence between linearly ordered lattice ordered rings of functions with strong unit and linearly ordered PMV-algebras. Later he introduced PMV_Δ-algebras (PMV-algebras enriched by the 0-1 projector Δ) and proved the categorical equivalence between PMV_Δ-algebras and certain extension of lattice ordered rings of functions (so-called δ-*f*-rings). Finally it was shown by Montagna and Panti that the variety of PMV_Δ-algebras is generated by the standard PMV_Δ-algebra (over the real unit interval).

In the forthcoming paper, Montagna introduced a quasi-variety **PMV**+ containing only the PMV-algebras without non-trivial zero-divisors and showed that **PMV**+ is generated by the standard PMV-algebra (over the real unit interval).

However, so far there was no logic corresponding to the all above-mentioned algebras. In the papers [1,2], we define and develop such logic. Our logic, which corresponds to PMV-algebras, is called PŁ logic. Further, we introduce PŁ' logic corresponding to the algebras from **PMV**+. We also study the extensions of PŁ and PŁ' logics by Baaz's Δ ($PŁ_\Delta$ and $PŁ_\Delta'$ logics). The algebras of truth values of $PŁ_\Delta'$ logic correspond to PMV_Δ-algebras. This, together with the fact that there are also several other different algebraic structures called PMV-algebras, is the reason why we call PŁ-algebras the algebras of truth values corresponding to PŁ logic. Analogously, we introduce PŁ'-algebras, $PŁ_\Delta$-algebras, and $PŁ_\Delta'$-algebras.

We use the above-mentioned algebraic results to obtain completeness of all of these logics with respect to the class of the corresponding algebras of truth values, i.e. a formula φ is provable in the given logic if and only if φ is a tautology in all corresponding algebras of truth values. Since we have also the subdirect representation theorems for all of these algebras, we can strengthen the completeness result by considering only the class of the linearly ordered algebras of truth values, i.e. a formula φ is provable in the given logic if and only if φ is a tautology in all corresponding linearly ordered algebras of truth values. Further, we also obtain the strong completeness theorems for all of these logics, i.e. a theory T proves a formula φ if and only if φ is evaluated by 1 for all models of T in all corresponding algebras of truth values. For PŁ' and $PŁ_\Delta'$ logics we prove even the standard completeness theorem, i.e. a formula φ is provable in the given logic if and only if φ is a tautology in the corresponding

algebra of truth values over the real unit interval. In other words, it means that the standard PŁ'-algebra (standard $PŁ_\Delta$'-algebra) generates the whole variety of PŁ'-algebras ($PŁ_\Delta$'-algebras). We are also able to extend this result for theories but only for finite ones. This gives us the finite strong standard completeness for PŁ' and $PŁ_\Delta$' logics, i.e. a finite theory T proves a formula φ if and only if φ is evaluated by 1 for all models of T in the corresponding standard algebra of truth values. Further, we show an example of a PŁ-algebra demonstrating that PŁ logic is not standard complete. It means that the standard PŁ-algebra does not generate the whole variety of PŁ-algebras. The fact that the variety of PŁ -algebras is not generated by the standard PŁ-algebra was already mentioned by Montagna but he gave no proof, only a reference to Isbell's paper. In that paper, Isbell proved that the equational theory of formally real *f*-rings (lattice ordered rings satisfying all lattice-ring identities that are true in a totally-ordered field) does not have a finite base, or even a base with a finite number of variables. Since the connection between Montagna's remark and Isbell's paper is not so straightforward, we present the above-mentioned example demonstrating that PŁ logic is not standard complete. Moreover, this example represents also a substantial simplification of the proof of this fact. Finally, we show the relation of our logics to the well-known ŁΠ logic. Roughly speaking, the logic ŁΠ is an extension of PŁ' logic by the product residuum.

Furthermore, we extend these logics by rational constants in the same way as the Rational Pavelka's logic (RPL) extends Łukasiewicz logic. We obtain RPPŁ, RPPŁ', $RPPŁ_\Delta$, and $RPPŁ_\Delta$' logics. We prove Pavelka-style completeness of these logics and show that the logics $RPPŁ_\Delta$ and $RPPŁ_\Delta$' coincide. Furthermore, we prove standard completeness of $RPPŁ_\Delta$ and show the relation of these logics to RŁΠ (the extension of ŁΠ by rational constants) and RPL.

Then we investigate the predicate versions of all logics mentioned above with one exception of PŁ' (the problem is that we can prove only completeness of this logic with respect to all PŁ'-algebras, but we are not able to prove it with respect to the linearly ordered PŁ'-algebras). We prove completeness theorem for the predicate versions of PŁ logic, $PŁ_\Delta$ logic, and $PŁ_\Delta$' logic. Further, we prove Pavelka style completeness for predicate version of RPPŁ logic, RPPŁ $_\Delta$ logic, and even standard completeness theorem for RPPŁ $_\Delta$' logic. Then, we deal with the arithmetical complexity of the set of tautologies of these logics which entails that the predicate versions of PŁ logic, $PŁ_\Delta$ logic, and PŁ $_\Delta$' logic, do not satisfy the standard completeness theorem. Finally, we show the relation of these logics to the predicate versions of ŁΠ and RŁΠ logics and the well-known logic of Takeuti and Titani.

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Reconstruction from Many Images by Factorization

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The traditional problem in computer vision is reconstruction of a 3D model of a scene from a set of 2D images capturing the scene from different points of view. Such 3D model describes the structure (shape) of the scene and the configuration (motion) of the cameras by which the images have been taken.

The main contribution of this work is a general method for projective reconstruction from many images by factorization which works for practical situations i.e. the perspective camera, occlusions in scene and not entirely exact correspondence algorithm. The most significant novelties are factorization of lines from perspective cameras and the extension of factorization of points from perspective to omni-directional cameras. These methods exploit all known data about the scene, namely in the same way and at once owing to they provide almost optimal reconstructions using already linear algorithm. Automatic detection of wrong correspondences finds the largest set of inliers.

In paper [2], we tackled factorization of lines from perspective cameras. We formulate reconstruction of lines as factorization. Our formulation is new and has not been published yet. Its main importance lies in enabling the projection of lines into images be written as a linear mapping, and thus to use factorization. However, we have to pay for this ``linearity''. The valid solution has to fulfill nonlinear identities, which are not easy to enforce in practical situations, and therefore it is not apparent at the first sight that the method is usable in practice. We show, and this is its second important contribution, that the chosen representation enables to reconstruct lines with small error (after bundle adjustment) though the identities were not fulfilled during the calculation but enforced at the very end. Our method enables to reconstruct even lines which do not have any point correspondence.

In [3], we fused our factorization of points [1] with correspondence estimator by Matas & Chum for wide base-line stereo. The main contribution of this work is a robust integration of the partial correspondences from image pairs provided by the correspondence estimator into a reconstruction consistent with all images of the scene. Compared to previous methods, this method can handle perspective views, occlusions, and outliers in image correspondences jointly. It appears that the method is able to detect outliers which cannot be detected using the epipolar geometry only and therefore it is suitable for integration with wide base-line stereo from image pairs.

In [4], we extended our factorization of points from perspective to omnidirectional (non-perspective) images. It can handle occlusions and outliers as well. We developed method for metric reconstruction from multiple images using the essential matrix of an arbitrary image pair. It was enabled by improving the metric reconstruction of the image pair by iterating linear projection of the internal parameter matrix closer to identity. It turned out that it is possible to correctly join correspondences with close reprojections in an automatic

way. As a consequence, the resulting reconstruction is more precise thanks the new correspondences found during joining. It also turned out that this method works very well for closed sequences without using any a-prior knowledge of that. The fact that the cameras are directional was exploited for outlier detection. It was done in a very early stage so that the process was not contaminated by outliers during finding the quasi-affine reconstruction.

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Probabilistic Models of Thermal Actions

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Any structure exposed to climatic temperatures or operating process temperatures is subjected to non-stationary and spatially non-linear temperature fields inducing strains or stresses. Some structures need to be therefore checked to ensure that temperature changes and induced structural movements will not cause overstressing. Consideration of thermal effects in design may lead to various modifications of the structure including proposals for movement joints.

Basic variables influencing thermal effects include

- climatic agents: air temperature (daily and seasonal changes), solar radiation (direct and diffused), wind speed influenced by regional wind climate of the specific country and local factors as terrain roughness or orography in the location of the structure,
- operating process temperatures (inner environment of the structure depending on the function of the structure),
- characteristics of construction works: space orientation of the structure (direction and height over the terrain), shape of the structure, dimensions and cross-sectional geometry, joints of the structure, types and colours of used materials and their mutual links, static system, thermal properties of materials used, other parameters such as moisture content, thickness of surfacing, building cladding, initial temperature at which the structure is restrained,
- properties of atmosphere and terrain.

Significance of various basic variables in the design depends on particular structural conditions. Shade air temperature and solar radiation being the non-stationary stochastic processes are the main climatic factors influencing the effects of resulting thermal actions on structures.

The two-dimensional temperature field may be commonly considered for structural analysis. It may be decomposed into a uniform component T_u (effective mean bridge temperature), two temperature differences DT_{My} and DT_{Mz}, and a residual non-linear self-equilibrated component T_E. The procedure of determination of temperature components is described in [3].

Shade air temperature has significant influence on the uniform temperature component T_u. Information on shade air temperature should be obtained from the National Meteorological Office. For the modelling of shade air temperature, distribution of extremes of the type I can be often applied [1, 2]. Confidence on statistical evaluation of air parameters is dependent on the duration of observation. For statistical analysis of these parameters, the observation data for not less than 25 years are necessary to be used [2]. However, significant differences from measured data may be obtained if the site is located in specific local climatic conditions, e.g. frost pockets (the difference can be more than 5°C). Recorded data given by the thermocouple located beneath the bridge shows, in general, less variation than the data provided by the Meteorological station or the Stevenson screen on site. The difference could be affected by the bridge mass above the thermocouple.

Solar radiation has significant influence on the temperature difference components. Data on short-wave solar radiation should be obtained from pyrheliometric observations, covering direct radiation on the surface perpendicular to sun rays, diffused radiation and total radiation on the horizontal surfaces of the structure. The intensity of solar radiation depends on

- the geographical latitude of the site, on the clearness of the sky and the environment,
- the season,
- the orientation of the structural surface with respect to the sun,
- the colour and surface properties of the structure.

Two temperature components DT_{My} and DT_{Mz} in the vertical and horizontal directions may be commonly distinguished if the temperature variation in the direction of the longitudinal bridge axis is not significant. Both the components are influenced by properties of surfacing cover and its depth. Statistical characteristics for the models of temperature components DT_{My} and DT_{Mz} may be assessed on the basis of extreme value distribution [2].

At present only limited national information about thermal actions on bridges and other construction works is available in the Czech Republic. As a first estimate, probabilistic models of a uniform temperature component and temperature difference components may be assessed on the basis of models given in EN 1991-1-5 [1]. The type of probability distribution (extreme value distribution) and coefficients of variation for different types of bridges are indicated in background documents [2] and other materials, e.g. [3, 4].

It is expected that long-term measurements will provide new information on performance of bridge structures subjected to thermal actions. The measurements will be initiated by the Czech Technical University in Prague, Ministry of Transport and Road and Motorway Directorate of the Czech Republic.

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Section 2

PHYSICS

The improvement of Physic Teaching Based on Student Laboratory Work at Faculty of Transportation Sciences

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It is necessary to reflect fast development of physical knowledge in the level of physics education in all natural sciences and technical branches. The important tool in physics education for students of bachelor program are practical labs in which they deal with contemporary knowledge of physics.

The student physical labs established at the Faculty of Transportation Sciences of Czech Technical University four years ago are a part of the Department of Applied Mathematics, fully covering practical exercise for the subject Physics I and Physics II (about 260 students per year). Students work in pairs fully independently and actively measure lab experiments dealing with practically all parts of physics. Such extensively use of student labs needs a corresponding technical base. Despite the effort in last year the current state of the labs has not been satisfactory yet. The reasons are both the fact that the labs were established short time ago and because of the fact that the financial means which were at our disposal during last four years were not sufficient.

Thanks to financial support of the grant it was possible to realize two laboratory exercises: measuring of optical fibres properties and determination of the gravitation constant. The basic description of these exercises is summarized below.

The present state of knowledge of technical university students in the branch of modern optics and optoelectronics does not reflect the contemporary development of this progressive technology field. So we proposed a project to improve our physics teaching course in the field of optical fibres. A new program was realized at our department and it created new conditions for a current laboratory training in the above mentioned branches of optics. Under the project the set-up was completed for the following experimental study topic: properties of optical fibres, numerical aperture, attenuation.

Optical fibre, in modern days, it is used widely in communications, both in computer networks, as a fast Internet connection source and in telecommunications. An optical fibre is flexible optically transparent fiber, as glass or plastic, through which light can be transmitted by successive internal reflections. There are two types of fibres: stepindex fibre, graded-index fibre. The main difference between these fibres is the refractive index profile of the core.

The allowed directions are called modes and their angles satisfy the conditions for constructive interference due to the wave nature of light. A multimode fibre supports more than one propagation mode. Single mode fibres usually have a smaller diameter core than multimode fibres. The light gets attenuated when traveling in optical fibre. Attenuation is measured in decibels per kilometer.

Using a gravitation torsion balance as a highly –sensitive force-sensing device, the gravitation constant is determined experimentally. A torsion balance of this type was used for the first time by Cavendish in 1798. It permits forces of the order of magnitude of 10^{-9} N to be measured. A mirror is secured on the torsion wire with very small angular restoring moment. It is thus possible to measure the twisting of the wire by means of light pointer.

The two bodies with large mass ´M´ rest on a rotary plate whose position can be changed so that a large ball is first opposite the other small ball. In order to determine the gravitational force acting between ´m´ and ´M´, the angular restoring moment of the torsion wire and the angle between the two equilibrium positions of the measuring system must be determined.

It should be pointed out that the Cavendish experiment was the first direct measurement of the mass of the Earth and it is considered as one of the most illustrating experiments in the field of physics.

The pamphlet and laboratory guides were created for both mentioned exercises. The pamphlet contains also the basic theory and basic information concerning evaluation of measurement precision and especially the measurement uncertainties. The experiments are described in [2,3], where the physical background relative to experiment is discussed in detail.

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The Innovation and Complementation of Practical Physic Teaching at Faculty of Transportation Sciences CTU

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The fact that the deep knowledge of mathematics and physics is necessary condition for all technical branches is generally accepted. The ability to measure and evaluate data is very important part for any engineering application. However, the quick development of measuring equipment and, particularly, the computerization have brought many changes into education system. The modern teacher must transform the old proved laboratory exercises in such a way that the experiments (e.g. measurement, data processing) will be carry out using modern equipment. Nevertheless, the purpose of these experiments stays the same.

The student physical labs at the Faculty of Transportation Sciences of Czech Technical University were established four years ago and it is possible to say that their equipment corresponds to requirements of modern technology. In our laboratories the pair of students measure exercises covering almost all part of physics. Computers are used very frequently as measuring equipment, moreover, students use them for data processing. As was mentioned, the labs are relatively new, thus, the current state of the labs has not been satisfactory yet. Thanks to effort of teachers and financial support of the grant mentioned below new exercise was established – Study of magnetic induction.

Knowledge of magnetic field is important part of physics taught at Department of Applied Mathematics. It is the reason, why the experiments dealing with this topic must be included into laboratory exercises. Students have to apply the fundamental physics laws and show their ability to measure experimental data.

The principle of this laboratory exercise is based on knowledge of Maxwell's equations, particularly second equation describing relationship between magnetic flux and induced voltage. A magnetic field of variable frequency and varying strength is produced in a long coil. The voltages induced across thin coils which are pushed into the long coil are determined as a function of these variables:

1. the strength of the magnetic field
2. the frequency of the magnetic field
3. the number of turns of the induction coil
4. the cross-section of the induction coil.

The variations of the induced voltages with variables mentioned above are presented in graphs and their linearity is proven in the graphs with logarithmic scales. Moreover, the value of magnetic induction on the axis of long coil is calculated using the coil parameters and

compared with the value obtained from the experiment, in this case from the dependency of the induced voltage on the strength of the magnetic field.

The experimental set consist of field coil, induction coils, function generator, the coil current is measured with multi-range meter and the induction voltage with the digital hand multimeter. The effect of frequency should be studied between 1 kHz and 12 kHz. The function generator allows measure in wider range of frequencies, but in frequency below 500 Hz the coil practically represents a short circuit and above 12 kHz the accuracy of measuring instruments is not guaranteed.

The pamphlet and laboratory guides were created for modulus of elasticity. The pamphlet contains also the basic theory and basic information concerning evaluation of measurement precision and especially the measurement uncertainties. The experiment is described in [1], where the physical background of magnetic induction relative to experiment is discussed in detail.

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Ozone Production by Non – Thermal Electrical Discharges

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Ozone is a powerful disinfecting and oxidizing agent, and this is a reason why it is used in a wide range of applications such as a water treatment, treatment of municipal water and waste water, food processing, fire restoration, restoration of buildings and other objects after floods etc. When ozone comes in contact with organic compounds or bacteria, the extra atom of oxygen destroys the contaminant by oxidation. Thus ozone will neutralize virtually all organic odors, specifically those containing carbons as their base element. This will include all the bacteria as well as smoke, decay and cooking odors.

Ozone is usually generated in three different ways:

- Electrochemical generation - in this case an electric current passes through the liquid electrolyte, to produce a mixture of gases, which contains ozone.
- Generation of ozone by ultraviolet rays (this process happens in the upper layers of the atmosphere).
- Generation of ozone in non-thermal plasma produced by electrical discharges.

Most of the ozone for practical applications is produced by electrical discharges. To reduce the cost of ozone-based technologies the design of efficient ozone generators based on electrical discharges has always been the focus of many researchers. Even though industrial ozonizers based on electrical discharges are in use for a long time, the design of an ideal plasma-chemical ozonator is a difficult task. To produce ozone from air efficiently, an ozonator should produce, first of all, large quantities of oxygen atoms at reasonable cost. When nitrogen is present in the feeding gas, the ozone production cannot be separated from the generation of nitrogen oxides. Taking into account the mechanism of ozone formation from air it is therefore obvious that for efficient ozone production it is necessary to suppress the excessive production of nitrogen atoms.

Formation of nitrogen oxides is however favored by heat produced in the discharge. Thus for example NO and NO_2 form a cycle for ozone destruction by reactions:

$$\begin{aligned} O + NO_2 &\rightarrow NO + O_2 \\ NO + O_3 &\rightarrow NO_2 + O_2. \end{aligned}$$

The last reaction is significantly enhanced by the increase of the gas temperature, or

$$k_6 = 1,5 \times 10^{-12} \exp\left(-\frac{1300}{T_g}\right) \quad [\mathrm{cm^3 s^{-1}}].$$

Thus if the temperature of the gas T_g is increased from 300 K to 400 K then the reaction rate given by the coefficient k_6 is more than 3 times increased.

The main ozone formation reaction dominant at atmospheric pressure is reaction

$$O + O_2 + M \rightarrow O_3 + M,$$

for which the reaction rate dependence on the gas temperature T_g is given by the following expression

$$k_{12} = 2{,}5 \times 10^{-35} \exp\left(\frac{970}{T_g}\right) \quad [\mathrm{cm^6 s^{-1}}].$$

It is seen that reaction rate of ozone generation decreases with increasing gas temperature. Thus if the temperature in the discharge space is increased from 300 K to 400 K then the reaction rate given by the coefficient k_{12} is 2.2 times decreased. Increasing gas temperature therefore substantially reduces the ozone generation processes. The gas temperature T_g, which appears in the rate coefficient of reactions, is assumed to be the time and space averaged temperature in the discharge space.

The dependence of reaction rates of ozone and nitrogen oxides generation on temperature causes unpleasant effect, which is called discharge poisoning - that is the production of nitrogen oxides prevails over the production of ozone, so that finally no ozone is produced.

Due to the fact that the ozone loss processes are significantly enhanced by increasing gas temperature then to reduce ozone destruction channels it is necessary to keep the temperature as low as possible.

We have tested the efficiency of ozone production for five different plasma generators, namely for:

- pulsed positive corona discharge in wire-cylinder geometry,
- DC hollow needle-to-plate discharge enhanced by the gas flow,
- low-current DC gliding discharge,
- surface dielectric barrier discharge,
- diffuse coplanar surface discharge.

A comprehensive survey describing different aspects of ozone generation by electrical discharges can be found in [1–4].

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N-Heptane Decomposition by Non – Thermal Electrical Discharge

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Air pollution is one of the dominant environmental problems facing the world today. Air pollutants can be composed from particulate matter, greenhouse gases, toxic gases and volatile organic compounds - VOCs. The non-thermal plasma techniques based on the application of electrical discharges offer an innovative approach to the solution of some of these problems. There are several types of electrical discharges, which have been tested for VOC decomposition, namely corona (DC or pulsed) or dielectric barrier discharge. The corona discharge involves different configurations of electrodes. The most frequent one is wire to cylinder configuration, pin to plate and multi-pin to plate electrode configuration. As far as the corona discharge is relatively low power discharge, different methods have been applied for its enhancement. One of these methods is the application of the gas flow. In this way the discharge power can be increased without the danger of the discharge transition to spark.

Several different types of the gas flow stabilized electrical discharges have been tested for VOC decomposition [1,2]. The classical type involves multi-pin to plate electrode configuration in which the gas with VOC flows in the rectangular channel the wall of which serves as an anode and multi-pin electrode as a cathode. To stabilize the discharge and to prevent its transition to a spark the velocity of the mixture should be about 100 m/s. To relax these velocity requirements we suggested [3] the modification of this arrangement in which the pins are substituted by hollow needles. In this case the mixture of a gas with VOC flows around the needles with relatively small velocity and a small amount of admixture gas, which serves for discharge stabilization, is supplied through the needles.

In the plasmachemical reactor based on our proposal all the polluted gas, that is the mixture of air with VOC, is supplied into the discharge through the needles only. The main advantage of this arrangement is that the dead volume of the reactor is eliminated. The needles are situated vertically from upward and the plate electrode is horizontal. The experiments, which are described below were obtained with this type of the reactor.

VOC decomposition efficiency for particular VOC depends on following variables:

- type of the discharge used,
- gas temperature,
- humidity,
- residence time or flow rate,
- energy density (that is the ratio of the power delivered to the discharge and gas flow rate),
- type of the VOC,
- VOC dilution level in the background gas.

We performed an experimental study of the n-heptane decomposition in the multi-hollow needles to plate discharge. We choose n-heptane, a common part of organic solvents and automotive fuels, as a representative of saturated alkanes.

The experimental arrangement consisted from a plasmachemical reactor, DC power supply, system of air supply, system of precise dosage of n-heptane into the preheated air and the total hydrocarbon analyzer to determine the decomposition efficiency. The electrode system of the plasmachemical reactor consisted from 15 hollow stainless needles that were used as a first electrode. The mixture of n-heptane with air was supplied into the needles. The needles were situated perpendicularly against the metallic plate, which was used as a second electrode. The needles were arranged in three rows of 5 needles in a square lattice. A compressor supplied air through water and oil separator, mass flow controller into mixing and heating unit. The experimental arrangement is in details described in [4].

The first requirement for the study of VOC decomposition by the multi-needle to plate discharge with the flow of the mixture of air with n-heptane through the needles was to find stable operational regimes of the discharge. As far as the decomposition experiments were performed with increased temperature of the mixture and with different n-heptane concentrations we at first examined the influence of the temperature of the mixture and influence of n-heptane concentration in the mixture on V-A characteristics.

The second part of our experiments was devoted to the study of decomposition efficiency as a function of different input n-heptane concentrations. The concentration of n-heptane varied between 50 till 190 ppm, the airflow rate was fixed to 140 slm. The temperature of the mixture at the output of the mixing unit was adjusted to 79°C, relative humidity was 6 % and the energy density was 53.9 kJ/m^3. The decomposition efficiency was defined as a difference of n-heptane concentration before and after the discharge treatment divided by the concentration of n-heptane before the treatment multiplied by 100.

The results of the experiments can be summarized as follows:

- Increased temperature of air decreases for particular current the discharge voltage. The discharge voltage for the mixture of air with n-heptane for particular current is lower than the discharge voltage for discharge in air.
- Within the investigated range of n-heptane concentrations the V-A characteristics of the discharge for needle negative do not significantly depend on n-heptane concentration.
- For constant energy density with increasing n-heptane concentration the decomposition efficiency decreases.

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Study of Induced Radioactivity in the Inner Detector and JF Shielding of the Experiment ATLAS

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The Monte Carlo simulation results of the induced radioactivity in the forward shielding (JF) and in the copper collimator (TAS) region of the ATLAS detector are presented. The calculations are based on the simulation code GEANT. The program used for these simulations contains detailed geometry and material composition of the ATLAS detector.

The ATLAS detector, which is constructed at CERN at present, will operate in very hard radiation environment. During operation of the LHC many radioactive isotopes will be originated in the whole volume of the ATLAS detector. During the ATLAS detector operation there is expected a necessity to dismount several times some parts of the ATLAS detector. The knowledge of the induced radioactivity is very important from the point of view of people protection against ionizing radiation and in the case of inner detector also from point of view of noncorrelated background signal which could decrease the efficiency of particle detection. ATLAS detector has several shielding. One of them is shielding in forward region (JF shielding) which protects muon chambers against neutron and γ-rays background. The composition of the JF shielding was proposed by Prague's group and was published in [1]. The JF shielding and the TAS are placed behind the end-cap toroids up to the end of the experimental hall. The distance of the beginning of the JF shielding from the interaction point is appr. 13 m. Its length is about 6.5 m. The JF shielding is composed of two main parts. The first part has cylindrical shape while the second part is octagonal. Both parts are made of ductile iron (DI) core covered with 5% borated polyethylene (5 or 8 cm thick) and iron plate (3 cm thick). The DI section of the JF shielding is manufactured in Škoda Plzeň at present and the exact material composition and geometry were used for calculations. The TAS composition was taken according CERN information.

The first step of calculation was based on the GEANT Monte Carlo simulation program to generate particles due to p-p collisions in the ATLAS interaction point. It also transports particles through the ATLAS detector. The program saves information about the types and the positions of reactions inside the JF shielding and the TAS volume. 2000 p-p collisions were simulated which correspond to appr. 2 μs of the LHC running time. The most important reactions were inelastic hadronic scattering, neutron capture, hadronic reaction, and nuclear absorption. From these results the numbers of newly generated isotopes in the volume of the JF shielding and the TAS per second were obtained. Using the information about the generated isotopes in the JF shielding and TAS volumes, the disintegration of these isotopes was analyzed, especially from the point of view of γ-rays radiation. Only isotopes with half-life between 12 hours and 20 years were taken into account. Based on positions of newly generated isotopes the GEANT style program was used to calculate the self-absorption of the generated γ-rays in the volumes of the JF shielding and the TAS. The directions of delayed

γ-rays were generated isotropically. Our approach to investigate the induced radioactivity in the JF shielding and the TAS region was based on detailed study of the isotopes generated in the volumes of interest. The analysis of the obtained data allows us to find all newly generated isotopes. Many radioactive isotopes originated in the volumes (up to 110 isotopes) but the most part of the total dose rates is caused particularly by only several isotopes. In the case of the JF shielding the most danger isotope is $^{54}_{25}$Mn. After 10 days of cooling time it contributes by 50% to the total dose rate, while for 250 days of cooling time its contribution reaches up to 95%. For the TAS the situation is different. There are eleven isotopes which highly contribute to the total dose; seven of them give more than 4% to the total contribution. Between them the most important isotopes are $^{58}_{27}$Co, $^{56}_{27}$Co, $^{60}_{27}$Co, and $^{54}_{25}$Mn.

During simulations, the γ-rays spectra at different borders have been obtained and the corresponding dose rates on the surface and in several distances from the JF shielding were evaluated. The results show that the dose rates on the outer surface of assembled JF shielding are low. After 100 days of LHC operation and 10 days of cooling time maximal dose rate reaches 0.037 μSv/h at a distance of 20 cm from the JF shielding surface. According to the CERN safety rules the surrounding area of the JF shielding is so called public area, i.e. area with no restriction. The situation is dramatically changed when the JF shielding is disassembled. The inner surface of the JF shielding gives much higher dose rates (385.2-661.0 μSv/h). These dose rates are much higher than limit which is called at CERN limited access. It should be taken into account during the storage of the JF shielding. The situation is much worse closely to the TAS region where the dose rate reaches level of 11.12 mSv/h. In this region people must be supervised by the radioprotection group and can stay in this area only for a few minutes. Finally, the TAS itself and partly the JN shielding (shielding surrounding part of the TAS region) are very radioactive due to induced radioactivity (up to 60 mSv/h). It means that these parts of shielding need special care at the end of ATLAS detector operation.

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Two-neutrino Double Beta Decay of Mo100 to the Excited 0+(1) State

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The search for neutrinoless double beta decay ($0\nu\beta\beta$) is today a very attractive topic of neutrino physics as this process implies massive Majorana neutrinos and the existence of right-handed currents. Nevertheless, a great effort is also dedicated to a fine examination of the allowed two-neutrino double beta decay ($2\nu\beta\beta$) which would provide a better understanding of double beta decay process and would check theoretical models for calculation of nuclear matrix elements.

One of the currently running experiments searching for neutrinoless double beta decay is NEMO3. The sensitivity of the experiment to the effective neutrino mass $\langle m_\nu \rangle$ is on the level of 0.3 – 0.1 eV [1]. The NEMO3 detector, which is cylindrical in form and composed of twenty equal sectors, combines two detection techniques: the particle identification provided by a tracking wire chamber and the energy and time measurements with a calorimeter [1]. The apparatus, which is installed in the Modane Underground Laboratory (LSM Modane) in France, accommodates around 10 kg of highly enriched double beta decay isotopes, including ^{100}Mo, ^{82}Se, ^{116}Cd, ^{130}Te, ^{150}Nd, ^{96}Zr, and ^{48}Ca. The detector has been taking data since May 2002 and at the present time they give very encouraging results for the $2\nu\beta\beta$ decay of all the installed isotopes.

The quantity of ^{100}Mo in the detector (7 kg) also allows an effective measurement of the $2\nu\beta\beta$ decay of ^{100}Mo to the excited 0_1^+ state of ^{100}Ru. In this process, the $2\nu\beta\beta$ decay is followed by the emission of two γ-rays of 590 and 540 keV respectively coming from the $0_1^+ \rightarrow 2_1^+ \rightarrow$ g.s. cascade. These photons are often scattered inside the NEMO3 detector. This type of decay was previously observed in three spectroscopic experiments using HPGe detectors [2]. Compared to these experiments which were able to detect only γ-rays, the NEMO3 setup detects both photons and electrons. The wire chamber of NEMO3 provides three dimensional tracking of electrons, while the calorimeter measures energy and triggering time of electrons and photons. Although the NEMO3 calorimeter cannot reach the same level of energy resolution like HPGe detectors, the advantage of the adopted technique consist of the simultaneous detection of the two electrons and the two de-excitation photons from the $2\nu\beta\beta$ decay to the excited 0_1^+ state. As the calorimeter also measures the triggering time of particles, the use of appropriate time-of-flight criteria, in addition to energy cuts, reduces very efficiently all the kinds of background.

In order to study the $2\nu\beta\beta$ decay of ^{100}Mo to the excited 0_1^+ state of ^{100}Ru, the ee$N\gamma$ channel (i.e. a channel with two electrons and N photons where N = 2,3,4,…) and specific selection conditions were constructed. In the first stage the selection is focused on electrons and only events with two electron tracks having a common vertex in ^{100}Mo source foils and satisfying energy and time-of-flight cuts are selected. In the second stage the event selection is refined with energy and time-of flight cuts applied on photons. We impose, for instance, that events have to contain two photons which originate from the same vertex like electrons and which are perfectly in time with them.

As regards backgrounds, the only significant contribution in the eeNγ channel comes from the $^{214}Bi - ^{214}Po$ events produced by decay of radon that penetrated inside the wire chamber either through the porosity of organic joints between two adjacent sectors, or through some micro-leaks of the wire chamber. This fact was confirmed by both the simulations and the data analysis. The radon induced background is also dangerous for the 0νββ decay study. The present average radon activity inside the detector is of 25 mBq/m^3, while the activity of the air in the laboratory is around 10 – 20 Bq/m^3. The level of radon inside the detector will be reduced by a factor of 50 with an anti-radon setup composed of a tent surrounding the detector and of a system extracting radon from the air. The anti-radon system, which will be fabricated in the Czech Republic, will be set in operation in the Modane Underground Laboratory in 2004.

Runs from May 2002 to May 2003 have been analysed in order to look for a signal from the 2νββ decay of ^{100}Mo to the excited 0_1^+ state. However, these runs had to be divided into two periods according to different operating conditions of the detector. The first period, which is characterised by the detector's efficiency for the eeNγ channel reduced down to 60 %, corresponds to runs from May 2002 to January 2003 (1530 hr of running time), whilst the second period, with the same kind of efficiency reaching up to 92 %, corresponds to runs from February to May 2003 (1390 hr of running time). The signal is determined from the eeNγ events seen in twelve sectors with the ^{100}Mo source foils. The level of background is deduced from the eeNγ events observed in the non-molybdenum sources and from the eeNγα events in all the twenty sectors. Using the detector's efficiency for the eeNγ channel, the results from both periods can be combined. Then the final result for the 2νββ decay of ^{100}Mo to the excited 0_1^+ state for both periods given in the term of the half-life is $T_{1/2} = (8.8 \pm 2.2) \times 10^{20}$ yr. This result, which is a 4σ effect, is consistent with the previously published positive results from the spectroscopic experiments using HPGe detectors which range from 5.9 to 9.3×10^{20} yr. The current result of NEMO3 will be improved by the accumulation of statistics and by the reduction of the radon level inside the detector.

Detailed description of the NEMO3 detector, the complete selection criteria for the eeNγ channel, their construction based on Monte-Carlo simulations, as well as details about the applied data analysis can be found in Ref. [3].

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Multidetector Spectrometer TGVII for Studying of Double Beta Decay of ^{106}Cd

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The TGV (Telescope Germanium Vertical) project aims at the study of double-beta decay processes of ^{106}Cd and ^{48}Ca.

The experiment TGVII is based on the experience gained with the TGVI apparatus [1] (16 HPGe detectors each with diameter 40mm) which investigated double-beta decay of ^{48}Ca. Even though the very small natural abundance (0.187%) of ^{48}Ca complicates the production of radioactive sources in sufficient quantities, the large energy of reaction available ($Q_{\beta\beta}$ = 4272keV) makes this nucleus suitable for the study of such very rare processes. The total mass of ^{48}Ca examined in the TGVI detector was 1.08g ($1.35 \cdot 10^{22}$ atoms). This project was terminated in 2000 and gave the half-life of the two-neutrino double-beta decay mode and an estimate on the limit of the half-life of the neutrino-less mode of ^{48}Ca [2].

Since 2001 the spectrometer TGVII has been under construction. The main aim of the project is an improvement over the results on ^{48}Ca obtained by TGVI and especially an investigation of double-beta decay processes in ^{106}Cd (with emphasis on EC/EC channel). The EC/EC channel is the most favorable among the ββ processes due to the largest energy of reaction ($Q_{EC/EC}$ = 2778keV).

The spectrometer TGVII consists of 32 HPGe planar detectors mounted one over another in one common cryostat. The active area of the detector is of diameter 51mm and of thickness 6mm. The radioactive source in the form of a thin foil is inserted between neighboring detectors. As the TGVII spectrometer is primarily designed to investigate very rare effects, several methods to minimize possible background are used. The cryostat itself is surrounded by passive shielding made of copper and lead. The cryostat and the copper shielding are enclosed in an airtight box against external radon gas contamination. Anti-neutron shielding (16cm thick) made of boron doped polyethylene is used. The experimental facility is located in Modane Underground Laboratory in France (4800 m.w.e.).

Two different electronic setups were constructed for measurements with the TGVII spectrometer [3]. In the case of ^{48}Ca two electrons emitted in double-beta decay are detected. The energy region of interest extends from 2.7MeV (due to the end-point of natural background, 2614.5keV) to 4.2MeV ($Q_{\beta\beta}$). An additional technique for background suppression based on pulse shape analysis is used for the ^{48}Ca measurement. This method (combined with the coincidence technique) allows to suppress background due to gamma

events by a factor of 4–9 [4]. The measurement with ^{106}Cd consists in the detection of two X-rays (having energies from 21keV to 24keV) accompanying double-electron capture. In such a low-energy region the most important source of background is microphonic and electronic noise. To suppress such noise, a technique utilizing two spectrometry amplifiers with different shaping times is used.

Since year 2002 several measurements have been performed in order to determine the level of background. The experimental setup for each of the ^{106}Cd and ^{48}Ca experiments was assembled, tested and tuned. Preliminary background measurements have been performed. Further evaluation of background data is in progress.

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Photovoltaic Solitons

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Photorefactive spatial solitons have been investigated in the past few years. It is now well established that photorefracive nonlinearities can support self-trapping of optical beam in both transverse dimensions and these solitons can be observed even at very low power levels (microwatts and lower). At present, several types of photorefracive solitons are known: quasi-steady state solitons, screening solitons, and photovoltaic solitons, all of with can form in dielectric photorefractive crystals. Each type of soliton has still two types: bright soliton and dark soliton. A bright solitons, in which a beam of light propagates without change in its transverse profile, occurs when self-focusing due to light-induced change in the index of refraction balances diffraction. A dark soliton, in which a dark band, or notch, is superimposed on an otherwise uniform background illumination, occurs when self-defocusing due to a light-induced index change balances the diffraction of the notch. A dark soliton may be black, in which the intensity minimum is zero, or gray, in which it is nonzero but less than the background intensity.

We report here the observation of photovoltaic spatial solitons, which are predicted to occur in a medium with a significant photovoltaic effect. The optical nonlinearity responsible for soliton formation is due to the transport of electronic charge dominated by the bulk photovoltaic currents. Electrons are photoexcited from impurity centers with momentum preferentially directed along c axis of a ferroelectric crystal, and are then trapped in different impurity centers. The resulting space-charge distribution gives rise to an index gradient through the electro-optic effect. This index gradient is responsible for the self-guiding needed to generate photovoltaic solitons. We examine here Fe:$LiNbO_3$, for which the photovoltaic effect results in a negative index perturbation capable of supporting dark solitons. We investigate the specific case of dark planar photovoltaic solitons, in witch a dark notch is trapped in one transverse dimension and analyze their formation under open-circuit realizations.

Theoretical description is based on the standard set of rate and continuity equations and Gauss's law, which describe the photorefractive effect in a medium in which the photovoltaic current is nonzero and electrons are the sole charge carriers, plus the scalar wave equation for the slowly varying amplitude of the optical field. We look for stationary (nondiffracting) solution of the form

$$A(x,z) = u(x)\exp(i\Gamma z)\sqrt{I_d}\ ,$$

where A is the slowly varying amplitude of the optical beam, I_d is the dark irradiances, Γ is the solution propagation constant. The solution of these equations is the nonlinear wave equation that describes stationary (soliton) propagation in this photovoltaic nonlinear medium:

$$\frac{d^2u}{d\xi^2} = -\left(\frac{\Gamma}{b} - \frac{u^2}{(1+u^2)}\right)u\ ,$$

where b is the parameter that characterizes the strength and the sign of the optical nonlinearity, $\xi = x/d$, d is the characteristic length scale.

The tensorial nature of the photovoltaic and electro-optic effects due to the noncentrosymmetric nature of Fe:$LiNbO_3$ favors soliton propagation along a direction perpendicular to the crystalline c axis, light polarized along the c axis, and the gradient of amplitude profile along the c axis. In this arrangement, the electric field arising from the space-charge separation is along the c axis, so that the refractive index perturbation is proportional to the product of the strongest electro-optic tensor element ($r=r_{333}$) and the strongest photovoltaic tensor element ($\beta=\beta_{333}$).

The experimental setup consist of a iron doped sample of $LiNbO_3$ (the iron concentration is 0.2%mol in the sample), a argon ion laser beam of 514nm, a beam is collimated with microscope objective (10:1) with pin hole and the plano-convex lens with focal length 15 cm. We use 2x1x0.3 cm Fe:$LiNbO_3$ crystals. The intensity collimated continuous-wave is controlled with two polarizer, then the wave illuminate a strip of wire to yield a phase step across the beam (we use the wire with diameter 200μm), and a telescope to image the collimated beam onto the front crystal surface. The telescope consist of two plano-convex lenses, the first have f=10 cm and the second f=1 cm (this telescope make diameter of beam 10x smaller). The collimated beam on the crystal surface have 3mm diameter and the dark notch have diameter 20 μm, and the power of the background beam is about 20 mW. All measurement are performed at room temperature. The crystal is oriented with its c axis perpendicular to the direction of the laser beam, and the beam is polarized parallel to the c axis. The beam profile is magnified by microscope with magnification 40x, and then the beam profile is detected by a charge-coupled device array and captured by a computer-controlled frame grabber.

We have observed dark planar spatial solitons in a photovoltaic-photorefractive medium. The photovoltaic solitons exhibit tensorial and orientational properties manifested in the dependence of their shape and size on their polarization, direction of propagation and gradient of the amplitude profile, with respect to the principal axes of the crystalline photovoltaic medium.

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Carbon Fibre Z-Pinch at CTU

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The aim of this article is to explain the main reasons for taking an interest in z-pinch physics, and to present some results of the z-pinch research at the Department of Physics at Faculty of Electrical Engineering, CTU in Prague.

Z-pinch may be defined as a cylindrically symmetric plasma column in which plasma carrying an axial current is confined by its own magnetic field (owing to Lorentz force $\boldsymbol{j}\times\boldsymbol{B}$). Z-pinches belong to the most fascinating objects in plasma physics because of their simple principle and natural occurrence (including geophysics – lighting, and astrophysics - current channels in galactic scales). And it was the simple principle and geometry in particular, why pinches enjoyed great attention in the early 1950s in conjunction with research on controlled thermonuclear fusion [1]. The idea behind this research was to heat a fusion mixture by the Joule heating (or by the adiabatic and shock compression) and then to confine the plasma by its own magnetic field until a sufficient amount of fusion energy was released. However, since a large number of magnetohydrodynamic instabilities caused the disruption of a plasma column and confinement, plasma physicists abandoned the idea of z-pinches as a fusion reactor.

The interest of z-pinches was renewed in 1970s when the high voltage pulsed power technology was developed and used to drive a z-pinch load. Using pulsed power technology, it became possible to deliver electrical power and energy of ~50 TW and ~10 MJ respectively, into a small volume of ~ cm^3. Because a significant part of concentrated power is radiated in x-rays, z-pinch is the world's most powerful (290 TW, 1.9 MJ) and most efficient (15%) laboratory x-ray source [2], which can be applied e.g. in:

(i) laboratory measurements of material and radiation properties at densities and temperatures that could be otherwise reached only in underground nuclear explosions;
(ii) the inertial confinement fusion;
(iii) the development of x-ray lasers and x-ray sources for EUV lithography and x-ray microscopy;
(iv) astrophysical research (z-pinches can produce plasma with similar radiation properties that are in the outermost layer of stars).

The primary objective of our research at the Department of Physics (FEE, CTU in Prague), however, is not high x-ray yield, but a detailed description of a fibre z-pinch development in general. It started in connection with experiments carried out at Imperial College (London) at the end of 1990s [3]. Our British colleagues were using a carbon fibre as a load because it possesses similar properties as a frozen deuterium fibre which was proposed to achieve nuclear fusion and radiative collapse.

Our research has been performed on a small device Z-150. In most cases, the Z-150 capacitor bank of 3 μF was charged to the voltage of 25 kV. The current was peaking at ~70 kA with an 850 ns quarter period rise time. The experiments were carried out with the carbon fibres of 15, 80 or 300 μm diameter and 8 mm length.

For observing plasma dynamics, different diagnostic tools were used simultaneously, e.g. an Al filtered PIN diode, an XUV spectrograph, and a VUV pinhole camera. The temporal resolution was carried out with two 4 frame MCP detectors with the exposure time of 2 ns and the time delay between exposures of 10 ns. The laser probing enabled the visualisation of the electron density gradient. The sensitivity of the schlieren set-up was 3×10^{-4} radian. From each shot we obtained the output from a PIN diode and electric probes, 3 gated pinhole images, 3 gated XUV spectra, and 1 schlieren image. This diagnostic set-up, and by extension the results obtained from it, enabled us to observe the evolution that can be summarized as follows [4]:

(i) Before the onset of the first pulse detected with a PIN diode, the VUV radiation was emitted predominantly from the anode. The coronal plasma was below the detection limit and as far as XUV spectra are concerned, we did not observe any lines in the 2-7 nm spectral region.

(ii) At the onset of the XUV pulse the radiation was emitted from the cathode and coronal plasma near the cathode. After that the emitting region was moving with the velocity of 10^5 m·s^{-1} predominantly towards the anode. Finally, the radiation from the anode dominated over the radiation emitted by the cathode. At the onset of the X-pulse we also detected K-shell lines of carbon ions.

(iii) XUV pulse with FWHM of 10-50 ns occurred approximately 250 ns after the current breakdown. At the very peak of short XUV pulses, we could see that the coronal plasma radiated from those regions where m=0 instabilities were developed. K-shell spectra were analyzed by means of non-LTE atomic physics code FLY. The maximum electron temperature and electron density of the "hottest" region were estimated to be 80 eV and 10^{19} cm^{-3} respectively.

(iv) Next, we observed the magnetic pinching of evaporated material from the electrodes. Schlieren and pinhole images, as well as the drop in the load dI/dt gave evidence of the „pinch". Moreover, the resonance spectral line of He-like oxygen was detected although it was very weak.

(v) Finally, at the time of the maximum current, the long lasting emission was peaking. The radiation was emitted from evaporated and ionised material of the electrodes. One of the salient features was the existence of a non-evaporated fibre almost 1 μs after the current breakdown.

We believe that these findings will help us to get deeper insight into the processes of generation of x-ray radiation and charged particles in dense z-pinches – the processes that have not yet been fully understood but seem to be a key to further and wider z-pinch applications.

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Diffractive Optical Elements Realized on Twisted Nematic Liquid Crystal Spatial Light Modulators

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Recently, synthetic optical diffractive elements have become still more interesting because of the fast development in the field of technology of fabrication devices. However, the limitations introduced to the design process due to the fabrication still play very important role and must be considered from the very beginning of the process. In this contribution, main focus is oriented on computer driven spatial light modulators based on twisted nematic liquid crystals as devices for displaying generated elements. In comparison with lithographic techniques, the limitations are more complicated now. The transfer function of the modulator is fully complex, there is no pure phase or amplitude operating mode. This is especially true in the case of twisted nematic modulators when the twist factor complicates the modulation. Motivation for adaptation of twisted nematic modulators for diffractive elements realization is strong, due to their low price and wide commercial availability. The goals of our contribution can be divided into two main parts. The first one is an issue of modelling the modulator's transfer function – dependence of the complex transmittance function of the device on the input voltage. The second part discusses diffractive optics optimization procedures with consideration of the modulator properties.

The twisted nematic cell can be modelled as a system of birefringent layers where optical axis of each layer is slightly twisted. Application of electric field on the cell leads to the change of refractive indices of the layers. Input and output polarization are important parameters that can be used for tuning the transmittance of modulator together with voltage applied over the crystal. It has been shown that it is possible to find values of these parameters that ensure desired response of the modulator, e.g. phase mode with minimal amplitude variations, etc. Theoretical predictions have been proved also experimentally. The next studied problem of the modulators is an influence of dead areas (electrodes) that can scatter an incident light and disturb functionality of the diffractive element.

In the field of design algorithms several issues have been approached. Most commonly used algorithms for computer-generated diffractive structures design are typically adapted for so-called Fourier-domain holograms. In this contribution, a modification of such procedures for Fresnel-domain is presented. Furthermore, the design process is extended to structures with simultaneous multiple focuses at different distances. As it turned out, design and optimization algorithms for Fourier-domain structures can be effectively used in such cases, only after some modifications. Further in this contribution, design procedures based on iterative approaches such as iterative Fourier transform algorithm (IFTA) and direct binary search (DBS), applied to designing such structures, are presented. Furthermore, the elements with tilted focal plane have been of interest due to their potential applications, and design algorithms for such elements have been developed and implemented.

As noted above, two optimization techniques have been considered – IFTA and DBS. Concerning the IFTA, we have used for designing structures our design code HOLOGENERATOR. Since we are interested in amplitude-only input objects, the phase freedom (i.e. a random initial phase distribution) within the signal window, as well as the amplitude freedom outside this window, are applied. In general, depending on degrees of

freedom chosen, an input signal, represented within the signal window, is transformed from the object plane to the hologram plane and back using the relevant transform (i.e. Fourier transform or its modifications). Within each iterative step, the requirements in both object and hologram plane are applied. The other iterative approach, the DBS algorithm, on the other hand, starts with a random distribution of the binary hologram transmittance function. The hologram pixels are then sequentially inverted, and after each inversion, new values of the quality parameters are checked. Acceptance of the current inversion depends on the quality development. Introducing the acceptance probability distribution (instead of the unity probability in DBS case) leads to varieties of simulated annealing (SA) algorithms.

Both described algorithms can be used for designing multi-focus elements with reconstruction in multiple parallel planes. However, sometimes an object can consist of many points that are distributed continuously in the space. The multi-plane approach then becomes very complicated because of high number of planes. Typical examples are elements with reconstruction on the curved surface or in the tilted plane. In this case different approach can be applied, i.e. when each object point is constructed separately without dividing object into slices. Implementation of such approach has been demonstrated on an element with reconstruction in the tilted plane.

Within the experimental part of the work the twisted nematic liquid crystal based spatial light modulator was used for realization of designed elements and verification of their functionality. First, the modulator was analysed and its transmittance was evaluated as a function of the input signal. Also other parameters as fill-factor and pixel-shape have been considered. Afterwards, the modulator was used for displaying various designed elements. Optical reconstruction was recorded using a standard CCD camera. During experiments, the modulator was made operating in different amplitude and phase modes. The experimental results verify functionality of used approaches to the design of synthetic diffractive elements and also confirm our twisted nematic cell model that stands behind the experiment.

Finally, we can conclude that liquid crystal based spatial light modulators represent a prospective way of realization of synthetic diffractive elements. Their unique dynamical properties enable us to perform fabrication process very fast and realize dynamical elements that can be very useful in various branches of the industry and research. The twisted nematic modulators are interesting mainly for their low price and good availability. Our approaches show how they can be adapted for application in diffractive optics. Considering the fast development in the technology of modulators, especially decrease of the elementary pixel size, increase of the fill-factor and speed, we can state they promise very interesting possibility of diffractive elements realization already in the near future.

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Neutron Production at PF 1000

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The plasma focus discharges are studied due to high efficiency of the X-rays emission and the neutron yield production (supposing we use deuterium as a filling gas). The facility PF-1000 is working at the IPPLM in Warsaw, where the high-energy plasma is studied in collaboration of a few laboratories in the program of ICDMP. This research is concentrated on comprehensive X-ray and neutron diagnostics with the temporal spatial and spectral resolution of the pinch phase of the plasma focus [1-3]. It is studied the influence of the fiber or wire placed in the axis at the top of the inner electrode on the production of X-rays and neutrons. In paper [3] the PIN and soft X-ray signals were observed in experiments with and without fiber or wire at the electrode configuration with the same length of inner and outer electrodes. In this paper the XUV pulses conditioned by the carbon fiber are investigated and discussed at the electrode configuration with the cathode 20 cm longer than the anode. At this electrode configuration X-ray signals and neutron production were studied in shots with and without the fiber.

The experiments were performed with the current maximum of 1.5-1.8 MA. The inner anode (length 600 mm) had 230 mm in diameter. The outer cathode (length 800 mm, 400 mm in diameter) was put together with the use of 12 stainless steel rods. The carbon fibre (80 μm in diameter and 7-9 cm in length) was placed at the axis of the electrode outlet having no galvanic connection to the anode. The filling pressure of deuterium was 4 hPa.

The side-on radiation from visible to hard X-ray range was measured with temporal, spatial and energy resolution. The PIN silicon detector filtered with 10 μm Be detected X-rays with energy above 600 eV. Three frame cameras (gated time 1 ns) imaged the location of the plasma source in the visible spectral range. Two Ne102a scintillators (filtered with either 10 μm Al or 20 μm Cu) detected X-rays in the range above 4 (soft) or 10 keV (hard) respectively. The slit of the streak camera (for visible wavelength range) was oriented perpendicular to the fibre, and it imaged the plasma region at the distance of 1.5 cm from the anode top. The time integrated pictures of X-rays were detected with the pinhole camera. The pinhole diameters of 150 μm were filtered with 10 and 20 μm of Be. The time integrated XUV grazing incidence spectrograph was used for the study of carbon K-shell lines in the spectral range of 200-700 eV. The high-energy electrons with energy above 100 keV were registered with Cherenkov detector. Three scintillation probes located at the distance of 7.5 m (1 down-streams, 1 up-streams, 1 side-on) were used to perform time-resolved measurements of the neutron emission. The neutron yield was measured with indium and silver-activation counters. The diagnostics set up was described in detail in [4].

The presence of the carbon fibre in the axis of electrode outlet intensified the radiation in the spectral range of carbon K-shell lines ≈ 300 eV. This radiation was emitted from the total length of the fibre corona of 7-9 cm in length and 2 – 3 mm in diameter at the electron temperature above 100 eV and electron density 10^{20} cm^{-3}. We suppose that the XUV radiation of the plasma in the fibre corona is generated by the dissipation and transformation of internal helical magnetic field.

The electrode configuration with the longer outer electrode is not optimal for good compression of the pinched plasma sheath. It we see from 3 cm minimum diameter and the lower neutron yield (maximum 10^{11}). The zero PIN and MCP signals of XUV in the shots without fiber can be interpreted by a lower increase of the plasma temperature at the implosion. The temperature is not sufficient high for overcoming of a threshold of the XUV registration in comparison with the experiments at the configuration with the same length of the electrodes, when the minimum diameter of the pinched plasma sheath was below 2 cm and the maximum of neutron yield reached 10^{12} [3]. The resulted plasma energy density (1-2)$\times 10^7$ Pa in plasma corona was estimated from electron density and temperature, calculated from intensities of carbon K-shell lines. Let us suppose, that this value of energy density is the same inside of the total volume of the pinched plasma. Naturally both questions arise, in which sort of energy transforms the imploding plasma in the axis area, and why this energy is not released in the shots without fibers and why is released at the radiation of the fibre corona in the shots with fiber. The first answer could be given by presence of the axial magnetic field, which self-generates during current sheath implosion, and which is more intensive at the configuration with the different length of electrodes. The pinched plasma focus is confined by helical magnetic field, when the axial internal component is compressed by azimuthal component. Then the density of magnetic energy is constant in the total pinched plasma column. A rough estimation of the magnetic pressure we can make by following consideration. For the current 1.5 MA and the diameter of the pinched plasma sheath 2-3 cm we obtain the magnetic pressure of (4-8)$\times 10^7$ Pa. The answer to the second question we do not know. The important role must play the dense fiber corona.

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Cation Distributions in Faujasites NaX and NaLSX by Powder Neutron Diffraction and ^{13}C MAS NMR

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Nature of acid or basic sites and the distribution of sodium cations and chemisorbed methyl groups in the zeolitic lattice belong to the most important problems of surface chemistry. Theoretical investigations [1] as well as experimental results [2] demonstrated that chemical properties of protons are controlled by actual basicity of the lattice oxygen atoms and by the character of bonds where protons are attached. Experimental support was obtained also from the results of diffraction methods, where namely neutron diffraction provided direct evidence on the location of protons in faujasites with various H+/Na+ ratio [2]. The aim of our study was to estimate the location of chemisorbed species in the lattice and to elucidate the role and participation of various lattice oxygen types in chemisorption of methyl cations. We have made an attempt to estimate regular distribution of cations and chemisorbed species over the lattice and to locate chemisorbed CH_3^+ ions at different oxygen atoms.

Well-developed crystals of NaY, NaX and NaLSX with high content of sodium cations and with low content of defects and decationation were used in this study. The reaction of methyl iodide with sodium cations was used for the preparation of anchored methyl groups in the structure of zeolites. ^{13}C MAS NMR spectra were measured on a BRUKER DSX200 spectrometer. Neutron powder diffraction patterns were collected at temperature of 298 and 7 K on the KSN-2 diffractometer, which is placed at the LVR-15 research reactor in Řež near Prague. This device was equipped with close circuit liquid helium cryostat - type CP-62-ST/5 (Cryophysics SA). The wavelength of 0.1362 nm was used and the resolution $\delta d/d=0.00075$ was achieved (d is the interplanar spacing). The complete structural parameters were determined by Rietveld analysis of powder neutron diffraction data using the GSAS software package (Tab. 1).

Tab. 1: Experimental and refinement informations for chemisorbed NaX and NaLSX samples

Sample	Temperature	Space group	a /nm/	R_{wp}	R_p
NaX	7 K	Fd-3	2.4895(6)	0.0523	0.0487
NaLSX	7 K	Fd-3	2.4975(4)	0.0538	0.0492

Remarks: Weighted and unweighted profile R factors are defined as $R_{wp} = \{[\Sigma w_i (I_{o,i} - I_{c,i})^2] / [\Sigma w_i (I_{o,i})^2]\}^{1/2}$ and $R_p = \Sigma |I_{o,i} - I_{c,i}| / \Sigma I_{o,i}$. ($I_{o,i}$ and $I_{c,i}$ are the observed and calculated powder diffraction intensities for the ith point, respectively, weights w_i are $1 / I_o$).

Our structural parameters for the initial dehydrated bare samples and parameters for characteristic chemisorbed NaX and NaLSX samples are given in [3,4]. The occupation numbers of cations (Tab. 2) and the location of CD_3 groups were determined. Zeolite LSX (low silica X) has a Si/Al ratio of 1 and represents the highest number of charge-compensating cations among all faujasites. Parameters of NaLSX given in [4] were refined

in both recently discussed space groups, as in Fd3 space group as in Fddd (orthorhombic) group but without any significant difference.

Cations are distributed over six possible sites as proposed by Olson [3]) in the frame of Fd3 space group. The occupation numbers of Na cations in chemisorbed NaX has been decreased for $S_{I'}$ and $S_{I''}$ in contrary to the increase for S_{III} in comparison with the initial NaX. S_{II} is practically fully occupied in both of the lattice atoms in original evacuated NaX and in the same sample after chemisorption of methyl iodide.

Table 2. Cationic Sites in Dehydrated Faujasites NaX and NaLSX

Zeolite	Cation Site	Type	Hunger[1]) et al. *)	Grey[2]) et al. *)	Olson[3]) **)	Plevert[4]) et al. **)	Vratislav et al. ***)
NaX	SI	16c	4	2	3		3
	SI'	32e	16	28	29		29
	SII	32e	32	32	31		31
	SIII'(1,2)	96g	25	13	21		21
	SIII'(3)	96g	6	10	8		9
NaLSX	SI	16c	4			0	0
	SI'	32e	18			32	25
	SII	32e	32			32	32
	SIII'(1.2)	96g	26			16	34
	SIII'(3)	96g	13			15	8

Remarks: *) NMR results, **) X-ray diffraction, ***) neutron diffraction, our study
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We observed serious changes in the distribution of the lattice elements after chemisorption of methylium ions. These changes were detected not only in occupation factors but sometimes also in coordinates of Na^+ cations. Our results (in Table 2) are well in line with these findings of the other authors [1,2,3,4]). For NaLSX we observed in addition another effect resulting from the influence of chemisorbed species on the geometry. This effect was associated with some distortion of cubooctahedra caused probably by chemisorbed species together with associated cation displacement.

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Origin and Growth of Instabilities on Transition Between High and Low Density Plasma in Cylindrical Geometry

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In this paper, a local axisymmetric perturbation analysis of the magnetorotational instability in a weakly ionized rotating plasma flow with low density is presented. A rotational symmetric stratified plasma flow threaded by a weak constant magnetic field is considered. The flow is influenced by the ohmic diffusion and thermal conductivity along magnetic field lines. Already, both cases were examined separately, but in this study the focus is put on their combined effects. A general dispersion relation is derived, which in the limit of vanishing plasma resistivity and/or thermal conductivity coefficient simplifies to known results. The ohmic diffusion dissipates small scale magnetic field perturbations so the instability is damped.

Although the astrophysical accretion on the central object could be a very vigorous process, many cases of so-called low luminosity or a radiative-inefficient accretion is also observed; e.g. Galactic center Sgr A*. Several different mechanisms try to explain this quiescent state in MHD area. One of them assumes the standard MRI instability [1] with an outward angular momentum transport and an energy surplus emitted in funnel regions around poles. Another expects a domination of convective modes (i.e. modes with the inward directed angular momentum transport as in the hydrodynamics) co-existing with standard MRI modes. Convective modes cause an effective damping of the angular momentum transport and consequently less energy is radiated away. Hence, a local perturbation technique is used to investigate a stability of axisymmetric modes in an accretion disk with global magnetic field. Especially, the focus is put on the growth of magnetorotational instability (MRI) in the partially ionized low-density plasma. The examination of the instability growth rate will be emphasized and the dependence of the growth rate on effects of dissipation and conductivity will be investigated. Next, the relevant component of the stress tensor will be computed numerically.

An axisymmetric rotating magnetized accretion disk threaded by uniform magnetic field is considered. The accretion disk is not fully ionized everywhere. Next, a thermal conductivity along magnetic field lines is assumed (according to Balbus [2]), which is possible in the low density plasma. The low density plasma means that the mean free path of a particle traveling along magnetic field line must be much longer than one Larmor orbit. The Boussinesq approximation is used to filter out magnetosonic waves, but to retain effects of the magnetic field. Further, the self-gravitation of the disk is neglected. The equilibrium disk is rotating with the angular velocity depending on the radial distance from the center; other initial quantities are allowed to depend on both radial and vertical distances. The equilibrium magnetic field is constant and the Alfven velocity is smaller than the rotational velocity. It means that a weak magnetic field is considered. The last assumption is that magnetic field lines are isothermal. The procedure of the examination closely follows those in [2, 3, 4].

The magnetized disk is described as a rotating plasma flow, so standard set of magnetohydrodynamical equations can be applied. A dispersion relation can be found as a condition on the determinant of the linearized equations set to be zero. The obtained dispersion relation is the sixth order algebraic equation. One root is a trivial damping mode

that depends on the magnitude of plasma resistivity. It is a pure effect of the magnetic field dissipation. In the analysis this root is ignored. At first, we check if the obtained dispersion relation gives known results in limit cases. Then we look if the dispersion relation gives some new different results. For study of convection dominated accretion flows the dependence on Brunt-Vaisalla frequency is important. This dependence is hidden in the expression for the growth rate. Numerical results that demonstrate the character and behavior of the obtained relation for several typical values are presented. Here we only mention that it seems that the direction of an angular momentum transport can be inward not only for very long wavelengths but also if the wavelength of instability is medium or short. It seems that if convective mode appears, it has a potential to force an angular momentum transport to be directed outwards. This process is similar to the one known from classical hydrodynamics. The outward transport is realized at short or long wavelengths. For intermediate wavelengths the ordinary magnetorotational instability still occurs and the direction of an angular momentum transport is inward.

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Study of Discharge with Parameters of Lightning

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The study of the high power electric discharge with parameters of the lightning channel [1] was directed to the investigation of possibilities of the ball lightning generation. The properties of the ball lightning are summarized in [2]. Experiments were held in the High Power Discharges Laboratory of the Institute of Plasma Physics and Laser Microfusion in collaboration with the International Center for Dense Magnetized Plasmas in Warsaw.

The apparatus was supplied with capacitor bank. The total electric charge was about 50 C and the average current reached ~ 150 A. Duration of the discharge was a few hundreds ms. The electrodes were connected with the copper wire of 30 μm diameter before the discharge to enable the breakdown through the horizontal distance of 40 cm.

For diagnostics the digital cameras (FASTCAM-X 1280PCI model 1KC, FASTCAM-X 1280PCI model 1K and FASTCAM-PCI R2 model 10KC) were used with the time resolution of 1000 (3000) frames per second. Time resolved visible spectra were registered with spectroscope Mechelle 900 with 12-bit resolution in range (200 ÷ 1100) nm and exposure time 100 ms. During the discharge the current is going through a temporally changeful and spatially non-uniform channel. We observed winding, becoming brighter, pinching and exploding parts of the channels and forming of spherical and helical structures.

The spherical structures, balls, with diameters from 10 to 140 mm were observed a few times during each discharge. Usually the bigger balls had the greater lifetime (tenth of ms) and lower intensity of the visible radiation. The small balls with 10 mm diameter radiated more intensive and they lived about 1 ms only.

In some discharges the mode of channel was observed in form of a big ball in diameter of (10 ÷ 20) cm with low emission in visible range of wavelength. This ball was observed during considerable time of the channel evolution and it was composed from a few layers of the discharge channel. Its diameter has the value of ~ 150 mm and the lifetime was 12 ms. The relatively long lifetime enable roughly estimate the conductivity of the plasma in the ball, using formula for dissipation of magnetic field:

$$\gamma = \frac{\Delta t}{\mu \cdot L^2} = \frac{0{,}012}{4\pi \cdot 10^{-7} \cdot 0{,}075^2} = 4{,}1 \cdot 10^5 \,\mathrm{S/m}\,, \tag{1}$$

(L represents characteristic dimension, in this case the ball radius). This conductivity is much higher than the conductivity of $\gamma \approx (1 \div 3) \times 10^3$ S/m calculated from Spitzer formula for an estimated temperature of (1 ÷ 2) eV. This combination of low temperature and high conductivity is typical for more structures in the current channels of these discharges.

Spectral lines of cuprum atoms and ions CuI, II and III are dominant in the spectrum in the (350 ÷ 500) nm region. However, also lines of N I, NII, OI and OII are present. The

electron temperature was calculated for LTE assumption and it reaches 1 eV for CuI lines and 1,6 eV for NII lines. The parts of channel near the electrode had similar spectra as the channel in the center. A fluctuation of temperature for various shots and times was estimated as 15%. The plasma in the channel is formed with elements evaporated from the electrodes.

The observed phenomena in the channel of this discharge, mainly the surface tension, low diffusion of the surface plasma, and long lifetime of the channel structures strongly supports the hypothesis of an important role of the magnetic forces in the evolution of the channel when the magnetic lines are frozen into the plasma. The frozen magnetic field must be conditioned with very high conductivity, a few orders higher then the Spitzer´s conductivity related to the temperature of the current channel. Then the structure of the plasma in this discharge channel with very high conductivity will be studied in the future research.

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New Passive Methods for Nonlinear Effects Suppression in Acoustic Resonators

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This paper deals with the problems of new approach to suppression of nonlinear effects in the gas-filled acoustic resonators. Recently, it has been shown that it is possible to generate the high-amplitude standing acoustic waves in closed cavities (acoustic resonators) driven by means of vibrating piston or by external volume force when nonlinear effects are suitably eliminated. Further these high-amplitude acoustic waves can be used in a wide area of human activities such as industry, medicine, etc. Some promising applications based on the strong acoustic field are compressors, refrigerators and thermoacoustic engines.

When acoustic wave is driven into high amplitude, the nonlinear effects (nonlinear relation between density and pressure, convection) transform energy from low- to high-frequency harmonic components. It is connected with heightened dissipation and conversion of acoustic energy into heat. This is connected with the effect of acoustic saturation. It means that amplitude of the acoustic wave is not increased even if the amplitude of driving grows.

Some "classical" techniques of nonlinear effects suppression in acoustic resonators are described in specialized literature (Resonant Macrosonic Synthesis, multifrequency driving method, see for example [3]). Other new methods are subject of this project. Generally, higher harmonics of originally sinusoidal wave are suppressed due to non-accomplishment of resonance conditions for them while the conditions for the fundamental harmonics are fulfilled. Whereas planar acoustic waves in axisymetric resonators were used previously, utilization of cylindrical and spherical waves was published in [2]. The frequency-equations were derived in the first (linear and non-dissipative) approximation to show that the higher resonant frequencies are not integer multiples of the frequency fundamental. These equations have form of transcendent algebraic equations and they are solved numerically. Next, the analysis in the second approximation has been carried out. Model equation based on the one-dimensional Kuznetsov's equation was derived which takes into account nonlinear effects, viscosity and thermal conduction. While an exact analytic solution is not known for this type of partial differential equation, suitable algorithm for its numerical integration was found. Numerical simulation has shown that higher amplitudes of acoustic wave are obtained in case of spherical and cylindrical resonator; the sound field is also less harmonically distorted.

Amplitudes of higher harmonics may be also controlled by means of suitable materials used at the resonator's frontal walls that are capable of resonance frequency shift or selective absorption of acoustic energy. For these purposes was derived model equation for constant-diameter resonator with arbitrary boundary conditions at its walls. The model equation is based on non-homogeneous Burgers' equations describing two contrapropagating waves that are connected at the resonator walls by the boundary conditions considered. Because a general analytical solution for this set of partial differential equations is not known, suitable

algorithm for its numerical integration in retarded-time frequency domain was found, see [1]. The algorithm is based on independent integration of equations describing forward and retrograde waves and the integration can be performed for hundreds of harmonic components. Validity of the model equation was proved experimentally, the numerical results were in good agreement with the experimental data. It has been shown that even if all acoustic energy of higher harmonics is absorbed at the resonator walls the higher harmonics are not fully suppressed and they participate on small acoustic energy thermo-viscous dissipation. It has been also shown that it is possible to use the time-reversal mirror at one resonator's frontal wall, i.e. its reflection coefficient $R = -1$ for all the harmonic components of the acoustic wave (pressure release interface), the nonlinear effects are suppressed very efficiently as well.

Another approach of nonlinear effects suppression studied is based on connection of an additional resonant system to the main acoustic resonator. It suppresses the second harmonic component excited and so the cascade process of higher harmonics generation is stopped, see for example [3]. Additional Helmholtz resonator is not a suitable solution for high pressure waves. Here, acoustic energy is lost due to vortices at the Helmholtz resonator orifice and its quality factor is then decreased strongly. Better features provide an additional mechanical system based on flexibly mounted vibrating piston (the mechanical system is tuned to the second harmonics of the resonant frequency of the acoustic resonator). Analysis in the first approximation has been performed to describe properties of mixed acousto-mechanical resonant system analytically, afterwards, numerical simulation has been performed in the second (nonlinear) approximation. Numerical results show that in the case of the mixed acousto-mechanical system, the nonlinear effects can be well suppressed.

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Arbitrary Lagrangian-Eulerian (ALE) Methods in Plasma Physics

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Plasma can be treated as a fluid consisting of ions and electrons. Many problems from plasma physics can be modeled by hydrodynamical Euler equations which form conservation laws for mass, momentum in every direction and total energy accompanied by appropriate equation of state. Conservation laws possess discontinuous solutions including shock waves and contact discontinuities which require special numerical treatment. When solving these equations, we can use several approaches.

The classical Euler-type method solves the hydrodynamics equations on the static computational grid. In the Lagrangian approach, the Lagrangian grid moves together with the fluid movement. The advantage of the Lagrangian method is very good resolution of the material interfaces, and it allows usage of free problem boundaries. This method is often used in problems with big changes of volumes, in cases of big fluid compressions or expansions, where the Eulerian approach would be problematic. On the other hand, it may happen, that the moving grid looses its regularity, or it may degenerate in the critical regions, e. g. the edges of the cell intersect each other, or the cell becomes non-convex, so the assumptions of the numerical method do not hold, e. g. some cell volumes become negative. The classical example is the Rayleigh-Taylor instability, which evolves on the interface of two fluids with different densities. The interface profile is better resolved with the Lagrangian-type methods, but as the instability evolves, some cells degenerate. One possibility, how to solve this problem, is the usage of ALE methods.

The ALE (Arbitrary Lagrangian-Eulerian) method combines the advantages of both mentioned methods. It uses the Lagrangian solver as long as the grid is not too distorted. Now comes the Eulerian part - we regularize the grid and conservatively recompute the values of the conserved quantities on the new grid [1]. Now, we can continue in the Lagrangian computation.

For Lagrangian step we have developed a 2D Lagrangian solver based on support-operator method. In tests of the Lagrangian step we tested several classical problems from fluid dynamics. We simulated the Noh problem, Sedov problem, several modifications of Riemann problems, smooth moving sine profile, or the classical Rayleigh-Taylor instability. All tests correspond well with the expected results.

A robust, general method for grid regularization (mesh untangling) has been prepared and tested [2]. The untangling procedure uses combination of direct node placement based on geometric computation of the feasible set and node repositioning driven by numerical optimization of an element area based objective function. It is shown, that a combination of the feasible set based method and the optimization method achieves the best results in untangling the meshes.

The main part of the work was done in the conservative interpolation of conservative quantities between different grids with the same topology [3, 4]. Our method is based on the swept-area approach, where the mass in the new grid cell is computed as a sum of the original mass and the masses of swept regions. By swept region we mean the area created by smooth

movement of the cell face to the new position. The difference against the most natural approach (exact integration of the function) is the algorithm efficiency. In the exact integration approach we must compute all the intersections of the original grid with the new one, which is time consuming in 2D and would be very difficult in 3D. Our swept-region approach is much more efficient, we do not have to compute any intersections. On the other hand, unlike in the exact integration approach, in the swept-region approach the computed mean values on the new computational grid can reach the local extremes from the previous time level, so new extremes can be created. We have developed a repair method for solving this problem. So finally, our remapping algorithm has three stages: first, we reconstruct the original function by computing the slopes in each grid cell from the surrounding mean values, second, using swept-area integration of the reconstructed function we compute mean values on the new grid, and third, we repair these means to preserve local bounds. This complete remapping algorithm is stable, conservative, local-bound preserving, second-order accurate, efficient, and applicable for general unstructured meshes in 2D and 3D. We have performed several numerical tests to verify properties of our remapping method. The remapping method was tested on a number of typical functions, both smooth and discontinuous. We have compared our swept-region integration with the classical exact integration showing, that the speed increase outweighs the possible problems with bound preservation.

Based on three previously mentioned ingredients including Lagrangian solver, mesh regularization and remapping, a 2D ALE code has been developed. The code has been tested on several problems including Rayleigh-Taylor instability. The tests were successful and we can continue in applying our method to selected, more complex problems from plasma physics.

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Research and Development of Special Phase Recording Materials

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Photopolymer holographic recording media differ from other recording materials (silver halide emulsions and dichromated gelatine) in their self-developing characteristics. A volume phase diffraction grating forms itself already during exposition which simplify and accelerate the process of grating preparation, however this may also bring undesirable effects in a sense of the original recording interference field modification and hence the grating growth dislocation in later recording phase. Mechanisms of grating recording were studied both experimentally and theoretically. We have laboratory prepared own recording material on which experimental tests were performed. In the theoretic part, we have analyzed the recording process of simple diffraction grating with the help of extended coupled wave theory. Also we have developed the numerical first harmonic model of transmission grating recording.

The recording material based on PVA binder, acrylamide monomer and TEA initiator was prepared. We exploited experiences presented in [1], [2], but concentrations of chemical components were properly modified and further chemical substances were added to get the best performance of the recording material. Prepared liquid material was coated on glass plates in different thicknesses and dried. The material was sensitized by erytrosine B to "green" wavelengths, because Nd:YAG laser at second harmonics (532nm) was used for recording of the interference field. On the recording, absorbed incident light starts process of radical polymerization. The interference field has a nonuniform light distribution and hence in bright regions monomer polymerizes faster and hence its concentration decreases faster than in dark regions. This effect then leads to the process of diffusion which finally causes formation of diffraction grating. Our recording material is not sensitive to red light, therefore He-Ne laser (633nm) was used for instant monitoring of diffraction efficiency of growing grating. Various gratings were recorded with different intensities in materials with different thicknesses. The results show that the reciprocity law between exposition energy and intensity is not valid in these cases, i. e. for any intensity of light the optimal exposition time is different. Other conclusion, which is obvious from our measurements, is the presence of starting and terminating effects. Mainly the terminating effect has positive impact on additional refractive index increase, because the diffusion process may further continue, even if the exposition is stopped.

Within the theoretic part of the project, first we have analyzed the interference field in permanent diffraction grating. The coupled wave theory, developed by Kogelnik [3], takes into account only one plane wave incident on the diffraction grating. This theory was extended to the case of two incident waves, which both satisfy the Bragg condition. In other words the boundary condition was changed and the coupled constant was set to be a complex number which includes information about the phase shift of the refractive index grating. Concerning the result, planar waves are solutions of these coupled wave equations and the intensity of light interference field can be obtained from these waves by the usual way. The

intensity distribution depends on amplitudes and phases of incident waves and refractive index modulation (the grating). In a special case, when amplitudes of both waves are the same and relative phase of the waves and the phase of the grating are the same, light intensity and refractive index distribution coincide. In other cases, e. g. for different amplitudes, light intensity distribution of interference field differs from refractive index distribution and the field and grating do not coincide.

These results show that the interference field can be modified by the growing grating and hence the dynamical model of transmission grating recording was developed. In photopolymer materials the grating (refractive index modulation) grows up cumulatively. There is no index modulation on the very beginning of the recording phase. The first elementary refractive index grating, which grows up in this early phase, coincides with interference field, but in later phase the elementary grating influences the recording interference field and the next increments of refractive index are shifted with respect to the new field (the increments are calculated by the help of first harmonic model presented in [4]). Within our recording model, the material is divided along z-axis into narrow layers. Each layer satisfies conditions for volume phase grating so that the coupled wave theory may be applied. The model shows that when amplitudes (intensities of light) of both waves are similar, the refractive index distribution coincides with original recording interference field. In other cases the grating is slightly slanted and the diffraction efficiency of such structure drops.

We have experimentally prepared photopolymer material for dynamic diffraction grating recording. It is possible to record transmission diffraction gratings with high diffraction efficiency (90%), but the outcome strongly depends on parameters as recording intensity, recording time, termination delay, thickness of the material, etc. which must be set up to get the best result. The model has turn out that the ratio of incident wave intensities is another crucial parameter. When the ratio differs from unity, the growing grating influences the interference field and the efficiency drops. The results of our modelling help for better understanding of physics of recording process and hence proper adjusting of recording parameters in such applications as display and security holograms and holographic memories.

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Dental Implant Imaging

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Radiographic techniques play an important part in the successful planning and execution of implant treatment. The most used techniques in dental implantology today are: Dental Panoramic Tomography, Intraoral radiography, Computerized Digital Radiovisiographs, and CT scans [1-2]. During planning namely radiographs allow the clinician to have an initial assessment of the available bone for the implant therapy, providing quantitatively (and sometimes also some qualitatively) information about the bone and surrounding tissue. Usually, the Dental Panoramic Tomography (DPT) is the radiograph of choice. The information provided by DPT can be usefully supplemented using other standard extra-oral and intraoral radiographs such as Lateral Cephalogram and Standard occlusal views [1]. CT scans provide the most detailed images currently available for dental implant planning. However, because of their cost and high radiation dose, CT scans are often devoted to more complex cases such as full arch maxillary reconstructions, bilateral posterior mandible imaging or to assess whether patients require extensive grafting procedures [1]. Intra-oral radiographs, which are taken with a long cone paralleling technique, are devoted for the planning of single tooth replacement and small bridges. They are also used during the prosthetic phase to ensure full seating of components and frameworks as well as during follow-up such as for crestal bone level assessing [1].

Computerized Digital Radiovisiography is becoming more commonplace and can provide an alternative medium to dental imaging. Radiovisiography is useful as it produces an instant image at a lower radiation dose making its use is at present largely extended while replacing the intra-oral conventional radiographs. Studies demonstrate that Radiovisiography is the most reliable radiographic technique in assessing the status of periimplants [2-3]. Radiographic techniques offer reliable options to asses the clinical situation of the implant, bone and surrounding tissue. Nevertheless, Dental Implantology suffers from the lack of a tool which can provide the clinicians with precise information about the real situation *in-vivo* and *in-situ* of the bone to implant interface (i.e., namely material and tissue that develop in the space between the bone and implant). The osseointegration of a dental implant is a non homogeneous microscopic condition. An excess of fibrous tissue lacunae in contact with the implant surface can determine the implant failure or changes in the loading and prosthetic procedures. The development of a suitable imaging tool with these capabilities is desirable and could offer a considerable advance in the modern Dental Implantology.

We make use of the state-of-the-art detector Medipix [4] in order to obtain high resolution images of dental implants placed in various samples in real time. The Medipix device is a hybrid semiconductor detector which consists of a 300 μm Si detecting chip mounted on a readout chip [4]. We conducted several tests using the Medipix1 detector (which has 64 x 64 pixels of dimensions 170 μm x 170 μm each) and with the Medipix2 detector (256 x 256 pixels of dimensions 55 μm x 55 μm each). In these devices, every

individual pixel has its separate preamplifier, discriminator and counter. In order to enhance the spatial resolution, we used a Hamamatsu microfocus X-ray source L8601-01 with 5 μm focal spot size. This source was operated at 20-40 kV with a current of around 250 μA. Samples were prepared in plaster (to simulate bone) and wax (to simulate osseointegrating tissue) placed in Aluminum holders. Images were obtained in scans of 100 seconds. Using the Medipix2 detector, a spatial resolution down to 10 μm (in the plane transversal to the beam) has been obtained. Along the beam direction a spatial resolution of about 10-50 μm has been established. In order to obtain 3-dimensional images we are considering the use of computed tomography methods.

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Visual Corona Discharge Study for Different Electrodes Configurations

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Today polymer and plastic materials are mostly used for mechanically less stressed construction elements. Polymer based materials are applied as replacement of metals. In praxis continual effort is connected with the mass reduction of produced parts and constructions in mechanical engineering, e.g. in car, aircraft and aerospace industry. The application of polymer-based materials is one method of this problem solving. Chemistry of plastic and polymer materials shows that these materials' characteristics can be improved by innovation of technological operations. Still under study is the improvement of mechanical and other characteristics of polymers. A promising method of the hardened layers creation on the surface of parts made from polymer based materials is being developed for the surface treatment. This method is based on the application of various electrical discharges. One of them is corona discharge burning at atmospheric pressure in the air or in other gases [1]. Results of experimental investigation of corona light emission scanned by CCD camera for different point-to plane electrode configurations are presented in this contribution.

Corona discharge is a low energy electrical discharge with non-thermal ionisation. Corona discharges can be classified as positive or negative in compliance with the polarity of the "edge shaped" electrode. In a negative point-to-plane corona discharge with the metal electrodes the current consists of a train of very short pulses with a rather well defined repetition frequency, so–called Trichel pulses. In the air at atmospheric pressure the current pulses have a very fast rise time about 1.5 ns and short duration with a relatively long period between the pulses. The corona discharge is self-sustained and usually occurs when one of two electrodes has a shape causing the electric field at its surface to be significantly greater than that between the electrodes. Discharge can be identified as filaments or diffuse light extending from the sharp point electrode towards the substrate. The ionisation region is confined to close vicinity of the discharge electrode and in the remainder of the interelectrode space the ions drift due to the electric field without additional ionization. With decreasing inter-electrode spacing electric fields relevant to individual electrodes seem to interact [2]. For three electrodes this interaction may result in suppression of the middle electrode´s electric field, and hence its light emission, too. For plasma treatment technology optimisation this attribute appears to be useful.

For surface treatment technology in view better understanding of the spatiotemporal behaviour of the corona discharge in the ionisation region near the sharp point electrode is necessary and that is the reason, why discharge light emission characteristic was studied.

The single-point-or multi-point-to-plane electrode distance was fixed at 7.8 mm. All experiments were performed in the stationary air under atmospheric pressure (735–742) torr, humidity (50-60) % and temperature (20-23)°C. Stabilised D.C. voltage was applied to the point electrode(s). Driving voltage was changed between (4–12) kV. The spark discharge ignition at (12.0-12.5) kV limited the voltage setting in some electrode configuration. Similar measurements were performed with the photomultiplier. [3]

Emitted light intensity distributions for combinations of two and three electrodes predicate that corona discharge light emission in dependence on the individual electrodes spacing resembles to that of more point light sources combination. With decreasing inter-electrode spacing electric fields relevant to individual electrodes seem to interact. For three electrodes this interaction may result in suppression of the middle electrode's electric field, and hence its light emission, too. For plasma treatment technology optimisation this attribute appears to be useful.

Dynamic characteristics of the CCD camera limited the range of measurements. The measurements had to bee performed separately both in the region of ionisation and in the region of charged particles drifting. Intensity of light in the region of ionisation is mainly affected by the intensity of external electric field. Resulting electric field is influenced in the interelectrode space due to the existence of charged particles.

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Measurement of Corona Discharge Light Emission

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Corona discharge is a very low energy electrical discharge with non-thermal ionisation. The corona discharge is self-sustained and usually appears when one of two electrodes, mostly immersed in gas, has a shape causing the electric field changes near its surface are significantly greater than that in the outer space. Thus the ionisation region confines to a close vicinity of the sharp edged electrode. Ions forming the discharge current originate in this region and in the remainder of the interelectrode space drift due to the electric field towards the other electrode without additional ionisation.
Corona discharges may be classified as positive or negative ones in compliance with the polarity of the edge shaped electrode. Corona discharge can be identified with a soft diffuse light burning in the close vicinity of the sharp edged electrode or bright filaments extending from the sharp point electrode towards the opposite one.

Discharge current in a negative point-to-plane corona consists of a train of very short pulses with a rather well defined repetition frequency, so–called Trichel pulses. Current pulses in the air at atmospheric pressure have very fast rise time about 1.5 ns and short duration with a relatively long period between the pulses.
It has been found that the waveform of the regular Trichel pulses is almost independent on applied voltage and is less independent on the cathode material and tip radius [1]. The pulses repetition frequency is approximately proportional to the average discharge current and extends from some kHz up to some MHz. Although a lot of work has been done on this subject, basic physical description of Trichel pulses is far from complete.

Corona discharge seems among others to be a very perspective tool for improvement of mechanical and other characteristics of polymers and that is the reason why corona discharge characteristics´ intensive study falls within the research provided in the Department of Physics of CTU FEE at present. In this connection some effort was made for better understanding of the spatiotemporal behaviour of the corona discharge in the ionisation region near the sharp point electrode. This comprised also study of the discharge light emission characteristics by means of a photomultiplier. Obtained characteristics were linked to the discharge current pulse records.

Corona discharge was generated between grounded brass large plane electrode (diameter 8 cm, thickness 7 mm) and different point electrodes:

(a) iron electrode of cylindrical shape, diameter 0.7mm, spike curvature radius about 25 μm;
(b) set of two parallel identical mutually connected electrodes each as that of (a) separated by 2 mm and placed in a brass holder,
(c) set of three parallel identical mutually connected electrodes each as that of (a) separated by 2 mm, located in one common plane and placed in a brass holder.

Experimental apparatus consisted of the set of electrodes as described above and was powered via protective resistor with a high voltage supply. Driving voltage was changed between (4-12) kV. The driving voltage setting was limited by the spark discharge ignition at (12.0-12.5) kV. The single-point- or multi-point-to-plane electrode distance was fixed at 7.8 mm. All experiments were performed in the stationary air under atmospheric pressure (735–742) torr, humidity (50-60) % and temperature (20-23)°C.
Applying stabilized D.C. voltage to the point electrode(s) corona discharge current pulses were measured by means of a voltage drop at a serial resistor connected in series with the grounded plane electrode. Discharge light emission was observed through a small aperture of a proper diameter placed in the holder movable in the x-y plane. Passed light came through the fiber optic link to a photomultiplier with additional converging lens. For discharge light emission measurement in visible region of spectral characteristics the Carl Zeiss Jena M12FVC52A photomultiplier was employed. Photomultiplier's output current was registered through PC and obtained data subsequently processed by PC, too.

During each measurement distribution of emitted light intensity corresponding to the single point-to-plane electrode configuration was restricted to the region of truncated cone with smaller base placed in the vicinity of the point electrode's spike. It seemed that discharge emission might be correlated with emission of a spot light source shining in the truncated cone [2].
Emitted light intensity distribution corresponding to combinations of two and three electrodes predicated that corona discharge light emission in dependence on the individual electrodes spacing resembled to the light emission of an appropriate combination of more spot light sources. With decreasing inter–electrode spacing electric fields relevant to individual electrodes seemed to interact. In case of three electrodes' configuration this interaction might result in suppression of the middle electrode's electric field, and hence its light emission, too. For plasma treatment technology this attribute might be significant.

Measurements proved increase of the discharge current in relationship with the rise of the applied voltage, too. Light emission intensity grew also in dependence on the discharge current and with the growth of the Trichel pulses´ frequency. For details see [1].

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Modification of PET Polymer Films by DBD Discharges

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Polyethylene terephtalat (PET) and polytetrafluoroethylene (PTFE) were used for surface treatment. High voltage barrier discharge and UV (ultra-violet) radiation treatment were applied for polymer surface modification. Influence of the treatment was studied by water contact angle measurement and AFM method (Atomic Force Microscopy). Decreasing of surface strain was found in both methods treatment. Comparison with another studies was also done [1,2].

Two-cathodes setup for polymer modification was designed. Square cathodes were covered with 1.5 mm thickness glass. One of them is a substrate for polymer sample, which is mounted with an epoxy adhesive. Distance between metal cathodes is 5 mm. The AC voltage 15 kV_{ef} (50 Hz) was applied in experiments. Between the dielectric barriers, the surface charges spill over the channels. The average charges density depends on three basic parameters: 1) applied voltage and its amplitude, 2) thickness and dielectric properties of cathode coverage, 3) cathodes distance. At 50 Hz voltage the average current density is low (in time and in space) and modification rate is low too. Low frequency of applied voltage results in many independent discharge channels and the parameters of the discharge are slightly different. UV radiation on Hg-lines 253.7 nm and 185 nm was used also for surface modification.

Water contact angle measurements were used to study surface energy of polymer materials and AFM measurements were used to study morphology of polymer surface.

PET is a well-known polymer material with excellent mechanical, dielectric and temperature properties. As another polymers PET is characterized by a big surface strain. As a result polymer doesn't like to stick or be covered by some addition materials. For modification PET surface two methods were used: 1) modification by barrier discharge, 2) modification by UV radiation (Hg radiation). Both methods show the decrease the surface strain. Modification rate in barrier discharge method depends on the treatment time. Only non-contact mode in AFM measurements one can use for surface scan. During contact mode of AFM measurement some noise effects appear, probably due to surface charges.

So popular polymer PTFE, polytetrafluoroethylene (teflon) plasma polymer films [3] are widely used in different branches. Further studying is important to research it properties. Some successful experiments [4] of PTFE surface modifications were performed at low pressure RF discharge in H_2, where H_2 replaced fluorine in polymer chain. As first, we try to modify the polymer surface of PTFE and PTFE-graphite by barrier discharge in air. After the modification, the quality of the surface was measured by the water contact angle method. Decrease of the contact angle from 90° to 40° was found. But this modification disappears at pure PTFE after treatment its surface by acetone. The similar process takes place with a composite of PTFE and carbon.

Instruments for following investigations are in preparation now. They will allow us to study barrier, high frequency, corona and others discharges with different gases, pressures and flow rates. In the spirit of modern researching we are going to use radio-frequency pulse

sources operated from tens kHz to the hundreds kHz and high-frequency voltage up to several MHz.

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Radiation Damage of $PbWO_4$:(Mo,A^{3+}) Scintillator and Its Dynamics

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$PbWO_4$ (PWO) scintillator became the subject of interest because of its possible usage in radiation and particle detectors in high energy physics accelerators, for example in large CMS (Compact Muon Solenoid) detector in the LHC (Large Hadron Collider) experiment in CERN. The main reasons consist in PWO fast response, low prize, and relatively easy growth of large crystals by Czochralski technique. The light yield is rather low [1], but possibility to increase it at least by a factor of 2, while keeping its scintillation response reasonably fast was reported recently [2]. During the scintillation process the transport of the thermalised charge carriers is influenced by their capture at various trapping states. This may lead to light yield decrease and slowing-down scintillation decay kinetics. The charge carriers trapped in deep traps form radiation induced colour centres stable at room temperature as a result of a need for restoring the charge balance in the lattice. This phenomenon is called radiation damage. Reduction of concentration of traps and related defects (often cationic or anionic vacancies) can be achieved for example by aliovalent ion doping. The aliovalent ions introduce an unbalanced charge in the lattice and can therefore significantly change the concentration of intrinsic point defects and consequently the concentration of colour centres [1].

The aim of this work was to study the influence of trivalent ion A^{3+} (Y or La) codoping in PWO:Mo and to compare the samples coming from two different technological laboratories and eventually to investigate possible influence of Mo concentration on the radiation hardness.

Fourteen samples of PWO were analyzed. Eleven of them were prepared by Czochralski growth method in the Institute of Physics AS Czech Republic. The concentration of MoO_3 in the melt varied from 0 to 50000 ppm and Y_2O_3 was either 0 or 100 ppm. Another three samples were grown also by Czochralski method in Furukawa Co., Japan using three times crystallization procedure [1]. MoO_3 concentration (in the melt) was either 0 or 1350 ppm, one Mo-doped sample was codoped with 80 ppm La_2O_3.. Samples were irradiated by ^{60}Co gamma source at the dose rate from 15 to 17 Gy/h in the air. Applied doses were 10, 55, 200 and 500 Gy. Optical absorption spectra before and after irradiation were measured at SHIMADZU UV 3101 PC spectrophotometer from 200 to 1200 nm. Radiation damage was quantified using the radiation induced absorption coefficient μ calculated as follows

$$\mu(\lambda) = \left[A_{irr}(\lambda) - A(\lambda)\right]/d \qquad (1)$$

where $A_{irr}(\lambda)$ and $A(\lambda)$ are the absorbances at a wavelength λ after and before irradiation respectively, d is the sample thickness. Radiation induced absorption spectra (dependences of μ on λ) of PWO samples were then decomposed by the SPECTRASOLVE computer programme into the sum of gaussians. Integral damage was computed as an integral of the spectral curve within a certain wavelength range.

The amplitudes of the spectra for Mo-only doped samples are higher for lower Mo concentration (under 2750 ppm) and decrease with increasing Mo concentration. Spectra were consistently decomposed into the sum of four gaussians for all the doses applied. Each gaussian can be ascribed to a colour centre, but we cannot exclude that some gaussians, mainly the widest ones, originate from two or more centres.

On the other hand most of the spectra of trivalent ion codoped samples were very complicated and thus difficult to fit consistently. This can be due to the fact that absorption in the region of 600-700 nm was significantly suppressed and some less intensive complex components became visible, or that trivalent ions can create/modify trapping centres as was reported for shallow traps [3].

The dependences of the integral damage on dose for the undoped, Mo-doped (200 ppm) and Mo,Y-doped (200 ppm, 100 ppm) Czech samples and for all the three Japanese ones were compared. The curves for the Japanese samples are shifted to significantly lower values,which suggests that the radiation hardness can rise with the number of crystallization. Curves for both Mo-only doped samples reach the highest values within each group, which can prove that new Mo-related trapping states are created when Mo is introduced. The curve for undoped PWO points to saturation of most of the defect-related traps by captured charge carriers. The curve for Y-codoped sample confirms the positive influence of Y-doping on radiation hardness, decreases with increasing dose and for 500 Gy reaches even the negative value due to strong bleaching observed around 400 - 420 nm at higher doses in all the Y-codoped samples. Addition of La also improves the radiation hardness and the integral damage curve has a saturation character similar to that for undoped samples.

Dynamics of the induced absorption spectra recovery at room temperature (RT) and at 60˚C was studied. From the measurements at RT we can conclude that very long lived trapping states (with lifetime of about weeks) take part in the induced absorption phenomena. The slowest recovery at RT was observed in the Mo-doped (200 ppm) sample. Increased temperature has not shown significant influence on the recovery speed neither for undoped nor for 200 ppm Mo, 100 ppm Y-codoped samples. On the other hand the recovery speed for Mo-doped sample was strongly enhanced by increasing temperature and decreased to a half of the original value in 50 minutes.

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Mathematical Methods in the Physics of Microworld

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The research of the group of 6 collaborators from the Department of Physics of CTU-FNSPE and 5 from the Department of Mathematics of CTU-FNSPE was carried out in 2003 in the framework of the long term research project in mathematical physics. The research was devoted, among other topics, to generalized symmetries connected with the physics of microworld, the associated algebraic and geometric structures, and their applications to classical and quantum systems. In this connection, special models were studied in terms of the corresponding Schroedinger operators as well as via the solution of the Schroedinger equation and the Hamilton equations. The investigations by the participating qualified researchers were performed in direct collaborations with the students of Mathematical Engineering at FNSPE. They are given below under each research theme together with our foreign collaborators.
The research topics were the following:
(1) Quantum groups and related algebraic structures, their representations; quantum integrable models: 7 publications by Burdík, Havlíček, Hlavatý, Šnobl, Šťovíček together with Doc. O. Navrátil (CTU) and students of FNSPE (Marek Filan, Ing. Vít Jakubský, Ing. Václav Kavka, Ing. Hynek Lavička).
(2) Gradings and graded contractions of Lie and Jordan algebras: 4 publications by Havlíček, Pelantová, Tolar together with Prof. Jiří Patera (Montréal) and students of FNSPE (Ing. Jiří Hrivnák, Ing. Petr Novotný, Ing. Milena Svobodová).
(3) Quantization and quantum mechanics in finite-dimenstional Hilbert spaces, applications in quantum optics (coherent states) and quantum information theory (9 publications by Chadzitaskos, Jex, Šťovíček, Tolar together with Prof. G. Alber (Darmstadt), Dr. E. Andersson (Glasgow), Prof. S.M. Barnett (Glasgow), Prof. V. Bužek (Bratislava), Dr. A. Delgado (Ulm), Prof. A. Odzijewicz (Bialystok) and students of FNSPE (Ing. Petr Luft, Ing. Jaroslav Novotný, Ing. Martin Štefaňák, Ing. Jan Vymětal).
(4) Mathematical models of quasicrystals and their applications to wavelets, coding and pseudorandom number generators: 12 publications by Burdík, Pelantová, Masáková together with Prof. Ch. Frougny (Paris VII), Prof. J.-P. Gazeau (Paris VII), Dr. L.-S. Guimond (Paris VII), Prof. Jiří Patera (Montréal), Prof. R. Twarock (London) and students of FNSPE (Ing. Miroslav Andrle, Ing. Jan Patera, Petr Ambrož, Petr Baláži, Ondřej Turek, Jan Zich).
(5) Schrödinger operators periodically dependent on time, solutions of Schrödinger equation and Hamilton equations for special models, classical chaos: 9 publications by Gemperle, Jex, Krbálek, Svoboda, Šťovíček together with Prof. P. Duclos (Toulon), Doc. L. Krlín (ÚFP AV ČR), Prof. P. Šeba (FzÚ AV ČR), Prof. M. Vittot (Toulon) and students of FNSPE (Ing. Ondřej Lev, Ing. Karel Maršálek, Ing. Miroslav Červený, Jan Smotlacha).
Quantum properties of matter are becoming increasingly important in modern technological applications. This leads to the necessity to investigate quantum or classical models which

yield qualitative as well as quantitative view of the observable characteristics of physical systems. We have used simplifying assumptions on symmetry or geometry which allowed us to derive typical models possessing at the same time physically relevant properties of real systems, and to solve them in a mathematically rigorous way. In this manner such mathematical models have served as suitable laboratories for the study of fundamental properties of microsystems.

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Study of Theoretical Models of the Pinches with Helical Structure

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Phenomena, passed in matter under very high pressure and temperature, are very intensive studied in plasma physics. The reason for it is that under such conditions comes to interesting behavior such as X-ray and neutron emission, nuclear fusion and others, which can have hopeful possibilities for interesting application in future and some already in the present time. One of the ways, to achieve such high pressure and temperature, is usage of the pinch effect. There are various experimental devices based on pinch-effect such as z-machines, plasma focus devices, spark discharges devices and so on. Our department participates on experiments at 1 MJ plasma focus device PF 1000 in Institute of Plasma Physics and Laser Microfusion (IPPLM) in Warsaw, which is one of the most of the world.

On studying of the pinches, not only in laboratory plasma but also in astrophysics, are founded out that there can be present relative stabile phase during time development, where is in cylindrical coordinates in addition the axial component B_z of the magnetic field present, whereas in classical z-pinch is present only the azimuthal component B_ϕ. Such type of pinch is called helical pinch, because the shape magnetic lines is helix. How much helical is the magnetic field characterize the density of magnetic helicity, defined by relation $h_B = \mathbf{B} \cdot \mathrm{rot}\, \mathbf{B}$. The total helicity, volume integral of mentioned density is conserving in ideal magnetohydrodynamics under specific boundary conditions. Axial magnetic field can originate spontaneous due to the dissipative processes because in helical structure must be in any case present electric current density component, which is parallel to the magnetic field and such combination is called force free configuration.

In this work are showed some of analytical solutions of pinch with helical structure in steady-state phase, based on magnetohydrodynamic approximation. Conditions used for all of the models are following:

- axial and azimuthal symmetry,
- steady-state case,
- one and two-fluid MHD description,
- isotropic or anisotropic Ohm's law in case of one-fluid description.

Consequence of the first two conditions is that all of the variables depend on the only radial coordinate r and the model then consists from ordinary differential equations. Equation system consists from Maxwell's equations for electric and magnetic field, equations for mass density and velocity and suitable enclosure by algebraic, no differential equation. In the case of one fluid model it is used the Ohm's law for current density, in two fluid model is current density given by electron and ion densities and velocities.

Previous results showed, that helical configuration does not exist around the axis under mentioned assumptions [1-2]. This is due to presence of diffusion term in equation for magnetic field. However, if the electric conductivity goes to infinity, i.e. the magnetic Reynolds number is much greater than 1, the diffusion term goes to zero and helical solution can be obtained. The other possibility is to choose such boundary conditions, which excluded

the z-axis. Such solution is called hollow pinch. All of the solutions published in [3] are based on the one-fluid MHD description. There it is showed, that if we assumed magnetic dominant plasma, where the diffusion term can be neglected, wide class of solutions with four free parameters is obtained. Two of them could be determined by preference of the specified coordinate system and choice of remaining two parameters determines the form of solution. Pressure has local minimum in the axis of pinch, if the tangent of spiral angle is in certain interval. If the angle is above this interval, pressure has in the axis maximum and falling monotonically. If the angle is under this interval, helical solution does not exist.

Whereas in one fluid description the radial electrical field E_r has identically zero value and this result does not depend on the fact, whether isotropic or anisotropic Ohm's law is used, in two-fluid description appear nonzero value of E_r, proportional to gradient of pressure. This means, that E_r is nonzero in the case of all nontrivial solution. In addition the electric field is bounded with electric charge density and it can be see, that if E_r is nonzero, it is also nonzero electric charge density. From estimation of how great is the electric force in comparison with magnetic force, acting to the plasma element in radial direction, follow that for thermalised plasma, where the temperatures of ions and electrons are equal and constant, the ratio of electric and magnetic force is approximately equal to squared ratio of Debye length to pinch radius and is much less then 1 for typical laboratory pinches.

Showed results presented very simple theoretical models, which can be used as starting points for others, more detailed studies. The possibilities for next research are the investigation of time-depending solution given from initial conditions with small perturbation, analysis of stability and so on. Because in such models must be two and more independent variables, thus equation system consists from partial differential equation and it is expected that some of the solutions can be obtained only numerically.

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Construction of the Omni-directional Sound Source

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Generators of sound are infinitely diverse in their physical forms and characteristics. Although classification is useful for the purposes of idealized mathematical representation and analysis, it is not immediately obvious that such idealization has any material bearing on the practice of sound measurement. Theoretical analyses of elementary source fields can be of considerable assistance in elucidating the causes of the results of experimental measurement.

The Dodecahedron has been a source of metaphysical interest for at least 2000 years. Like a crystal or gem, its facets and symmetries compel our eyes and hearts to observe life more deeply. Some have believed that the Dodecahedron represents an idealized form of Divine thought, will, or idea. To contemplate this symbol was to engage in meditation upon the Divine. Today many people believe there is a lost knowledge residing in the past, slowly being rediscovered. It is known that figures like Pythagoras, Kepler, and Leonardo, among many, were educated in these Sacred Geometries, and held many beliefs about them and their role in the Universe.

For the purposes of identifying sources, interpreting sound intensity measurements and selecting the most effective noise control measures, it would be very useful to be able to characterize sound fields on the basis of experimental data. Conventional instrumentation using a single pressure transducer can yield measures of the spatial average value and spatial distribution of mean square pressure and its associated sound pressure level. Some indication may be obtained of the extents of the direct and reverberant fields of source.

Most sources encountered in engineering practice are extended in space, exhibit a mixture of idealized source characteristics, contain components which perform mutually correlated actions, and usually operate in the sound fields generated by other sources. The source of the troublesome agent, sound pressure at some point in space, may not correspond at all closely to the source as defined in terms of the generation of sound power. This is perfectly evident within enclosures such as vehicle passenger compartments at low audio-frequencies.

It should be realized that there is no simple relationship between sources of sound pressure and sources of sound intensity, because the latter involves the product of two field variables. Only under certain conditions will relationship between the measured quantity, and the troublesome quantity be predictable and exploitable for the purposes of noise control, and then only in terms of the total sound power of source, rather than any local intensity. These are conditions in which the injection of a certain amount of sound power into a volume of fluid generates mean square pressure in some predictable proportion. The principal physical feature of sound fields which inhibits any universal relationship is that of interference. The field pressure at points removed from the source region is determined not only by the source mechanism, but by local wave interference behaviour which has no influence on the source power.

Qualification of anechoic chambers is intended to demonstrate that the chamber supports the intended free-field environment within some permissible tolerance bounds. The generic procedure for a qualification test is to position a sound source within a chamber, and then to make acoustic pressure measurements along radials extending from the source. We will call such measurements along a radial a traverse. We classify traverses as being either

continuous or discrete. A continuous traverse is obtained when one continuously moves a microphone along a radial, continuously recording data as the microphone moves. A continuous traverse generally yields pressure measurement that represent a very fine spatial resolution along the traverse. In contrast, a discrete traverse is obtained when one moves a microphone in discrete step along a radial, with the microphone motionless during data acquisition at each microphone location. Discrete traverses on a fine spacing are very time consuming, such that the usual practice is to employ a spacing that is quite coarse as compared to what is attainable through the use of a continuous traverse.

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Synthesis of Focused 3D Images Using Optical Diffractive Structures

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Synthetic 3D images are nowadays one of the most important tools of holography. Production processes used by laboratories and companies around the world are industrially protected. This motivates the research and development of own in-house technology allowing the fabrication and application of such products. Compared to classical display 3D holography, using interference optical method of recording, synthetic holography brings a couple of advantages. Above all, it is possible to record nonexisting objects and scenes (just using computer generated models) of arbitrary size and setting.

The method of synthesis of focused spatial images is based on the decomposition of a recorded object into series of 2D images, perspectives, each representing view from a slightly different angle [1]. All these images are then directly recorded in a plane of recording material which represents also their plane of focus. During reconstruction, each perspective is observable from the same angle of view as it was captured so that using parallax the 3D image could be synthesized by an observer. Each perspective is decomposed into elementary diffraction gratings, serving as image dots, in such a way that all images can be recorded within the same area without overlapping. Presented research was aimed to develop the method of generating 2D perspectives needed for synthesis of an object, to develop the method of decomposition of each perspective into elementary diffraction gratings forming the reconstruction light, and finally to design and construct synthesizing equipment itself. In addition, it was necessary to develop own software for generation of perspectives and their preparation for recording, including the set of sample elementary gratings, and also driving software for controlling the whole recording process.

The theoretical part of presented research deals with the analysis of properties of elementary diffraction gratings which are used to compose the whole recording. By modifying grating period of elementary grating as well as orientation of its grating vector, it is possible to determine color and direction of diffracted light. Based on the effect of conical diffraction [2], which appears when a diffraction grating is rotated about axis perpendicular to its plane, the analysis was carried out to determine the angles of view for a set of sample elementary gratings. This set of elementary gratings originates from technical possibilities of equipment designed for their recording and is sufficient for intendent application. Once there are determined directions in which one can observe individual 2D perspectives of recorded object, there are also determined angles of view from which these images should be captured to achieve correct reconstruction of 3D object.

More practical problem to be solved was the development and construction of optical lithograph, i.e. the equipment used for experimental verification of theoretical model as well as for final realization of designed 3D images. As a source of light, UV laser diode with wavelength of 405nm was chosen which is optimal for photoresist recording material. Photoresist as a recording material enables the use of embossing for duplication of recorded structure. Disadvantage of short wavelength consists in extreme requirements on optical elements of the equipment so that specially designed and fabricated optics had to be used.

Process of recording itself consists of repeated expositions of small areas, tiles, of the computer generated structure, ordinarily composed of hundreds of elementary gratings. Each tile is displayed by transparent liquid crystal based spatial light modulator and imaged by afocal optical system with a minification so that dimensions of one exposed tile are below 0.2 mm, which is enough below resolving power of human eye. After a pulsed exposition of one tile, recording material is mechanically moved so that the next tile could be exposed right beside the previous one. After all the tiles, composing recorded structure, are exposed, the recording material is chemically developed and embossed structure can be further galvanically metallized for its mass replication. For the proper function of the whole recording system, movement of lithograph with photoresist, alternation of tiles displayed on SLM, and moments of exposition pulses must be in good synchronization. This is achieved by a driving software providing communication between electronic operation unit controlling lithograph movement and laser diode pulsing, and PC responsible for displaying tiles.

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Physics and Information

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The concept of information was not a traditional concept of physics. Physics studied simple systems and structures of systems and searched for their interactions and for the laws of their motions.

The notion of information entered physics indirectly in thermodynamics hidden in the concept of entropy. Work and heat distinguish degrees of freedom of a system. Those that are in our disposal are associated with work and those that are connected to microscopic motions and are out of our control correspond to heat. The idea of Maxwell`s demon entered physics here and the notion of information came in with it.

A scientific theory dealing with information was established in relation with a development of communication technologies and the theory of cybernetics. The vague and unclear notion of knowledge was specified and quantified as a measurable quantity – information. It was introduced as the difference between the uncertainties of probabilistic distributions before and after a reception of a message or performance of an experiment.

However the unit of information 1 bit was implicitly present earlier in the Szilard's analysis of Maxwell`s demon activity in one - molecular heat engine in 1929.

The idea of Maxwell`s demon is useful when dealing with the question how much energy must be inevitably dissipated when processing information. The problem is if it happens when gaining it (in a measurement), when transporting it (in a computation) or when destroying it (when cleaning memories).

Information is always carried by some physical means. It is always registered by states of physical systems. Communication, computation etc. are physical processes. Information is surely also a physical term [1].

Questions related to the notion and the role of Maxwell`s demon return regularly time to time in some actualized form. Today they are mostly connected with possible limitations of the 2nd law of thermodynamics on a molecular level [2].

Contemporary physics is not interested in motions of simple systems only. It is also interested how complex and non-linear systems work and how they evolve in time. In theory of deterministic chaos the question is about the rate of forgetting the initial conditions and about the predictability of future states of a system. Synergetics deals with formation and evolution of complex systems. They can behave similarly to living systems. Here the concepts of entropy and information play a very important role.

An exclusively physical role is played by information in quantum physics. The so called "quantum information" with its three very active branches ("quantum computation", "quantum cryptography" and "quantum teleportation") is the most attractive part of contemporary physics. It promises intriguing possibilities, particularly in quantum computation. It even puts a question about full adequacy of the standard concept of Shannon information in quantum situations. In any case the information stored in quantum system exhibits surprising features: information stored in such a system can be infinite but only a finite amount of it can be read, quantum state cannot be copied etc.

New discussions about an interpretation of quantum mechanics (particularly in connection with EPR paradox, Bell`s inequalities, non-local situations etc.) lead to a possibility that the whole mathematical structure of quantum mechanics can be established on ideas taken from information theory. The quantum state is not understood as a state of an object but as a state of our knowledge about this object. The structure of Hilbert space, the basic mathematical tool of quantum mechanics theory is treated as a secondary and derived structure. See e.g. [3].

Information technologies are based on physics. The carriers of information are physical objects. The success of modern information engineering was enabled by new discoveries in physics. Opposite, the foundations of physics can probably be understood using concepts from information theory.

These facts should have an important impact on the education in both these fields of science. Physical faculties must devote on appropriate attention to information concepts and ideas and vice versa. Technical universities where information and communication engineers are prepared must pay attention to a good knowledge in physics. Unfortunately, it is not the present situation. The role of physics in underestimated here, particularly in MSc programs. Departments of physics must be able to offer appropriate and valuable courses. [4].

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Particle to Particle Simulation of Plasma Fibers

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In the Department of Physics of the CTU the pinches are investigated for many years. The experimental background is oriented on diagnostic methods including schlieren photography, Quadro camera diagnostics, X - ray diagnostics, interferometry measurements, etc. In 1997 spirals surrounding the pinch were detected. This phenomenon seems to have the same nature as similar structures observed in space plasma. In previous theoretical research the pure z-pinch was studied. This model was based on the equilibrium equation, Ampere law, energy balance equation and Ohm law. The radiative processes were included in the energy balance equation.

The velocity field fluctuations cause nonzero current component in magnetic field mean value direction. This current component behaves like Birkeland current and generates azimuthal magnetic field. The statistical plasma fluctuations together with magnetic reconnection processes enable transformation between axial and azimuthal magnetic field components and so the nonzero pinch helicity

One of the most common numerical models describing successfully plasma fibers are PP (Particle to Particle) methods. This method is precise, but very slow. This method can show us the elementary motion of particles in pinch. On the contrary PIC methods are more fast, but so precise. There are situations in which the PIC method is not sufficient enough for the plasma description. Namely simulating deformations of the Maxwell statistical distribution of the particles, collisions of the particles, etc. For detailed simulation of these phenomena are the PP modes irreplaceable. That is why we need to evolve concurrently with the PIC models the PP ones. Nowadays these models are rather slow and we can use them for smaller amount of particles. But the evolution of computer power is so quick that we can expect interesting results in near future. In this paper I would like to describe the principle of the method and furthermore to discuss present state of the PP model in our department.

In the PP model we must first initialize input variables. We have to know the number of particles of various kind (electrons, ions, neutrals), their initial velocities, distribution, positions, parameters of the calculation, etc. Because this method is high-powered on the computer time, we can use only thousands of particles. Initial velocity distribution is relized via some Monte Carlo method. During one computational cycle we have to predict future particle positions according to the Lorentz equation of motion. Next we can diagnostic all the changes, especially the deformation of the initial Maxwell distribution. The new statistical distribution will be analyzed. For best visualization we use PIC module for drawing.

Three dimensional code was tested on system with 10000 electron and ions. Both the external and the internal electric and magnetic fields are implemented in the code. Various combinations of the numerical methods for calculating particle movement are tested in the present time. The code is written in Fortran 95. The calculations are time and memory consuming. We intend to develop some network of workstations in our department and to perform parallel calculations with the help of the PVM or MPI libraries. We hope to detect

the origin of surface turbulent structures which lead to the development of the diocotron instability and to the onset of the observed helical mode.

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Nonlinear Acoustic Interactions in Cylindrical Resonators

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Nowadays, nonlinear acoustics represents an important field of physical acoustics. The reason lies in new possibilities of using acoustic resonators. Frequently, the application of nonlinear standing waves is connected with the high quality resonators. These resonators enable to accumulate large amount of acoustic energy. A number of devices use the high quality resonators because the sound waves are so powerful in these resonators that they can potentially carry out tasks, which conventionally require mechanical moving parts in current technologies (e.g. the acoustic compressors). In addition the high quality resonators enable to increase efficiency of the thermoacoustic engines (e.g. acoustic refrigerators).

Thus, the important characteristic of the resonators is the quality factor Q that shows how many times the amplitude of the steady-state wave is higher than the amplitude of vibration of the exciting piston. The Q-factor depends on the amplitude of the vibrating piston due to the nonlinear attenuation. The nonlinear attenuation is connected with nonlinear acoustic wave interactions when we can observe generation of higher harmonics. As the thermoviscous attenuation is proportional to the square of frequency it is possible to decrease the nonlinear attenuation by suppression of the wave cascade processes. It means that the energy transfer from the fundamental harmonic into higher ones is reduced and for this reason the acoustic saturation effects are also suppressed. The suppression of acoustic saturation causes that both the amplitude of the steady-state wave and Q-factor increases. The higher Q-factor means that more acoustic energy is accumulated in the resonators.

There is quite a large number of methods enabling to suppress the nonlinear attenuation and thus to increase the quality factor of the given resonator. One of the methods is the method called the macrosonic resonance synthesis (see e.g. [1]), which uses the resonators of variable diameters. These resonators have eigenfrequencies which are nonequidistant, that is the higher eigenfrequencies are not integer multiples of the fundamental one. If the source frequency is equal to the fundamental eigenfrequency of the resonator then the generated higher harmonics do not coincide with the higher eigenfrequencies. It means that the resonator eigenfrequencies interact with higher harmonics ineffectively and thus the harmonics do not achieve levels like we can observe for the resonators with a constant diameter.

When we want to control generation of higher harmonics it is possible to place a selective absorber directly into the resonator. If the selective absorber is used for the second harmonic we can interrupt the cascade processes, see e.g. [2].

It is known that the nonlinear attenuation due to the higher harmonics may be avoided by introducing phase speed dispersion as well. This fact was utilized by Sugimoto in [3]. In this work he used periodic array of Helmholtz resonators to obtain the artificial dispersion.

Another very promising method is based on the active suppression of the second harmonic component of the acoustic wave (see [4]). For this purpose it is necessary to employ the piston which vibrates with two frequencies. The first one agrees with the an eigenfrequency f and the second one is equal to the eigenfrequency $2f$. The phase shift of the second piston motion is 180 degrees. The method of the active second harmonic suppression mentioned

above was solved both analytically and numerically. It is known that for this case it is possible to describe generation of the higher harmonics by means of the inhomogeneous Burgers equation. The resonator is driven by a piston whose motion is characterized by two superposed sinusoidal motions. This problem was treated for stationary state in a number of works. However, the authors of the papers took into account only inviscid solutions. It means that discontinuities were contained in their solutions.

Unlike these solutions we found new asymptotic solutions (see [4]) which take into account dissipative effects. Some of the solutions are also in the spectral form that it is more suitable for study of generation higher harmonics in the resonators. The asymptotic solutions are compared with numerical ones. It can be shown that the inhomogeneous nonlinear Burgers equation can be used for a description of nonlinear standing waves in the cylindrical resonators. This model equation can be transformed by means the Cole-Hopf transformation. The transformed equation represents the linear Whittaker-Hill equation which is solved in terms of an asymptotic method. The found asymptotic solutions are transformed back and represent asymptotic solutions of the original inhomogeneous Burgers equation and can be used for modeling nonlinear standing waves in the resonators. On the basis of these comparisons it is evident that the asymptotic solutions give very good results. The asymptotic solutions can be used for a demonstration of the active suppression method of the second harmonic component. In addition, the solutions enable to calculate Q-factor of a given resonator.

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Optical Methods for Measurement of Physical Properties of Building Materials

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The research deals with an analysis and a design of non-destructive optical methods for measurement of physical properties of various building materials. We focused on optical methods for measurement of moisture and porosity of building materials.

At present, one can use various methods for testing the physical properties of building materials in the building industry. The trend in recent years shows a tendency to apply widely non-destructive testing methods and measurements, which can be relatively simply carried out and analysed in real time [1].

A very important physical property of building materials is the moisture. The building materials built in structures, generally absorb water. It is possible to use a wide spectrum of measurement methods, e.g. the capacitive or gravimetric method. However, the use of the gravimetric method is limited to smaller tested samples, and it cannot be used for measurement in situ. One possibility of non-contact moisture measurement of building materials is testing the building material using surface optical methods. Due to moistening of the sample, the average values of dielectric parameters of the material are changed, i.e. the reflectivity is changed and the scattering characteristic of the surface is also modified. The properties of the scattered light from the surface of the tested sample depend on its moisture. By analysis of scattered light, it is possible to determine the moisture of the sample.

We have proposed two non-contact optical methods for measurement of moisture in our work [2,3]. These methods are based on the interaction of the optical wave field with the investigated sample of the building material. The surface of the tested sample of building material can be machined by techniques used for fabrication of optical elements in optical industry. If a wave field of defined properties (e.g. plane or spherical wave) impinges on such surface, then it is scattered after the reflection, and the physical properties of the scattered wave field depend on the structure of the surface (e.g. roughness) and dielectric parameters of the tested material. By analysis of the interference pattern, which appears after interference of the test wave field with known reference field, we can determine the properties of the investigated surface. The characteristics of the scattered light will differ according to the moisture of the material. If we consider that the surface of the tested sample is practically „flat“ and assume the validity of the Kirchhoff diffraction theory for the first approximation of the problem, a change of moisture of the tested material will lead to the phase and amplitude changes of the test wave field. Then, one can determine the moisture from the values of amplitude changes in a chosen spatial area of the tested sample.

Another possibility, how to determine the moisture of the sample, is an application of Fresnel's equations for a reflection from a plane surface [3]. These equations show the dependence of the reflectivity on dielectric properties of the interface between two materials. The moisture can be determined from the changes of reflectivity of the sample. This method can be simply calibrated according to the gravimetric method. We can measure even such samples, which are hardly measurable with different types of methods. By analogical way, we

can use for moisture measurement the method TIS (Total Integrated Scatter) and the method BRDF (Bidirectional Reflectance Distribution Function), which are described in [1,3].

Another part of our research has been devoted to a proposal of optical non-destructive methods for measurement of porosity of concrete. Concrete is one of the most important building materials and therefore it is necessary to develop suitable methods for measurement of its physical properties that affect its behaviour in structures. A very important role in concrete behaviour plays its porosity, which affects many other physical properties of concrete, e.g. compressive strength.

At present, it is paid a special attention to measurement of porosity, and various measurement techniques are developed [4]. The gravimetric technique is used as a standard measurement method nowadays. However, this method is not able to determine the pore structure, i.e. to determine if the tested material contains either small or large pores. It is not developed a satisfactory technique for measurement of the size and structure of pores at present. Our work proposes two optical non-destructive methods for porosity measurement of concrete, which are based on the interaction of light with the surface of the concrete sample. By analysis of scattered light, it is possible to determine the quantity and the size of pores, which are located on the surface of the investigated sample. Our work theoretically describes and analyses two methods: phase relief method and scattering method [4].

The first one is based on making a phase relief of the surface of the sample. That can be performed by making a copy of the surface using an optically transparent material with a high fluidity and a short transition from a fluid to a solid state. Such a phase relief of the surface is then evaluated using the Fourier spectrum analysator, and the spatial spectra are detected using a CCD camera. One can obtain information about the size and quantity of pores as a result of the frequency analysis. The second method is based on analysis of scattered light from the tested surface, where the pores were filled with the mercury. The pore structure can be determined either by the analysis of the scattered light with the method TIS and the method BRDF or by comparison of Stokes parameters of incident and scattered light.

The work shows that it is possible to use several different optical measurement techniques, which differ in their approach to evaluation and in complexity of the experimental measurement device. The main advantages of these methods are their non-destructive character, a possibility of application in situ and real time evaluation of the measurement.

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Aberration Analysis of Elements in Optical Measurement Systems

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The research was focused on a theoretical analysis of aberrations of various elements in optical measurement systems in industrial practice. The first part of the work analyses an influence of the change of imaging conditions on the accuracy of optical and optoelectronic measurement systems, which are used in various industrial branches, e.g. in mechanical engineering, optical industry, building industry, etc.

The problem of noncontact measurements of dimensions of various products or distances is very frequent in mechanical and civil engineering. Depending on a specific measurement situation, the object is situated in different distances from the measurement system [1]. Theodolites, level instruments, microscopes and projection systems are mainly used for such measurements. These instruments are designed from the producer so that they provide ideal imaging properties only for a specific distance from the measured object. The optimal design distance is characteristic for a given measurement instrument. For example, in case of theodolites and level instruments it is assumed that the object is situated in infinity and for projection systems and microscopes the ideal distance from the object is given by the manufacturer. If we carry out measurements with mentioned instruments under different conditions, then the final accuracy of measurement is affected. The obtained accuracy can differ substantially from the optimal accuracy, which is given by the manufacturer.

The consequence of the above-mentioned effect is the change of the imaging quality of optical systems in measurement instruments. This effect is not principally removable. An analogous situation appears in the field of 3D metrology that is intensively developed nowadays. In practice, various industrial companies purchase very expensive measurement systems, which should guarantee the specific accuracy, and these systems are in many cases absolutely unsuitable for a practical use.

Our work [1] theoretically describes the mentioned effect in terms of geometrical optics. On the basis of the third-order aberration theory [2] it was shown that the change in position of the object with respect to the measurement instrument leads to the change of aberrations of the optical system, and this change affects negatively the measurement accuracy. The work has shown the measurement errors, which can appear if the imaging conditions recommended by the manufacturer are not observed in practice.

Furthermore, it was thoroughly analysed the case of thin oscillating mirrors, which can be used for designing optical measurement systems [3]. Vibrating thin flat mirrors are used in various areas of science and engineering. Such mirrors vibrate either deliberately or their oscillations are excited by the external environment, e.g. by mechanical vibrations, etc. These oscillations give rise to the deformation of the mirror surface, which consequently causes the aberration of the wavefront that is reflected by the mirror. If the reflected wave-front is used for measurement purposes, then the wavefront deformation will affect the accuracy of measurement and similarly it will affect the imaging properties of optical systems with such mirrors.

A detailed theory of deformation of a thin flat mirror, which vibrates in the direction of the normal to its surface, has been introduced in our work. It was also derived the relation for the dynamic wave aberration. The wavefront aberrations, which originate from mirror oscillations, were described and the criteria for evaluating the quality of optical systems, e.g. the Strehl definition, has been derived and calculated. The analysis of the mirror deformation was carried out both analytically and numerically. Obtained results can be used for an analysis of the influence of mechanical vibrations on the accuracy of optical measurement systems in various practical applications.

Our work has also been focused on an analysis and a design of the non-contact scanning methods for making measurements in industry. The scanning methods, which use a properly deflected optical beam, are frequently applied for non-contact measurements of linear dimensions of various mechanical components. The dimension of the tested component is then given by the time, which takes the beam to pass between two different locations on the tested object. If the velocity of the beam motion changes with respect to its position in the measurement space, then an error will appear in a such measurement. It should be possible to consider theoretically a spatial dependence of the velocity of the beam movement. However, a practical realization of such measurement instruments would be very difficult.

The main purpose of our work [4] was to show an influence of the sine condition on the kinematics of the measuring beam and to determine such requirements on the optical measuring system, which ensure a constant velocity of the motion of the beam that is transformed using the optical system. The measurement error occurs due to the dependency of the velocity of propagation of the beam on the position. It is desirable to minimize the measurement error and obtain a higher accuracy.

It was carried out an analysis of the influence of optical system aberrations on the kinematics of aperture rays using the third-order aberration theory [2] and the relation for a deviation from the sine condition was derived. This relation must be fullfiled by the optical measuring system in order to obtain a constant velocity of rays transformed by the optical system. Our work describes conditions, which must be fulfilled, in order to obtain the optimal measurement accuracy. It was shown that the common optical measurement systems do not satisfy these conditions, and so these systems cannot obtain the optimal measurement accuracy. Furthermore, the design parameters were proposed for such optical measurement systems, which consist of two achromatic dublets that satisfy the mentioned requirements.

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Modification of Wave-front Sensor for Optical Testing

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The research deals with a proposal and an analysis of the modified sensor for detecting a wave-front shape, which can be used in optical testing. Various measurement methods [1,2] can be implemented for testing a quality of optical surfaces. Interferometric techniques [1] are most frequently used in industrial practice. These methods enable to measure the deformation of the tested wavefront with respect to the specified reference wavefront with specially designed Fizeau or Twyman-Green interferometers. These measurement instruments can obtain the accuracy higher than $\lambda/100$, where λ is the wavelength of light. However, the interferometers are very expensive and relatively very difficult measurement systems. In comparison to interferometric methods, which determine the wavefront aberration from phase values, one can use the gradient methods, which enable to measure the wavefront slope, and consequently calculate the wavefront aberration. Such techniques have several advantages. These are more simple, less expensive, do not need a coherent source of light, and wavefronts with large aberrations can be tested.

We focus on the Shack-Hartmann method [3,4], which uses for wave-front evaluation the microlens array and the CCD sensor. The Shack-Hartmann sensor estimates the wave-front local slopes (wave-front gradient). The tested wavefront is spatially sampled by the microlens array and the sampled wavefront impinges on the CCD sensor, which is usually situated in the focal plane of the microlens array. The area of the CCD sensor is divided virtually in many subdetectors. The size and the number of subdetectors correspond to the size and number of microlenses. The incident (tested) wave-front, which impinges on the array of microlenses, has a general shape and the normal to the wave-front has in different positions a different direction. The microlenses focus the light into their focal plane, where the CCD detector is placed. The spot array obtained in the focal plane of the microlens array is detected.

The detected "spots" (several pixels) correspond to the intensity distribution after sampling by the sub-apertures of the microlens array. A position of the spot on the sensor is given by the direction of the main normal corresponding to a specific microlens and the focal length of the microlens. The main normal of each microlens is a normal to the wave-front, which passes through the center of the microlens. In order to calculate the deformation of the tested wave-front using wave-front gradient measurements, we must determine a deviation of the spot of a given beam, which is specified by the size of the correspondent microlens and by the direction of the main normal, from a position of the spot in the case of an ideal (reference) flat wave-front. In the case of a flat wave-front, which impinges on the microlens array in the normal direction, the spots of beams from individual microlenses will be detected in certain parts of the detector. The spots of individual beams have a relatively difficult intensity profile and we can determine a centre of the spot as a centre of gravity of the intensity profile. These spots form a specific grid, which is named the Hartmann pattern. The position of each spot is dependent on the slope of the part of the wavefront, which impinges on the corresponding microlens. The displacements of the spot positions can be measured with respect to the reference position and the wave-front can be numerically reconstructed

from the values of the spot displacements. A disadvantage of classical Shack-Hartmann method appears in the case of large gradient of the tested wavefront, e.g. when testing aspherics. Such steep changes of wave-front shape cause a limited measurement range of the sensor. In the case of large wave-front gradients the spots can overlap and the evaluation of the wave-front is ambiguous. In order to avoid the previous case, the measuring range of the sensor must be limited to small wave-front gradients. The range is also limited by diffraction of light, i.e. by a specific size of the detected spot. Our work proposes and analyses a method for elimination of the described disadvantage, which is able to extend substantially the dynamic range of the sensor.

A simple extension of the measurement range of the Shack-Hartmann sensor can be performed using the LCD (liquid crystal display), which is situated either in front of the microlens array or behind the microlens array [4]. We can simply generate subapertures on the LCD using a computer. The subapertures have the same size as the individual microlenses. The light spot on the CCD sensor is then determined by the coordinates of the centre of the corresponding subaperture on the LCD. The range of wave-fronts, which can be tested, is then extended because the spots cannot overlap, and generally the whole area of the CCD can be used for detection. Using the LC display wave-fronts with both small and large gradients can be tested, which is not possible with the present gradient methods. These are restricted only on a specific range of wave-front deformation to be measured. It is caused by the fact that these methods cannot automatically distinguish between two spots on the CCD originating from different parts of the tested wave-front. The LCD element unambiguously specifies a part of the wavefront, and only the radiation from the specified part of the tested wave-front impinges on the CCD. The combination of the LCD element and the lenslet array objective forms a quite new measurement system, which removes disadvantages of designed gradient-based systems at present.

The primary stage of the project has been focused on a detailed theoretical analysis of the proposed method, especially on evaluation algorithms. The algorithms for automatic evaluation were derived and the wave-front evaluation process was simulated using a computer. The array objective, which will be used in the primary part of the research project for evaluation of the wave field, has been designed and manufactured. The lenslet array objective consists of 20x20 microlenses with the diameter 0,3 mm and the focal length 40 mm, which are made from fused silica. This objective, which represents one of key elements of the measurement system, has been tested. Further work will be focused on programming the software for an automatic evaluation and designing, manufacturing and testing the proposed modified wave-front sensor. The described sensor can be used for testing the quality of optical elements and in adaptive optics.

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Scattering and Diffraction of Acoustical Waves on Sphere

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The scattering and diffraction are phenomena which can strongly affect results of acoustical measurements. For corrections of measuring results the description of a created secondary sound field is necessary. Lord Rayleigh published the analytical solution for a sphere and the approximate solution for a cylinder [3]. He had already published some papers on this topic before ("On the Vibrations of a Gas Contained within a Rigid Spherical Envelope", "Investigation of the Disturbance Produced by a Spherical Obstacle on the Waves of Sound"). Some papers on this topic were published by Stokes also. For other shaped bodies than a sphere and a cylinder the analytical solutions do not exist. "Bible of acousticians" written by Eugen Skudryzk [4] contains solutions for some elementary cases only (Rubinowics-Kirchhoff theory of diffraction, Sommerfeld theory and its usage for straight edge and wedge). In a book [1] there are results of deductions for scattering on a sphere and a cylinder only (correspond to results in [3]). Many authors studied scattering and diffraction experimentally and on the experimental basis described the secondary sound field numerically (for example [2]).

An analytical description of a created secondary sound field for a spherical shaped body exists because of its symmetry, which makes possible to solve the Helmhotz equation by a proper substitution. It is supposed that a plane wave incidents to a spherical shaped body. The obtained velocity potential of scattered wave contains Legenders polynoms and harmonics functions that were founded by Stokes. The approximate solution for a cylinder is deduced also in [3].

From the technical point of view, for example, the description of a secondary sound field affected by a cylindrical body is important because measuring microphones have a cylindrical shape. When a sound field is measured, the obtained values should always be corrected because they are affected by the microphones placed in the field measured.

When we would like to reduce noise which surrounds a person (noise produced by an airplane or a car when a person sits inside, etc.) we apply the method of active noise control. For a proper application of this method a scattering and a diffraction of the person's body has to be considered.

The development of a measuring method to serve as the basis for a numerical description of a secondary sound fields affected by inserted bodies has been considered. The scattering and diffraction effect on a sphere-shaped body were measured. Measurements were performed in an anechoic room with dimensions 7,5 m × 6,25 m × 5,7 m, which is an ideal model of a free field. For testing of the measuring method, model of a rigid sphere-shaped body was used. Body is made from glass. The diameter of the sphere is 25 cm. The loudspeaker was placed towards the sphere, the distance was 5 m. A sinusoidal logarithmic sweep signal from frequency 10 kHz to frequency 100 Hz was generated, and the response was picked up by a measuring microphone. The position of the measuring microphone was changed on line between the sphere and the loudspeaker from the distance 0 cm to the distance 30 cm from the sphere. The step was 1 cm. PULSE system was used for measuring. Data were processed in system MATLAB.

The settings of the measuring microphones and the body, as well as the definition of their positions and their fixing were optimized. The dependence on entrance condition and the repeatability of measuring method were tested. Accuracy of the measuring method was estimated. The results obtained were compared with the analytical solution for a rigid sphere-shaped body.

The mathematical model of a received secondary sound field is presently undergoing development. Later on, bodies of different shapes (including complex bodies), which will be chosen with consideration of technical needs, will be used.

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Characteristic Properties and Synchronisms of Diffraction Efficiency in Diffraction Gratings

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This contribution concentrates on studying diffraction characteristics in optical diffraction gratings. As modeling tools, both rigorous and approximate approaches have been analyzed and/or modified and successfully implemented [1-4]. As for the diffraction characteristics, a general background is briefly presented, i.e. an idea of characterization of mechanisms and diffraction processes, classification of diffraction characteristics and regions with typical diffraction regimes. Different types of synchronisms as the parametrical dependences of the diffraction efficiency on the two of important parameters are discussed. Parameters chosen can either be of a grating or a mount type, thus defining different areas of applicability. A special role is devoted to the volume phase synchronism, i.e. a parametrical dependence of the efficiency on the relative structure period and relative structure/modulation depth. Then, extending the previous studies, description of the two types of grating classes, namely metallic and volume planar (holographic), based on the simulations, is given. Main part of the paper is devoted to new synchronism studies within resonant regions, namely to guided-mode resonance effect (reflection case). Apart from volume phase synchronism, other important parametrical dependences of the diffraction efficiency are given.

In order to effectively model desired diffraction characteristics with appropriate modeling tools, both rigorous (rigorous coupled wave analysis - RCWA, coordinate transformation method - CM) and approximate (effective medium theory - EMT, scalar theory of transmittance, perturbation approach) approaches have been analyzed and/or modified, successfully implemented and extensively used within our group in last years (see, e.g. [1-4]). In order to model and characterize the diffraction process in a complex manner, typically, we have employed the (Λ/λ, d/λ) representation of the diffraction efficiency for a particular diffraction order, called the volume phase synchronism. At the contour plot, each particular point in the (Λ/λ, d/λ) plane represents the diffraction efficiency (of a given diffraction order and angle of incidence) of a diffraction grating with a particular period and grating profile depth. A comparison of dielectric (surface-relief and volume planar index modulated) and metallic gratings is given.

The attention was further brought to modeling grating resonances of a resonant waveguide form. Such resonances can appear either in the non-resonant Rayleigh form (connected with a new diffraction order formation at the grazing angle) or in a resonant waveguide form where the leaky modes are excited. Such waveguide gratings, often called as guided-mode resonant filters (GMRF), have been found very useful in many applications, and have been extensively modeled in the last years. The basic physics of the phenomenon lies in coupling of externally propagating waves to the waveguide modes that induce sharp resonances. A diffracted wave generated by a grating is phase matched to the waveguide structure leaky mode. Essentially, diffraction grating parameters represent in this case useful degrees of freedom for the phase matching control. Typically, high-spatial frequency gratings are used in designs since all higher-order diffracted waves become evanescent; this ensures

complete energy exchange between the propagating zero-order waves. Moreover, multilayer waveguide - grating structures are used, they can exhibit the guiding-mode resonance (GMR) effect if particular layers function as effective waveguides, and if an overall structure includes a grating layer for adjusting the phase matching. A typical GMR response is given by combination of induced resonance and thin-film interference effects whereas off - resonance reflection is effected by the equivalent homogeneous layer (effective refractive index of the grating layer).

Concerning the design procedure itself, briefly saying, first, a simplified waveguide-grating theory is used, with the help of high special frequency structure approximation with equivalent homogeneous layers (using effective medium theory plus thin-film interference theory). Here, typically, the limit of small modulation is applied, and the effective mode propagation constant (*m*-th order evanescent diffracted wave) is calculated. Then, by solving the eigenvalue problem, approximate parametric resonance location is obtained. In other words, first, the polarization used for the structure is chosen (TE/TM), together with materials for fabrication (refractive indices), and grating period. Within the appropriate resonant region, the wavelength and angle of incidence is selected, and the approximate locations of resonant reflectivities (anomalies), i.e. the guided modes in a planar waveguide - planar grating structure, are obtained by tuning the structure depth. For the exact location of the resonances, rigorous calculation is needed (as the RCWA or CM method used). These exact simulations will be presented in a complex manner of the synchronism concept.

The contribution further concentrates on various examples of the resonant GMRF behavior described through appropriate types of synchronisms. In other words, parametrical dependences on key grating and guide parameters are shown and discussed for some typical GMRF configurations. By modeling and presenting diffraction characteristics of selected types of diffraction gratings, we have contributed to better understanding of diffraction processes and behavior in optical diffraction gratings. In general, it was shown that it is important to consider resonant diffraction characteristics when looking for potential applications, e.g. of grating resonances. Such considerations would be important not only in theory but also for practical designs.

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Generation of Picosecond Pulses in Neodymium Lasers with the help of Solid-State Saturable Absorbers

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Compact NIR sub-nanosecond lasers operating at 1 um wavelength are required in wide range of applications like environment sensing, laser marking, telecommunication, medical diagnostics, measurement techniques, range finding, frequency conversion, optical parametric oscillators and Raman laser pumping etc. The most efficient lasers emitting in this spectral range are neodymium host lasers pumped by diode lasers, but flashlamp pumping is still used in low repetition high power systems. The best active media with respect to maximum average output power are Nd:YAG, Nd:YLF and Nd:YVO_4 crystals.
Sub-nanosecond pulses are generated by mode-locking techniques, which have been performed in flashlamp pumped systems for more than thirty years mainly using liquid saturable absorbers. These are organic dyes that are toxic and decompose gradually under UV radiation and therefore their replacement is highly desirable. Semiconductor saturable absorbers based on InGaAs/GaAs are an attractive alternative since they are non-toxic, chemically stable, and solid-state and moreover their linear and non-linear optical properties can be tailored by modifying the parameters during their growth mainly by molecular beam epitaxy techniques.
In typical design used in last years for continuously diode pumped solid state lasers the semiconductor saturable absorbers are directly integrated into a mirror structure, resulting in a device, whose reflectivity increases as the incident optical intensity increases. In these low gain systems the low non-saturable losses are most important and only very small depth of modulation (about 1-2 %) of absorber is required [1].

On contrary, high power flashlamp pumped solid-state lasers with high gain require the higher depth of modulation (more than 15 %) and the simultaneous Q-switching action of the absorber is desirable. For this purpose the semiconductor saturable absorbers without Bragg mirrors, inserted inside the laser resonator, can be used.

We report on progress in research of solid-state saturable absorbers based on InGaAs/GaAs multiple quantum well (MQW) structures. Our samples are grown on 400 um thick GaAs substrates at Center for High Technology Materials, University of New Mexico, by MBE method. Samples used for mode locking of diode pumped lasers have 1 to 10 quantum wells and have an additional Bragg mirror between the substrate and quantum well structure.

Samples used for mode locking of flashlamp pumped lasers have 50 or 100 quantum wells, each consisting of an 8 nm thick InGaAs between two 10 nm thick GaAs layers. The low signal transmission of the samples in non-polarized light under normal incidence is 30 – 33 %. The saturation intensity is 300 uJ/cm^2 and saturation of transmission from 60 % to 75 % is observed (the probe beam was a train of 50 ps pulses incident at Brewster angle).

We made experiments with the MQW samples in different laser setups. One of our systems in a linear 1 m long flashlamp pumped Nd:YAG laser. The laser resonator was formed by one highly reflective mirror with radius of curvature 1 m, a semitransparent flat

mirror with transmission of 48 % and contained a pumping chamber with Nd:YAG rod and one flashlamp. The multiple quantum well saturable absorber was placed near the output mirror at Brewster angle to minimise losses.

In previous articles [2] we reported on stable generation in passively mode locked regime, where no active parts such as acousto-optical modulator are needed. Using a MQW with 50 layers of InGaAs/GaAs 75 ns long trains of mode locked pulses, with individual pulse duration 50 ps, and 300 uJ in each pulse were generated. Shortening of pulses thanks to passive negative feedback with various non-linear elements was previously reported, but now we have demonstrated that no extra intracavity element (such as extra GaAs plate) is necessary and the passive negative feedback can be generated *in the GaAs substrate* of the MQW itself. The results (as to the duration of pulses and the length of the pulse train) are promising, but due to extensive sensitivity to MQW alignment, this setup requires further investigation.

Multiple quantum well saturable absorbers are also widely used in diode pumped systems where the MQW is integrated into one of the mirrors of the resonator. In our laboratory a repetitive short pulse generation in Nd:YAG crystal was demonstrated. Using a continuous 2 W pump diode as much as 280 W of peak power in 9 ps pulses was achieved. The repetition rate of this laser was 150 MHz. This laser is going to be used as a suitable pump for an optical parametric oscillator (OPO) in order to shift the generated 1 um to the 1.5 um telecommunication window [3].

An unique experiment using a transmission mode MQW in a quasi-continuously diode pumped Nd:YAG laser was also demonstrated in our laboratory [4]. The used MQW had 10 layers of GaAs quantum wells and the laser produced short trains of pulses in passively mode locked regime. The number of pulses per train was smaller than in the flashlamp pumped laser (described above), allowing shorter and more intensive pulses.

It can be concluded that selected solid state saturable absorbers were successfully implemented into both diode pumped and flashlamp pumped Nd:YAG lasers and that generation of picosecond pulses was achieved in all used systems.

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Lifetime of Carriers and Seebeck Coefficient in Semiconductors

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The lifetime of carriers represents an important parameter of radiation detectors which is characteristic for them. Usually the current experimental technique for their measurement makes use of different experimental methods, as photoconductivity. Very often the product $\mu\tau$ of mobility μ and lifetime τ is introduced as a criterion for the semiconductor suitability of radiation detection.
In our paper we have focused on lifetime determination from common experiment performed on p-CdTe and p-CdZnTe – temperature dependence of Hall and Seebeck effect and electrical conductivity. The evaluation of our experiments was done on the basis of the new theory of Yu. Gurevich et al [1]. The theory is formulated for a bipolar semiconductors and brings expressions for Seebeck coefficient under the assumption that bulk (τ) and surface (S) recombination mechanisms operate. The phonon drag [2,3] effect is not included in this theory.

Seebeck coefficient is given by the formula

$$\varepsilon = 2a\left[\frac{E_1}{\lambda a + \lambda^2\ \tau\, a\, S} - E\right],$$

where τ is lifetime of carriers, a is the length of sample, S is surface recombination velocity, σ_n , σ_p stays for electron resp. hole electrical conductivity, α_n ,α_p are Seebeck coeficients of electrons resp. holes and

$$\lambda^2 = \frac{\sigma_n + \sigma_p}{\sigma_n \sigma_p}\frac{n_0 p_0}{n_0 + p_0}\frac{e^2}{\tau\, kT},$$

$$E_1 = \frac{\sigma_p(\alpha_p - \alpha_n)}{\sigma_p + \sigma_n}\frac{dT}{dx} \quad \text{and} \quad E = \frac{\alpha_n\sigma_n + \alpha_p\sigma_p}{\sigma_p + \sigma_n}\frac{dT}{dx}.$$

First results of our calculations for three different samples (for low surface recombination velocity S = 0) are summarised in next table

Sample	Hole concentration [cm^{-3}] (300 K)	Seebeck Coefficient [μV/K] (300K)	Lifetime [s] (300K)	Hole concentration [cm^{-3}] (250 K)	Seebeck Coefficient [μV/K] (250K)	Lifetime [s] (250K)
1 p-CdTe	8.6 x 10^{14}	1200	2 x10^{-3}	7 x 10^{14}	1300	2 x 10^{-3}
2 p-CdZnTe	8 x 10^{8}	2200	4 x 10^{-3}	3.8 x 10^{5}	2900	5 x 10^{-3}
3 p-CdZnTe	8 x 10^{15}	625	5 x 10^{-4}	10^{15}	850	10^{-5}

The obtained results are in good agreement with generally published values of $\mu\tau \in \{10^{-5}, 10^{-4}\}$ cm^2/V for holes. We intend at present to measure photoconductivity on our samples CdTe and to compare the measured and calculated values of lifetime.

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Plasma Fibers Influenced by Gravitational Field

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Dusty plasmas have many differences in comparison to "standard" plasma. Some of these phenomena are: plasma levitation, growth of the grains, charging of the grains, plasma crystal growth. The dust causes break the Jean's criterion for gravitational instabilities. The dust is more massive and more charged than ions and therefore it can cause new effects.

MHD set of equations after Fourier transform looks like:

$$-i\omega\delta\rho^{(\alpha)} + \rho_0^{(\alpha)} i\mathbf{k}\cdot\delta\mathbf{v}^{(\alpha)} = 0$$

$$-i\omega\delta\mathbf{B} + \frac{k^2}{\mu_0\sigma}\delta\mathbf{B} - \left[\mathbf{B_0}\cdot\mathrm{i}\mathbf{k}\right]\left(\frac{\sum_\alpha m_\alpha \delta\mathbf{v}^{(\alpha)}}{\sum_\alpha m_\alpha}\right) +$$

$$+\left[\mathrm{i}\mathbf{k}\cdot\left(\frac{\sum_\alpha m_\alpha \delta\mathbf{v}^{(\alpha)}}{\sum_\alpha m_\alpha}\right)\right]\mathbf{B_0} + \left[\left(\frac{\sum_\alpha m_\alpha \delta\mathbf{v}^{(\alpha)}}{\sum_\alpha m_\alpha}\right)\cdot\mathrm{i}\mathbf{k}\right]\mathbf{B_0} = 0$$

$$-i\omega\rho_0^{(\alpha)}\delta\mathbf{v}^{(\alpha)} + \mathrm{i}\mathbf{k}\delta p^{(\alpha)} + \frac{\mathrm{i}\mathbf{k}}{\mu_0}(\mathbf{B_0}\cdot\delta\mathbf{B}) - \frac{1}{\mu_0}(\mathbf{B_0}\cdot\mathrm{i}\mathbf{k})\delta\mathbf{B} - \rho_0^{(\alpha)}\mathrm{i}\mathbf{k}\delta\phi = 0$$

$$\delta p^{(\alpha)} - c_\alpha^{\,2}\delta\rho^{(\alpha)} = 0$$

$$-\mathrm{k}^2\delta\phi - 4\pi G\sum_\alpha \delta\rho^{(\alpha)} = 0$$

Some interesting symmetries can be found in this equation. The analysis of this relation is performed nowadays. I am searching for imaginary roots which can evoke instabilities.

I have used two component dusty plasma with ions and dust. The dust grain mass is bigger than the ion one and its charge is about 10 000e. I performed numerical simulations for many type of parameters. The test of correctness of the solutions was done for zero value of magnetic field. For this parametr I have obtained two spherical wavefronts as we predicted (the dust and the ion sound waveform). We solved a MHD set of equations of the unlimited space plasma pinch with magnetic and gravitational self-interaction and found the behavior of magnetoacoustic waves in this structure.

$$\frac{1}{4\mu^2(m_1+m_2)^2}$$
$$(\rho_1\rho_2\omega^3(-\rho_2(\mathrm{B}^2\mathrm{k}^2-2\mu\rho_1\omega^2+\mathrm{B}^2\mathrm{k}^2\mathrm{Cos}(\alpha))m_1-\rho_1((\mathrm{B}^2\mathrm{k}^2-2\mu\rho_2\omega^2+\mathrm{B}^2\mathrm{k}^2\mathrm{Cos}(\alpha))m_2)$$
$$(\rho_2(2\mu\rho_1\omega^2(-\mathrm{k}^4c_1^2c_2^2+4\pi\mathrm{G}(\rho_1+\rho_2)\omega^2-\omega^4+\mathrm{k}^2(-4\pi\mathrm{G}(c_2^2\rho_1+c_1^2\rho_2)+(c_1^2+c_2^2)\omega^2))+$$
$$\mathrm{B}^2\mathrm{k}^2(\mathrm{k}^4c_1^2c_2^2+4\pi\mathrm{G}(\rho_1-3\rho_2)\omega^2+3\omega^4+$$
$$\mathrm{k}^2(4\pi\mathrm{G}(c_2^2\rho_1+c_1^2\rho_2)-(c_1^2+3c_2^2)\omega^2))+$$
$$\mathrm{B}^2\mathrm{k}^2(\mathrm{k}^4c_1^2c_2^2-(12\pi\mathrm{G}\rho_1-4\pi\mathrm{G}\rho_2+\omega^2)\omega^2+3\omega^4+$$
$$\mathrm{k}^2(4\pi\mathrm{G}(c_2^2\rho_1+c_1^2\rho_2)+(-c_1^2+3c_2^2)\omega^2))\mathrm{Cos}(2\alpha)m_1+$$
$$\rho_1(2\mu\rho_2\omega^2(-\mathrm{k}^4c_1^2c_2^2+4\pi\mathrm{G}(\rho_1+\rho_2)\omega^2-\omega^4+$$
$$\mathrm{k}^2(-4\pi\mathrm{G}(c_2^2\rho_1+c_1^2\rho_2)+(c_1^2+c_2^2)\omega^2))+$$
$$\mathrm{B}^2\mathrm{k}^2(\mathrm{k}^4c_1^2c_2^2+(4\pi\mathrm{G}(-3\rho_1+\rho_2)+3\omega^2)\omega^2+$$
$$\mathrm{k}^2(4\pi\mathrm{G}(c_2^2\rho_1+c_1^2\rho_2)-(-3c_1^2+c_2^2)\omega^2))+$$
$$\mathrm{B}^2\mathrm{k}^2(\mathrm{k}^4c_1^2c_2^2+4\pi\mathrm{G}(\rho_1-3\rho_2)\omega^2-\omega^4+$$
$$\mathrm{k}^2(4\pi\mathrm{G}(c_2^2\rho_1+c_1^2\rho_2)+(3c_1^2-c_2^2)\omega^2))\mathrm{Cos}(2\alpha))m_2))$$

We solved a MHD set of equations of the unlimited space plasma pinch with magnetic and gravitational self-interaction and found the behavior of magnetoacoustic waves in this structure. The program code was written in FORTRAN 95, FORTRAN compiler and linker were used from Compaq Visual Fortran embedded in the MS Developer studio GUI.

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Q-switched Er:YAG Laser with LiNbO3 Pockels Cell

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The aim of this work was to investigate and construct the Q-switched Er:YAG laser. Giant pulse generation of Er:YAG laser is complicated mainly due to the properties of the Er:YAG active medium itself - the short lifetime of the Er:YAG crystal upper laser level (τ_1 ~ 100 μs) and a small gain for one pass of the radiation through the active medium. Other difficulties follow from higher absorption of Er:YAG laser radiation (wavelength 2.94 μm) in the routinely used optical components.

For Er:YAG laser Q-switching a specially designed $LiNbO_3$ electrooptic shutter was constructed. Electrooptic Q-switching in λ/4 configuration requires polarizers in a laser resonator arrangement. In case of Er:YAG laser radiation (wavelength 2.94 μm) optical polarizers are not commonly available and therefore Brewster angle cut faces of $LiNbO_3$ crystal were utilized as partial polarizers in the laser resonator. An electrooptic effect for used $LiNbO_3$ crystal was studied and precise half-wave voltage value was calculated to be U_π = 12294 V. Pockels cell transmission dependency on applied voltage was evaluated for various polarization of the incident radiation.

The Q-switched Er:YAG laser was designed, developed and constructed. Er:YAG cavity was composed of the Er:YAG crystal with a diameter of 4 mm and a length of 90 mm. The crystal along with a xenon flashlamp was placed into a diffused ceramic pumping LMI cavity. A planparallel optical resonator consists of a dielectric 100 % reflectivity mirror and a dielectric mirror with 87 % reflectivity, which serves as an output coupler. The physical length of resonator was 305 mm. Laser repetition rate was 1.5 Hz.

For Er:YAG laser Q-switching an electrooptic shutter in λ/4 arrangement utilizing transverse linear Pockels effect was constructed. As a nonlinear medium $LiNbO_3$ crystal (cross-section 7 x 8 mm, length 26 mm) with Brewster angle cut faces was used. This crystal with electrodes and a housing, on which the electronic switching circuit was mounted, was placed inside the optical resonator of Er:YAG laser between the rear mirror and Er:YAG active crystal. In Pockels cell closed state the sufficient value of voltage was applied on its electrodes. The polarization plane of laser beam was turned and after double passage through Pockels cell the radiation was reflected out of the resonator and optical feedback was prohibited. When a population inversion inside the active material during pumping process reached maximum value, a specially designed delay circuit provided switching Pockels cell and permitted turning off the applied voltage. Polarization of passing laser beam was not changed and minimum horizontal polarization radiation losses were reached, thereby giant pulse could be generated. Switching time of electronic switching circuit was ~10 ns.

The developed system was investigated from the point of view of generated giant pulse energy and length. Dependence of the output giant pulse parameters on the input parameters (high voltage applied on Pockels cell, pumping energy, delay between switching of flashlamp and Q-switch circuit) was investigated.

Output parameters of constructed Er:YAG laser oscillator were measured in free running regime. When $LiNbO_3$ crystal was not inside the resonator, the maximum generated energy was ~ 500 mJ and the length of pulse was measured to be 250 μs (FWHM). In case of $LiNbO_3$ being inside the resonator, inherent passive losses for vertical polarization radiation

inside the resonator increased and therefore the laser threshold rose and a slope-efficiency was lowered. Consequently, the maximum of generated pulse energy in free running regime was 238 mJ. The length of flashlamp pulse was measured to be 571 μs (FWHM).

The optimum parameters for Q-switched Er:YAG laser system predicate only one giant laser pulse with maximum energy and minimum length of generation. Minimum applied high voltage value sufficient for closing Pockels cell was required. In the first step the optimum value of delay between flashlamp pulse trigger and starting point of the Pockels cell opening was investigated. The measurement of the generated giant pulse energy dependency on the delay of Pockels cell switching for various high voltage value applied on the Pockels cell was carried out. This high voltage was changed from 1.4 kV up to 3.5 kV and the delay of Pockels cell switching was changed inside the interval of 300 μs up to 600 μs. From measurements it is seen that the maximum generated energy is obtained for applied high voltage value from 1.4 kV up to 2.6 kV which is in good agreement with our theoretical calculations (transmission of the Pockels cell). The optimal delay value was 450 μs and the lowest high voltage value sufficient for closing the Pockels cell was 1.4 kV. In case of lower delay value, multiple pulses were generated and the output energy was higher (postlasing operation). Consequently, the giant pulse length, energy and build-up time dependency on pumping energy was measured for optimum parameters (applied voltage 1.4 kV and delay of Pockels cell switching 450 μs). For maximum pumping energy 131 J the minimum giant pulse length and maximum giant pulse energy were measured to be 69 ns and 26 mJ, respectively. The build-up time decreased from 960 ns to 420 ns depending on increased pumping energy from 105 J to 131 J, respectively.

As summary, the electrooptic Q-switched Er:YAG laser was constructed and stable giant pulse generation with the minimum applied high voltage on Pockels cell was achieved.

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V:YAG Saturable Absorber for Diode Pumped Nd:YAG Solid State Lasers

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In the past few years, the target of many investigations has been generation of radiation with the wavelength in the vicinity of 1.5 μm so called "eye safe" radiation. These wavelengths can be generated using of Raman or parametric conversion in nonlinear crystals excited by the radiation 1.3 μm. Threshold intensity needed for the initialization of those nonlinear effects suppose the higher power it means that the primary laser could work in Q-switched or mode-locked regime with an active or passive Q-switch. The passive Q-switch (saturable absorbers) has some advantages in comparison with the active one: they are a compact, inexpensive and easy-to-operate. Crystal of Yttrium-Aluminum Garnet (YAG) doped with three-valence vanadium V^{3+} in tetrahedral position suggests an efficient passive absorber for lasers operating in the range of 1100 - 1400 nm. V:YAG is a hard and durable material which has good thermal conductivity, is chemically stable, and capable of being grown to very high quality. This solid state saturable absorber has high damage threshold and it can operate without optical degradation. Q-switching and mode-locking action has been obtained by help of this saturable absorber with a number of active media such as Nd:YAG, and Nd:YAP under flash-lamp and laser diode pumping in last ten years. [1,2]

The goal of this study is optimization of continuously diode pumped Nd:YAG laser operating at wavelength 1340 nm Q-switched by V:YAG saturable absorber. This optimization was done from the point of view of the saturable absorber initial absorption and laser resonator output coupler reflexivity.

The active medium of realized laser was end-pumped composite Nd:YAG crystal. This YAG crystal consists of 8 mm long active part doped by Nd^{3+} ions (1 at. %) and of 4 mm long undoped part. The diameter of this crystal was 5 mm. The outer frontal part of the laser crystal had broadband antireflection coatings (AR) for the 1064 nm wavelength. The undoped part was bounded to the pumping face of the crystal doped part. In our previous study [3] we have confirmed that using of such undoped part of laser rod enlarges the active material cooling surface and improves a laser active media thermal field uniformity and heatsink. The pumping source used was a laser diode HLU20F400 (LIMO Laser Systems) emitting radiation at wavelength 808 nm with the maximum output power 25 W at the end of the fiber (fiber core diameter: 400 μm; numerical aperture: 0.22). The diode radiation was focused into the active Nd:YAG crystal by two achromatic doublet lenses with the focus length f = 75 mm. The measured diameter of pumping beam focus inside the crystal was 450 μm. The 80 mm long resonator of the Nd:YAG laser was formed by a planar dielectric mirror R_1 with high transmission for the pumping radiation (T > 98 %@808 nm) together with the high reflectance for the generated radiation (R_1 = 100 %@1340 nm), and by a concave (100 mm or 146 mm) dielectric mirror R_2 serving as an output coupler. As this coupler five various dielectric reflectors was proved: $R_2^{(1)}$ = 98 %@1340 nm, r = 146 mm; $R_2^{(2)}$ = 94 %@1340 nm, r = 100 mm; $R_2^{(3)}$ = 91 %@1340 nm, r = 146 mm; $R_2^{(4)}$ = 86 %@1340 nm, r = 146 mm; and $R_2^{(5)}$ = 82 %@ 1340 nm, r = 146 mm. For the Q-

switching three samples of V:YAG crystals with different initial transmission was used: T_0 = 92 %, 90 %, and 88 %. The V:YAG crystal samples used in our experiment were grown from molybdenum crucibles using of Czochralski method in reducing protective atmosphere. High purity oxides were used for crystal growth. Concentration of V_2O_5 in the melt reached up to 1 wt. %. The composition of the crystals was measured using of an x-ray fluorescence spectrometer. Post-growth annealing in reducing atmosphere was applied on the crystals. The V:YAG discs with 5 mm diameter were both sides polished and AR/AR coated so that a minimum reflectivity on 1060 and 1340 nm was reached.

In free-running regime (without passive Q-switch inside the resonator) constructed Nd:YAG laser was operating with all five available output couplers. From measured dependencies of generated output power at wavelength 1342 nm (pump power at 808 nm) it was found that optimum output coupler reflexivity is between 87 and 90 %. In this regime, the maximum output power 1.6 W (absorbed pumping power 10 W) was reached with output coupler reflexivity 91 %. The differential efficiency was better than 20 %.

For Q-switching regime there were 15 possible combinations of the output coupler reflexivity and passive Q-switch absorptions, but only for the eight combinations the laser emission was reached. For these cases following parameters of Nd:YAG laser output radiation in dependence on pumping power were measured: a mean output power, generated giant pulse width (FWHM), and repetition rate of generated pulses. From obtained values, single pulse energies and peak powers were calculated. It was found, that the shortest pulses (21 ns) are generated when the saturable absorber with the lowest initial transmission (88 %) was used. This absorber was operating only together with the output coupler having the reflexivity 94 % and the corresponding peak mean power, single pulse energy and peak power were 215 mW, 64 μJ, and 3.1 kW, respectively. Longer but more powerful pulses were generated when the output coupler having close optimal reflectivity 91 % was used. The generated pulse lengths were 30 ns and 25 ns for V:YAG saturable absorbers with T_0 = 92 %, and T_0 = 90 %, respectively. In these cases, the higher mean power (525 mW for T_0 = 92 %, and 365 mW for T_0 = 90 %) was reached which corresponds to higher pulse energy (118 μJ for T_0 = 92 %, and 126 μJ for T_0 = 90 %) and higher peak power (4.3 kW for T_0 = 92 %, and 4.8 kW for T_0 = 90 %).

The results obtained in this study will serve as a basis for design of Q-switched Nd:YAG microchip laser.

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Alexandrite Laser System for Ultravioulet Radiation Generation

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Frequency conversion is a useful technique for extending the utility of high power lasers. Non-linear optical devices, such as harmonic generators extend the frequency range of available laser sources. The results of alexandrite laser second harmonic generation (wavelength 375 nm – ultraviolet) are presented. Generated UV radiation was used for interaction experiments in dentistry.

The pulsed laser system was based on a single mode lamp-pumped alexandrite (chromium-doped chrysoberyl Cr^{3+}:$BeO.Al_2O_3$) laser which emits output energy of 200 mJ with 70 μs pulse in free-running mode. The lasing wavelength was untuned and laser operates at 752 nm. The water flow from the laser-rod cooling system is independent of the lamp cooling system. The laser-rod cooling system is capable of controlling the coolant temperature over a range of 20 °C – 90 °C. The excitation cavity was composed of silver-plated elliptical reflectors which focused the 7 mm ID by 75 mm long xenon-arc lamp radiation onto a laser rod. The laser rod 4 mm in diameter and 90 mm long had a chromium concentration of 0.15 at. % and antireflection-coated (AR) ends.

As a harmonic generator β-barium-borate (β-BaB_2O_4, BBO) crystal was used. This nonlinear negative uniaxial crystal is well known to be a good candidate for the generation of UV light. A transparency range of this crystal covers wavelengths from 189 nm up to 3 500 nm. Damage threshold of this crystal is higher than 1 MW/cm^2 for 10 ns pulse at wavelength 532 nm. Dimensions of this crystal (phase matching type I; orientation $\theta = 31{,}2$ °, $\varphi = 0$ °) were 10 mm in length and 6 × 6 mm in width. Crystal faces were AR/AR coated for 750 nm and transmission at wavelength 375 nm was better than 99.9 %. Because the efficiency of second harmonics conversion depends on radiation intensity an intra-cavity and extra-cavity arrangement was compared and two different laser resonators were realized. These resonators were designed with a beam profile simulation using an ABCD matrix to have as high as possible intensity inside the BBO crystal and as high as possible mode volume inside the laser active medium. The thermal lens inside the laser rod was also taken in account.

The first designed laser cavity consists of two dielectric mirrors. Rear resonator mirror with 100 % reflexivity at 750 nm was concave with radius 0.5 m. As an output coupler flat mirror with reflexivity 73 % at 750 nm and transmission 90 % at wavelength 375 nm was used. Distance between alexandrite crystal and rear mirror was 100 mm. The distance between the output coupler and the laser rod was 310 mm. The total resonator length was 500 mm. Between the output coupler and the laser rod, a Fabry-Perot etalon and diaphragm (1.5 mm diameter) were placed to control the spatial and longitudal mode structure of the fundamental radiation. The waist of this resonator was closed to the output mirror and a calculated spot size diameter was 180 μm. The measured value of spot size was 250 μm. In extra-cavity arrangement (BBO crystal was out of the laser resonator, 20 mm behind the output coupler) 0.7 % conversion efficiency from the fundamental to the second harmonic

radiation was reached. In the intra-cavity arrangement (BBO crystal was inside the resonator, 20 mm in front of the output coupler) the conversion efficiency of 2.5 % was reached. When a special dichroic mirror (reflexivity R > 99 % for wavelength 375 nm and maximal transmission for fundamental wavelength 750 nm) was placed into the resonator, the conversion efficiency was reached 3.2 % which corresponds to the output energy 4.5 mJ at wavelength 375 nm.

Next, the laser resonator was changed to obtain higher intensity inside cavity waist and the bigger mode volume inside the laser active media. For this purpose "V" shape cavity was used. This resonator was composed of two concave mirrors and flat output coupler. Rear mirror with reflexivity of 100 % for the laser base wavelength had 3 m radius, middle mirror (which serves for focusing) had radius 0.5 m and reflectivity 100 % for the base wavelength. Distance between this two mirrors was 390 mm. Total length of this resonator was 640 mm. The output coupler was the same like in the previous resonator. The resonator mode waist was located at the output coupler and spot size calculated diameter was 120 μm. The efficiency for intra-cavity second harmonic generation was 2.5 %. When the dichroic mirror was placed into the resonator the conversion efficiency increased to 4 %. Corresponding output energy at wavelength 375 nm was 3.5 mJ.

Generated UV radiation was used for interaction experiments in dentistry – for tooth bleaching [1, 2] and for endodontical treatment (a root canal disinfection) [3]. For UV radiation delivery a special hollow glass waveguide was used [4].

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Effect of Mid Infrared Laser Radiation on Ureter Tissue

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The aim of the work was to investigate the possibility of the human ureter wall perforation by various types of mid-infrared radiations and to explore the basic interaction characteristics for ureter surface and its deep structures.

For these experiments free-running Er:YAG (2.94 μm), CTE:YAG (2.7 μm), CTH:YAG (2.1 μm), and Tm:YAG (2.01 μm) laser systems were adapted. Laser radiation was delivered to the investigated tissue by a special waveguide system (a cyclic olefin polymer-coated silver hollow glass waveguide - diameter 700/850 μm, length 1 m - connected with a sealed cap). Dependencing on the interaction efficiency the interaction energy was from 100 mJ up to 400 mJ. The interaction fluences were in the range of 26 J/cm^2 up to 104 J/cm^2.

The summarization of the wavelength, pulse length, maximum generated laser energy, used delivery system, maximum interacting energy and fluence is in following table.

Laser	Er:YAG	CTE:YAG	CTH:YAG	Tm:YAG
Wavelength [μm]	2.94	2.70	2.10	2.01
Pulse Length [μs]	190	200	250	175
Maximum Laser Energy [J]	2.00	0.97	1.85	1.80
Laser Repetition Rate [Hz]	1.5	1	1	1
Delivery system COP/Ag HGW [μm/m]	ϕ700/1	ϕ700/1	ϕ700/1	ϕ700/1
Max Interacting Energy [mJ]	100	200	400	210
Max Interacting Fluence [J/cm^2]	26	52	104	55

The waveguide consists of a supporting fused silica glass capillary tube with a silver layer deposited on the inside wall. This silver layer is coated by the cyclic olefin polymer (COP) film about 0.1 μm thick. The inner diameter of the waveguide was 700 μm and its length was 1 m. At the output side of the waveguide the specially developed sealed termination had to be used for the applications in which waveguide output is in contact with ureter tissue.

In the first experiments the pulse fluences needed to perforate the ureter wall tissue (thickness 1 - 1.5 mm) were found for CTH:YAG, Er:YAG, and CTE:YAG laser irradiations. With Tm:YAG laser radiation, the ureter wall perforation was not achieved even if the maximum possible fluence (55 J/cm^2) and the number of pulses 200 was applied. Er:YAG

and CTE:YAG 100 mJ radiation can drill a hole for 8 and 51 pulses, respectively. CTH:YAG radiation drills a hole for 68 pulses/400 mJ energy applied.

From the histological evaluation it follows that CTH:YAG laser radiation induces surface carbonization without any influence on the deeper structures. Er:YAG laser radiation causes tissue alterations only up to 0.05 mm deep from the surface. The most interesting results in these measurement sets were obtained for CTE:YAG and Er:YAG laser, whose application resulted in precise tissue perforation with minimum tissues alterations.

To conclude, it can be summarized that CTH:YAG, Er:YAG, and CTE:YAG laser radiation can accomplish good wall ureter perforation; however significant differences appeared in tissue modifications of both the surface (epithelium) and deeper structures (mesenchym).

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Deep Level Impurities Measurement

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There are many types of impurities in semiconductors. Some of them are incorporated as dopant atoms (shallow-level impurities) and they are important for the carrier concentration, or conductivity of semiconductor material. On the other hand, many impurities are unintentionally incorporated during crystal growth and device processing.
When the periodicity of the single crystal is perturbed by foreign atoms or crystal defects, discrete energy levels are introduced into the forbidden energy gap and lie deep in this band. Each line represents one such defect with energy E_T. Such defects are called generation-recombination centres (G –R), or traps, or simply deep-level impurities. For semiconductors as silicon, germanium, or gallium arsenide, these impurities are metallic atoms like iron, gold, copper, or chromium. They are also as result of crystal imperfection, such as stacking faults, or faults due to a radiation damage.
The main origin of radiation damage [1] in semiconductors is bulk damage caused by displacement of atoms from their sites in lattice. It leads to the creation of discrete energy levels within band gap. They act as trapping or (G – R) centres for mobile charge carriers. It could lead to slow collection of signals in semiconductor detectors [2]. Another important phenomenon is that such defects act as to compensate the material and thus change the resistivity of the bulk material.
The properties of deep-level impurities in semiconductors are best measured electrically. The carriers emitted from deep-levels can be detected as a current, a charge, or a capacitance.
Capacitance measurements are well suited to determine charged impurities in semiconductors. As is well known the capacitance C of the Schottky diode or PN junction is

$$C = A\,[\, e\varepsilon_0\varepsilon_r \,.\, N_{SC}/2(V_d + U)]^{1/2} \qquad (1)$$

where N_{SC} is the ionized impurity concentration in the space-charge region with a cross section A and n_T is concentration of centres occupied by electrons. In a PN junction the shallow level donors are fully positively ionized and their concentration is N_D and $N_{SC} = N_D - n_T(t)$ for only deep-level acceptor impurities that are negatively charged when occupied by electrons. The time dependent capacitance reflects the time dependence of $n_T(t)$.

Steady-state measurements
It is possible to determine N_T from the plot of $1/C^2$ vers. U. For the reverse biased PN junction $n_T(t)$ is negatively charged when occupied by electrons. With time t centres become neutral because electrons are emitted from the centre and therefore (($N_D - n_T(t)$) and C increases and $1/C^2$ decreases with time. The reverse-biased capacitance C at $t = 0$ and $t \rightarrow \infty$ is compared. If a slope S(t) is defined as $S(t) = - dU/d(1/C^2)$ than

$$S(\infty) - S(0) = (2/e\varepsilon_0\varepsilon_r)^2[n_T(0) - n_T(\infty)] \qquad (2)$$

gives the concentration N_T of centres if we assume that $n(0) = N_T$ and $n(\infty) = 0$.

Transient measurements
The space-charge region width changes with time as electrons are emitted from centres. The time varying capacitance is detected. In the case when the deep-level impurities concentration is very low and form only small fraction of the space charge one can use first-order expansion of Eq. 1 and obtain

$$C = C_0 [1 - n_T(t)/2N_D] \qquad (3)$$

where $C_0 = [e\varepsilon_0\varepsilon_r N_D/2(V_d - U)]^{½}$ is the capacitance without any deep-level impurities at reverse bias U, V_d is diffusion potential at U = 0, and ε_r dielectric permittivity of semiconductor. The most measurements are emission measurements. The PN junction is initialy zero biased allowing impurities to capture majority carriers and device capacitance is C(U=0) . Following a reverse bias pulse, majority carriers are emitted and we find for time dependence capacitance

$$C(t) = C_0[(1 - n_T(0)/2N_D) . \exp(-t/\tau_e)] \qquad (4)$$

where τ_e is the emission time constant and depends on the electron capture cross section σ_n of the center.
The measurements have been performed in the laboratory of Faculty of Mechanical Engineering, CTU, Prague, for one semiconductor untreated detector on Si substrate with P^+NN^+ structure. With the DLTS measuring device Polaron S4600 the experimental data have been obtained and the appropriate activation energies E_T of the centres and the electron capture cross sections σ_n have been calculated. The temperature range was 85 K – 330 K and PN junction of the diode was reverse biased at U = -10V. The decay rate of capacitance has shown two maxima corresponding to the two deep level energies E_{T1} = 0,45 eV and E_{T2} = 0,23 eV under the conduction band and one value of $\sigma_n = 2.10^{-16}$ cm^2.
Comparing obtained values of the energies and cross section with the table [3] we have got probably results of intersticial iron impurity acting as the electron traps in silicon material.

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Computer Processing of Interferograms

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Interferograms may be evaluated in a many ways. This article describes the method of computer processing of interferograms namely for aparaturs adjusted to infinite, or finite fringes width.

For instrument adjusted to infinite fringes width the of measurement output represents one interference pattern. This pattern is converted to digital bitmap form and futher proceeded:

As first processing step we convert this picture, which has by default 256 shades of gray, to the two-color black and white picture. This simple technique consists in selection of gray threshold shade and transformation of all bright points to the white ones and darker to the black ones. Threshold shade must be selected so, that each interferential fringe must remain continuous and adjoining fringes must not touch each other. The threshold shade is independent on thickness of fringes. For more complex interferograms it is possible to apply this process on the interferograms only partially, due to difficult threshold setting.

Secondly, when explicit differentiation between interferential fringe and surrounding areas are finished, we must distinguish individual areas between fringes. We search subsequently over the whole interferogram and colour each white point or points creating a white area by color not yet used in the bitmap.

In the third step we reduce the interference fringes used for separating of areas up to now. Following algorithm can reduce the interferent fringes: By sequential searching in the picture by one direction (e.g. up to down) it looks for all pairs of contiguous points, where the first is black, and the second is of different color. In this process we repaint the black point by the color of the second point. Applying this process subsequently, in four directions (up to down, left to right, down to up, right to left), all black points are reduced. This process reduces the fringes and bound areas encounts in the middle of fringes.

In fourth step we assign the shift of fringes or optical way changes to the individual areas. The relative difference of two bound areas is always plus or minus one wavelength, but theoretically is it unable to determinate the sign. This step of processing is so far possible only with user´s interaction. User determines one area as the reference one. This area is predicted for zero displacement. Due to complicated adjustment of the interferometer and expected result can be predicated designate the relative displacement sign of others areas.

In case of interferogram with finite width of the interference fringes, the change appears not only in the genesis of new interferential fringes but especially in the shift of existing fringes. In this case we have principally two interferograms at the start. First measurement is without studied region the second one includes it. Important is, that on the interferograms must be some reference items, according to those it is possible to overlap these two pictures. Each interferogram is processed with the same method as that with infinite fringes. We must take care, that in the fourth step we select the reference area, which is independent (or at most) on the measured sample. This will simplify the following identification.

For the final computing of shifts we lay both interferograms over in agreement to the reference dots and thus a new picture is calculated, where the color of each point is set as the distinction of optical way changes for overlays points on processing bitmaps. This method can comprehend some errors, meanly by determination of small shifts of fringes or bigger relative space between fringes. This matter may be a subject of further improvement of method described above.

This method results in a picture displaying in color the optical way changes evoked by investigation samples rounded to the displacement of integral multiple of wavelength. Sometimes is desirable to smooth this picture, whereupon it may be used any smoothing algorithm (interleaving of polynoms, splines and others) namely according to the tangible exactions and measurement character.

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Hollow Needle to Plate DC Electrical Discharge at Atmospheric Pressure Interferometry

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Non-thermal plasma at atmospheric pressure is usable in many applications – electrostatic precipitation, air ionization in interiors, pollution control of gases from combustion sources, destruction of toxic compounds in air and ozone generation. Hollow needle to plate electrical discharges have been studied in our laboratory for two main purposes – decomposition of volatile hydrocarbons and ozone generation. Hollow needle to plate configuration of electrodes is modification of classical pin-to-plate motive widely used in corona discharges. The discharge is stabilized by an air flow through the hollow needle (needles in case of multineedles systems) [1,2,4]. Air leaving the needle forms a thin jet impacting the plate electrode and consequently leads to a complex air velocity field in the discharge chamber. The discharge current is typically 1-2 mA per a needle. The gap between electrodes is several millimeters; therefore contact diagnostic methods are practically excluded. As far as plasmachemical reactions are temperature dependent, for used discharge chambers the reactor design optimization should be performed according to the gas flow and temperature distributions in the discharge chamber. Gas flow velocity distribution in the chamber can be studied in absence of the discharge [3]. On the other side the temperature distribution in the chamber is time dependent dynamical characteristic. Its values can be affected by the working gas flow rate and electrical characteristics of discharge changes. Due to local overheat hot spots caused by the discharge non-homogenous current density can lead the degradation of required plasmachemical reactions. Interferometric overheat watching method (based on the use of the Mach -Zehnder interferometer) have been tested for detection of forming hot spots.

The discharge chamber was situated in the Mach-Zehnder interferometer. Coherent light beams were emitted from the He-Ne laser (wavelength about 633 nm). For interference pattern registration a classical photographic camera was used. To prevent the film from the discharge self-radiation the monochromatic filter was used. To insert the discharge chamber in interferometer arm it was necessary to adapt the chamber – to avoid parasite reflections on the walls its front and back glass walls were removed. The cathode (a hollow needle of an 1.2 mm outer diameter and 0.7 inner diameter) was placed perpendicularly to the anode crated by an iron block (height 1.4 cm, width 2 cm and length 8 cm). The tip of the needle was sharpened at the angle of 15 degrees. The gap between electrodes was 3.2 mm. The cathode was supplied from a DC high voltage source or alternatively heated by an electrical heater supplied by the heater source (temperature on output of the needle was 323 K). The cathode was ballasted by an resistor (R = 0.8 MΩ). The air was supplied into the needle by a compressor through regulating valve and flowmeter.

The first group of experiments simulated heating of the gas in the discharge chamber. The air flowing through needle was heated to 323 K. The ambient air temperature was 296 K. The high voltage source was disconnected during measurements. For temperature field better detection the interferometer was adjusted in the way, that registered interference fringes also included a set of perpendicular parasitic interference fringes. The pattern for the flow rate of 5 slm was different comparing to the 10 and 15 slm ones and they had to be interpreted

separately. Due to supercritical flow rate (10, 15 slm) of the jet and interferometer proper adjustment optical density changes were better detectable in the parasitic interference fringes. Impact jets were about 1 mm in diameter and temperature drop did not exceed 27 K. These facts can be applied to estimation of used interferometric method sensitivity. The temperature field in case of 5 slm flow rate (subcritical) flow was better detectable due to interaction with surrounding air and large scale vortices forming.

The second group of experiments was oriented to discharge interferometry. The hollow needle to plate discharge can burn in the diffuse mode (lower currents, the discharge diffusive lights, the ozone yield increases with increase of the discharge current) or in the filamentary mode (higher currents, the discharge forms separate filaments, the ozone yield decreases with the increase of the discharge current). The experiments show that optical density changes caused by plasma are very small and therefore detection of plasma presence is under resolution of this method.

For better evaluation registered interference patterns were scanned, coloured and numerically combined. Some pixels of the first interference pattern were replaced by corresponding pixels of the second pattern resulted in a dichromatic pattern. The diffuse discharge mode (air flow 15 slm) and the discharge chamber without discharge (air flow 5 slm) and the diffuse (discharge current 1.1 mA, discharge voltage 5.34 kV, air flow 15 slm) and filamentary (discharge current 1.5 mA, discharge voltage 6.03 kV, air flow 15 slm) mode were compared. Processed pattern shows no significant changes of fringes.

Artificial heating of the flowing gas leaded to significant changes of interference pattern in case of subcritical flow rate through the needle. Supercritical flows were visualized by the set of parasitic fringes. Local temperature changes of at least 26 K are detectable with the spatial resolution of 1 mm. Obtained temperature fields indicate the absence of regions of local overheating. The ozone yield decrease with increase of the discharge current (observed in filamentary mode) might be caused by other processes than temperature dependence of ozone generation and local overheat.

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Photorefractive Oscillator with Ring Resonator

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The Photorefractive effect is well known nonlinear optical effect. It was first observed in Lithium Niobate ($LiNbO_3$) by Arthur Ashikin in year 1966 in Bell's Laboratory. Townsend and LaMacchia observed this effect in Barium Titanate ($BaTiO_3$) in 1970. Until these days, the effect was widely studied by many researchers and different applications like data-storage, real-time holography or phase-conjugate wave-front generation has been published [1].

In this paper I present a theoretical model of the photorefractive pumped unidirectional laser oscillator with ring resonator, experimental realization of such oscillator and its characterization. I have studied this oscillator in multi-mode and single-mode regime.

Theoretical model[2] of this oscillator proceed from a properties of nearly degenerate two-wave mixing (TWM) process such as TWM amplification and nonlinear phase shift of an amplified signal beam. Let's two optical beams with nearly same frequency ω_1 and ω_2 intersect and interact with nonlinear photorefractive media. These two beams interfere together and create spatial light modulation (interference pattern) slowly moving perpendicular to the axis of an interacting angle θ. Velocity of moving is proportional to a spatial frequency of the interference pattern.

For photorefractive material description I used band pass energy model with one type of photorefractive center with two energy levels Fe^{2+} and Fe^{3+}. It's usually assumed that Fe^{2+} act as a donors and Fe^{3+} act as an acceptors. Because of photosensitivity of the photorefractive materials, in bright areas electrons are excited into conduction band. Because of diffusion electrons tend to go to dark areas, where they are trapped by acceptors. This process of excitation and trapping can be many times repeated. Thus light pattern may generate space charge redistribution. As a result spatially modulated electric field appears. This electric field induces a local volume refracting index change through the Pockels effect. In general, the refractive index grating will be spatially phase-shifted relative to the light interference pattern. This phase shift ϕ is responsible for energy transfer between interacting beams, as will be shown later.

These theoretical results give me possibility to solve wave equation for the interacting beams. I have used a scalar wave equation in parabolic approximation. It can be shown that intensity of the signal beam is an increasing function of z axis (direction of propagation) and because of principle of energy conservation, an intensity of the pump beam is simultaneously decreased. This energy transformation can be described by coupling constant γ.

Some additional nonlinear phase shift $\Delta\psi$ of signal wave appears at this interaction. It can be noted, that both parameters γ and $\Delta\psi$ are dependent on frequency difference $\Omega=\omega_2-\omega_1$ of the interacting beams.

The gain inside the ring resonator will be provided by amplification of signal beam in two-wave mixing. Theoretical model describing oscillations is simplified to plane wave model, and is based on two main conditions. First, the two-wave mixing gain has to cover passive losses inside resonator, and the second, the phase of oscillating wave after one roundtrip has to be the same. In conventional resonator, the oscillation occurs at frequencies which fit the phase reconstruction condition and which lie in a frequency band of the gain

curve of the laser medium. These frequencies are separated by the mode spacing constant c/L, typically not more than 1GHz. Since the width of the gain curve for the conventional laser gain medium is typically several GHz, oscillation can occur at almost any cavity length L [3]. Unlike in a conventional (solid state laser) gain medium, the bandwidth of the photorefractive two-wave mixing is very narrow, typically not more than 30 Hertz. In spite of this narrow gain bandwidth, unidirectional oscillation can still be observed at any cavity length. As the theory shows, this can be explained in terms of additional phase shift $\Delta\psi$ which circulating wave gets at photorefractive beam coupling. The theory predicts gain threshold, which is necessary to reach for different cavity length for oscillations occur, including spectral regime where gain is above threshold.

I realized photorefractively pumped unidirectional ring resonator pumped by Argon-Ion laser beam (λ=514,5 nm). Ring resonator consists of four plane mirrors of reflectivity 99,9% and undopped electrically poled $BaTiO_3$ crystal as the photorefractive gain medium in the laser resonator.

Multi mode generation with less than 10% instability has been observed and the output power 4,5mW was received with conversion efficiency up to 50%. Gauss-like generation was observed in single mode resonator oscillations with less than 10% instability. Single mode generation beam divergence was 0,91mrad, and maximum frequency shift of 0,39Hz was measured. Output power at TEM_00q was 0,35mW with conversion efficiency 3%. I have also observed spectral shift of whole gain curve, which was discussed and successfully explained by nonideal photorefractive material, where the phase shift ϕ between interference pattern and induced index grating is not exactly $\pi/2$ as theory expects.

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Iodine Laser Interactions with Low-Density Foams

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Experimental studies of iodine laser PALS interactions with light-element foams of various initial average densities and thicknesses are performed. X-ray streak camera and multi-frame shadowgraphy and interferometry are used for the experimental diagnostics. Experimental results demonstrate fast energy transport and thermal smoothing in the porous matter. Efficient thin solid foil acceleration by Mbar pressure produced in the foam plasma is revealed. Our experiments are modeled by means of hydrodynamic code ATLANT-HE.

A very smooth ablation pressure profile (typically up to a few percent) is required in the direct-drive laser fusion experiments to suppress the onset and a subsequent growth of Rayleigh-Taylor instability, which might disrupt the target compression. As it is generally very difficult to meet the required uniformity level in the ablation pressure by an improvement of the illumination scheme as such, other smoothing mechanisms have been proposed, which are based on a modification of the laser-target interaction process. One of these methods employs a low-density porous matter as a voluminous absorber of laser radiation in ICF targets [1], another method uses laser prepulse to enhance transverse thermal smoothing in expanding plasma corona [2].

The main goal of this work is to study energy transport through the low-density foam and to demonstrate a sufficient efficiency of thin foil acceleration together with a substantial smoothing effect of the low-density foam absorber. Specific feature of our experiments is the laser pulse duration (~0.4ns) shorter than foam homogenization characteristic time. This study succeeds to our paper [3], including previous experiment and analytical theory. Here, recent experimental results are presented together with their two-dimensional hydrodynamic simulations.

Experiments were conducted on the PALS iodine laser facility in Prague. The laser provided 400 ps (FWHM) pulse with the energy up to 600 J at the basic harmonic ($\lambda_1 = 1.32$ μm). Laser was incident normally on the target; the laser spot radius in the best focus was $R_L \approx 40$ μm. Here the target was placed out of the best focus and the laser spot radius $R_L \approx 150$ μm was used. Laser irradiances were varied from $I \approx 10^{14}$ W/cm^2 up to $I \approx 10^{15}$ W/cm^2. The laser intensity distribution in the irradiated area was not quite uniform and several concentric diffraction rings were observed.

Several types of foam target were used. Most experiments were done with polystyrene foam with density in range 8 – 10 mg/cm^3 and typical pore diameter $D_p \approx 50$ –70 μm. Polystyrene foam with $\rho \approx 30$ mg/cm^3, $D_p \approx 10$ μm, and with $\rho \approx 20$ mg/cm^3, $D_p \approx 5$ μm, and PVA foam with $\rho \approx 5$ mg/cm^3, $D_p \approx 5$ μm were also used. Aluminum layer 2 μm or 0.8 μm thick was placed at the foam rear side in the majority of foam targets.

Plasma emission in x-ray region (photon energy > 1.7 keV) was observed by KENTECH low magnification x-ray streak camera placed in a side view. The temporal

resolution was either 30 or 70 ps and spatial resolution of 50 μm was in the direction normal to the target surface (target depth). X-ray streak camera was used to observe the longitudinal propagation of the heat wave inside the foam. From preliminary data, the inward propagation velocity of the x-ray emitting plasma region was found to be approximately ~$6 \cdot 10^6$cm/s. We didn't observe sharp heat wave front so it is difficult to determine its speed. X-ray streak records show no noticeable emission near the Al foil for all targets used, though the x-ray signals last for about 2ns. It is deduced that laser radiation penetrates only a small portion of the overdense foam thickness and the foil is not heated to high temperatures by hydrothermal wave.

Optical diagnostics employing interferometry and shadowgraphy were carried out by means of 3-frame polari–interferometric system with automated image processing technique. Each of three recording channels was equipped with a CCD camera of the Pulnix TM-1300 type, with a matrix of 1300 × 1030 pixels. The diagnostic system used a probing beam at the third harmonics with the same pulse duration as that of the main beam. The position of the point P (rear side opposite to the laser beam center) is measured with the precision of 5 – 10 μm, and thus the speed of the accelerated Al foil can be determined. Moreover, the time t_f when the hydrothermal wave reaches the foil may be estimated. The shape of the accelerated foil is smooth without any detectable small-scale structures that are present inside the laser beam. Maximum velocities of the accelerated Al layer up to 10^7 cm/s have been measured.

Simulations were performed by two-dimensional Lagrangian hydrodynamics code ATLANT-HE in cylindrical geometry including an advanced treatment of laser propagation and absorption. The code does not take into account fine scale structure of the foam.

Foil acceleration by the pressure of foam matter has been observed and modeled. Hydrodynamic efficiency up to 14 % was obtained. A good agreement of experiment, and simulations in the accelerated foil velocities is found [4].

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Ultrashort-Pulse Line X-ray Emission from Solid Targets Irradiated by a Femtosecond Laser Pulse

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With rapid progress in the generation of intense femtosecond laser pulses, new opportunities like laser-driven radiation sources with picosecond pulse duration and photon energies ranging from 100 eV up to several MeV are now becoming available. These sources open ways to experimental studies of the structure of matter with a unique combination of micrometer spatial and subpicosecond temporal resolution. For such experiments, K-α pulses are particularly interesting as the emitted energy may be comparable with the most intense resonance lines and the pulse length may be considerably shorter. While the emitted pulses of intense resonance lines cannot be shortened significantly below a typical duration of a few picoseconds [1], K-α pulses much shorter than 1 ps have been predicted and observed. K-α emission has already been used in pump-probe experiments to measure dynamic response of various materials by means of x-ray diffraction with picosecond temporal resolution [2].

K-α emission is here studied by means of numerical simulations performed in one-dimensional planar geometry. The purpose of our numerical study is to propose suitable target design and appropriate laser intensity and pulse shape so that both high efficiency of laser energy transformation into K-α emission, and subpicosecond duration of the emitted x-ray pulse can be reached. Several emitting materials are investigated in order to assess x-ray source in various spectral regions. Multilayer target design may facilitate discrimination between radiation generated in corona and in cold matter without a significant decrease of the emitted energy.

Interaction of laser prepulse with target is modeled via 1D hydrodynamic code MEDUSA. The results of these simulations provide information about preformed plasma for various laser and target conditions and pulse separations. Resulting plasma density scale length L is the most important parameter for resonance absorption during interaction of p-polarized obliquely incident main pulse.

The simulation of interaction of the main pulse is then split into two regions: the corona treated by PIC code, and the cold solid target, where the transport of fast electrons is modeled by our Monte Carlo code "HEIKE" (Hot Electron Induced K-α Emission) and where K-α photons originate. We assume here a step-like boundary between hot corona region and cold solid matter, however a jump in electrostatic potential on the boundary, important especially for non-conducting materials, may be applied.

The interactions of obliquely incident p-polarized femtosecond laser pulses with plasma are here investigated via our relativistic PIC code using "boost" frame. Detailed description of our PIC code is presented in paper [3]. Fast electrons crossing the rear boundary of the simulation box are substituted by a flux of Maxwellian electrons with initial electron temperature. Fast electrons leaving PIC simulation box serve as an input for our Monte Carlo code, which is used here as a post-processor to the PIC simulation. Monte Carlo code calculates K-α emission from cold solid matter only.

In our Monte Carlo code "HEIKE", we have used the "single scattering" model with elastic collisions described by screened Rutherford cross section and inelastic collisions described by cross sections based on generalized oscillator strength model. K-shell ionization is treated here as a separate event and more precise semiempirical cross section is used. The branching ratio between non-radiative Auger process and K-α emission is taken from literature. The reduction of photon number during their transport to the target front side according to the Beer's law is taken into account together with the time of flight. The impact of bremsstrahlung on fast electron transport was approximated by a stopping power. Stopping power approximation was also used to simulate the influence of self-generated electrostatic field, however no significant difference in K-α emission was found.

Hot electron spectrum was found to be nearly independent of the maximum electron density and of the initial electron temperature used in PIC simulations. Both, maximum kinetic energy of hot electrons, and the total laser energy transferred into hot electrons are increased at plasma density scale length L_{opt} optimum for resonance absorption, i.e. when laser prepulse is applied with a proper pulse separation. Hot electrons are collimated to a cone nearly normal to the target surface.

Very short K-α emission pulses were observed in simulations. Laser pulse duration 120 fs FWHM was assumed and K-α pulses were less than twice longer (~180 fs for Al and ~250 fs for Cu). Emission pulse duration does not vary significantly with the density scale length L.

Hot electron energy optimum for K-α emission exists for each target material and it grows with material atomic number. If hot electron energies are greater, many photons are generated too deep to be capable to escape from the target. We have used the integration over the focal spot in an attempt to reproduce experimental dependence of the K-α emission energy on the density scale length L. For low laser intensities, the energy transformation efficiency is maximal at the density scale length L_{opt}. For this scale length the relative contribution of lower intensities at the focal spot edge is maximum. Thus, the effective focal spot area for K-α emission is enlarged for the density scale length L_{opt}. The details are presented in paper [4].

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Optical Spectroscopy of ZnO and ZnO:Li Thin Films

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ZnO thin films are the subject of growing interest for various applications in optoelectronic devices since doping of different elements substantially changes properties of this II-VI semiconductor (E_g = 3.29 eV at the room temperature) with hexagonal symmetry (P6mc) [1]. The resistivity of ZnO ($\rho \sim 10^2$ Ωcm) is decreased with Al^{3+} doping ($\rho \sim 10^{-4}$ Ωcm) and increased ($\rho \sim 10^{10}$ Ωcm) with Li doping. Doping with Li ions (replacing Zn ions) also induces ferroelectric phase transition (PT), so the optic memories chips made from this material can be considered [2]. Since in ZnO the blue and UV emission of light was occurred, it is promising material for blue lasers and the higher density of records can be reached in CD-ROMs [3]. The ZnO thin films are also used as conductive transparent electrodes in the solar cells. ZnO undergoes a new type of PT from the polar high-temperature phase to the low-temperature ferroelectric phase via the existence of dilute local dipole without lowering of the symmetry. The temperature of the PT proportional to the molar concentration of Li ($T_c \sim x$, $Zn_{1-x}Li_xO$) has been found in the region from 330-470 K [2].

The present work is devoted to the ZnO:Li thin films to contribute to the elucidation the influence of the dopant on the host lattice properties. Special attention was paid to the study of thin film photoluminescence (PL) in order to detect an attendance of defects.

Polycrystalline thin films with thickness between 300 and 800 nm were prepared by the low temperature deposition in the plasmachemical reactor with the hollow cathode. The reactor was continuously pumped and so the pressure in the reactor during the deposition was not higher than 6 Pa. Zinc was reactively sputtered in the hollow cathode discharge plasma supplied by Ar and O_2 as working gases. Doping of growing thin films was ensured by the sputtering of small ring of Li_2ZnO_2, which was inserted inside the hollow cathode. Selected thin films with a different Li content were annealed in the hydrogen atmosphere at temperatures within the range 300-600 ºC inside the plasmachemical reactor immediately after the deposition without any breaking of low pressure. Polycrystalline structure of the deposited films with thickness between 300 and 800 nm was confirmed by X-ray diffraction analysis. The lattice parameters of the crystallites were found to be in a good agreement with the standard pure ZnO single crystal (a = 3.25 Å and c = 5.20 Å) with hexagonal symmetry. The preferred orientation of the crystallites with the (001) plane parallel to the substrate surface was revealed. The chemical composition of all specimens was investigated by electron microprobe. Emission and excitation spectra of luminescence of the deposited Li-doped ZnO thin films were investigated in wide temperature (12-340 K) and spectral (260-1000 nm) regions.

„As-grown“ undoped and ZnO:Li thin films do not exhibit any PL. Only after annealing of samples in the hydrogen atmosphere at 600 ºC for 2 hours, the PL has appeared. An analysis of the emission spectra revealed two broad bands peaking near 2.1 and 1.68 eV at 12 K with strongly sample-dependent intensities. Emission band peaking near 2.1 eV was not observed in the emission spectra above room temperature. Unfortunately we are not able to measure PL emission spectra at temperatures higher than 340 K due to construction of sample holder in cryostat, where the indium plates are used. Temperature dependence of PL intensity measured at maximum of both above mentioned emission bands show slower decrease of PL

intensity of the band peaking near 1.68 eV in comparison with 2.1 eV emission. It means that the activation energy of the luminescence quenching is for the 2.1 eV emission lower than for the 1.68 eV one. The following differences between the low-temperature PL emission spectra are apparent from obtained results: (i) ZnO:Li films exhibit, in addition to undoped films, an emission band peaking at 1.68 eV, (ii) ZnO:Li films do not have UV emission bands, and (iii) the broad emission band within the spectral region 3.10-1.77 eV is strongly sample-dependent. The origin of this band is not still completely understood but is usually related to the transitions between energy levels of Zn interstitial or O vacancy to Zn vacancy in various ionized states. Our emission spectra measured at 12 K show a large shift of this band maximum to lower energies with a decrease of the exciting photon energy. This effect is probably caused by the existence at least two different PL centers with different emission bands and diversely different excitation spectra. We have concluded that: (i) the broad emission is originated by the intrinsic centers of pure ZnO and (ii) the emission near 1.68 eV is associated with a transition from a state at bottom of the conduction band to a hole trapped in a localized state introduced by Li.

The shape of the low-temperature PL excitation spectra of ZnO and ZnO:Li thin films are very similar. They start with pronounced peaks in the exciton region near 3.4 eV followed by the band-to-band excitation for photons with energy $h\nu > E_g$. Three peaks observed in the excitation spectra at 3.375, 3.387, and 3.429 eV are in a good agreement with exciton lines of ZnO reported at 3.371, 3.378, and 3.418 eV [4].

From an analysis of the PL excitation spectra can be concluded: (i) excitation peaks near 3.4 eV originates from the formation of free excitons of pure ZnO, (ii) excitation at spectral region $h\nu > E_g$ belongs to the generation of the electron-hole pairs arising due to release of valence band electrons into the conduction band. Thus the absorbed energy is transferred to the recombination centers by excitons or charge carriers.

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Optical Spectroscopy of $Sn_2P_2S_6$ Crystal

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Tin hypothiodiphosphate $Sn_2P_2S_6$ is semiconducting material with the forbidden band gap width E_g = 2.3 eV at the room temperature [1]. At this temperature the $Sn_2P_2S_6$ crystal has also ferroelectric properties because the ferroelectric phase transition can be observed at temperature 337 K. X-ray diffraction analysis showed that the symmetry changes (2/m → m) at the ferroelectric phase transition is connected with displacement of Sn^{2+} ions with respect to fixed lattice of $(P_2S_6)^{4-}$ [2]. Voltaic conductivity of $Sn_2P_2S_6$ crystal, which is also influenced by Sn^{2+} ions, is changing at room temperature after irradiation of the sample by white light from value 2.10^{-12} $\Omega^{-1}cm^{-1}$ to 1.10^{-12} $\Omega^{-1}cm^{-1}$. Initial value of conductivity can be obtained after bleaching of the sample at temperature 340 K over a period of 30-60 min or spontaneously after a few weeks. This phenomenon is the reason for considering the localized energy levels (traps) in the forbidden band.

$Sn_2P_2S_6$ is a promising uniaxial ferroelectrics with a favorable photorefractive properties in the near-infrared spectral region, a pronounced photoconductivity, and also large values of pyroelectric, piezoelectric, and linear electrooptic coefficients. Although luminescence of $Sn_2P_2S_6$ crystals can provide valuable information about defect energy levels within the band gap, which influence photorefractive properties and photoconductivity, it has been still briefly noticed only in [3]. Therefore, we performed a systematic study of photoluminescence (PL) and thermoluminescence (TL) of nominally pure $Sn_2P_2S_6$ crystal within a wide temperature (12-360 K) and spectral (260-1000 nm) regions. The crystal studied was grown by the chemical vapor transfer technique and it had a typical brown color.

Excitation of $Sn_2P_2S_6$ crystal with monochromatic light with wavelength shorter than about 710 nm at low temperatures allowed us to detect broad-band PL in the red and near–infrared spectral regions. At steady–state excitation with monochromatic light the changes of PL intensity was observed with time of crystal illumination at temperatures lower than 110 K and so the emission spectra were recorded when the integral PL intensity had reached the saturated value. With increasing temperature the emission band peak shifts to longer wavelength side and the integral PL intensity steeply decreases. The emission band shape somewhat depends on the excitation wavelength but its peak position always lies between 1.7 and 1.57 eV at 12 K. The emission spectra of crystal studied differ markedly from corresponding ones published in [3] that have more complex shape and the maximum considerably shifted to the higher energy side.

The emission spectra of the crystal studied are fitted well with superposition of three Gaussian curves. The parameters of Gaussian curves follow individual temperature dependencies but at a given temperature only the curve amplitudes depend on an excitation wavelength. These results indicate that the broad asymmetric PL emission band of $Sn_2P_2S_6$ crystal consists of three overlapping bands of nearly Gaussian shape with a peak position and FWHM independent on an excitation wavelength at a given temperature. Therefore, the observed dependence of the peak position of PL emission spectrum on an excitation wavelength at a given temperature is caused by the changes of relative intensities of these bands. The positions of 1.87, 1.72 and 1.51 eV, and FWHMs of 0.17, 0.24 and 0.35 eV, respectively, were found for the overlapping emission bands at 12 K. The positions and

FWHMs of these bands change only slightly with increasing temperature. Moreover, the emission bands peaking near 1.87 and 1.72 eV completely disappear at temperatures higher than 20 and 80 K, respectively, so the observed shift of the PL emission spectrum peak to the lower energy side with increasing temperature is predominantly a consequence of the increasing contribution of the emission band peaking near 1.51 eV to the integral PL intensity.

Predominant excitation band peaking near 2.64 eV (469 nm) at 12 K extends in the vicinity of the absorption edge of the $Sn_2P_2S_6$ crystal that has been found at 2.5 eV (496 nm) at temperature of 10 K. The shape of excitation spectrum does not change significantly with increasing temperature.

Light with wavelength shorter than about 510 nm decreased PL intensity whereas light with longer wavelength increased. Subsequent heating of the crystal with a rate of 0.082 K/s allowed us to observe TL spectrally very similar to PL within 15-190 K. The heating of the crystals to temperature higher then the temperature of phase transition of $Sn_2P_2S_6$ to paraelectric phase near 337 K fully restored the initial PL intensity. Glow curve of integral TL of the crystal studied possessed a composite structure with two pronounced glow peaks near 22 and 41 K and five weak peaks near 53, 59, 68, 81, 102, and 176 K that were partly hidden due to peak overlap. These glow peaks were separated by partial heating of the crystal to selected temperatures before glow curves recording ("partial cleaning" method). Afterwards the trap depths of 41 and 88 meV corresponding to the glow peaks near 22 and 41 K were determined by an “initial rise” method. We assume that during crystal illumination with wavelength shorter than about 710 nm at 12 K the changes of charge state of luminescence centers responsible for the $Sn_2P_2S_6$ crystal PL occurs and created free charge carriers are captured by shallow traps. The glow peaks of TL, spectrally similar to PL, are then associated with the thermal release of charge carriers from shallow traps followed by radiative decay of luminescence centers excited by their recapture. This process also explains the complete restoration of the initial PL intensity that was observed after the heating of the crystal to temperatures higher than the temperature of the phase transition of $Sn_2P_2S_6$ to the paraelectric phase near 337 K.

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Subjective Evaluation of Fan Sounds - Paired Test

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This paper follows after the earlier research ([1], [2]), when we investigated the sounds of computer fans. The semantic differential test was used in this research in which the human subjects evaluated a few characteristics of sounds. The semantic differential test asks human subjects to place a stimulus on a scale between two opposite adjectives (e.g. the characteristic *Roughness* was evaluated the pair *smooth – rough*, see [1]). We want verify correctness of the semantic differential test. Therefore, we performed the paired comparison test.

In the paired comparison test the human subjects of evaluation listened to two sounds and determined the rougher sounds from two consecutive sounds. This method has the disadvantage when for human subjects the both sounds seem to be equally rough, but the advantage is that it takes shorter time.

The procedure of the realization of paired test is alike as in the semantic tests. We have not a problem with the choice of computer models because we used the same models as in a semantic test (see [2]). The choice of human subjects, we selected human subjects, who have experience with the evaluated sounds. The group of human subjects would be a statistically appropriate sample of people, who have worked with computers before. The sounds, that the human subjects listened in the paired test, were slightly modified. The left channel of each sound was alike as the right channel of sound.

The subjective test was performed with a total number of 44 human subjects (20 women, 32 men) from 19 to 48 years old. The average age of human subjects was 28,08 year. The evaluations of such human subjects, whose evaluations were differentiated from the average evaluation, were eliminated.

The results of the subjective test were processed by using statistical method *multiple linear regression*. This method shows the relationship between several independent variables and a dependent variable. The product of multiple linear regressions is the equation that predicts the values of dependent variable. The r^2 or *coefficient of determination* compares the predicted values and the actual values of dependent variable. The r^2 can assume values between 0 and 1. If r^2 is near to 1 then between predicted values and the actual values it is no difference – ideal correlation. If r^2 is near to 0 then the regression equation can not predict the values of dependent variable. We can test a statistical significance of the multiple linear regressions (t – statistics and F – statistic, see [2]). More information about a use of the t – statistics and F – statistic is published in the special statistics books (e.g. [3] or [4]).

The results of the paired comparison test are presented in the table. The value p for each tested sound can assume values between 0 and 1. If the p is greater then the sound is evaluated as rougher.

Devices	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Comp8
p	0,28	0,65	0,46	0,24	0,47	0,48	0,81	0,89

Before subjective testing, the psychoacoustic metrics were calculated (loudness, sharpness and roughness). The values of this metrics are presented in [2] (see values of right

channel). In next step, the equation of the multiple linear regression was enumerated, where the metrics were taken as the independent variables and the values of the paired test as the dependent variable. This equation can predict values of the paired test (y) by used values of metrics (x_1 – loudness, x_2 – sharpness, x_3 – roughness and b is constant). There is the equation of regression line:

$$y = 2{,}52.10^{-2} x_1 + 0{,}472 x_2 + 0{,}354 x_3 - 1{,}456 \quad (1)$$

This equation fulfils the F – statistic on confidence interval 97, 5 % and therefore it is acceptable for prediction values y. Also the value of r^2 is large (0,893), hence it means that the dependence between independent variables and a dependent variable is very strong. The independent variable *roughness* fulfils t – statistic on confidence interval 95 %. Therefore, the metric *roughness* is very important variable in the equation (1).

In the paper [2] the results of differential semantic test are presented. The paired comparison paired test followed after the realization of the semantic test. The paired comparison test proved veracity of the semantic test. In both tests the human subjects similarly evaluated the tested sounds. The people determine the most rough and smooth sound. We enumerated the equations that can predict values of tested characteristics and we can realize no subjective tests that are time-consuming. The prediction of the values of tested characteristic is made by using of the objective metrics.

The results of these tests are next processed to creation or editing of some objective metrics of the evaluation of product – sound quality. These objective metrics replace the subjective methods and make easy the certain process of the evaluation of product – sound quality. The results of the evaluation of product – sound quality participate on new product development.

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Phase-Demodulation in Heterodyne Laser Interferometer

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This paper deals with phase demodulation of signal of a laser interferometer. We use the heterodyne laser interferometry method for detection of acoustic pressure and for measuring of displacements [1, 2]. The proposed and implemented apparatus consists of heterodyne laser interferometer and electronic circuits, where signals from interference of optical beams are being processed. Advantages of this method are high signal to noise ratio and possibility of absolute determination of signal level.

The heterodyne interferometer output signal carries the information about phase changes of detected laser beam. This information is transformed to the Bragg cell frequency, much lower frequency then the frequency of laser light. The expression for the interferometer output signal is based on a sum of Bessel functions. When we can obtain the information about acoustic pressure or about amplitude of displacement, we must demodulate it, as analogy with processing of radio signal. After demodulation we do not obtain absolute value of pressure or displacement, but the obtained amplitudes are directly proportional to the acoustic pressure or displacement of the individual harmonic components. The absolute values can be evaluated on the base of demodulation constant.

More complex and higher amplitude acoustic fields or displacements produce more complex interferometer output signals with the wider frequency spectrum. The commonly used phase demodulators are not suitable for this application. A demodulator with demodulation bandwidth large enough was not available. We were looking for a demodulation bandwidth up to several MHz band. As a first solution we used spectral analyser, HP 8593E, which contains a FM demodulator with variable bandwidth up to 0,5 MHz. After FM demodulation we got the signal, which corresponds with a time integration of the laser light phase variation. The information about amplitude of the phase variation of each frequency component was obtained by division this signal component by the appropriate angular frequency.

Finally we solved this problem in a way of construction relatively simple phase demodulator. The method of processing is based on the phase demodulation by means of a double-balanced diode mixer.

As long as the displacement is smaller than the wavelength of the laser light there is a carrier frequency, in our case 80 MHz, present in the spectrum of the signal. This unmodulated carrier signal is extracted from the measured signal spectrum with the help of a narrow-band crystal filter. Its phase is shifted by 90 degrees. This reference signal and the modulated measured signal pass amplitude stabilization (by means of a limiter and a gain control amplifier) and then compared in a phase-detector. This carrier frequency and other unwanted products are eliminated by an output low-pass filter. In our phase-modulator, the sensitivity is constant over entire frequency range, from several hundred Hz to about 60 MHz. The slope of the phase sensitivity of this system can be changed by the length of the phasing line. The

higher multiplication of quarter-wave length, the sharper slope is the result. This idea is original and so far not used in such interferometric devices.

Both systems, the one with the frequency-demodulator and with the phase-demodulator, were compared. The sensitivity of the frequency-demodulator is linearly dependent on the modulation frequency. For low frequencies its signal to noise ratio is very small. Because the sensitivity of our phase-detection is independent on the modulation frequency, the frequency value of the same sensitivity must exist. This limit is at 100 kHz. Up to this frequency is the phase-demodulator much better.

The demodulated signal is recorded by the spectral analyzer and processed with a computer in the Matlab environment. The value of a demodulation constant was determined experimentally.

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Study of Phase Segregation in the $Pr_{0.8-y}La_y Na_{0.2}MnO_3$ Manganites ($y \leq 0.15$) by Neutron Diffraction

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In a very simplified approach, three different electronic phases can be distinguished in manganites – an insulating electronic solid, a poorly conducting electronic liquid, or a metallic electronic gas [1]. The most readable manifestation of the first case is the charge ordering for special ratios of Mn^{3+} / Mn^{4+} (1:1), (1:2) or (1:3) while the electronic gas supposes a uniform distribution of e_g carriers over all the Mn sites. The recent research reveals, however, that even in the most conducting ferromagnetic manganites the electronic state is not homogeneous but consists of regions with different density and dynamics of carriers [2]. In some cases, the higher and lower density regions may arrange regularly to form stripes in a nanoscale level [3]. The limiting situation is a spontaneous separation of a manganite system into the metallic ferromagnetic (FM) and insulating antiferromagnetic (AFM) domains. Such phase-separated systems appear to be extremely sensitive to external actions like magnetic field, pressure, or laser illumination, which is very attractive for possible applications.

Suitable candidates are manganites close to the compositional boundary between different magnetic ground states. The manganites $Pr_{1-x}Ca_xMnO_3$ at the borderline between FM and pseudo-CE AFM states ($x \sim 0.3$), attracted considerable interest. A similar case is presented by the lesser known praseodymium sodium manganite $Pr_{0.8}Na_{0.2}MnO_3$. According to recent findings, this compound undergoes charge and orbital ordering below $T_{co} = 215$ K, followed by a transition to an AFM arrangement of the pseudo-CE type at $T_N = 175$ K [4]. This electrically insulating ground state can be easily transformed to the metallic FM-state by an external field of 2 to 3 Tesla. This transition is irreversible at low temperatures. In order to examene in more detail the competition of the AFM and FM phases, we prepared a series of compounds by partial substitution of praseodymium by the larger ion lanhanum, $Pr_{0.8-y}La_yNa_{0.2}MnO_3$. On the basis of magnetic and transport properties (i.e. assuming the volume fractions of phase-separated phases) we selected the sample with $y = 0.15$ and performed its neutron diffraction investigation, both on cooling and warming.

The samples $Pr_{0.8-y}La_yNa_{0.2}MnO_3$ with $y = 0$, 0.05, 0.10 and 0.15 were prepared by a standard ceramic method using Pr_6O_{11}, La_2O_3, Na_2CO_3 and $MnCO_3$ as starting chemicals. After calcination at 900° C, the mixtures were pressed into pellets and sintered for 20 hours at 1150° C in air. All the products showed a single perovskite phase with the orthorhombic Pbnm symmetry. The zero-field resistivity was measured by a standard four-probe method on sintered bar sof size 2 x 2 x 8 mm^3. The magnetization measurements were performed with a SQUID magnetometr (Quantum Design) in a field of 0.5 T. Powder neutron diffraction on the $y = 0.15$ sample was carried out on diffractometer KSN-2 in Řež, near Prague, at a wavelength $\lambda = 0.1360$ nm. The diffracttion patterns were taken in the range of $\theta = 6 – 67$ ° at selected temperatures on cooling and heating. The data were analysed with the Rietveld method using the FULLPROF program.

Our neutron-diffraction study shows that the FM and pseudo-CE type AFM long range ordered moments are present. The average moment ($m^2 = m^2_{FM} + m^2_{AFM}$) reaches $3.4_{\mu B}$, which means that the coexisting magnetic phases are nearly fully ordered at 7 K, composed of 85% FM and 10% AFM phase. On warming this ratio is practically retained while on cooling a higher amount of AFM phase is stabilized at intermediate temperatures and, furthermore, a significant part of the sample (about 25% at 100 K) remains disordered. It is worth mentioning that neutron diffraction does not repeal the broad transition centered at ~ 100 K, that is evident in the resistivity and magnetization cooling curves. This suggest that the disordered part of the sample consists most libely of FM clusters which are easily polarised in an external magnetic field.

In summary, the present neutron-diffraction study shows that the FM phase in lanthanum- substituted $Pr_{0.8}Na_{0.2}MnO_3$ forms immediately below the charge ordering temperature T_{co} = 210 K and its amount increases suddenly below 50 K, which could be in a direct relation with the spin reorientation of the secondary pseudo-CE AFM phase [4]. For lanthanum content of 0.15, the FM phase ratio reaches finally 85% and on warming is retained up to $T_C = T_{co}$. A pronounced thermal hysteresis is found also for the AFM moments, which proves that the pseudo-CE phase is thermodynamically destabilized towards low temperatures. This is in contrast with the behavior of common CE-type systems like $Pr_{0.5}Ca_{0.5-x}Sr_xMnO_3$ ($0.2 \leq x \leq 0.4$).

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Soft X-ray Emission Spectra from Capillary Plasma

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Experimental and computer studies of plasma created in initially evacuated polyacethal and polyethylene capillaries are reported. Soft X-ray spectroscopy is used as a capillary plasma diagnostic tool. The measured time integrated spectra for polyacethal and polyethylene capillaries correspond properly to the spectra resulting from the computer simulations using NPINCH and FLY codes.

Non-stationary plasma of a fast capillary electrical discharge is studied as a potential active medium of soft X-ray lasers. We aim to obtain 18.2 nm lasing wavelength with hydrogen-like carbon ions C^{5+} in polyacethal or polyethylene plasmas [1]. The appropriate pulse plasma should be initially heated and carbon ions have to be fully ionized. In the next stage, the plasma electron should be quickly cooled to obtain favorable conditions for the process of three-body recombination. To understand the details of capillary plasma evolution we combine MHD plasma modeling and spectral lines kinetic evaluation with time integrated soft X-ray spectra measurement.

Our system is composed of capillary discharge and diagnostic parts. The polyacethal and polyethylene capillaries (1.1 mm diameter and 5 cm length) with coaxial trigger electrode are used. Electrical energy is stored in 24 knob capacitors of 2.5 nF mounted in serial-parallel to capillary. Total capacity is 15 nF and maximum voltage is 40 kV. The measured voltage waveforms have character appropriate to a serial RLC circuit with quasi-period about 260 ns. Emission spectra in the wavelength region 10 – 26 nm are measured by means of the JOBIN YVON monochromator PGM-PGS 200 and Reflex, Ltd. BICCD camera RXBIC 512c in many repetitive shots.

In the selected spectral range only the spectral lines appropriate to both carbon and oxygen ions with the ionization degree $Z > 3$ are expected. Our diagnostic system with the record of the two-dimensional image of the monochromator slit provides wavelength resolution 0.11 nm. The spectra are measured step by step (0.02 nm) and each point is obtained by averaging the signal from at least five subsequent shots. The resulted spectra obtained with polyacethal $(CH_2O)_n$ and polyethylene $(CH_2)_n$ capillaries are presented. In the case with polyacethal capillary, the spectral lines appropriate to O^{4+} and O^{5+} are dominant and are more intensive than the line intensities measured with polyethylene. The identified spectral lines correspond namely to C^{3+} and C^{4+} ions.

Capillary discharge plasma quantities have been evaluated by means of NPINCH code under the one-dimensional two-temperature one-fluid MHD approximation [2]. The model considers the material of the wall as dense cold neutral gas (Z=7, A=14, and initial mass density ρ_0=1 g/cm^3) .

Our results confirm that during the current pulse the capillary is gradually filled by material ablated from the wall. The first peak of electron density $N_e = 2.10^{18}$ cm^{-3} on the axis at 20 ns reflects a quick compression of plasma. The plasma electron temperature T_e is increasing due to increasing local electric current density. The peak value of plasma electron temperature about 130 eV is reached on the axis at t_{max}= 40 ns. Relatively quick cooling is found at the end of the first half period of the electric current. In the second half period the plasma is relatively cold $T_e \leq 20$ eV and electron density $N_e > 2.10^{18}$ cm^{-3} on the axis grows due to wall ablation. The ion and electron temperatures are almost equal all the time and everywhere.

Time dependences of ionization fractions and energy level populations for lithium-, helium- and hydrogen-like carbon and oxygen ions have been evaluated by means of the computer code FLY [3]. The file containing temporal history of axial plasma electron temperature and density, resulting from NPINCH MHD simulations is used as an input for the FLY code. The results show predominantly that the carbon ions C^{4+}, C^{5+} and oxygen ions O^{5+}, O^{6+} and O^{7+} are presented during the whole current quasi-period. The concentration of hydrogen-like ion C^{5+} prevails on the interval 25 ÷ 90 ns. The concentration of fully stripped ion C^{6+} is negligible all the time. In the same time predominant part of oxygen is in helium-like ionization state O^{6+} during the whole investigated interval. Spectral line intensities are generally proportional to the instantaneous populations of the upper levels of relevant transitions.

Using the subprogram FLYSPEC we evaluated emission spectra separately for carbon and oxygen ions both integrated on the time interval 0 - 500 ns. The most intensive spectral lines are calculated in the range 8 - 18 nm and belong to O^{4+} and O^{5+} ions. But, in the range 18 - 25 nm the spectral lines of carbon ions C^{3+}, C^{4+} and C^{5+}, become more intensive than the oxygen ones.

Time integrated spectra evaluated and measured have been compared and found that correspond each other. Further modeling with higher amplitude of current pulse passing through the capillary and with optimized initial gas filling have been done and have shown a way for further discharge system optimization.

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Modelling of the Propagation of Ultrasonic Pulses Through Imperfect Contact Interfaces

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Ultrasonic techniques may be very useful in providing qualitative information on the details of interface defects and bond quality in materials. Interfaces play significant role in determining the quality of structural materials on a wide variety of dimension scales, from grains in metals, to inter-laminar bonds in composites. A principal problem in establishing efficient and reliable nondestructive evaluation (NDE) ultrasonic methods is the deficiency of a distinctive relationship between nondestructively measured data and interface properties. Frequently different kinds of imperfections may provide very similar experimental parameters. In order to more quantitatively evaluate experimental data, it is beneficial to compare them with theoretical calculations. Due to the complexity of the subject analytical calculations are not commonly feasible and numerical simulations are necessary.

In the case of sharp perfect contact interfaces we have designed and implemented two and three dimensional numerical models in which recursive relationships yielding the time evolution of the displacement field are derived on the basis of the Local Interaction Simulation Approach (LISA) [1]. With these numerical codes we can study the propagation of ultrasonic pulses of arbitrary shape in arbitrarily complex media. Cross-points at the intersection of orthogonal interfaces separating media of different physical properties are treated in the framework of a sharp interface model (SIM) [2]. SIM assumes that any relevant variable is constant within any cell but possibly discontinuous at any cell interface. The displacements and stresses are then matched at each interface. A comparison with conventional finite difference techniques shows that sharp interface model avoids the ambiguities due to the smoothing of the physical quantities. This smoothing procedure may cause severe numerical errors, when the variations of the physical properties across the interface are large.

To extend the model LISA to defective interfaces and to nonlinear media, we have used approach similar to spring model of treatment of imperfect contact interfaces [3]. In this method arbitrarily complex medium is discretized into cells represented by grid-points, each split into four sub-nodes, connected through “tensor springs”. With properly defined spring constants spring model can represents a plausible approximation of the propagation medium. Springs are characterized by quality tensor. A proper definition of quality tensor as a function of the physical properties of the different materials in contact can describe various kinds of interface defects. In the case of imperfect contact interfaces the iteration equations are evaluated not only for the nodes but independently for all the sub-nodes.

In our work we have verified and extended spring model in 1D and 2D case by means of the computer algebra system Reduce [4]. We have used system Reduce namely for discretization of partial differential equations and for flexible numerical code generation. Our Imperfect contact LISA (ILISA) spring model in 2D is implemented in computer program written in C programming language, parts of which have been generated semi-automatically by Reduce. The implementation in computer program is done in a very general way. Geometric shapes of the predefined physical properties can be of completely arbitrary form. Input signals (initial wave displacements and external volume forces) can adopt a large number of profiles both in

space and time. The number of signal sources, their position and incidence angle can be also arbitrary. Various boundary conditions are implemented in the code, including periodic, free boundary and non-reflecting boundary conditions.
Due to a large amount of data produced as a rule by the simulation programs of this type, the results in ILISA code are stored in a flexible scientific database format called netCDF (http://www.unidata.ucar.edu/packages/netcdf/). NetCDF (network Common Data Form) is an interface for array-oriented data access and a library that provides an implementation of this interface. The netCDF library also defines a machine-independent format for representing scientific data. Together, the interface, library, and format support the creation, access, and sharing of scientific data. Various quantities (e.g. displacements, velocities, stress tensor components) are stored in ILISA program with use of this direct-access and self-descriptive netCDF data representation. Efficient and extensive set of subroutines, operators and utilities is available for both on-line and in detail off-line visualization and analysis of the data generated in simulations, for production of the publication-quality images, video movies and for representation of the results in the VRML (virtual reality modeling language) format (http://www.vrml.org/).

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Research of the Influence of Atmosphere on the Laser Ranging Precision

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Laser ranging is a research of capabilities of range measurement precision. The main goal is as precise measurement of range as possible, using a laser beam and a retro-reflector. The recent requirement of the Satellite Laser Ranging (SLR) technique is to reach the accuracy of 1 mm. This requires keeping systematic biases on the millimeter level. Summarizing the present results, the ranging precision to ground target is 1-3 mm; to satellite it is 3-7 mm [1]. The laser ranging bias has several contributions. It is influenced by the retro characteristics, as well as the laser and detector errors and the atmosphere. Therefore precise laser ranging requires a wide research of the atmosphere and its variances as well as their influences on their optical characteristics. The atmosphere behaves like an optical set, which keeps changing its optical properties. The point of laser ranging is therefore observation of the atmospheric effects and attempt to predict the parameters of the optical set [2] the effects represent. By predicting the optical behavior of the atmosphere extensive corrections of the ranging precision are possible.

The research in the laser ranging, as well as the satellite laser ranging, measurement of the satellite distance, is ran since 70's and has many useful application capabilities like space debris detection, measurement of space objects surfaces identification, as well.

According to Gardner [3] equation we created a computer simulation of the behavior of the atmosphere in dependence to the path length deviation of the range measurement for various elevation angles. Unlike Gardner, we used more realistic model of refractive index structure constant C_n^2.

The Gardner's formula is:

$$\left\langle \Delta L^2 \right\rangle = \sqrt{26.31\ C_n^2\ L_0^{5/3}\ L_e} \tag{1}$$

where $<\Delta L^2>$ is the mean square path length deviation caused by atmospheric turbulence, L_0 is the outer scale of turbulence, C_n^2 the refractivity turbulence structure constant and L_e the effective path length, for non-horizontal path:

$$L_e = \frac{1}{C_n^2} \int_0^L C_n^2(\zeta) d\zeta \tag{2}$$

where ζ is path of the beam through atmosphere $\zeta = \frac{h - h_0}{\cos\varphi}$, where φ is a zenith angle, L is the distance from the ranging site to the target and C_n^2 can be properly modeled by this:

$$C_n^2(h) = 3.59 \cdot 10^{-3} \cdot (h \cdot 10^{-5})^{10} \cdot e^{\frac{-h}{1000}} + 2.7 \cdot 10^{-16} \cdot e^{\frac{-h}{1500}} + 1.7 \cdot 10^{-14} \cdot e^{\frac{-h}{100}} \tag{3}$$

In equation 3, the h means height above sea level and can be expressed by ζ. The simulation integrates the L_e both analytically and numerically.

The easier horizontal path case needs no integration, C_n^2 is constant, L_e equals the beam path length (which we are able to measure when horizontal) and the L_0 matches the average height of the beam above ground, as long as it is lower than 200 m.

Recently predicted values of RMS for ranging of the ground target (horizontal case) is from 0.2 mm up to 1 cm according to weather conditions and terrain and for the vertical path 1.5 mm for the position of the ranging site on the sea level and 0.5 mm for 2 km above the sea level [4].

The results based on this program were checked experimentally on the observatory in Graz, Austria. On this observatory the measurement of 6 km ground target was made; 6 kilometers of the horizontal path through the atmosphere corresponds with the whole diameter of the atmosphere in the vertical path in the way of optical behavior. The target, placed 6006 meters away from the observatory (as we could measure very precise), was equipped by corner retro-reflector. The observatory is equipped by 532 nm laser and Single Photon Avalanche Detector (SPAD) to be able to transmit and receive photons. On the 6 km target we measured the 1 mm of RMS the theory predict, which we consider a great success. From this result we deduced the average depth of the valley between the observatory and the target site was 30 m.

Another experiment made on the Graz observatory included a motoglider with corner retro-reflector placed on its wing. The point was to measure non-horizontal passage of the beam. More results are expected using this method, as we solve technical problems with targeting randomly moving object. The same goal was also given for experiment with helium balloons carrying a “shiny ball”, a perfect 10 cm in the diameter silver coated sphere. This experiment was successful; the time equivalent of RMS for shiny ball we measured was 28 ps.

The observatory in Graz is also able to measure range of all the satellites equipped by corner retro-reflector every time such satellite passes in its operating radius.

The results of such measurements are available as large data files, which have to be processed by any data fitting and smoothing application to avoid the huge amount of received noise. The noise is also reduced by setting a proper time gate for receiving the reflected photons.

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Breakdown Rapidity Model for Avalanche Photodiode

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The solid state photon counting detector was pioneered by S. Cova and co-workers [1]. The detector called Single Photon Avalanche Diode (SPAD) is an avalanche photodiode structure on Silicon prepared using a conventional planar technology reported by R. Haitz [2]. Solid state photon counters are widely applied by the group of K. Hamal [3]. Single photon sensitivity is achieved by biasing the diode above the junction break voltage. In this stage, the first absorbed photon is capable of triggering the avalanche multiplication of carriers; a fast rise-time current pulse is generated. The leading edge of the current pulse marks the event of the photon absorption with picosecond accuracy. When two or more photons are absorbed quasi-simultaneously the correspondence between the detection and output leading edge is affected. A theoretical model describing this effect is presented. Consequently, the avalanche is actively quenched by a circuit connected to the diode; the typical value of the gain achieved exceeds 1×10^9. No linear amplification or pulse forming is needed for next pulse processing. The SPAD based photon counter works in a purely digital mode: the uniform output signal is generated once the photon is detected. Following the analogy of nuclear technique instrumentation, such an operation mode is called a Geiger mode.

In an attempt to construct a detector capable to discriminate the optical signals corresponding to single versus multiple photons, we did develop a model of an avalanche build-up. The original model of avalanche build-up is described in ref. [4]. This model is focused to high ($> 10^3$) initial number of photoelectrons to achieve a maximum possible timing resolution and adopted for a special experiment with two independent detectors. We will start from the same equations and another approach will be used to describe avalanche build-up.

Lets the time T is a time interval between the generation of m photoelectrons and the moment of crossing the electronic triggering level in the subsequent electronics –the detection delay. The avalanche build-up process is characterized by the multiplication time τ. During time τ the number of carriers grows two times. As the ratio between efficiency of impact ionization of electrons and holes in the silicon is greater then 100, only electron avalanche can be take in consideration. The initial number m of photoelectrons is expected to be generated quasi-simultaneously within a time interval shorter than time τ.

The electronic trigger level is described by the minimal number of carriers N_{th}. It is determined the total number of multiplication steps required. For modest avalanche current threshold levels we can suppose the multiplication to be far from saturation, the intensity of the avalanche accelerating field is constant therefore τ is constant, as well. When number of steps is determined, the detection delay can be expressed in the form

$$T(m) = \begin{cases} \tau \cdot \left(\log_2 N_{th} - 1 \right) & \text{for } m = 1 \\ \tau \cdot \left(\log_2 N_{th} - 1 - \left(1 + \log_2 (m-1) \right) \right) & \text{for } m > 1 \end{cases} \quad (1)$$

One can conclude that for high *m* the detection delay is decreasing with a logarithm of the number of photoelectrons triggering the avalanche. And from this fact can be derived a dependence of delay variance on initial photoelectrons number in the form

$$\delta T(m) = \frac{\delta T(1)}{m - 1} \tag{2}$$

for m>1 where δT(1) is a variation on single photon level.

Due to a quantum nature – regarding photon statistics of the laser light – the average signal strength s is known instead of number of photons. For pure single photon event the distribution of detection delay is a normal distribution with mean T(1) and sigma δT(1). For real mixture of single and multi-photon detections distribution D of detection delay follows

$$D(m,s) = \frac{\sum_{n=1}^{\infty} P(n,s)\, N\big(m, T(n), \delta T(n)\big)}{\sum_{n=1}^{\infty} P(n,s)} \tag{3}$$

where P(x, mean) is a Poisson distribution and N(x, mean, sigma) is a normal distribution.

The mean and the variation of the distribution resulting from eq. 3 must be calculated numerically and describe the mean and variation of real measured detection delay *T* for average signal strength *s*. The mean *<T>(s)* determined so called the detector time walk. The variation of detection delay *δT(s)* is the uncertainty of the time interval between generation of *m* photoelectrons and avalanche current intensity increase above the threshold level. This parameter is usually referred as a detection jitter.

The presented model describes the avalanche build-up for the initial number of photoelectrons *m* in the range of interest 10^0-10^3. The model is in a good agreement with experimental results on a Silicon SPAD and it will be verified on another semiconductors.

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E-Learning for Information Physics

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Information Physics is a scientific / engineering discipline which synthesizes facts and methods from physics, applied mathematics and computer science. Its objectives are to use complexly ICT methods and tools (1) to create new physics knowledge, (2) to develop its novel applications and (3) to support effective knowledge transfer in these areas.

Education of future specialists in this demanding branch of study supposes extensive use of computers both as professional tools for study of physics problems and education tools with respect to specific features of information pedagogy of exact sciences **[1].**

Characterizing features of e-learning of exact sciences are: (1) Rich mathematics and many special symbols in teaching materials. (2) Specific character of scientific / engineering graphics. (3) Absolute demand to support interactivity and individual student creativity. (4) Necessity of access to relevant technical software and computing power. (5) Specific features of knowledge verification non available in standard testing programs.

This paper (1) summarizes some experiences with the creation of the courseware for *Information Physics* and (2) presents selected results of this development effort.

Fundamental concepts of our development work are: (1) Combination of sophisticated development tools for Web with technical software. (2) Coordinated development sets for courseware creation. (3) In the future: Integrated electronic environment for learning and problem solving (PSE).

Various sets of development tools – using both freeware and commercial programs – have been tested / used. Examples of three reliable development sets are given in TAB.1 **[2].** Substantial part of our education materials has been developed by using the Set 2, application of the Set 3 (considered as the main technology for the future) is in a testing stage **[3].**

TAB. 1. COORDINATED DEVELOPMENT SETS FOR E-LEARNING

Development Set 1 *Low-Level Set*	*FrontPage 2003* + PhotoImpact XL + Advanced Grapher 1.5 + Hot Potatoes 6 / Respondus Lite + (PowerPoint 2003, Physlets)
Development Set 2 *Medium-Level Set*	*Dreamweaver MX 2004* + Fireworks MX 2004 / Flash MX 2004 + CalculationCenter 2 + Respondus 2 / CourseBuilder + (MM Extensions)
Development Set 3 *High-Level Set*	*Studio MX 2004 with Flash Professional* + Maple 8 / 9 + MapleNET + Maple TA / Mathematica 5 + webMathematica 2 + (Contribute 2, MM Extensions)

The key courses of the curriculum *Information Physics* offered at the Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, are listed in TAB.2. Two additional courses, applicable in international activities, are also mentioned.

Non-negligible applications of e-learning development technology present also many smaller net-based documents made ready for various purposes, few examples are shown in TAB. 3.

TAB. 2. COURSES WITH INTENSIVE ICT SUPPORT

Course	Semester	Allocation
Practical Information Science for Engineers 1, 2, 3	1 + 2 +3	2 + 2 +2
Numerical Methods for Physicists	4	4
Computer Algebra	5	2
Introduction to Modern Physics	4	3
Methods of Computational Physics	5 + 6	4 + 4
Development Technology for Computer-Based Knowledge Transfer	5 / 7	2 Planned 4
Concepts of Information Physics 1,2	7 + 8	2 + 2
Workshop Courseware Development Technologies for E-Learning in Physical Sciences	Ad hoc	4 hours
Concepts of Postmodern Physics	Under development	30 hours

Non-negligible applications of e-learning development technology present also many smaller net-based documents made ready for various purposes, few examples are shown in TAB. 3.

TAB. 3. EXAMPLES OF SOME SMALL E-DOCUMENTS

Introduction to Modern Physics : Course Structure & Tests. / Úvod do moderní fyziky : Struktura kurzu a testy. http://vega.fjfi.cvut.cz/docs/uvmodfyz/
Computational and Laboratory Astrophysics : Invitation. In : Physics Week 2003. / *Počítačová a laboratorní astrofyzika : Pozvánka.* In : Fyzikální týden2003. http://vega.fjfi.cvut.cz/docs/pocastro/
E-Learning and Mobile Technology in Physics: Addendum to the Invited Paper. In: MPTL 8: 8th EPS Workshop on Multimedia in Physics Teaching and Learning, Prague 2003. http://vega.fjfi.cvut.cz/docs/elmtp/

A detailed and updated version of this contribution with live links to some our products is available as an e-poster on the Web address given in **[4]**.

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Atmospheric Fluctuation Induced Seeing versus Laser Ranging Precision

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Satellite Laser Ranging (SLR) is a method of determining the distance of an Earth-orbiting satellite by emitting a short laser pulse (most often at a visible wavelength) and waiting for the reflected light. The distance is then computed simply by multiplying the measured time interval between the emission and the detection of the light by the light speed in the given environment (air and vacuum), and by dividing this product by the factor of two. The measured satellites must be equipped by arrays of retroreflectors (mostly cube-corners), that reflect the incoming light back to its original direction. Recent most precise satellite laser ranging systems achieve the single shot precision of one millimeter, if ranging to a ground target. This precision is influenced by many sources of jitter, for example the timing unit precision, the laser pulse length, the timing resolution of the start and stop detectors in the measuring chain, etc. However, if ranging to a satellite, the maximum achieved precision is around three millimeters. Hence, there is an obvious discrepancy between the ground target and satellite measurements, and we are trying to explain it.

There are two major possible sources of the additional random error in the case of satellite target: the properties of the target and the influence of the atmosphere between the SLR station and the satellite. The arrays of retroreflectors can spread the incoming pulse, and therefore decrease the ranging precision. However, even the ranging to satellites having this effect reduced to a negligible level (such as ERS-2) yields still not better precision than 3 mm. It means that the most suspect effect is the influence of the atmosphere. The recent measurements are routinely corrected for the air refractive index influence, but there still remain some fast-changing random fluctuations from its standard model, that are caused by atmospheric turbulence (turbulent mixing of air of different temperatures). The question is how strongly these random fluctuations of air refractive index can influence the satellite laser ranging precision. The problematics of atmospheric optical turbulence was partially studied for the purposes of the adaptive optics, but it is not the same problem as the satellite laser ranging, because the adaptive optics is sensitive only to the inclination of the incoming wavefront and it is not influenced by the absolute shift of the whole wavefront.

The turbulence-induced ranging jitter can be predicted using an analytical equation derived by Gardner [1]. To evaluate this equation, we must know how the turbulence strength is changing along the propagation path. In case of a horizontal path, the turbulence strength is considered to be constant (it is mainly height-dependent). The near-ground turbulence strength can be derived from horizontal path seeing measurement [2]. For a case of a slant path, several models of turbulence strength height dependence are available [3]. In October 2003, we visited the Observatory Lustbühel Graz, which is one of today's most precise satellite laser ranging stations. Since summer 2003, it is equipped with a new laser, operating at repetition rate of 2 kHz, allowing us to monitor much faster effects than before. We have predicted that at such high repetition rate the turbulent fluctuations of the air refractive index could be directly observable as "waves" at the plot of the measured distance versus time [4].

We used a 6-km distant ground target: cube-corner retroreflector mounted at a pole. The world unique value of single shot precision of 1 mm (7 ps RMS) ranging to long path ground target was achieved. The plotted dependence of the measured distance on time really exhibits the predicted long-term (0.1 – 1 s) fluctuations, that can be consequently explained by the atmospheric turbulence influence.

The RMS of these long-term fluctuations, extracted by adjacent averaging over 50 ms intervals, is 0.36 mm (2.4 ps). We have also simultaneously measured the turbulence strength by measuring the seeing on the same horizontal path, and from the measured value we predicted the atmospheric contribution to the ranging jitter, using the Gardner's equation. The predicted value was 0.4 mm, in perfect agreement with the observed value mentioned above. We have also made an attempt to measure the laser ranging jitter over several different slant atmospheric paths of various zenith angle and length, and to compare it with theoretical predictions based on the Gardner's model. We used a cube-corner retroreflector mounted on a wing tip of a small airplane as the moving target, but we were unsuccessful due to unexpected problems with communication and navigation. This experiment is planned to be repeated using more sophisticated technology (automatic telescope pointing, driven by GPS receiver onboard the plane) during spring 2004. The results show the atmospheric contribution dependence on the path geometry and prove the applicability of the Gardner's model for slant paths.

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Low Earth Orbiting Satellites Numerical Applications

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The DORIS (Doppler Orbitography and Radiolocation Integrated by Satellite), one of the four techniques contributing to the IERS (International Earth Rotation Service), is an integrated system of measuring and data processing facilities for determination of satellite orbits and related parameters. The measurements are based on the *Doppler effect* (it causes a frequency shift of electromagnetic waves when a transmitter and receiver move relatively one to another). The receivers are installed on satellites and the transmitters are ground beacons. The IDS (International Doris Service) is a project for an international service to provide a support, through the DORIS data and products, to geodetic, geophysical and other research and operational activities. Currently only two independent solutions are developed in the framework of the IDS: GINS-DYNAMO and GIPSY-OASIS software. This is not enough for result comparison and successful IDS funding. The goal of the work is to found and apply a new solution that will later be used in the planned Czech analysis center of IDS.

The analysis software should process the observed data and other inputs (apriori orbit, meteorogical files, apriori pole files, tides files, …) and compute values of requested quantities, especially the Satellite ephemerides and ground 3D coordinates and velocities (for long-time series). First step is creation of the normal equations system, which includes the modeling of the perturbating forces. For the top precision the dynamical model including the estimation of the additional auxiliary variables should be used. This requires solution of the variation equations. The second step represents mainly the least square method solution of the previously designed normal equation system. See [1,3,4] for details.

The chosen strategy is an implementation of the DORIS data analyses to the already existing software, used for other space geodesy technique data analyses. In cooperation with the Astronomical Institute of Bern University the Bernese GPS software is employed. Therefore, the program implementation is reduced to the DORIS specific part of the problem. The very important circumstance is the external format of the DORIS data provided by CDDIS data center. Directly observed quantities (number of cycle counts on both nominal frequencies – 2GHz and 400 MHz) are not included in the data file, they are substituted by the RANGE RATE (average Doppler velocity) value calculated only for the 2GHz frequency.

More advanced, as input for the Bern GPS software, is the "difference between two pseudoranges" – RANGE RATE simply multiplied by velocity of light and added correction with respect to the difference between nominal satellite receiver and ground beacon frequency. The first idea was to reconstruct also the 400MHz observation using the 2GHz one and the ionosphere correction, which is also available in the data file. This seemed to be possible, because the ionosphere delay is indirectly proportional to the second square of the frequency. Though according to [2] the ionosphere correction from the data file includes also other additional effects, not atmospheric and frequency dependent (difference between antenna phase centers, differences between count interval for both frequencies). This fact prevents unfortunately reconstruction of the 400 MHz frequency data.

For the first testing campaign, the data from a single satellite covering one month (TOPEX, July 1995) were used. The a priori orbit was fixed; the ground coordinates and the

troposphere zenithal delay were estimated (corrections for the ionosphere applied from the file). Altogether 43 ground stations and over 80.000 DORIS observations were included. It is important to notice, that the precise modeling of low orbit dynamical representation has not been implemented yet – the used one was designed for the high orbit and did not include the atmosphere drag and atmosphere wind effects. The missing models were partly substituted by empirical force model, see [1]. The RMS of the dynamical orbit was then 2-3 cm in radial component with respect to the AVISO a priori orbit (top precision of the orbit can be about 1 cm in radial component). The estimated RMS value of a single measurement was 6 mm (for mostly 10 seconds long observations). This value corresponds very well to the 0.4 – 0.5 mm/s RMS in the RANGE RATE, estimated by GINS-DYNAMO (other software designed by CNES in Toulouse). The basic instrumental noise is about 3 mm for 10 seconds interval. Important is also comparison between the four weekly solutions (only the 29 stations observed every week at least four days were included) and the consideration of the RMS of the estimated coordinates. RMS from monthly solution in 3D positioning is about 1 cm, but this value looks too optimistic More realistic should be value estimated from the comparison between the individual weekly solutions, which is 4.5 cm.

The developed software is also able to estimate the orbit parameters, but only with the precision limited by the used empirical models. An implementation of the atmosphere drag model allowing estimation of the orbit and other corresponding parameters in the top precision is the aim planned for 2004.

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Progress in the Atlas Inner Detector Cooling System Design

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The design of the Atlas Inner Detector cooling system passed several stages of development over the last five years and this paper describes the current status of the design. The Department of Appplied Physics has been involved in its design via international cooperation supervised by CERN since 1995.

The evaporative cooling system has been choosen as the baseline solutions to cool down the sensitive electronic components of the Atlas Inner Detector that are formed by the following parts: the Pixel Barrel and End Caps, SCT Barrel, SCT End Caps and SCT thermal enclosers. The evaporative cooling system is to cool the Pixel and SCT detectors maintaining the temperature of the silicon modules at – 7 °C and at the same time it has to evacuate approximately 80 kW of the dissipated heat.

This scope is achieved by means of:

- Direct cooling of the detector modules: either with direct contact of cooling tubes to modules (SCT) or by means of local support structures with integrated cooling tubes (pixels).
- Indirect cooling of on-detector services and other heat sources (incoming heat through the thermal/gas enclosures walls) by means of extra cooling power of the module cooling circuits
- Direct cooling of the Pixel opto-board.

Cooling of other specific items: SCT thermal enclosure facing the TRT volume and pixel type I services on panels (same cooling circuit of the opto-board) is additional issue.

The evaporative system basic functionality is similar to that of a standard industrial fridge system. The selected refrigerant C_3F_8 is non-flammable, non-conductive and radiation resistant. It has a good heat transfer coefficient and a small vapour specific volume allowing minimal tube sizes. The fluid is delivered in liquid phase at room temperature from the condenser to the capillaries located immediately before the detector structures. The fluid expands through the capillaries and then remains in saturation conditions (boiling) in the detector structure. The residual liquid at the exhaust of the detector structures is evaporated by means of an heater which also raises the temperature of the vapor above the cavern dew point and then reaches the compressor in superheated vapor state.

A recuperative heat exchanger between the inlet liquid (warm) and the return fluid (cold) allows to increase the efficiency of the cycle, decreasing the vapor quality at the inlet of the detector structures and hence the required flow.

The temperature in the cooling structures is maintained by setting the pressure of the return vapor by means of backpressure regulators (BPR) located at the end of the return tubes.

The flow is set by changing the pressure of the inlet liquid by means of pressure regulator (PR) located at the beginning of the inlet tubes. Both the PRs and BPRs are located in distribution racks on the external ATLAS platforms.

The components of the evaporative cooling system are located in different areas and threfore the cooling circuit is devided into two parts: external (main cooling plant and pipelines and distribution racks) and internal part (inside the Atlas Detector).

The cooling plant, the pneumatic rack and the control cubicles as well as the monitoring/control unit of the internal part are situated in the accessible cavern USA15. The distribution racks and the internal part of the system except heater power supplies are located in the experimental hall UX15 on the ATLAS detector on the ATLAS detector platforms and they are exposed to a magnetic field

The detector structures of the Pixel, SCT Barrel, SCT End Caps and SCT thermal enclosers are grouped in 244 independent cooling circuits. Each cooling circuit consists of one recuperative heat exchanger, 1, 2 or 3 capillaries, detector structure, one heater on a return vapor line and piping connecting all the components to the distribution racks via one pressure and one back pressure regulator.

The evaporative cooling system control is based on CERN recommended Programmable Logical Controllers (PLC). The control system is based on a standard components and well-proven model architecture.

The process control layer is handled entirely in the PLCs, which can work even if the supervisor is not working. The PLCs, located next to the cooling plant, are independent of the supervisor being used. The Inner Detector SCADA system based on PVSS software controls the operation of the cooling system.

The role of the our Department of Applied Physics has been recognized not only for participation in the development work but also due to the number of the measurements performed on the pilot prototype structures, prototype cooling systems and also for the DAQs system applications employed during the measurements.

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Optimization of Diode Pumped Er:Yb Fiber Laser

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Rare-earth doped fibers are very promising for the construction of compact light sources with a high output power and a very good beam quality. Good stability and reliability make fiber lasers attractive for various scientific and industrial applications. Thanks to the shape of active media fiber lasers do not necessitate external cooling. The output powers of fiber laser systems have grown rapidly over recent years thanks mainly to improvements in fiber design and fabrication and in the performance of pump sources.

The erbium ytterbium doped glass laser operating at wavelength around 1.54 μm is very interesting, mainly due to its emission wavelength located in the optical telecommunication window (1.5–1.6 μm), in the so called "eye-safe" region (1.5–2.0 μm), and in the transmission window of the atmosphere. The active laser ion is erbium Er^{3+}, for pumping of this ion is possible to use the radiation at wavelength from ~ 960 – 990 nm which corresponds to the transition between levels $^4I_{15/2}$ and $^4I_{11/2}$. Ytterbium co-doping increases absorption bandwidth (800 – 1100 nm) and provides versatility for pump optimization. [1], [2]

Erbium ytterbium fiber laser operates in core-pumped as well as in cladding-pumped configurations. The main design problem of double clad fibers is to find geometry for an efficient coupling of the pump light into the doped core. In fiber laser propagate two kinds of rays: meridional and helical. In conventional, circular fiber only the meridional rays can be absorbed, helical rays which cannot go through a core are not absorbed. It is possible to avoid the propagation of helical rays or by bending the fiber in different shapes like kidney or rounds or by using a fiber with asymmetric cladding or core. [3]

The aim of our research is to realize and optimize diode end-pumped erbium – ytterbium fiber laser based on double-clad fibers developed on Academy of Sciences of the Czech Republic, Institute of Radio Engineering and Electronics. We also compare the efficiency of core-pumped and in cladding-pumped configurations for fiber lasers.

In double clad fiber laser the single-mode glass core is doped with the desired laser ion in our case erbium and ytterbium. This fiber core is encased in a surrounding undoped glass cladding that has a diameter many times bigger that the fiber core and lower index of refraction. The inner pump cladding is coat in an outer undoped cladding of yet-lower index of refraction. In this fiber geometry, multimode diode pump radiation is injected into the inside cladding through an end facet of the fiber, than propagates along the fiber structure and periodically travers the doped single-mode fiber core and in every passage produces an inversion of population in the active core.

As active medium of our double clad fiber laser was used specially developed fiber SG 736 containing 13 % of P_2O_5. Doping ions concentrations are 730 ppm for erbium and 14600 ppm for ytterbium the concentration ratio Er^{3+}:Yb^{3+} is 1:20. This silica glass fiber with core and cladding diameter 8μm and 120 μm, respectively, was covered with polysilax polymer Silgard 184 (refractive index n = 1,41). High numerical aperture (polymer cladding/silica cladding = 0,367) allowed us to couple the pumping radiation generated by laser diode. This

laser diode was operating at wavelength λ = 967 nm, bandwidth 2 nm (FWHM). Emitting area was rectangular 150 x 1 µm. This diode has a specially focusing optics. The maximum output power was 860 mW. [4]

Our system consists in order of laser diode, fiber, focusing lens and filter blocking pumping radiation. The fiber laser system was operating in a free-running regime. Successively we measured dependence of output power on fiber length, number of spires and radius of fiber banding. We found that the optimal fiber length at this configuration was 190 cm; this length was independent on number of spires, but the number of spires increases the conversion efficiency. The maximum output power obtained for this optimized configuration (fiber length 190cm, radius of twist 12 cm, number of spires 3) was 47 mW at wavelength 1535 nm for pumping power 860mW, this correspond with conversion efficiency 5,4%. The measured output power is less then 50% of total generated power due to booth fiber ends emission.

For comparison we also have developed core pumped fiber laser. As active medium for this laser we used fiber SG 738 containing 12 % of P_2O_5. Doping ions concentrations are 1 000 ppm for erbium and 20 100 ppm for ytterbium; the concentration ratio Er^{3+}: Yb^{3+} was 1:20, core and cladding diameter was 8 µm and 120 µm, respectively. The fiber was 720 cm long.

This second system used as a pump source a single transversal mode diode pumped Nd:YAG laser operating at wavelength of 1.06 µm. The pump radiation was focused into fiber containing micro-lens on input end. In both cases the laser resonator mirrors were formed by uncoated fiber ends. The fiber laser was operating in a free-running regime at wavelength of 1543 nm. The laser emission (wavelength and output power) was independent on fiber shape. Maximum output power was 47 mW (from one end only) for pump power 1250 mW at 1.06 µm.

The presented results demonstrating first successful operation of diode pumped double clad fiber laser using fibers developed at Academy of Sciences of the Czech Republic are the very promising and give potential for next improvement of this laser.

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Raman Spectroscopy of Ferroelectric Thin Films

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Ferroelectric thin films have been intensively studied in recent years. Possible applications have been widely extended due to continuously improving fabrication technology (e.g. sol-gel technique). Ferroelectric thin films show great potential for computer memories (DRAMs and FeRAMs), micro-sensors, RF devices applications etc. It is obvious that future trends in microelectronics are closely related to high permittivity materials.

Dielectric properties of thin films are often substantially different from those of ceramics or single crystals. The permittivity ε is often lower in the case of a thin film; it exhibits different temperature dependence and may depend on the film thickness. Dielectric losses are usually higher in films. Dielectric properties are influenced by various factors like external field, growth orientation of the film, surface layer effects, mechanical stress of the film-substrate interface, domain wall motion, non-stoichiometry, point defects, grain size.

Barium titanate ($BaTiO_3$ or BTO) has been known as a prototype ferroelectric perovskite for several decades but in spite of extensive studies, its lattice dynamics and dielectric permittivity data are still incomplete. Several crystallographic modifications can be distinguished: cubic (above ferroelectric phase transition ~ 400 K), tetragonal (400 – 280 K), orthorhombic (280 – 190 K), and rhombohedral (below ~ 190 K) phases. In the high-temperature cubic phase there are 12 optical modes at $k = 0$, which transform as the $3T_{1u} + T_{2u}$ irreducible representations of the *m3m* point group. The $3T_{1u}$ modes are infrared (not Raman) active. The T_{2u} is silent (neither Raman nor infrared active). In the tetragonal phase (*4mm* point group) there are $3A_1 + 3E$ modes which are both Raman and infrared active; each of these modes splits into TO and LO mode due to long-range electrostatic forces.

$BaTiO_3$ films of different thickness and way of preparation on (0001)-oriented sapphire substrate were studied by means of micro-Raman and far-infrared (FIR) spectroscopy. The data allowed us to discuss the phase transitions and lattice dynamics and to evaluate the complex permittivity of the films in the 20-300 cm^{-1} frequency range.

Three $BaTiO_3$ films (BTO1, BTO2, and BTO3) have been studied in the present work. One of them, 200 nm thick BTO1, has been deposited by injection metalorganic chemical vapor deposition (MOCVD) and its structure, according to the XRD analysis, may be considered as quasi-epitaxial [1]. The two other films, 375 nm thick BTO2 and 750 nm thick BTO3, prepared by chemical solution deposition (CSD) were polycrystalline. Raman scattering spectra were recorded using Renishaw Raman microscope in the 80-550 K temperature range. A notch filter for suppression of Rayleigh scattering did not allow resolving the spectra below 80 cm^{-1}. Far-infrared (FIR) transmittance measurements in the 20-300 cm^{-1} frequency range (limited at high frequencies by the substrate transparency) and 10-520 K temperature range were carried out using Bruker IFS 113v Fourier transform spectrometer.

Our Raman spectra show gradual weakening of polar modes on heating, which indicates a diffuse ferroelectric–paraelectric transition near 400 K in all the films. Raman spectra are dominated by the TO1 and TO4 modes as in unpolarized spectra of multidomain crystals. They broaden and weaken on heating but do not vanish up to 550 K. The TO3 and LO4 modes exhibit similar behavior. All Raman peaks are most pronounced in the spectra of the thickest film, BTO3. They show gradual softening of TO1 mode on heating from 270 to 240 cm^{-1}, TO3 mode from 312 to 306 cm^{-1}, TO4 mode from 530 to 510 cm^{-1}. At higher temperatures, the latter merges with TO4 component, lying at ~ 490 cm^{-1} at 80 K.

The films demonstrate a different behavior below 250 cm^{-1} compared with multidomain crystal. Raman spectra of BTO1 indicate a weak interference dip at ~ 176 cm^{-1}. BTO2 has two dips at ~ 150 and at ~ 176 cm^{-1}. The first minimum gradually deepens on heating while the second weakens. Low-frequency wing rises above 200 K. BTO3 spectra below 200 K distinctly reveal interference between sharp TO2 mode at 179 cm^{-1} and a strong broad peak, corresponding to the rhombohedral TO1 component of the soft mode. This maximum or its part abruptly softens below 200 K, which results in appearance of two dips similar to those of BTO2. On further heating, it is possible to resolve a weak peak at ~ 103 cm^{-1}.

FIR transmittance spectra were fitted with classical damped oscillator dispersion model to obtain the complex permittivity. The spectra contain broad maxima of highly damped modes, which makes determination of mode parameters rather inaccurate. Nevertheless, the infrared and Raman spectra qualitatively demonstrate a similar behavior, i.e. presence of smeared phase transitions in agreement with single crystals. FIR spectra of our films show also a strong, highly damped mode at about 150 cm^{-1}, which was not observed in crystals. Its possible origin could be due to the anisotropic grains in the films generating strong depolarizing fields within the individual grains [3]. The possibility of such additional mode (so-called geometric resonance) in our case may result from stiffening of the TO1 soft mode due to these depolarizing fields.

The lack of reliable data does not allow us to determine precisely the form of the dielectric function below 20 cm^{-1}, essential for understanding the critical dynamics of the ferroelectric-paraelectric transition, i.e. the accurate soft-mode behavior and possible central mode phenomena in $BaTiO_3$. This question is still under debate even for single crystals. We hope to address this problem soon using time-domain terahertz spectroscopy.

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Nanocrystalline Diamond Films Preparation by Hybrid Pulsed Laser Deposition

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Many efforts have been done to the development of diamond synthesis since 1797 (diamond was discovered to be carbon). It took more than 150 years from that time until a method of diamond synthesis was invented. The secret was pursued by many scientists but not unlocked until the 1950s, when diamond was synthesized almost simultaneously by Swedish and American researchers. Diamond has been prepared by two methods - at high pressure and at low pressure. Variety of chemical vapor deposition (CVD) techniques is most commonly used for diamond preparation at low pressure but also pulsed laser deposition (PLD) has been shown to be successful technique in this field. Recently, with the development of nanoscience and nanotechnologies, also nanocrystalline diamond (NCD) thin films have been comming in the wide concern of many researchers because of their interesting properties such as a low friction coefficient and low electron emission threshold voltage. The small grain size (approximately 5-100 nm) gives films valuable tribologic and field-emission properties, compared with those of conventional polycrystalline diamond films. It has been proposed that applications for microelectromechanical systems (MEMS) devices, MESFETs, electrochemical electrodes and biomechanical devices (e.g. to use NCD as coating of artificial heart valves) can be created by taking advantage of these excellent properties.

We used pulsed laser deposition (PLD) and hybrid PLD (HPLD) techniques for NCD thin films preparation. KrF excimer laser beam (Lumonics, λ=248 nm, 20 ns, 500 mJ) was focused on graphite target with energy density of 4-7 J·cm^{-2}. Films were deposited on sapphire and Si(100) substrates in hydrogen and argon/hydrogen ambient. Substrate temperature (Ts) was changed from 20°C to 660°C, pressure from 1 Pa to 220 Pa, and $H_2/(Ar+H_2)$ ratio from 9% to 91%. HPLD systems were used in two different configurations: HPLD1 system – RF discharge is hold between two plan parallel electrodes. HPLD2 system – the heated substrate holder is used as a "life" electrode for generation of RF discharge and chamber is used as a grounded electrode. RF power varied from 25 W to 100 W.

The deposited films were studied by Alfastep profilometer, Raman spectroscopy (Ar^+ laser – λ=514.5 nm, power: 0.5 mW, spot: 10 μm was used for excitation) and by scanning electron microscopy (SEM).

Growth rates of films deposited in PLD system varied in region 0.01-2 Å/pulse. They increased with increasing laser energy density. We did not observe any clear dependence of growth rates on substrate temperature. Growth rate was influenced by hydrogen concentration in H_2+Ar ambient – with increasing $H_2/(Ar+H_2)$ ratio the growth rate is decreasing, this phenomenon occurred in both systems HPLD1 and HPLD2. We can explain that by increasing etching effect of hydrogen with its higher concentration in the RF-laser plasma. At HPLD2 system the deposition rate was strongly affected by RF power - with increasing RF power (and DC bias) in region 25-100 W (110-270 V), (at $H_2/(Ar+H_2)$=83%, pressure 100 Pa) growth rate was decreasing.

The Raman features of the samples mainly exhibit two clearly distinct bands near 1340 cm^{-1} (D-band) and 1560-1600 cm^{-1} (G-band) and the weak band near 1180 cm^{-1}. The D and G bands are related with graphite-like islands (sp^2-bonded carbon). Band in region 1150-1180 cm^{-1} was shown to be related to calculated phonon density of the nanocrystalline phase of diamond and was also found in spectra of films containing NCD. We did not observed clear diamond peak (1332 cm^{-1}), this may be caused by the fact that sp^2–bonded carbon has ~50-100 times higher cross-section for Raman scattering than sp^3 bonded carbon and Raman cross-section of amorphous carbon (a-C) is even 233 times higher than that of diamond.

We obtained clear trend in dependency of NCD formation on Ts at PLD system (at hydrogen pressure 100 Pa). NCD is rather formed at higher temperatures (570 and 660°C), at lower temperatures (370 and 470°C) diamond-like carbon (DLC) is created only. Films prepared in RF plasma assistance exhibited better composition homogeneity than films prepared by PLD. We found out that the concentration of hydrogen in ambient together with RF power affected the NCD formation. At HPLD1 system NCD is rather formed at low hydrogen concentration ($H_2/(Ar+H_2)$=9%, 17%) - NCD band is clearly observed, at higher hydrogen concentration ($H_2/(Ar+H_2)$=83%) NCD band disappeared and D' band (at ~1620 cm^{-1}) occurred. Appearance of D' component closely resembles the disordered highly oriented pyrolitic graphite (HOPG) feature. At HPLD2 system we obtained clear trend in dependency of NCD creation on RF power (DC bias). NCD band only occurred in spectra at RF power 25W ($H_2/(Ar+H_2)$=83%). With increasing RF power it is disappearing and D/G band intensities ratio is increasing. At RF power 75W, D' component was clearly seen. This means that also high RF power leads to creating more disordered carbon structure as well as high H_2/Ar ratio. We can conclude that higher hydrogen etching rate causes formation of smaller graphite crystallites and area of grain boundary is increasing.

SEM images showed that most of deposited films have rather smooth surface. One sample exhibited the presence of single diamond nanocrystallites with grain size on the order of 50 – 200 nm. Most probably the observed crystallites present the initial stage of the film growth.

In conclusion we can say that Raman and SEM analysis of deposited films show features, which can be attributed to nanocrystalline diamond. We found that NCD formation in hybrid pulsed laser deposition systems is affected by RF power and H_2/Ar concentration ratio. It also seems that NCD is rather created at higher temperatures.

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Section 3

INFORMATICS
&
AUTOMATION ENGINEERING

Further Development of the DNEP Database Program: Conditions and Utilisation in Real Operation

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Introduction

A central aspect of the work of the Czech Technical University in Prague, and of all technical universities, is wide-ranging, meaningful, high-quality and useful scientific and research activities. The budget dedicated to science and research is not as large as might be desirable, but it is by no means inconsiderable.

The great creative potential of a large number of academic staff members is available for research projects. This creative potential places our university in a position in which it can - indeed must - utilise the results of research. The primary aim of our research is to support the increasing competitiveness of a wide range of Czech products on the local and international market.

Many efforts to provide a good research infrastructure have been made in recent years. Whole catalogues of materials have been produced and distributed face-to-face at trade fairs, at exhibitions, and via the CTU web pages.

The DNEP database offers a more comprehensive tool for presenting the university's research capabilities than has been available until now. Information on our results and offers will form a part of the overview database **Technological Profile of the Czech Republic**, which is created by the Association of Innovative Business of the Czech Republic. In addition, DNEP can provide transparent communication and co-operation with similar databases in other countries

DNEP – a database program with real professional information on the Web

The DNEP Database program provides:

a) information in the form of records of research results together with their potential future applications,
b) a list of experts in technical branches covered at CTU,
c) an overview of unique research equipment and instruments that are available at CTU.

DNEP aims to support the intensive transfer of research results and technologies, also on a commercial basis. Other items for utilisation and expoitation are the expertise of CTU staff members and the new computers, networks and software tools in which the university has invested considerable sums.

The highlights of such an arrangement are as follows. DNEP is implemented in the Inforek web server located at http://inforek.cvut.cz:8085/. DNEP froms an integral part of the University Information System (IS). It is implemented at a server of the CTU Computation and Information Centre, located in the Dept. of Information Systems, which provides technical support. The CTU Dept. of Science and Research takes care of the contents of DNEP. Partial DNEP databases are filled from various information sources. The ***Offers*** part of the DNEP database is freely accessible on the Web, not only by CTU staff members and students, but also by a wide specialised and interested public in the Czech Republic and

abroad. An English-language version of the ***Offers*** database was put into operation in summer 2003. The ***Expert*** and ***Instrument*** parts are oriented more internally into CTU and therefore they remain in a Czech version only. The inputted data is of a personal nature, and the records should be treated with the ethics followed in the world of science and research.

The submission of new records operates by means of the Web. The submission forms are tailored to the character of the record. The submitting person is guided by a system of pop-up menus, which support consistency of the records made by different staff members (e.g., name of the faculty, place of work, its address, etc.) The submission is then processed off-line, i.e. the completed and submitted form comes to the editor, who displays it publicly via the Internet.

The person submitting the entry vouches for the truthfulness of the information submitted, and confirms that it may join the register of offers/experts/equipment, that it may, together with the contact data, be publicly displayed on DNEP or used at exhibitions, fairs, etc., in order to inform the public about the activities and educational and research results of CTU.

Some of records are time-limited - e.g,. the submission form for an offer, where the submitting person can select the date until which the record will be displayed.

The submission of new records is limited to CTU staff members. The home page of the Czech version contains a link to the English-langague version. The Czech version consists of all three databases (i.e., offers, experts and equipment). The English version displays only the offers and a link to the Czech home page.

A user specifies his/her requirements for a search of records in a special search form. Pop-up menus with predefined items are also used there - e.g,. for the ***Type***, ***Faculty/constituent part***, ***Branch***. The user can search according to one criterion or several criteria simultaneously. He can list only one of the records that have been found, or alternatively several of them. A record of an offer can be illustrated by up to five figures (e.g., a digitised photograph, a b/w diagram, a gif/jpg figure).

DNEP is generally accessible. The operation control is mostly intuitive. Forms are supported by additional legends next to most of the items. In the Czech and English-language home pages on the lower left parts of the frames there are links to ***Helps*** and to ***Characteristics*** in Czech and in English. These guide the user step-by-step in submitting or searching for a record.

Conclusion

DNEP is now near to its final form, from the technical and operational point of view, and is in trial operation. Some problems have appeared in data acquisition of high quality offers. Research results are specific goods, which have to be commercially offered again and again. They cannot be utilised without any advertisement support. While we mention the often-published fact that Czech industry has shown insufficient interest in the results of university-based research, we must also acknowledge that it is necessary for the university to take the first step now and to clear the way to utilisation of research results.

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Peer-to-Peer Searching and Resource Sharing

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Introduction

Today, Peer-to-Peer (P2P) search technologies are more and more actual because of many disadvantages [1] of currently used search engines based on centralized database (index). These disadvantages are especially:

- low degree of reliability (all centralized databases are more vulnerable to various attacks),
- it is impossible to index the 'whole Internet',
- searching is done only over web pages or few common file formats not over computer resources in general,
- there are very weak possibilities to group computers into communities.

All these problems led to use the P2P search engines, i.e. distributed search engines, which use local databases instead of central one. This brings, in many cases, the solution of the problems mentioned above. One big disadvantage of distributed search engines is the speed of searching, which is unfortunately one of the pivotal part of searching. To increase speed of searching it is necessary to choose the right topology and message-propagation rules. Caching and replicating resources also help in achieving this goal.

Existing search engines and theirs topologies

Today, the most used distributed search-engines are especially Gnutella [2] and Freenet [3]. Both of them use a random graph as a underlying topology and are pretty well optimized to return results with acceptable latencies, which are, however, still too far from the latencies of centralized search-engines – query does not process only once (as it does in the case of central database), but many times, depending on the number of computers (nodes) in a network. In the worst case, Queries are propagated to all nodes, which is very time- and bandwidth-consuming. Fortunately, both Gnutella and Freenet use sophisticated algorithms to propagate queries in better way – both of them use flooding method to do it. The Flooding method lies in sending the query to all neighboring nodes. But in the case of bigger amount of nodes in a network, this method causes very high network load. To prevent this, every query has its own TTL (time-to-live) constraint which determines how many nodes should the query pass through. Nevertheless, this denies the queries to be propagated to distant nodes. Another problem appears when a node fails – in this case, all links pointing to it from neighboring nodes become unavailable. There is no existing way to handle this situation when using random graph topology.

The possible solution – a ring topology

One of the possible solution which may speed up the searching process is to group nodes, which may have (but it is not necessary) something in common, to rings. Each node in a ring manages a table containing links to at least two neighboring nodes (to build up a ring) and external links to nodes in other rings (in order to connect node's ring to other rings). The problem of loosing connectivity is partially solved by this approach – node failure within a ring can be successfully bypassed using redundant links to rebuild the ring. Unavailable links inside a ring will be destroyed, but queries can be propagated around a ring to gather new ones (or the same, if the node become online again). The ring itself is closed community which interacts with other closed communities in the matter of query interchange. The second sight will reveal that this approach is very similar to Gnutella or Freenet. Yes, it is true when we substitute nodes with rings – the advantage is that inside a ring we can perform a effective search and then we can propagate it further. This is faster than when using flooding algorithm apart from having more relevant results when searching in a specialized ring which represents some special information source (community) represented by a set of nodes.

The effective query propagation in a ring lies in so called advertisement. Each node which joins a ring sends a special message around a ring indicating which resource it provides. Other nodes store this information (the couple node address, advertised resource id) for future use. Using this mechanism, queries can be routed more efficiently than when they are only propagated over a ring.

Future Work

Future plans are to develop an experimental system which will use the ideas mentioned above. It will be crucial to spread the system at least across a university to gather any data for further analysis. Second way how to prove that these ideas are right in practice is to develop a sophisticated simulator which will be able to provide its characteristics at least as a good approximation. Simulator or practical data is needed, because is very hard to create a mathematical model of this system.

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Color for Black-and-White Cartoons

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In this paper we discuss a challenging problem of applying novel color information into the old black-and-white cartoons. Thanks to possibility, which allows us to convert the original analogue material to the sequence of digital images, we are able to solve this task using methods of digital image-processing.

Classical works from the history of cartoon making stay still in front of the recent worldwide cartoon production and become an invaluable source of inspiration for every new generation of children. Unfortunately aged cartoon animations were usually shot in black-and-white. However it has been proven that presence of color in cartoons stands for the most important influence on final artistic quality especially when it is intended for the adolescent audience. Novel color information usually emphasize original art style and increase overall visual impression.

Colorization of black-and-white movies has been extensively studied since 1970's. The general problem of adding color information to the grey-scale images introduces large ambiguity, which should not be resolved without additional knowledge about the scene structure. This crucial information is usually provided by human interaction and plays an important and time demanding role in the whole colorization process. To accomplish this difficult task an exhaustive brute force approach or various semi-automatic techniques have been used. While an amazing piece of work has been done on colorization of classical movies, a semi-automatic colorization of grey-scale images is not yet supported in recent cartoon authoring systems. Due to these circumstances artists endows on featureless and repetitive work, which disturbs them from real creative artwork.

For example well-known semi-automatic colorization technique luminance keying is able to apply selected hue, saturation and brightness on the each level of grey-scale intensity. However only additional tedious hand-driven image segmentation allows one to simultaneously use different luminance keys, which cover the same intensities on different locations in the original grey-scale image. Another problem is that usual cartoon world is not planar but in fact 2.5D. Occlusion and other topology variations imposed by virtual depth should destroy important local structure, which significantly decrease predictability. The intensity itself or shape-based features provide insufficient information to solve this topological problem. Additionally the movement in classical cartoon animations seems to be coarse in contrast to computer generated movies. The same motion phase is usually exposed twice using two consecutive movie frames. Accordingly the structural difference between current and novel animation phase becomes really noticeable. Moreover moving entities are not only characters that look like human but also some extraordinary creatures and other strange objects. Due to these circumstances we are not able to look to real world physical laws of motion because we have to track movements in fuzzy artificial world. Creating extra model for each novel entity is going to be inefficient.

We have introduced a novel semi-automatic colorization framework suitable for aged cartoon animations [1]. More specifically we focus especially on the foil or paper cartoon making technology. In this case the foreground layer usually consists of several homogeneous regions that are separated by force of boundary contours. Background layer is represented by a static image and only dynamic foreground has to be colorized frame-by-frame.

For this type of cartoon animations we show how to automate colorization pipeline, to reduce amount of hand-driven corrections, and to make the whole process cost effective and temporally feasible. Our framework consists of various image-processing techniques able to process animation sequences in television broadcasting quality on standard PC workstation preserving interactive performance.

More concretely we have developed a robust unsupervised contour-based image segmentation able to determine which part of the original image belongs to the foreground layer [2]. This technique allows us to divide foreground layer into the set of homogenous regions. Patch-based sampling [3] and probabilistic reasoning [4] are then used to predict which color will be used for particular region. Afterwards a user defined hue and saturation are applied to each pixel in the foreground layer while final color brightness is modulated using pixel intensity in the original grey-scale image. Moreover dust spots and band scratches are removed automatically exploiting region homogeneity. Limited manual interaction avoids propagation of prediction errors into the successive frames and consequently guarantees visual quality of the final colorized sequence. Foreground separation allows us to track camera movement over background layer and to reconstruct one big plane, which contains visible parts of the whole background. A skilled designer applies colors on this layer at once using standard image manipulation software. Finally background incremental movement vectors are used again to extract proper rectangle from already colorized background plane. Using such a color rectangle as background layer for current animation frame we make smooth composition with a yet colorized foreground to produce resulting color image.

Proposed framework has been used in practice to produce color version of Czech black-and-white cartoon "*O loupežníku Rumcajsovi*" which has been originally designed by Radek Pilař in 1967. In average two trained artists were able to colorize the whole episode (cca 10000 full PAL frames) during one week (40 working hours), in contrast to hand-driven luminance keying approach which takes in average one month to process the same amount of frames. Additionally our framework also increase the overall visual quality.

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Software Communication in Computer Integrated Manufacturing

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Introduction

In manufacturing enterprises is usually used a wide spectrum of software systems that operate with CAD-data. There are CA.. systems (CAD, CAM, CAE, etc.) that are producers and consumers of this kind of data. Computer Integrated Manufacturing (CIM) is an activity that deals with the integration of these systems and related processes. However, first concepts of CIM were published in 1970's and realized in 1980's [1]. Furthermore, another different category of systems, which manipulates with CAD-data, is the set of systems such as Enterprise IS, Product Data Management (PDM), Product Lifecycle Management (PLM), and suchlike. These software systems do not change the CAD-data, however manipulate, describe, and categorize them, thus they must be included into the focus of integration activities. Basic services of these software applications are the presentation of data and making them accessible. Usually in a typical company there are several CAD systems, other CA.. systems, and components of complex enterprise information system, such as PDM, used concurrently. In the common company these systems are heterogeneous and provided by different producers and/or vendors, of course.

It is evident that system interoperability and ability of data exchange, based on native formats of each system, is impossible. Fortunately there are a lot of data formats, such as STEP (ISO 10303) [2], but also VRML, XML-based formats and many others that help to solve the problem of data exchange. However, neither communication nor utilization of communication channels are unified enough. As a result, CAD-data exchange among enterprise software systems is systematic only rarely.

Goals

We assume that the problem could be solved by the possibility of using simple and unified communication method which is based on modern internet-based approach (because the mechanisms of internet are omnipresent). The main aim of our research is to develop a new unified communication method for CAD-data [3], based on internet technologies, which could be used by existing software systems. This method should enrich the existing methods of communication, not replace them.

Our method of communication is based on TCP/IP protocols. The communication is stateless, simple *Request – Reply*. Transferred data can be represented by basic primitive formats, such as text string, real number and etc., and/or by some known complex format, such as STEP, IGES, VRML, JPEG, etc. It means our method is above all the channel of communication, unified by unambiguous set of rules.

If software systems wanted to communicate with proposed mechanism, they would have implemented interface according to defined rules. The main goal of our effort is the advantage of just one interface (per system) for communication with each other system. It could seem that some changes in each system are necessary. And it could be seen as a problem, especially for CAD systems. However these systems are designed as quite open (it

means extensible by external software modules, plug-ins, and suchlike). Therefore there are mechanisms how to implement an interface by third-party programmers.

Our method consists of two layers. The basic one (low lever layer) is based on TCP/IP protocols. The second one (higher level layer) is based on XML web services, it means on XML, SOAP, WSDL and UDDI technologies [4]. It can simplify the utilization of the communication mechanism at Java and/or .Net based systems, which are more frequent platforms of distributed programming of modern enterprise IS. Moreover, a lot of another implementations of XML web services and support of essential protocols were released (free and noncommercial solutions including), such as Glue or Axis.

Our communication method is designed as open model with centralized supervision. We have proposed the Internet portal centered on the lifecycle of the method.

Research and Results

Described research has been divided into several stages. We have been realizing them in the following steps. At the beginning we started with the set of the case studies of contemporary state, which helped to refine the theoretical model of the real environment of computer supported and integrated manufacturing enterprises. The next step was to do a set of laboratory experiments. These experiments showed basic behavior of the new method. An action research followed laboratory experiments – the set of action research methods brought the main results of the measurement.

However the results of the laboratory experiments and especially of the action research were only the ratio between improvement and the cost of the improvement of software integration. Since this ratio is hard to evaluate out of companies (in artificial environment), we have decided to close and evaluate the research by survey that should help to detect the true outcomes of the application of the proposed method of communication and/or CA.. and related software integration. We are starting this final phase of research in a nowadays.

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Conclusions

We have reviewed the methods of communication among software systems that operate on CAD-data. This investigation has found out that there are a lot of data formats suitable for data exchange however the communication channels are lagging. We believe the unified communication method, based on simple and independent mechanisms of internet, helps to solve the problem of communication among enterprise software.

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An Emulator of the MOOSS Architecture

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The main goal of microprocessor architectures was to produce very fast chips in the past. Nowadays, besides the speed also the security and reliability of computer systems is becoming one of the most important issues. Thus, the support for semantic constructs of high level programming languages (HLLs), fine-grained memory protection is again investigated. Current microprocessors have only basic support for the memory management and usually have no greater support for constructs of HLLs. Today, most of the commercial CPUs have HW support for paging and some of them have also support for segmentation. The issue of fine-grained memory protection was addressed in many papers in the past. Several approaches were introduced: segmentation, paging, tag architectures, capability based systems, etc. The main problems of the previous solutions were that they were not able to solve the problem of protection of the non-uniform memory structures or they were too complex.

The MOOSS architecture, we have recently designed, is an innovative microprocessor with support for memory protection and semantic constructs of HLLs based on enhanced and refined segmentation model. The CPU can distinguish between binary data and pointers, perform range checking, and support garbage collection by reference counting. For temporary data and subroutines parameters it uses a structured stack. The HW manages the stack and guarantees the stack is always in a consistent state. These features solve the heap and stack overflow problems used by hackers to exploit the OS.

In the year 2003, we were working on the design of the MOOSS architecture and on an SW emulator of the architecture. Our effort was supported by the CTU grant. To summarize, the work run in the following cycle:

1. design of the architecture on the instruction level (ISA)
2. documentation
3. implementation of an SW emulator
4. benchmarking

We went 3 times through the cycle. The results and outputs of each cycle have influenced the next cycle. Out goal was to achieve the best performance and create a good platform for a VLSI implementation. In each cycle, we have also optimized the ISA. The timeline of the development follows:

1. July 2002 – May 2003: the first version
2. May 2003 – July 2003: the second version
3. July 2003 – November 2003: the third version
4. November 2003 – now: the current version

During the development in 2003, we have abandoned the variable length instruction encoding and we have designed a new MOOSS ISA with simplified fixed length instruction encoding

that uses Load/Store approach known in the RISC microprocessors. The documentation (including ISA description) with full history of the project can be found on our webpage:

http://moon.felk.cvut.cz/~xballner/mooss.

The results generated by the emulator indicated that the overhead of the memory protection can be mostly amortized using advanced ILP techniques and specialized units in the instruction pipeline. Especially, the arithmetic instructions and most of the memory operations can be performed without a slowdown.

We have introduced the MOOSS architecture on the ACSAC conference [1] and we have also presented benchmark results of the second version of the emulator. ACSAC is a top conference focusing on computer architectures.

The MOOSS architecture is an ongoing project and we continue the research.

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Usage of IP Protocol in Fixed and Mobile Networks

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With development of Internet happens to intense a data transmit growth, that begins to prevail over telephone traffic in existing telecommunication networks, i.e. telephone services traffic. Current development of telecommunication networks tends to the convergence data and voice services, and therefore to the convergence in the one, integrated and broadband network, that supports all kinds of telecommunication services. It comes to being the network next generation NGN (Next Generation Network). Although the particular conception of this network is not quite clear so far, it is supposed, that its problems will be construct on IP (Internet Protocol) and ATM (Asynchronous Transfer Mode) technology, eventually in the combination of both technologies.

For the future progress of the multiservice data networks in Next Generation Network is important MPLS technology (Multiprotocol Label Switching), which is used for the IP packets transfer throughout this network.

The MPLS technology has arisen mainly by demands on:

- Increasing throughput the routers thanks to the packet switching of the numeral labels with fixed length,
- The packet routing based on the destination address and the next fields in the IP header,
- The hardware usage based on destination address and the next fields in the IP header.

This technology is based on the labelling packets 3rd layer the RM-OSI model principle by marks (labels). Then the packets are transfer through the MPLS network in terms of these labels. The time and processor difficult analyses are wasted in connection with scanning the routing tables, that are realised only in input point. Labels determine the path of packet, but they could specify for example the service type.

The basic instrument for the label assign are the routing protocols, the IP protocol uses for example OSPF (Open Shortest Path First) or BGP (Border Gateway Protocol). These protocol provide certain set of the address prefixes for the router. The router can the prefixes classify into equivalence classes FEC (Forwarding Equivalence Class).

The one of the possibilities of usage the MPLS technology is creation Virtual private networks (VPNs). Most of the first implementations of VPNs by force of MPLS use the access described in the RFC 2547 standard, where the protocol MP-IBGP (Internal Border Gateway Protocol with Multiprotocol Extension) is used for transport extended VPN-IP addresses. The every entered packet into the MPLS network form the consumer network, is labeled the VPN label, which unambiguously identify this Virtual private network. This operation run over on the edge of MPLS network in the PE router (Provider Edge router) in terms of input router port, which the packet pass. This router then, in according to the MPLS network principles, put in the begin of the packet labelled by VPN label next label, which recommends path (Label Switched Path, LSP) between the PE routers in the MPLS network. The modified packet like this, is then forward by the PE router next into the provider MPLS network.

The advantage of the MPLS network is the connectionless VPNs creation. Then VPNs are easily configured, becouse the provider need not configure complicated structure of the permanent virtual circuits and tunnels.

The big advantage of the MPLS technology is its usage like the core network for areas that use integrated and differentiated services (IntServ and DiffServ). This idea propagate the MPLS services with the VPN services and smooth connection of the organizations with their others areas with guarantee the quality of services.

The disadvantage MPLS technology is the fact, that the technology has not been standardized so far. The big problem some time will stay IP multicast and the question is, how the vendors will touch with the IP version 6 support that is started to use.

The most important motivation for the phoning throughout the data networks against the phoning throughout classical telephone networks is the possibility the achievment lower prisez for calling customers. There is therefore possible that data network have lower the purchase costs and operating costs depending on the servise capacity are able offer for their customers. In other words, the data networks are essentially more effective than the classical telephone networks.

At present there is spoken mainly about the possibilities in the voice transfer in data network on bases the IP protocol (Voice over IP, VoIP). The reason is not mainly the advantages of these networks for the voice transfer, but abovel all broad availability and universal usage. In order to realize VoIP, it is necessary to include some functions into the network devices. The most important functions are the priority of voice data, the packet fragmentation, the reservation method for bandwith and the buffers (input and output). The one of some standards for VoIP is standard ITU-T H.323. It describe the overall network architecture, particulars components (terminal, gateway, gatekeeper, MCU) and together the higher level protocols RM-OSI model (H.225, H.245, RAS, RTP, RTCP).

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Colorimetric Aspects of the New Image Compression Methods

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This paper deals with image quality assessment of colour natural pictures. Purpose of this measurement is to determine relation between objective characteristics – numbers and subjective quality perceived by observers namely from colorimetric point of view. To assess technical quality of technical picture means to determine the impact of different imaging systems (including coding/processing techniques) on the technical quality of the picture made by apparatus (e.g. camera) or on the picture not made by apparatus but reproduced by apparatus (scanner). Among evaluated technical parameters of the picture belong sharpness, contrast, gradation and colour scheme. In this work, in the first place the colorimetric features of the natural pictures will be examined. For such task, two methods are used – objective and subjective [1].

Only one objective characteristics, which describes the whole variety of the distortions incurred by today imaging systems, does not exists. Objective characteristics can be categorized into pixel difference-based, correlation-based, edge-based, spectral-based, context and Human Visual System (HVS)-based. In [2], twenty-six characteristics are introduced. Characteristics describing colour distortion are introduced and then used in this work.

Subjective assessment, albeit costly and time-consuming, is accurate and constitutes a decisive criterion. Methodology for subjective assessment of the picture quality is described in ITU-R BT.500 recommendation. Subjective test presented here is modification of such recommendation. Objective methods, on the other hand, can at best try to emulate the performance of subjective methods, utilizing the knowledge of the human visual system.

The set of testing pictures was rigorously chosen in that way so that pictures contain, on one hand, large unicolour areas and, on the other hand, small details. Further so, those pictures contain well-known colours such as, e.g. sky blue, herbal green and especially body-colour. Two types of test were realised. The first one in focused on evaluation of colorimetric distortion due to today's image compression methods as are jpeg or wavelet. The aim of the second one is to find and calibrate the scale of colour disagreement of natural picture pair. For calibrating the scale, results of objective measurement will be used. All subjective tests were carried out using CRT colours. This is important in results interpretations.

With respect to limited attention of observers during subjective test, only five testing pictures were chosen (Portrait, Fruit, Garden, Posters and Square). Realised subjective test was performed on the adjusted PC monitor in close to reference viewing conditions according to IEC 61966-2-1 specification. The evaluated pictures have TV resolution that is 720x576 pixels (72 dpi). It means that thereinafter results of subjective tests and determined relations to objective characteristics have predicative significance for application based on TV or PC. More accurately, presented tests were realised using CRT-based display. Consequently, results have predicative significance for applications utilizing visualisation based on CRT

display. Qualitative requirements of the pictures based on the photographs will be certainly higher than the requirements on TV pictures. On the other hand, qualitative requirements of the pictures based on the mobile communicator will be surely lower than the requirements on TV pictures.

For needs of the first type of image quality measurement, i.e. for evaluation of distortion caused by image compression methods, only Portrait testing picture was used. The picture was compressed into three formats: JPEG 4:4:4, JPEG 4:2:2 and WI (wavelets, 3 paths). In both JPEG formats, nine pictures with increasing compression ratio (1:10 to 1:90) were saved. In WI format, fourteen pictures with increasing compression ratio (1:10 to 1:140) were saved. On the whole, 33 pictures (including original) were prepared. Bellow, this type of image quality measurement will be short mentioned as "Compression-based test".

Results above all describe only colour distortion and are relevant for digital TV field based on CRT display. All three objective characteristics ($RMSE_{RGB}$, $N_{u'v'}$, ΔE_{Lab}) are quite correlated and the relation to subjective quality is high. The limits of an excellent image are $RMSE_{RGB}$=5, $N_{u'v'}$=7.5 and ΔE_{Lab}=6.5. As mentioned in literature the just noticeable difference between the original and distorted colour pair relates to $N_{u'v'}$=1 and ΔE_{Lab}=2.3.

But, the mentioned criteria $N_{u'v'}$ and ΔE_{Lab} describe reliably colour differences perceived by the human observer in large equicolour areas without effective masking impacts. It would be possible to object that the background is such an equicolour area. It has to be pointed out that the observers' attention is focused on faces. The still acceptable quality is proportional to $RMSE_{RGB}$=7.5, $N_{u'v'}$=10 and ΔE_{Lab}=9.

JPEG 4:4:4 contains fairly excessive amount of colour information. To achieve the same compression as JPEG 4:2:2 we have to apply coarse quantization and elimination of DCT coefficients. Therefore the JPEG 4:2:2 is both objectively and subjectively evaluated better.

The wavelet algorithm (WI) gives the best results. Still acceptable WI compressed images reach the compression rate up to 1:110 (compare to JPEG approx. 70:1). The WI compression distortion is sensed as more natural, the typical smearing was similar to analogue VHS recording.

The still-excellent TV image (720x576 pixels, 8 bits per channel) gives a non-acceptable limit photograph of approx. 9x6 cm. In such way, it can be concluded that the standard TV resolution is equal to 72 dpi and the standard printed quality photograph (postcard format, conventional viewing distance) requires 250 to 300 dpi. The still-excellent photograph is in the JPEG up to the compression rate 1:10. This limit was practically proved.

Colour distortion is best described in CIE L*a*b* colour space via ΔE_{Lab} colour difference formula.

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The Environment for Vizualization of Simulation in Virtual Environment

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The main goal of this project was to design and implement a virtual environment enabling a simple visualization of simulated phenomena. It means to create tools enabling to extend already existing applications by a simulation of the environment. Let us highlight that the applications are targeted to Internet, where the visualization runs simultaneously on several computers. This paper introduces methods used for the simulation of weather conditions in urban visualization system. We present techniques for shadow generation, texture changes, and corresponding updates of a database on a web server.

We have focused on weather condition simulation incorporated into the Virtual Old Prague web application (VOP). The VOP is an advanced web-based visualization application originally developed in 1999 [1]. It currently serves as a platform for testing novel and specialized algorithms created by students and researchers.

The main task of the VOP is to display a 3D model of Old Prague in a virtual environment. Model definition is stored in mySql database (geometrical description, links to textures and meta-information), VRML browser presents the model on the client side, and supporting communication and computations are provided by PHP scripts. Since the VOP visualization is based on strictly normalized VRML language, some restrictions have to be taken into account when preparing extensions for special effects like modeling atmospheric effects.

Concerning weather conditions in city visualization, the position and movement of clouds are not considered as highly important visual effects. Instead, a position of sun together with intensity and color of sunrays influence a look of a city the most. Properly computed shadows and lighting conditions bring substantial changes into a final image. Such effects are appreciated by virtual visitors especially in the case of presenting historical and beautiful buildings of Old Prague with its specific “genius loci”.

From the technical point of view, sunrays influence textures mapped on surfaces of buildings - facades. To compute shadows and colors visible on textures in a large city, one has to use time-consuming global illumination methods. Such techniques are not suitable for a real-time visualization. Moreover, additional lighting effects should increase a load by no more than 10%. A solution for given state is to compute all textures in a preprocessing time and apply them selectively with respect to time (daytime, season, etc.).

Since the application consists of web server and client components, we had to decide where the weather simulation is computed. Local computation on client machine would bring a possibility to freely set various conditions, but it would take too much processing time.

Thus we have decided to run the simulation on the server. Instead of adaptation to individual user's requests, a simplified solution has been designed and is currently in the implementation phase. The weather and lighting conditions are applied to common database on a server depending on a real time in Prague. Thus users will see the virtual city in sunrise every morning, changes of shadows during a day, and sunset every afternoon. Due to the complexity of simulation, new data are prepared every hour.

Data, that are to be recomputed, represent textures mapped on facades. Originally, all textures in the city were prepared with the aim to show a city in perfect conditions, i.e. under optimal lighting without distractive shadows. Those textures have to be changed, since shadows and sunray colors are visible on them. The method consists of two steps. Firstly, shadows thrown from neighboring houses are computed for every single façade. Secondly, these shadows are combined with the original texture. Color effects are applied as well. Other weather effects like fog, rain, smog could be also included to the final texture.

To compute shadows of buildings, we have implemented a method based on scene projection on polygonal face. The result is a polygonal shape representing a superposition of several shadows. The shadow area is combined with the original texture using alpha blending. The same approach is used for displaying color of sunrays on the same texture. The alpha blending has been chosen as the most efficient and straightforward method, although some other possibilities has been studied. One of them was to convert the texture image from RGB to HLS color space and to apply shadows on the L (lightness) layer only. This avoids computations on two other color components, but the conversion between color models has been proven to slow.

Methods described in this paper were implemented in an experimental version of VOP available at http://nautilus.felk.cvut.cz/vop. While the simulation program (written in Java) works well in terms on evaluation of individual building facades, the integration into existing VOP application has to be still tuned. We further plan to experiment with a possibility to transfer the simulation program to client's computers, where weather conditions could be set individually by users' wishes.

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Teaching Support with Adaptable Elements

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1. INTRODUCTION

Adaptive hypermedia is a relatively new direction of research on the join of hypermedia and user modelling. One limitation of traditional hypermedia applications is that they provide the same page content and the same set of links to all students. This is often very objectionable, because every student has different requirements on given hypermedia system. For example, a traditional educational hypermedia system will present the same static explanation and suggest the same next page to students with widely differing educational goals and knowledge of the subject.

An adaptive hypermedia enlarges the functionality of a hypermedia system. The aim of this system is to personalize hypermedia system to the individual students. Thus, each student has an individual view and individual navigational possibilities for working with the hypermedia system.

An adaptive hypermedia system combines ideas from hypermedia systems and ideas from intelligent tutoring systems. It belongs to the group of student adaptive systems, which are, for example, student adaptive interfaces or user model based interfaces. Adaptive hypermedia systems use a user model to collect information about his knowledge, goals, experience, etc., to adapt the content and the navigational structure. For example, a student in an adaptive educational hypermedia system will be given a presentation that is adapted specifically to his or her knowledge of the subject and a suggested set of most relevant links to proceed further. Here, the choice of the right information at the right time is the task of the user model.

Adaptive hypermedia system is also an attempt to overcome the “lost in hyperspace” problem. The student's goals and knowledge can be used for limiting the number of available links in a hypermedia system.

Typical applications of adaptive hypermedia systems are educational hypermedia systems where the user or student has a certain learning goal. In these systems, the focus is on the knowledge of the students, which might vary enormously. The knowledge state changes during the work with the system. Thus, a correct modelling of changing knowledge, a proper updating, and the ability to make the right conclusions on base of the updated knowledge estimations are the critical parts in an educational hypermedia system.

2. MODELS OF ADAPTIVE HYPERMEDIA

Two models are needed for the creation of hypermedia that can be adaptive to student’s demands. The first model is the domain model which contains information from the given knowledge domain (e.g. knowledge domain about programming in language Pascal) structured into the text itself and the semantics. The semantics is in our interpretation taken as the description that enables to catch the links and relations among individual parts (e.g. chapters, subchapters, paragraphs, etc.) of the hypermedia. The second model is user model that serves for saving information about knowledge, aims, etc. of the students. User model is the structure kept by the system with the aim of ability to react to individual style of learning of the user and to provide adaptive parameters.

3. SYSTEM ARCHITECTURE

The architecture of the suggested system consists of tree main parts: *user model* (*UM*), *domain model* (*DM*) and *dynamic control unit* (*DCU*). The dynamic control unit is responsible for dynamic creating of the output using information in contained in domain and user model.
Dynamic control unit serves for control of the whole system. Its main tasks are adaptation of domain model on the basis of user model and interpretation of user's behaviour in purpose of actualisation of user model.
Main architecture DCU is based on co-operation of the following four units: user action unit (UAU), adaptive unit (AU), domain model unit (DMU) and user model unit (UMU).

4. USED TECHNOLOGIES

For the description of documents, articles, books, etc. the application of the XML language called DocBook was developed. DocBook is used in our system as the basis for adaptive hypermedia itself. As almost no hypermedia can exist without pictures and multimedia so this basis is extended to SVG language for description of two-dimension vector graphics and SMIL for description of multimedia such as video and sound. The description of semantics is created on the basis of standard frame that provides RDF language. RDF was created as a general tool for structure record of metadata and also it supports present usage of metadata of more standards.

5. CONCLUSION

Education is one of the most important applications of AH systems and it simultaneously shows that it is needed to create the tool that enables to access AH on the web. We try to develop such a tool on the basis of "standard" technologies and mechanisms. There are lots of advantages of AH system build on the basis mentioned above. The most important ones are:

1. The opportunity that can adapt not only the text but also multimedia. This opportunity is given by using SVG and SMIL languages that are based on XML.
2. To simple find of the given hypermedia in the web space by the thanks to using of Dublin Core.
3. Adaptive hypermedia created on the basis of the technologies mentioned above will be functional even in non-adaptive systems. Metadata won't be process in these systems though. It means that the given AH will be able to be represented only statically.

6. FUTURE WORK

At first we must finish the implementation of AH system, adjust the created user and domain models to fit best form to the needs of AH system. Further work will be concentrated on creation of the author tool which allows the creator of AH document the simple opportunity to create and edit the semantics. This tool should be WYSYWIG editor of semantics for the RDF scheme we have suggested.

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Editing of 2D Graphical Information in Mobile Environment

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Fast progress in the mobile technology has enabled us to run a lot of applications that we can find on the desktop computers and on the mobile (PDA) devices as well. The mobile environment however differs in specific aspects that make it difficult to perform the same task as on the desktop computers. The user interface in mobile environment requires new approaches. One of the most important ones is communication with graphical information by means of a small screen. This situation requires specific methods for handling graphical information. The ability of the user to browse efficiently huge amount of very complex graphical information is limited not only due to the limitations of the mobile device and wireless network but also due to the user's existing situation (e.g. limited time to decision making). In general we can say that a software application that provides the human-computer communication in specific environments must be highly adaptable to dynamically changing context of use (hardware and software platform, usage environment). Such a feature of an application is also called plasticity [1]. An application is considered to be more plastic if it is able to adapt to various contexts of use while preserving usability. All above-mentioned aspects force the interactive system to be more plastic. To see better how it concretely affects the application we will decompose it into three parts:

User Interface, which represents the way of interaction of the system with the user.

Functional Core, which represents the functionality and logic of the interactive system.

System Data, which represents all information that is manipulated by the user and interchanged between the interactive system and the user.

The adaptation of user interface or functional core to the context of use is addressed and satisfactory solved in several projects [1, 3]. There are defined abstract models, which can be used for semantic description of these parts and there also exist general methods for solving their adaptation to the context of use. This is not the case of system data, which should be also adapted to the currently active context to achieve the maximal plasticity of an interactive system. The abstract models for semantic description of system data that can be integrated with other two parts of the interactive system are missing. The methods for adaptation of complex application data (especially graphical application data like 3D scenes) solve only very limited application areas and thus the complete context model is not defined. General adaptation concepts based on general abstract system data models and complex context model are missing.

One of our goals is to complete the model of interactive system by designing the missing abstract system data model (ASD). When designing the ASD model we continue in our recent work [2]. We are focusing mainly on semantic description of the application data, which is often marginalized in other approaches. Our ASD model is based on following description scheme:

Geometric information contains mathematical description of object geometries.

Visualization information consists of a set of graphical information.

Structure information describes the ordering of objects in the scene - i.e. hierarchy etc.

Semantic information reflects the relations between objects of non-structural nature (e.g. ownership, functional relations, membership in a group).

Semantic and structural information can be described in the form of a graph. The nodes represent real objects in the scene and abstract objects. The edges represent the relations between objects. Construction of ASD model for certain application data takes place during the user's authoring process. It can be automatic (based on the context information) or manual.

This ASD model is used for designing general methods for manipulation with the system data and adaptation of system data to the context of use. For relatively complex manipulation requirements while adapting the system data (especially application data of graphical nature) we propose methods based on "transformation rules". While the System Data will be defined by Extensible Markup Language (XML), the transformation methods will be based on XSLT [6]. The time consumption of the transformation depends on the complexity of the transformation, which can be set automatically or by the user. Using ASD model the adaptability of an interactive system dealing with complex graphical information increases significantly. The usability of such a system for mobile users is higher.

We have developed several testing applications. One of them helps the user to find the needed information by analyzing the semantic description of the 2D graphical data (mentioned above) and configuring the semantic filter. This semantic filter is then used to extract only the needed information from the graphical data. The semantic description is defined in standard MPEG-7 format [5]. Another testing application tries to manipulate complex 2D vector graphics in mobile environment with minimized requirements on system resources. The data format used is Scalable Vector Graphics (SVG) [4] and the editor is based on JavaScript and runs as a thin client in the internet browser.

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Interaction of Visually Impaired Users in Virtual Environment with Spatial Sound Enhancement

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The number of applications of virtual reality steadily increases. Among the others the applications that should support users with various kinds of impairments are emerging. In our contribution we focus on the system allowing visually impaired users to train in getting orientation in real scene by means of exploring virtual environment.

The navigation in virtual environment in general can have several forms. One possible form generates description of a path from given initial point and the endpoint of the required trajectory [1]. Such navigation is useful in situations where the user requires an optimal path in an unknown environment (A solution to task such as: "Get me from the bank entrance to the cash desk."). In the application described we have chosen another approach where the user can move freely in a virtual scene and get the information about the closest environment using special queries. By means of information acquired in this way the users can make flexible decisions about their next move.

Proposed system allows the visually impaired users to virtually walkthrough in this environment and query for various information about the objects in the scene.

To provide more complex information about environment to the user we are employing special scene description compounding *geometric* description along with *additional information*. The additional information (called *functional* or *semantic* description) describes various scene object's properties and attributes (e.g. material the object is made of, color of the object etc.), inter-object relations (one object is next to another, object is sub-part of greater object etc.) etc.

The sound based information is also employed in this environment – the generated sound of simulated cane tapping along with the spatial audio can give the user new type of information that cannot be mediated in standard way.

The scheme for the user interaction was derived from the real walkthrough scheme used by visually impaired users: the use of cane used as probe producing sounds on collisions with the objects in the environment. The sound carries two types of information:

local – the material touched with the cane

global – echo generated in the room gives the room size information

Spatial sound also increases "level of immersion" and can work as *memoria loci* – reminder of specific room or part of the scene.

The approach described was derived from the experience gained from another audio-based system developed at CTU Prague [2].

The user interface of the *navigator* (module responsible for movement in the scene) is based on the idea of *avatar* (a representation of the user in the virtual environment) which is controlled by the user. It is necessary to provide appropriate feedback on the each operation performed by the user and to the changes (or events) in environment originating in movement

of avatar (possible collision, change of position, view direction etc.). Because the continuous movement would generate too much feedback information, the avatar's movement is discrete.

The question was how big should be the step and the rotation angle (the angle between two adjacent directions). We have performed several experiments and tests trying to determine the ability of visually impaired people to estimate distances and angles in space. The experiments also helped to choose an applicable direction association (it is not possible to report the direction the avatar is facing using angular value – it would demand very strong imagination ability). The results of tests implied following concepts:

- avatar can make turns in 30 degree steps - this means 12 possible directions – like clock dials, the numbers of which are used to describe the direction
- avatar's step length is scaled to five levels (0.2m, 0.5m (as default setting), 0.75m, 1.0m and 2.0m)

User interface does not contain any active components (such as buttons, text input fields etc.) – it is controlled using mouse gestures (mouse gesture can be defined as a sequence of mouse actions (movement, button click etc.) completed automatically once set in motion). We have analyzed the "demand factor" for each gesture using modified GOMS method [3]. The frequency of individual operations has also been analyzed. Based on these information and another aspects (analogy and metaphor criteria etc.) the gestures were assigned to the operations – this means that simpler mouse movements (gestures) are assigned to more frequent actions, the directions of mouse movement are identical with avatar's movement etc. All other actions (e.g. getting basic information about scene (avatar's position, direction, etc.), constructing inspection queries (queries providing information about avatar's neighborhood - direction and distance inspection) and virtual "tapping with the cane") can be also performed using mouse gestures.

Every operation performed by the user generates appropriate feedback in form of comprehensible ("human readable") text. This text is then converted to speech using special module.

Pilot version of the system has been developed and successfully tested – results proved validity of our concepts and usability of our solution.

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General Description of the JPEG2000 Standard

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JPEG2000 [1] is the new international standard for still image compression. The JPEG2000 standard is based on wavelet/sub-band coding techniques and supports lossy and lossless compression of single-component (e.g., grayscale) and multi-component (e.g., color) imagery. In order to facilitate both lossy and lossless coding in an efficient manner, reversible integer-to-integer and nonreversible real-to-real transforms are employed. To code transform data, the codec makes use of bit-plane coding techniques. For entropy coding, a context-based adaptive binary arithmetic coder [2] is used. In addition to this basic compression functionality, however, numerous other features are provided, including: 1) progressive recovery of an image by fidelity or resolution; 2) region of interest coding, whereby different parts of an image can be coded with differing fidelity; 3) random access to particular regions of an image without needing to decode the entire code stream; 4) a flexible file format with provisions for specifying opacity information and image sequences; and 5) good error resilience.

Due to its excellent coding performance and many attractive features, JPEG2000 has a very large potential application base. Some possible application areas include: image archiving, Internet, web browsing, document imaging, digital photography, medical imaging, remote sensing, and desktop publishing. The JPEG2000 core compression algorithm is primarily based on the embedded block coding with optimized truncation (EBCOT) of the bit-stream [3-4]. The EBCOT algorithm provides a superior compression performance and produces a bit-stream with features such as resolution and SNR scalability and random access.

The general structure of the JPEG2000 codec is consists of the following steps: preprocessing,forward intracomponent transform,quantization,tier-1 coding, tier-2 encoding, and finally rate control step.

The input to the encoding process is an image consisting of one or more components. Before any further processing takes place, an image is partitioned into one or more disjoint rectangular regions called tiles. This is done when the original image is quite large in comparison to the amount of memory available to the codec.

In the preprocessing step, each image component has its sample values adjusted by an additive bias, in a process called DC level shifting. The bias is chosen such that the resulting sample values have a nominal dynamic range (approximately) centered about zero. The RGB color space is transformed to YCrCb color space in the forward intercomponent transform step. In the forward intracomponent transform step, transforms that operate on individual components can be applied. The particular type of operator employed for this purpose is the wavelet transform.

The resulting wavelet coefficients are quantized in the quantization step. A different quantizer is employed for the coefficients of each sub-band. In the case of lossless coding, reversible transforms must be employed and all quantizer step sizes are forced to be one. In the tier-1 coding step, the quantizer indices for each sub-band are partitioned into code blocks and each of the code blocks is independently embedded coded.

The coding is performed using the bit-plane coder. There are three coding passes per bit plane. These passes are the significance pass, the refinement pass, and the cleanup pass,

respectively. In the tier-2 encoding step, the coding pass information generated during tire-1 is packaged into data units called packets, in a process referred to as packetization. The packetization process imposes a particular organization on coding pass data in the output code stream. This organization facilitates many of the desired codec features cited before. The rate control can be achieved through two distinct mechanisms: 1) the choice of quantizer step sizes, and 2) the selection of the subset of coding passes to include in the code stream.
The decoder structure essentially mirrors that of the encoder. That is, with the exception of rate control, there is a one-to-one correspondence between functional blocks in the encoder and decoder. Each functional block in the decoder either exactly or approximately inverts the effects of its corresponding block in the encoder. Since tiles are coded independently of one another, the input image is (conceptually, at least) processed one tile at a time. In the sections that follow, each of the above processes is briefly explained. For more details about the whole processes see [1].

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Classifications of the Wavelet-Based Still Image Coders

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The objective of an image compression algorithm is to exploit the redundancy in an image such that a smaller number of bits can be used to represent the image while maintaining an ``acceptable" visual quality for the decompressed image. The redundancy of an image resides in the correlation of neighboring pixels. For a color image, there also exists correlation, which can be exploited, between the color components. Image coder can be classified according to the organization of the compressed bit stream into: scalable image coders and non-scalable image coders. In non-scalable image coders, the complete image is only obtained by decoding the entire compressed bit stream. Truncation the compressed bit stream during the decoding process will produce incomplete reconstructed image. Scalable image coders are the coders that allow compressing the image data once and then decompressing it at multiple data rates or decompressing it at different resolutions of the image. Here by resolution we mean the size of the reconstructed image.

The scalable image coder that is able to decode different resolutions of the image from the compressed bit stream is called resolution scalable coder. While the scalable image coder that has the ability to decode the full resolution image with a certain bit rate from the compressed bit stream is called rate (SNR) scalable coder. Both types of the image scalable (resolution/SNR) coders are further classified into: embedded and non-embedded image coders.

In an embedded resolution scalable image coder, a lower resolution of the image is obtained by just decoding the first portion of the compressed bit stream. While in non-embedded resolution scalable image coder, a lower resolution of the image is obtained by decoding certain portions of the compressed bit stream. In both cases no complete decoding of the whole compressed bit stream is needed. In an embedded rate (SNR) scalable image coder, a lower quality of the image is obtained by just decoding the first portion of the compressed bit stream. By decoding more and more bits we can get a higher quality image (higher SNR). While in non-embedded rate (SNR) scalable image coder, a lower quality of the image is obtained by decoding certain portions of the compressed bit stream. Also, in both cases no complete decoding of the whole compressed bit stream is needed. It is important to note that if a compression technique produces an embedded bit stream, it implies that the technique is scalable, because embedded bit streams can be truncated at any point during decoding. However, not all scalable compression techniques are embedded.

Resolution scalability can be achieved by encoding whole wavelet sub-bands one after the other, without interleaving bits from different sub-bands. SNR scalability can be achieved by distributing encoded bits from one sub-band into the whole bit stream in an optimal way. Another very interesting property of some coders is the ability to decode only certain regions of an image; the property is called random access property.

A coder can support decoding of arbitrary shaped regions or of any rectangular shaped region. Region of interest encoding and decoding is also related to random access. For region of interest encoding, an arbitrary shaped region of the input image is only encoded, and the rest of the image is discarded that does not fall into the region of interest. Random access can be achieved by independently encoding portions of the whole image. All image coders can support random access by tiling the image and encoding each tile independently of the rest.

Embedded zerotree wavelet (EZW) coder [1] and set partitioning in hierarchical trees algorithm (SPIHT) [2] are two examples of embedded rate (SNR) scalable image coder. In these two coders the user can choose a bit rate and encode the image to exactly the desired bit rate. Embedded block coding with optimized truncation (EBCOT) algorithm [3] offers state-of-the-art compression performance together with an unprecedented set of bit-stream features, including resolution scalability, SNR scalability and a "random access" capability. All features can coexist-exist within a single bit-stream without substantial sacrifices in compression efficiency.

JPEG2000 [4] is the new international standard for still image compression. The JPEG2000 standard is based on wavelet/sub-band coding techniques and supports lossy and lossless compression of single-component (e.g., grayscale) and multi-component (e.g., color) imagery. In addition to this basic compression functionality, it has many other features such as: progressive recovery of an image by fidelity or resolution, region of interest coding, whereby different parts of an image can be coded with differing fidelity, random access to particular regions of an image without needing to decode the entire code stream, a flexible file format with provisions for specifying opacity information and image sequences, and a good error resilience. The JPEG2000 core compression algorithm is primarily based on the EBCOT algorithm.

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What's the Embedded Image Coding?

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Embedded image coding is very attractive approach for compressing digital images. Different applications require different data rates for the compressed images and different visual qualities for the decompressed images. In some applications when browsing is required or transmission bandwidth is limited, progressive transmission is used to send images in such a way that a low quality version of the image is transmitted first at a low data rate [1]. Gradually, additional information is transmitted to progressively refine the image. A specific coding strategy known as embedded rate scalable coding is well suited for progressive transmission. In embedded coding, all the compressed data is embedded in a single bit stream. The decompression algorithm starts from the beginning of the bit stream and can terminate at any data rate. A decompressed image at that data rate can then be reconstructed. In embedded coding, any visual quality requirement can be fulfilled by transmitting the truncated portion of the bit stream. To achieve the best performance the bits that convey the most important information need to be embedded at the beginning of the compressed bit stream.

The progressive image transmission or embedded image coding scheme prioritizes the code bits according to their reduction in distortion. To illustrate this concept, assume that the original image is defined by a set of pixel values $p_{i,j}$, where (i,j) is the pixel coordinate. To simplify the notation two-dimensional arrays is represented with bold letters. The coding is actually done to the array

$$\mathbf{c} = \Omega(\mathbf{p})$$

where Ω(.) represents a unitary hierarchical sub-band transformation (e.g., [2]). The two-dimensional array **c** has the same dimensions of **p**, and each element $c_{i,j}$ is called transform coefficient at coordinate (i, j). For the purpose of coding we assume that each $c_{i,j}$ is represented with a fixed-point binary format, with a small number of bits typically 16 or less and can be treated as an integer.

In a progressive transmission scheme, the decoder initially sets the reconstruction vector $\tilde{c}$ to zero and updates its components according to the coded message. After receiving the value (approximate or exact) of some coefficients, the decoder can obtain a reconstructed image

$$\tilde{\mathbf{p}} = \Omega^{-1}(\tilde{\mathbf{c}})$$

A major objective in a progressive transmission scheme is to select the most important information, which yields the largest distortion reduction to be transmitted first. For this selection the mean squared-error (MSE) distortion measure can be used,

$$D_{mse}(\mathbf{p} - \tilde{\mathbf{p}}) = \frac{\left\|\mathbf{p} - \tilde{\mathbf{p}}\right\|^2}{N} = \frac{1}{N}\sum_i \sum_j (p_{i,j} - \tilde{p_{i,j}})^2$$

where N is the number of image pixels. Furthermore, we use the fact that the Euclidean norm is invariant to the unitary transformation , i.e.,

$$D_{mse}(\mathbf{p} - \tilde{\mathbf{p}}) = D_{mse}(\mathbf{c} - \tilde{\mathbf{c}}) = \frac{1}{N}\sum_i \sum_j (c_{i,j} - \tilde{c_{i,j}})^2$$

From the above equation it is clear that if the exact value of the transform coefficient $c_{i,j}$ is sent to the decoder, then the MSE decreases by $|c_{i,j}|^2/N$ [3]. This means that the coefficients with larger magnitude should be transmitted first because they have a larger content of information. This corresponds to the progressive transmission method proposed by DeVore et al. [4]. Extending their approach, we can see that the information in the value of $|c_{i,j}|$ can also be ranked according to its binary representation, and the most significant bits should be transmitted first. This idea is used, for example, in the bit-plane method for progressive transmission [1].

As cited above the progressive transmission scheme incorporates two concepts: ordering the coefficients by magnitude and transmitting the most significant bits first. Ordering the coefficients by magnitude can be performed by the following scenario. An initial threshold To is first determined. The initial threshold To can be chosen so that $| c_{i,j} | < 2To$ for all transformed coefficients. All transformed coefficients (significant coefficients) that have an absolute value above or equal to the threshold are coded. This means that the coefficients with largest magnitude are coded first. These coded coefficients are not scanned in the remaining paths. To code the remaining coefficients (insignificant coefficients), the threshold is halved so that some of these coefficients become significant coefficients relative to the new threshold. The process continues until all transformed coefficients are coded or the desired bit rate is achieved. In embedded coding, usually a wavelet transform is used to decorrelate the image pixels and achieve frequency and spatial-orientation separation.

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Wavelet-Based Astronomical Digital Image Compression

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Nowadays the growth of communication networks and the increasing power of computers lead to large data transmission flows and storage requirements. Digital images generate a large amount of data, especially in astronomical imaging where image frames are obtained by receivers of ever increasing size. A typical 2048 x 2048 CCD with 16 bit/pixel leads to 8 Mbytes data. Such large format CCDs are currently used at the focus of telescopes. for example, The Canada-France-Hawaii Telescope (CFHT) generates about 100 frames each night and these produce up to 800 Mbytes per night which have to be stored. Future telescopes are planned to provide about 10 Gbytes per night.

With high quality digital image acquisition systems the scanning of the astronomical Schmidt plates provides a tremendous quantity of data. A single Schmidt plate produces about 2 Gbytes of digital information at 10?m resolution. These images must not only be stored but they are also currently transmitted over networks for remote observing or data processing. A particular solution to the transfer problem can be found with high bandwidth transmission links, which are expensive to install and operate.

Moreover the problem of image archiving is partially solved with optical disks or very high-density tapes, which do not allow easy access for remote users. A solution can be found by using both data compression and high digital density supports such as CD-ROM [1]. Many techniques have been developed for astronomical images compression. In this paper we present some of these techniques.

HCOMPRESS [2] was developed at Space Telescope Science Institute (STScI, Baltimore), and is commonly used to distribute archive images from the Digital Sky Survey DSS1 and DSS2. It is based on the fast Haar wavelet transform. The algorithm consists of the following steps: applying a Haar wavelet transform to the data, quantizing the wavelet coefficients linearly as integer values, applying a quadtree to the quantified value, and using a Huffman coder, respectively.

FITSPRESS [3] uses a threshold on very bright pixels and applies a linear wavelet transform using the Daubechies-4 filters. The wavelet coefficients are thresholded according to a noise threshold, quantized linearly and runlength encoded. This was developed at the Center for Astrophysics, Harvard.

Embedded image coding (progressive image transmission) is very attractive approach for compressing digital images. In embedded coding, all the compressed data is embedded in a single bit stream. The decompression algorithm starts from the beginning of the bit stream and can terminate at any data rate. A decompressed image at that data rate can then be reconstructed. In embedded coding, any visual quality requirement can be fulfilled by transmitting the truncated portion of the bit stream. To achieve the best performance the bits that convey the most important information need to be embedded at the beginning of the compressed bit stream.

In [4] embedded image coding approach is used for compressing an astronomical image. Three steps are used in this algorithm to compress astronomical digital image as follows: in the first an intensity mapping is used to generate an image that has roughly constant noise in each pixel, an orthonormal wavelet transform is used in the second step, and quadtree coding of the bit-planes of the wavelet coefficients is used in the last step. The

quadtree values may be further compressed by any standard compression technique, such as Huffman or arithmetic coding. If the 2-dimensional Haar transform is used, the calculations can be carried out using integer arithmetic, and the method can be used for both lossy and lossless compression. The Haar transform basis functions are well-suited to most astronomical images because they are highly localized. The performance of the algorithm using smoother, longer range wavelets has also been explored; they can give slightly better lossy compression at the cost of an increase in artifacts around point sources, but they are not effective for lossless compression using this scheme. The algorithm using Haar transforms is being used for compression of the STScI Digitized Sky Survey now being distributed on CD-ROMs.

This technique has been used as the basis of a progressive image transmission system that can be used for either remote observing or access to remote image archives. After less than 1% of the data have been received, the image is visually similar to the original, so it is possible to access the quality of images very quickly. If necessary, the entire compressed data set can be sent so that the original image is recovered exactly.

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Generation of Regression Trees Using Reinforcement Learning

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We propose a new methodology for generation of regression trees that uses some of the concepts of reinforcement learning. Main motivation of our effort is increasing the ability of algorithm to deal with enormous amounts of data and with time-evolving concept exhibited by the data. In this paper we present basic algorithm that will be in future extended to analogical task of decision trees generation.

This is the core concept of reinforcement learning—an agent has no or poor knowledge of the environment and acts randomly. Any action performed in the environment results in some kind of reward. According to this reward the agent reviews its previous behavior and performs better in the future. For deeper insight in this area see [2].

Our approach is motivated by idea that a regression tree could be generated independently of examples that we have (we can see it as a analogy to behavior of an agent in environment). The examples are used to evaluate the produced regression tree (and provide us hence with reward from the environment). According to the evaluation is the generator of regression trees updated to perform better. Algorithm runs in cycles that consist of generation of binary regression tree, its evaluation on training data and update of associative memory of the regression tree generator.

The generator consists of associative memory, the update schema for the neural network and node's attribute and threshold selection schema that bases its selections on neural network. When the tree is being generated we have to decide in each node of its decisive attribute and the threshold value for the attribute. In our implementation we use two step solution of this selection—in first step we choose the best attribute and after that we choose best threshold for the attribute. To select attribute we use prediction of mean square error for attributes and select ε-greedily among them. To choose the threshold for selected attribute we choose in most of the cases threshold mean value predicted by the associative memory and in ε percents of cases we choose random value based on probability distribution specified by mean and variance predicted by the neural network.

After the tree is generated its evaluation is performed on training data. It results in a mean square error of generated tree that is used as the only quality measure of generated tree in the basic version of proposed algorithm. We will in future perform experiments with other regression trees parameters as for example tree depth and number of used attributes.

The mean square error of generated tree is used to update the associative memory so in future better selection of attribute and its threshold value at each node could be performed. Of course to allow the algorithm to learn we must allow it to explore the possible selection among attributes and threshold values. The exploration of space of possible choices is searched using ε-greedy selection, i.e. in most cases the selected attributes have best predicted quality among others, but in a small part of cases, ε percents, the choice of attribute or threshold value is made randomly.

The first variant of proposed algorithm was implemented in the programming language Java. Although Java is not the fastest among programming languages it was chosen because of availability of useful software tools in Java, especially the WEKA Machine Learning Library [3],[4], the JFreeChart library and the artificial neural network library of the OpenAI project [1].

Our implementation is based on the basic concept of separation the classifier generator and the generated classifier. In following sections we describe the classes for classifier generators at first and then we describe the classes for classifiers. In our experiments we used cross-validation to assess the ability of our algorithm to learn and the quality of learned regression trees. Our results show that proposed method is comparable with methods for regression in the WEKA library (the linear regression method, regression by discretization, artificial neural network and others).

During the experiments we focused on two important properties of presented algorithm: on convergence of generated regression trees error rates and on its ability to improve the knowledge incorporated in its associative memory, i.e. to improve the quality of greedily generated regression trees. All datasets are a part of datasets that are available with WEKA library and can be found on the internet at [4]. While the algorithm uses the root mean square error of a generated regression tree, to assess convergence of generated tree we use relative root mean square error (RRMSE). It is important to note, that analogically to simulated annealing methodology we increase the coeficient of greediness during the time of learning, i.e. in the end of learning only best choices are made upon the associative memory.

In our experiments we showed that the proposed method achieves good results in comparison with other methods. The main disadvantage of our method is its high time and memory consumption that is due to immense state space that is needed to be searched through. These disadvantages could be justified in the online version of the algorithm where we keep the learned hypotheses and update it just slightly for most of the incoming examples. The time consuption is also justifiable in the setting when the classifier is learned once and used many times. We believe that further changes towards optimization of our algorithm will lead to substantial improvements of its performance, especially the search space can be significantly reduced by use of greedy tree growing algorithm and then the reinforcement learning would be used to updated the learning hypotheses in accordance with the data generating concept.

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Exploitation of Statistical Methods in Evolutionary Algorithms

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Genetic and Evolutionary Algorithms (GAs, EAs) have been recognized as a powerful optimization tool for a long time. They are robust with respect to the type of problem being solved. Moreover, they are able to escape from the locally optimal solution and find even better, hopefully the globally optimal one.

The EAs are inspired by the nature; they simulate the natural evolution and they use the outcomes of the simulation to solve the problem at hand. The principle is very simple. We encode the potential solution to our problem in the form of a *chromosome* or an *individual*, which is a part of a *population*. All individuals represent solutions of our problem of different quality. The population then undergoes some variation – typically, we apply the genetic operators *crossover* and *mutation*. By means of these two operations, the population should then constitute of hopefully better individuals than the original one. Evolution itself is then equivalent to searching the space of possible solutions, so called *search space*.

The EAs, however, suffer from several problems [1]. One of the most severe is so called *premature convergence*. It is the state when one individual takes over the whole population in the initial phase of evolution giving the algorithm not enough time to evolve better solution. In the state of premature convergence almost no evolution takes place because the population lost all the genetic diversity.

Another conceptual problem presents the way in which the algorithm works with individual parts of chromosomes, so called *genes*. The basic forms of EAs assume that all the genes are independent of each other, which is generally not true. Individuals can present good solutions if they consist of certain combination of genes. In EA community, this problem is called *linkage*, *epistasis* or *statistical dependency*. Both above mentioned problems should be addressed in order to optimize the behavior of EAs [1].

In the last decade of the 20th century, new type of EAs emerged, so called *Estimation of Distribution Algorithms* (EDAs) [2, 3]. They no longer use the genetic operators, crossover and mutation; instead they employ probabilistic and statistical modeling to estimate the distribution of good solutions in the search space. New individuals are not bred in the traditional way (take two parents, cross them over, mutate the offspring), rather the new population is created by sampling from the probabilistic model learned from individuals in the previous generation.

The most of EDA's behaviour is determined by the probabilistic model we use. Several types of models were successfully applied by EDA researchers to various problems. In the field of discrete or combinatorial optimization, one of the most successful model is Bayesian network. This model is used to encode general type of discrete probability density function. In the field of continuous optimization we can analogically use the Gaussian network to encode the general form of normal distribution. We also have possibilities to use the mixture of various density types, etc.

In EDA framework, it is conceptually very easy to take into account both problems mentioned above (premature convergence and linkage). By choosing the type of model, we can assure that in all phases of evolution there will be non-negligible probability of generating

new individuals in all areas of the search space. This way we can successfully fight the premature convergence of the population. Furthermore, if the model is able to cover some interactions between variables (genes) in the individuals, we can also use the information hidden in good individuals and estimate the non-trivial influences of various combinations of gene values, i.e. in some cases, we can make the linkage to work for us.

My research was aimed at models, which allows us to overcome the premature convergence (in this phase I was not concerned with the linkage problem). Several variants of the Univariate Marginal Distribution Algorithm (UMDA, special case of EDA) were tested [2]. They produce surprisingly good results even for hard problems. The probabilistic model they use has simple form. The univariate marginal probabilistic density of values for each gene is estimated; the joint density is then calculated as a product of all marginal densities.

In UMDA, four various marginal probability models were employed: three types of empirical histograms (equi-width, equi-height, and max-diff) and mixture of gaussians. The equi-width histogram is the best-known type of histogram. It has several bins, all of them are of equal width, but they differ in height. Among the tested models, this histogram was shown to be the worst. The equi-height histogram has in all bins equal number of individuals, i.e. all bins are of equal height, but they differ in the width. The last histogram type is the max-diff histogram. It is easilly constructed by placing the bin boundaries in the largest gaps between the individuals. On chosen test problems, these two histogram types, equi-height and max-diff, were the winners.

The last model presented in the study was the mixture of Gaussians (MOG). This type of model is able to describe the distribution of the data with high fidelity, but it takes considerably more time to construct. We must use some kind of iterative learning scheme (e.g. the expectation-maximization algorithm) to build the model. The MOG model produced only slightly worse results than the equi-height and max-diff models. The MOG can be also very easily extended for use as a multidimensional density estimator (which is not the case for the histogram models).

Although the principle of UMDA is very simple because of the assumption the algorithm makes, we have to stress out that in the same time this assumption allows the algorithm to overcome the curse of dimensionality. The UMDA is able to solve separable problems even of high dimensionality, and, surprisingly, it produces good results even for high-dimensional non-separable problems.

In the near future the linkage problem should be addressed as well. This requires the use of non-marginal probability models, which are able to cover interactions among variables. It is planned to employ a kind of tree-based probability estimators, kernel PCA based density estimator and models, which use non-linear transformations of coordinates (e.g. based on neural networks).

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Parallel Auction Algorithms

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The *Linear Sum Assignment Problem (LSAP)* is one of the classic network optimization problems. The task is to find an optimal *assignment* of *n persons* to *n objects*. More precisely, its input is a *cost matrix* $A_{n\times n} = [a_{ij}]$, where a_{ij} is the cost of the assignment of object *j* to person *i*. The goal is to find an *optimal assignment* $M = \{(i, j_i), i = 0,\ldots,n-1\}$, i.e., one-to-one mapping from the set of persons to the set of objects such that $\sum_{i=0}^{n-1} a_{ij_i}$ is maximum. We consider the maximalization formulation of LSAP, since it is closer to real-world auctions. Both minimalization and maximalization versions are computationally equivalent and one can be transformed to the other one. The LSAP can be also formulated using graph theory terminology as a *maximum weight matching problem* in bipartite graphs.

LSAP appears in many real-world problems, e.g., problems to find an optimal assignment of jobs to machines or an optimal schedule of engines in railway systems, or problem to locate or track moving objects (e.g., missiles) in space. It is frequently used as a subproblem in more involved combinatorial optimization problems, such as quadratic assignment, traveling salesman, or vehicle routing problems.

The most popular sequential algorithms are mainly based on the Hungarian method, the simplex method, or the interior point method. Our approach is based on the *auction algorithm* (AA), see paper [3], which we consider the most suitable for implementation on distributed memory parallel computers.

In paper [1], we have described distributed memory implementations of the forward and forward-reverse AAs on a cluster with a Myrinet network. Our algorithms were hybrids between Gauss-Seidel and Jacobi version of the AA and used *block adaptivity* mechanism to reduce the number of messages. Since these algorithms were synchronous, the evaluation of each block of bidders required some communication. Our algorithms were fully memory scalable, i.e., they were able to solve arbitrarily large fully dense instances by just allocating a corresponding number of processors. That eliminated the swapping effect of sequential LSAP algorithms.

Even though the speedup was promising for small number of processors, it was decreasing for more processors due to increasing collective communication overhead. Thus, provided we use the optimal version of parallel AAs for data with a given characteristics, the optimum number of processors is always equal or slightly greater than the minimum number of processors necessary for memory scalability, i.e., for storing the whole instance in their local memories.

The main bottleneck of the standard AA is the bidding round, in which the whole row of cost matrix *A* corresponding to person *I* is searched for 2 objects giving the highest benefits. Thus, each bidding round has complexity of *O(n)* local operations in case of a sequential AA and of

O(n/P) local operations plus one all-to-all reduce communication operation in case of our distributed AA. This observation motivated our further research. We have concentrated on finding a way to reduce the computational complexity.

Our new main result is a new algorithmic technique, we called it *look-back bidding* [2]. In sequential AAs, it reduces the computational complexity of the bidding rounds and in distributed AAs, it reduces interprocessor communication, since the processors can evaluate more bids locally than in the standard distributed AAs. This new technique allowed us to design a more efficient AA, called the *look-back auction algorithm* (LBAA).

The idea of the LBAA is to keep for each person *i* a *working set Wi* of *m* objects with best benefits where $2 < m << n$ is a chosen parameter and it is constant in the current version. The algorithm evaluates *Wi*, i.e., best benefits from previous biddings of a bidding person *i.* If 2 objects with highest benefits are present *Wi* the algorithm does not need to scan the whole row *i* and the look-back succeeds. Otherwise, the whole row of the cost matrix is searched and a new working set *Wi* is built.

Let us look now at the complexity of the look-back bidding. In a sequential LBAA, a look-back failure fires a search in the whole row *i* of objects in the cost matrix *A*, whereas in a distributed *P*-processor LBAA, a look-back failure fires local searches of *n/P* elements and one all-to-all reduce operation. On the other hand, in a sequential LBAA, a successful search in a working set has complexity *O(m)* per one bidding round, since all elements of the working set must be updated to new prices. In a distributed LBAA, a successful search in a working set is a purely local operation. Therefore, the computational complexity is also only *O(m)* and no collective communication operation is needed. This is the main source of performance improvement of LBAA w.r.t. forward AA.

We have implemented the proposed LBAA and compared its performance to Bertsekas's forward and forward-reverse AAs for the LSAP on a homogeneous distributed memory parallel computer. Our experiments confirmed that for huge dense random instances LBAA significantly outperforms previous AAs.

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Auction Techniques for AX (AgentExchange) Multi-Agent Model of Market Environment

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Introduction

Contemporary state of art in theory of electronic auctions does not exactly describe practically used principles enough. This implies in non-effective exploitation of auctions by traders. By understanding auction mechanisms better the main task of auction – effective resources reallocation in compliance with real demand and supply – would be fulfilled more effectively. We understand our task in developing powerful experimental virtual market environment and describing auctions minutely, analyzing their advantages and weaknesses. The first task was already accomplished in our previous work. Current project builds on the result of AgentExchange (AX) project [1].

Our experimental tools contain AX virtual market environment and VXLite that is simplified version of the previous one. AX allows individual agents be run on different computers and to be administered by different supervisors. AX use secure communication and control mechanisms protecting from cheating agents. System contains Trading-agents who own, buy and sell commodities, Exchange-agents organizing the auctions, Bank-agents maintaining money and commodity accounts, and Scenario-agents keeping the market in the move. In this project newly developed VXLite system runs on one computer, does not use accounts, and it does not provide security services. VXLite Trading-agents and Exchange-agents come from AX.

Basic Market Roles

The market is based on the fact that its participants own some commodities (products or services) and desire exchange them against another ones. Using money as a universally accepted commodity separates traders into two classes. The first role is seller, who owns commodity and wants to exchange it for money. Likewise there is buyer, who has the money and wants the commodity. The seller wants to gain as much money as possible and buyer wants to pay as little as necessary to maximize their respective profit. Both market participants' roles are played by Trading Agents in AX and VXLite.

Market Negotiation

Main variants of market negotiation are direct sale and auctions. Indeed the direct sale can be described as a specific variant of Continuous Double Auction with permanent and totally elastic supply.

We distinguish different types of auctions: iterative auctions and sealed-bid (one-bid) auctions. Iterative auctions are further divided by number of sellers (n) and buyers (m) participating in auctions in 1:m (and n:1) relation auctions (English Auction and Dutch Auction) and n:m relation auctions (Double Auction). All iterative auctions are unique if only one exchange is executed, or cyclic when after closing the auction following one is opened. Moreover, continuous variant of n:m relation auction exists (Continuous Double Auction). This one is never finished and new asks and bids are submitted and evaluated during one run of auction. Example of cyclic Double Auction is the New York Mercantile Auction; the most famous Continuous Double Auction is the New York Stock Exchange.

All sealed-bid auctions determine the winner as the one who offer the best price (the highest one if winner buys commodity) but they differ in setting up the price that is paid. If it is the price written in the winning bid, the auction is called the First Price Sealed Bid Auction. Vickrey Auction uses the price written in the second best bit. Likewise the third, forth and others prices auctions are theoretically allowed but they are not used in real life. Alike iterative auctions the sealed-bid auctions are unique and cyclic. Neither AX nor VXLite has implemented sealed-bid auctions in contemporary versions.

Beside sellers and buyers the auction contains another role: the auctioneer. Auctioneer is the one who organizes the auction. It means collecting and evaluating the bids applicable to the auction. The auctioneer role is usually played by the subject specialized to provide this service, or by seller/buyer if there is one seller and more buyers on auction and vice versa. AX employs Exchange Agents as auctioneers. AX doesn't support multiple roles others than seller/buyer by one agent.

Conclusion

Auctions work with the actual demand and supply. The actuality is their power as well as the weakness. Auctions are excellent for sellers and buyers trading from time to time or/and for ones who trade with common merchandise. Auctions (except unique auctions) are not suitable for dealing in highly specific commodity, which require insignificant switching production/consumption costs. The higher this cost is the longer contract a contractor must offer. Otherwise the actual benefit could result in global loss induced by local savings. The necessity to speculate about the future trends suppresses the relevance of the actuality brought by auctions.

Advantages and weaknesses of various auction models were analyzed in this project. Likewise we implemented selected auctions to the AX and VXLite system for further experiments. Auctions implemented in our systems are Continuous Double Auction, which is a basic auction of AX, and English and Dutch Auctions that are basic auctions of VXLite. All investigated auctions use the price as a single criterion for choosing the best bid.

Multi-criteria auctions have become significant (due to increasing use of the theory of constraints in industrial management) but they are still not explored enough to be widely exert. Our future research is aimed to describing them and implementing them in the VXLite system created in this project.

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Scene Reconstruction from Omnidirectional Cameras

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Many practical applications call for a stable ego-motion estimation and a 3D metric reconstruction from a small number of images. It can be achieved, for instance, by using omnidirectional cameras with large angle of view. There exist variety of omnidirectional cameras consisting of mirrors or wide-angle (fish-eye) lenses. In comparison to standard cameras with narrow view angle, omnidirectional cameras capture larger part of a surrounding scene. Large angle of view often allows to establish more spacious point correspondences which leads to a more complete 3D reconstruction from fewer images. We show how large part of a scene can be reconstructed from two omnidirectional images only. An occurrence of degenerate scenes (e.g. when only a single plane is observed in the image) is less probable with omnidirectional images and therefore more stable ego-motion estimation is often achieved.

For many vision tasks cameras need to be calibrated. In the case of omnidirectional cameras, the calibration seems to be complicated. Often, no information about mirror or lens parameters and no calibration object are available. In such situations, it is still often easy to acquire two or more images of a surrounding scene. Point correspondences can be established manually or automatically and the calibration of the camera should be performed from point matches only. This idea motivates our works [1, 2, 3] to calibrate the omnidirectional cameras (dioptric and catadioptric) from point correspondences contaminated by outliers only.

We show that it is possible to obtain a very complete 3D metric reconstruction of the surrounding scene from two or more uncalibrated omnidirectional images. We show that 3D metric reconstruction of the surrounding scene from two or more uncalibrated omnidirectional images can be performed very similarly as with standard perspective cameras. First, the omnidirectional camera is calibrated using image correspondences and epipolar constraint [1]. Secondly, a projective factorization-based reconstruction from many images handling occlusions [4] is used. Finally, an upgrade to a metric reconstruction is performed. The proposed linear estimation techniques give a good starting point for a non-linear bundle adjustment enforcing metric constraints on the reconstruction and including lens nonlinearity. We present in [4] a 3D metric reconstruction technique from uncalibrated omnidirectional images, i.e. from automatically established image correspondences only [1, 2]. We demonstrate our method in experiments with Nikon FC--E8 and Sigma 8mm-f4-EX fish-eye lenses. Nevertheless, the proposed method can be used for a large class of non-perspective central omnidirectional cameras.

Using camera with resolution 1200x1200 pxl and lens with field of view 183deg is equivalent to using camera with resolution 300x300 pxl and standard lens with field of view 45deg in the sense of ratio pxl/angle. Our work shows that very accurate reconstruction of camera positions and accurate reconstruction of scene points can be obtained with relatively small (4 times lower) resolution in comparison to a standard camera. The accuracy of reconstruction of scene points can be improved by using a camera with a higher resolution, e.g. Canon EOS--1Ds.

Some omnidirectional catadioptric cameras, consisting, e.g., of a parabolic, a hyperbolic, or an elliptical mirror, can be aligned in such a way that they possess a single projection center. Such catadioptric cameras can be treated as central cameras and the theory

of central catadioptric cameras can be employed. In practice, however, catadioptric cameras are not central. The most common reason is that i) a non-telecentric lens is used for a parabolic mirror or an orthographic camera and a parabolic mirror axes are not aligned properly, ii) a perspective camera is not placed in a correct distance from its hyperbolic or elliptical mirror, or iii) the mirror shape, e.g. a sphere, does not posses a single viewpoint. All the above may cause that the catadioptric camera becomes non-central and there is no single viewpoint from which all rays would emanate. Using the central camera model for a non-central camera leads to an inaccurate determination of 3D rays corresponding to image points and consequently to a skewed 3D reconstruction. A remedy is to derive the correct non-central camera model capturing the imprecise alignment of the camera and the mirror.

We present a technique for modeling non-central quadric catadioptric cameras consisting of a perspective camera and curved mirrors. The real quadric catadioptric cameras have to be treated as non-central cameras, since they do not possess a single viewpoint. The non-central model allows to reconstruct scene geometry accurately. The art is to find i) a simplified model that is accurate enough to reject outliers but simple enough to provide a tractable RANSAC estimation problem and ii) a sufficiently accurate non-central model providing accurate 3D reconstruction from correct image correspondences. We present a method allowing to solve the correspondence problem, auto-calibrate cameras, and compute a 3D metric reconstruction automatically from two omnidirectional uncalibrated non-central catadioptric images. The method is demonstrated on most common (spherical, parabolic, and hyperbolic) quadric mirrors.

We observed that the reconstruction & auto-calibration with non-central catadioptric cameras is as easy (or as difficult) as with central catadioptric cameras, provided that the correspondence problem can be solved with a suitable approximate central model. It turns out that it is the number of parameters of the camera model that matters rather than the exact centrality of the projection. Thus, spherical catadioptric cameras become most practical. They can be described by a simple model, and therefore easily auto-calibrated, can be easily manufactured, and provide images with fewer blur compared to other quadric mirrors.

Two important conclusions follow from our work. First, the correspondences between catadioptric images can (and need to) be validated using an approximation of the non-central camera model by a suitable central model. Secondly, the non-central camera model has to be used to get geometrically correct 3D metric reconstruction.

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Automatic Comparison of NPR Techniques

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In recent years a lot of effort has been given to the research of incorporation of human perception into the computer graphics methods. Thanks to this we have seen a big progress in several areas, e.g. in the field of comparison of images by a computer. It is well known that classical metrics like root mean square (RMS) error are not sufficient when applied to the comparison of images, because the RMS error poorly predicts the differences as perceived by the human observer. To solve the problem properly the visual differences predictors have evolved. These predictors have been formerly applied for various purposes [3, 4] mainly in the field of the realistic image synthesis. In this contribution we use one of these techniques [1] for comparison of images acquired by 2D-based NPR techniques [2]. The utilization of a NPR technique is in many practical cases more advantageous than the use of a classical realistic technique. Indeed, NPR methods allow us to emphasize or omit details in order to communicate information more effectively. For example, sketch rendered images (one group of NPR techniques) of architectural scenes have shown better result in appreciation between architects and clients, compared with that obtained through realistic rendering.

Nevertheless not as much attention as to comparison of classical rendering methods was given to the comparison of output images of NPR techniques. The existence of a mechanism or a metric able to compare individual NPR outputs is evidently required in many areas where the NPR techniques are used. The motivation for such a research is a suitability of individual NPR techniques for rendering specific scenes and objects. We guess the way towards the solution to this problem has two stages. The first stage is the "low-level" perception stage that we partly address in this contribution by the means of the Daly's VDP [1]. Second stage is the "semantic-level" perception where the phenomena like the meaning of a scene, semantics or context are treated. Since we use the VDP extensively in this work, we first give a brief description of its principles. The VDP is an algorithm for describing the human visual response. The goal of the VDP is to determine the degree to which physical differences between images become visible. It consists of components for calibration of the input images, a human visual system (HVS) model and a method for displaying the HVS visible differences. The input to the algorithm includes two images and parameters for viewing conditions, whereas the output is a map describing the visible differences between them. The output map defines the probability of detecting the differences between the two images as a function of their location in the images. An advantage is that we can see the nature of the difference and use the information to further improvement of the design. However we want to quantify the difference by a single number as well, so we can follow the approach described by Myszkowski [3]: the difference between images $D_{0.75}$ is the percentage of pixels for which the probability of difference detection is greater than 0.75.

We investigated 27 image-based NPR techniques divided into 6 groups: brush strokes, sketches, artistic effects, stylise tools, other techniques and certainly the unchanged original picture. We compared these techniques on several typical input images. These images included a natural photograph of a tree, a computer-generated bust, a classical radiosity scene (Cornell box), a ray-traced scene, and several other images. The radiosity scene contained soft shadows, while the ray-traced scene encompassed only sharp-edged shadows. We compared the output image of every technique with the output image of every other technique, so we

obtained 756 variations of difference maps for each input image (27 techniques plus the original image). For each difference map we computed the difference value $D_{0.75}$ and for each of the techniques we obtained 28 difference values. These difference values were treated as a discrete difference function $D_{0.75}(i)$, where the variable *i* stands for a technique. These functions were plotted in planar and 3D graphs and examined for correlations. We quantified the differences between each pairs of difference functions by the absolute metric $\rho_{0.75}(i, j) = \max | D_{0.75}(i) - D_{0.75}(j) |$, where *i, j* denote technique *i* or *j* respectively.

The results have shown that the absolute values of differences are high for particular methods, because the difference of the original image and the image produced by these NPR techniques is typically considerable. Therefore the difference is easy to detect for an observer and the absolute value of difference between images $D_{0.75}$ is high. Consecutively we have investigated the coherences between the tested techniques to be able to classify them. Coherences between discrete functions were examined using previously defined absolute metric. Using the 5% threshold we were able to distinguish three groups of techniques, that reflect our vague knowledge of common properties of the given techniques. In the group 1 there are techniques that do not distort the image a lot, they are just "improving" the input image in some purpose. Group 2 consists of "point-based" techniques and finally in the group 3 there are techniques producing similar "shake" distortion.

We have described our first steps towards finding a mechanism, which would be able to automatically compare NPR images. We have investigated the properties of the images obtained by various image-processing techniques, using the visible differences predictor. We have observed that by such a low-level mechanism like the VDP is (from the point of view of the complexity of the human perception of the NPR images) we are able to distinguish some of the naturally vague defined groups of images with similar properties. Next, we have observed that the absolute values of differences are inherently high for several techniques and these values are generally lower for synthetic images than for the photographs. However, it is evident that the VDP-like mechanisms are just a first stage in the field of comparing of the NPR techniques. NPR techniques are often utilized in such cases where we want to highlight fundamental semantic informations incorporated in the image, which principles of "low-level" perception are unable to catch. In the future, we will carry on psychophysical experiments on human subjects in order to validate the presented results. We will compare the results with other algorithms describing the human visual response to design an algorithm, the result of which will correspond with "semantic sensation" of a human observing a NPR image.

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Support of Information Subjects Education through Information Technologies

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Endeavor after faculty-wide information science education increase on the Faculty of Transportation in Prague is our project target. Particularly, it is question of following subjects: "Konstruování s podporou počítačů" (***Constructing with Computer Aid***), "Služby internetu a tvorba WWW stránek" (***Internet Services and WWW Pages Creation***) and "Prezentační a databázové systémy" (***Presentation and Database Systems***).

Since information subjects require, except theoretical training, also practical computer training for which only limited time is enabled in the course of training (for combined study, this time is extremely brief), the project solution was addressed for creation of the Web Interface accessing training materials in electronic form. Afterwards, a student is in a position of getting to know with theoretical fundaments of certain subjects and train them with the help of sample examples later.

Both timely and locally unlimited student access to computerized training materials for three information subjects is the project result.

The project realization was based on completing of the Faculty Web Server with necessary disk capacity for store of training materials with perspective plan of another subjects processing to electronic form. As for given purpose, the computer power is adequate and no other upgrade is necessary. The Faculty of Transportation connected all servers to its backbone network of 1 gbps transmission rate and consequently, no access rate barriers arise. For work on the given objective, one workplace was completed with a computer and scanner for scanning existing photographs and materials creating a part of electronic lectures. Furthermore, this workplace was completed with a digital camera enabling acquisition of picture material helping students to make better sense of studied problems.

Project results are presented on the Faculty Web Sides; addresses for individual subjects follow: http://dps.fd.cvut.cz , http://siw.fd.cvut.cz, http://autocad.fd.cvut.cz

After user name and password entering, the sides are accessible for both students and faculty employees. Sample examples are accessible even without user name and password entering; they serve as public information and inform about lectured problems in given subjects. Following three paragraphs contain a brief abstract of problems for information subjects solved in the project frame which are accessible on the Faculty Web Sides.

Presentation and Database Systems

On preface, it must be emphasized the information subject serves for presentation systems and relation databases training. On this point, presentation systems are not solved because it is the question of intelligible problems which is comprehensible in the frame of training during practices.

Database system are divided into five theoretical parts and solved examples. Theory of relation databases – basic terms is solved in the first part. Students are got to know with basic terminology. They learn to understand terms as data model, database, database scheme, database source, database tools, relation data model and E-R diagram.

Problems of database structure, basic normalization principles, remunerative decomposition, functional dependencies, candidate keys and normal forms are solved in the second part. Relation modeling is solved in the third part. Terminology: relation participants, relation level, full and partial relation participation, 1:1, 1:N, M:N relations definition. Unary and ternary relations modeling. It is necessary to ensure data integrity during database design. In this project, students are getting to know with terms of domain, transition, entity, reference, database, and transaction integrity. Terms of relation algebra and basic SQL language commands are lectured in the last theoretical part.

After theoretical part, example part follows. It will be extended in later years. An example of "e-shop" application is at everyone's disposal. On this example, it is possible to obtain a conception of spreadsheets creation, spreadsheets relations, queries on certain entries in a databases, data-entry forms and reports.

Internet Services and WWW Pages Creation

These days, students´ capability of work in network environment and presentation their own work through web sides represents an integral part of study work. Especially project-oriented training leads up directly to effort of release of work results on web sides. It eventuates in urgency of work on own theme, increased motivation to "presentable" results and overview of another ones´ focusing, optionally problems of thematic solved by them. This "motivation" environment raises students´ interest. The prepared course is divided into two basic parts.

The first is addressed on problems explanation of network history, data transmission technologies, Internet protocols and user environment setting. The problems are followed by simple and comprehensible examples.

The first is addressed on proper web sides creation. Practically, it means to know proper location for files which may be made public for other users and learn bases of the HTML language (tags, syntax, extension) as a basics for web publishing. Once again, the problems are followed by numerous examples.

Constructing with Computer Aid

The subject serves as general getting to know with CAD system problems and capturing of work in the AutoCAD (2D) environment. Students are progressively acquainted with the system facilities and user configuration possibilities enabling full use of electronic designing tools during solving of engineering problems in the field of transportation infrastructure. The Web Interface is divided into two parts:

1 Week schedule defining training procedure in the course of semester together with construction examples serving as a guide (instructions) for proper process during self-study.

2 Complex traversing of given thematic together with account of all settings, particular construction commands and systems variables with practical demonstration of solved entries.

Also drawing web presentation of some entries of our faculty's master study and transportation and engineering practice is an indivisible part of the subject. Consequently, a student is in a position to see the target which may be achieved.

Excepting capturing of basic work with the AutoCAD system, students may understand high creativity and CAD technologies application possibilities in practice.

Radiance Caching for Fast Global Illumination with Arbitrary BRDFs

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Global illumination is a physically accurate calculation of lighting in an environment. This simulation involves estimating light intensity at any visible point of the environment. The complexity of the task lies in the fact that light can reach the visible points not only directly from a light source but it can also undergo many reflective/refractive events on its way from the source. The properties of light reflection on a surface are fully described by a BRDF – bi-directional reflective distribution function – that describes how much light coming from certain direction is scattered to a different direction. BRDF corresponds to a 'look' of the surface. For the purpose of lighting simulation, we distinguish three types of BRDFs: *diffuse*, reflecting light to all directions equally regardless of the direction from which it comes; *specular*, acting as a perfect mirror and *glossy*, which is basically anything between diffuse and specular. Glossy BRDFs are the most hard to simulate since there is no special property that can be exploited to ease the task of lighting simulation.

In our contribution we propose a method to make Monte Carlo lighting simulation in presence of glossy materials feasible even when we take into account multiple light scattering events. The method exploits the fact that there is a strong coherence in indirect light field reaching a point in the scene. By indirect light field we mean all light reaching certain point that has been reflected at least once on its way from light source. Indeed, the expected change of this light field with change of position is very low and this fact can be exploited to speed up the computation by *interpolating the indirect light field* from a number of high quality samples. The basic idea of the algorithm is based on Ward's irradiance caching [1]. The algorithm is and extension of ray tracing and proceeds as follows: rays are cast into scene from camera, for every ray/surface intersection direct lighting and perfectly specular term are computed as in standard ray tracing and then comes the caching: Are there any samples representing indirect incoming light near this point? If yes, use these samples to interpolate the indirect lighting, otherwise compute a new indirect light sample, use it as indirect light for this point and moreover store it into the cache. In this way the cache is filled in a view dependent manner and as it gets filled, the indirect light can by estimated by a mere interpolation for more and more points. In Ward's work this scheme was used only for diffuse BRDFs and the physical quantity stored in the cache was the *irradiance* – a cosine weighted integral of all light arriving at a point from any direction. For a diffuse surface the reflected light in any direction is a mere product of surface reflectivity and irradiance. This makes irradiance caching a very effective and efficient algorithm. Glossy BRDFs are, however, in Ward's framework simulated by a direct application of Monte Carlo sampling that is very slow.

Our work extends the notion of caching of incoming light from caching irradiance to caching the full incoming radiance field at a point. Doing this allows us to interpolate on non-diffuse

surfaces saving a lot of computation time. Even if we work with very different quantities, the basic structure of the caching algorithm remains the same as in the original paper.

Radiance at a point is a function defined on hemisphere. We represent it by *hemispherical harmonics* (HSH), a technique we developed for the purpose of representing arbitrary function on hemisphere. With HSH a function is exactly represented by an infinite sum of products of coefficients and hemispherical basis functions and can be approximated by truncating this sum to a finite number of non-zero coefficients. Therefore the radiance samples in the cache consist of a vector of HSH coefficients. To interpolate between samples, we interpolate the coefficients, which is a valid approach since the HSH is a linear orthogonal basis.

Computation of outgoing light at a point is a hemispherical integral of incoming radiance field multiplied by the BRDF. In our system we represent BRDFs by a HSH expansions which simplifies the hemispherical integral to computing a dot product of BRDF and incoming radiance coefficients: an operation which is many times faster than Monte Carlo estimation of the integral.

Interpolation of radiance samples may lead to visible artifact that can be alleviated by using a higher order interpolation scheme. To this end Ward [2] proposes to compute irradiance gradients and use them as additional information for interpolation. We extend this approach by computing gradient for every coefficient of our HSH radiance representation, which in effect implies a very high order interpolation scheme that yields additional precision of the interpolation. We also propose a novel technique for computing the translational gradient which not only is better theoretically justified but also provides more accurate results.

We propose an adaptive representation of BRDFs. Each BRDF is represented by only as many coefficients as needed to obtain a user-specified accuracy. The radiance field at any point is represented by the same number of coefficients as is needed for the BRDF of the surface the point lies on (since more coefficients would be cut off anyway by BRDF low-pass filtering). This yields an elegant solution to the problem of choosing the number of coefficients for radiance representation. It is also important that we do not require any knowledge from the user to successfully use the algorithm: he or she provides only the desired accuracy.

Another problem that arises in a practical implementation of the caching is the HSH rotation. Every radiance sample is represented in its local coordinate frame determined by surface normal and tangent. The coordinate frames have to be aligned before the coefficients can be interpolated which leads to a HSH rotation. A general HSH rotation is a very costly operation and it is not affordable to perform it every time we interpolate. We solved this problem by decomposing the rotation into the ZYZ Euler angles (every rotation can be decomposed into three elementary rotation around Z, Y, Z axes) and approximating the Y rotation by its first order Taylor expansion. The rotation matrix for this approximation is tridiagonal and it is therefore very efficient to use it for rotation.

In conclusion we have proposed a complete solution for radiance interpolation that allows an efficient global illumination in scenes with general BRDFs. The techniques we have developed to this end are general and can be used for different purposes.

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QoS in Layer 2 Networks

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Capacities of backbone Internet circuits have increased such that most circuits are now lightly loaded or "over provisioned" (loosely defined as being loaded up to 10% of their installed capacity). Access networks (LANs and MANs) are often loaded to higher percentage of their capacity. Utilization peaks are also higher in access networks because of lower traffic multiplexing when compared to backbone circuits. Access networks are often based on layer 2 (link layer) infrastructure or on the combination of layer 2 and layer 3 (network layer) infrastructure. If we find that some explicit network QoS provisioning is needed in access networks o provide end-to-end QoS guarantees, such as priority or bandwidth sharing, it must be implemented with equipment available in access networks. This is usually represented by layer 2 switches sometimes enhanced with some layer 3 functionality.

At layer 2 QoS a service codepoint denotes a class of service for a particular packet. IEEE 802.1Q standard defines architecture for virtual bridged LANs (VLANs). A part of this architecture is the format of a tag header that can be used to carry VLAN ID and user priority, which is a service codepoint in IEEE 801.1Q networks. The tag header is inserted in an Ethernet frame after the source address field. The user priority field is three bits long allowing for eight different priority values. Each priority value was originally designed for certain purpose, namely 0 for best effort traffic, 1 for background, 2 for spare, 3 for excellent effort, 4 for controlled load, 5 for "video" < 100ms latency and jitter, 6 for „voice" < 10 ms latency and jitter and 7 for network control.

On a Linux host, the user priority field can be set as a part of IEEE802.1Q VLAN support or using a RAW socket. Alternatively, the user priority can be set on the connecting switch. Cisco uses the term CoS (Class of Service) to denote user priority. Cisco Catalyst 2900 and 3500XL switches allow one default CoS value per input port. On Cisco Catalyst 3550 switches, each port can have one default CoS value and one CoS value set for packets selected by an access list. For already tagged frames, their CoS value can be trusted or it can be overridden by a default CoS value.

According to IEEE 801.1Q standard, bridges must have ability o regenerate user priority. For each input port, a user priority regeneration table specifies correspondence between input and regenerated user priority. Default mapping is 1:1. Bridges can provide more than one transmission queue for each port. Frames are assigned to transmission queues according to their user priority using a traffic class table. Queues are mapped 1:1 with traffic classes. Furthermore according o IEEE 802.1Q standard, packets of the same user priority for a given combination of the source and destination addresses must not be reordered. We should consider this requirement when using policing on Cisco Catalyst 3550 switch. Out-of-profile packets can be dropped or marked down, that is their user priority can be changed. Due to different user priority, these packets can be put in a different queue, which can result in packet reordering.

Numerous articles on layer 3 QoS provisioning have been published. Here follows a short review of the service codepoint storage for layer 3, which is important for interaction with layer 2 QoS. Within the context of differentiated services in IPv4 and IPv6 networks, differentiated services codepoint (DSCP) field in the packet header can be used to indicate desired service, as specified in RFC 2474 and RFC 3260. DSCP redefines older IPv4 ToS octet and IPv6 traffic class octet. DSCP uses upper six bits of the former ToS octet. In MPLS networks, the desired service can be indicated in three experimental bits in an MPLS label stack entry. A sequence of these entries, comprising a label stack, can be stored after a link layer header and before a network layer header. Three experimental bits allow for up to eight different classes of service. MPLS also permits to infer a class of service directly from the label, to support more different classes of service. When interfacing a pure IP network with a MPLS cloud, the DSCP field in an IP header can be copied into experimental bits and the label in a label stack entry or vice versa. Network devices within a MPLS cloud can use experimental bits and the label to differentiate between classes of service.

When QoS support is configured on a Cisco Catalyst 3550 switch, packets are processed in several stages: classification, policing and marking are performed on input (ingress), queuing and scheduling are performed on output (egress). As a result of classification, each packet is assigned an internal DSCP, which determines further actions performed on the packet. For both IP packets and non-IP packets the following classification actions can be performed: An access list can be configured and a packet matching this list is assigned a specified internal DSCP value. User priority (called CoS in Cisco terminology) in a packet can be trusted and transformed into an internal DSCP value with the CoS to DSCP map. All packets can be assigned a default internal DSCP value of 0.

For IP packets the following additional classification actions are possible: DSCP value in a packet can be trusted and transformed into an internal DSCP value with the DSCP to DSCP mutation map. IP precedence in a packet can be trusted and transformed into an internal DSCP value with the IP precedence to DSCP map

Cisco Catalyst 3550 is a multilayer switch now commonly used in access networks. Individual ports can be configured as switched or routed, all commonly used routing protocols are available. However, we do not need any routing capability to implement QoS with Cisco Catalyst 3550 in an access network. All ports can remain configured as switched. The switch can convert layer 2 service codepoint (user priority, called CoS in Cisco terminology) to layer 3 service codepoint (DSCP) and vice versa, using the CoS to DSCP map and DSCP to CoS map. Queuing decision is based on output CoS, that is on the layer 2 service codepoint. The mapping features and capacity sharing worked for us as requested with small difficulties that should be considered when configuring he switch. First, the access-list failed to match all traffic. Second, it was not possible to set the port to trusted or override state and attach an input policy to this port a the same time.

Reliability Characteristic's Computations for Railway Crossing Interlocking Equipments

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The reliability analyses, models and reliability characteristics calculations of this system are described in this paper. Markov Chain models and Reliability Block diagrams are used for the reliability analyses of the railway's interlocking equipment. The TMR principles for fault tolerant system and the dual TMR logic have been used in our design and both attempts are compared.

This paper describes reliability modeling of the architecture of a safety system of the railway's interlocking equipment. The system will be used for control of the railway-crossing gate. This system is based on FPGA blocks and has to respond to the requirements for a fault tolerant system with a fail-safe function. The dual logic and the TMR principle are used to increase its dependability. Several self-test and self-diagnostics features are used, such as an LFSR built-in self-test, the FPGA readback and 1 out of 2 error detection codes. The function logic uses a majority correction and the FPGA box reprogramming for fails.

The reliability characteristics of previous described system are compared with the characteristics of the railway's interlocking equipment that are in use now. These systems are mostly based on the relay principle. The reliability of the AŽD 71 railway's crossing gate was modeled and evaluated, because any corresponding values are not available. The reliability block models of the relay's control system and of the whole equipment with all peripheries are made and evaluated. The values are also compared with reliability characteristics of other railway's interlocking equipment used by Czech railways, which was presented by its producer.

The safety function in railway's application was always based on the gravitational attraction (e.g. by relays or mechanical signals) for the stop-signals and on the mechanical pull or on the big value of the electrical current for the permit signal. It is very difficult to prove that the interlocking equipment with the electronics blocks is safe. The railway's operators are afraid of these blocks' unreliability and dangerousness. This paper shows that the fears of railway's operators are unjustified.

Since the electronic blocks were successfully used in the space program, the railway's operators have allowed using of these blocks in the railway's interlocking equipment. New designed systems usually use microprocessors, programmable or ASIC blocks are used only rarely. But the features of the programmable gate arrays (e.g. FPGA, CLPD) predestine these blocks for wide use in the railway's applications.

Authors of this paper want to show advantageous feature of FPGA for the design and reliability calculations of railway's interlocking equipment.

A real-time computer system (e.g. railway's interlocking equipment) must react to inputs from controlled object and from the operator. The instant at which a result must be produced is called a deadline. If a catastrophe could result if a firm deadlines missed, the deadline is called hard. A real-time computer system that must meet at least one hard deadline is called a hard real-time computer system or a safety-critical real-time computer system. [2]

The fault tolerance is very important in the safety-critical real-time application, when one component fail can cause the critical failure of the complete system (missing a hard deadline).

Therefore the error detection is very important in such system. The error detection needs good knowledge about the system behavior. This knowledge is based on the regular definition of the system behavior or on the comparing of two or more redundant systems.
The railway's interlocking equipment based on the principle ”2 out of 2” is tolerant to the no fault. But this system can be fail-safe, of course. The fault-tolerant systems work with principle ”2 out of 3” (TMR). The most safety and reliable railway's systems are based on the Dual TMR principle (D-TMR).
From the obtained results can be clear that a two times greater MTBF has been obtained with the Dual-TMR. This result can be expected with respect to 2 independent TMR systems using. But if the second system is implemented in one FPGA circuit and its design is only extending of the first one, the implementation is advantageous, because either the design cost, or the hardware overhead is not two times greater. Therefore this system is better then a classic hot back up.
This interlocking plant uses Dual-TMR arrangement and satisfies all the requirements of standards for system with safety integrity level 4 (SIL 4) [3,4]
This great value of the MTBF exceeds thinkable time of live for the railway's interlocking equipment, but this value is important, when more applications of the interlocking plant are really used in the traffic process. Then, it means the lower cost for maintenance of the interlocking plant.
For the reliability modeling and calculations SHARPE software has used. This software tool computes the reliability characteristics from a block diagrams, Markov-chains, tree analyses, etc. The hierarchical structure of the models can be exploited.
From the presented and computed values of the reliability follows that railway's interlocking plant with FPGA is at least so good, as other railway's interlocking plant with the processors or with the relays.[1].
The interlocking equipment of the designed railway's crossing interlocking plant has 1000x better MTBF that recently used railway's crossing interlocking plants and has 4x better MTBF of the complete interlocking plant with all necessary, but not so reliable peripheries.
The authors are convinced that new designed interlocking plants should be designed as a fault-tolerant system. In connection with the recommendation that all faults in the redundant parts are repaired within 24 hours, the railway's interlocking plants will be more reliable and safe.
The authors hope, that this work contributes to more expansion of the FPGA and others microelectronics blocks for using in safety critical applications.

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Symbolic Rule Extraction and Visualization using Network Function Inversion

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Due to ever increasing amount of collected data, automatic knowledge acquisition has become a key concern in artificial intelligence. An important type of representation, in which knowledge is represented, is sets of symbolic IF…THEN rules, as it is well understood by humans and amenable to symbolic manipulation and inferencing techniques. *Rule extraction using neural networks* [2] presents an attractive approach to knowledge acquisition because it combines the straightforward manner in which neural networks can learn from training data with the above given advantages of rule sets. The process of rule extraction using neural networks proceeds by first training a neural network on the data being analyzed, followed by transformation of the resulting network into a corresponding rule set representation. Extracted rules are of the form

$$\text{IF } x_1 \in S_1^{(k)} \wedge \ldots \wedge x_N \in S_N^{(k)} \text{ THEN } Class(X) = c_k \,,$$

where $x_1 \ldots x_N$ are values of attributes for a given object X, $S_1^{(k)} \ldots S_N^{(k)}$ are intervals or sets of discrete values and c_k is the class to which an object X is possibly classified by the rule.

Rule Extraction using Neural Network Function Inversion

An important type of neural-network-based rule induction techniques is techniques that employ inversion of the network function in rule induction process. Before generating decision rules, such methods first construct an inverse model of the neural network, which has been previously trained on the analyzed data. Inverse network model is subsequently used to find input space regions corresponding to individual output classes. Boolean decision rules can be then readily obtained by approximating the obtained input space regions by e.g. hyperrectangles. Moreover, inverted network can also be used for visualizing decision regions and thus obtaining greater insight into the induced classification model.

In the course of the project, we focused on two network inversion methods, both intended for networks with continuous inputs and outputs. The first of them, *backpropagation of polyhedra*, was originally proposed by Maire and is intended for feedforward neural networks with sigmoidal or linear activation functions. It is based on backpropagating regions, represented by unions of polyhedra, from the output back to the input layer. The required accuracy of polyhedral approximation can be controlled by method parameters and influences the number of polyhedra comprising the inverse image. The other network inversion method we examined was Holeňa's extension of Maire's method. Instead of sigmoidal neural network, Holeňa uses networks with piecewise-linear activation functions. The advantage of piecewise-linear networks is that their network function preserves linearly constrained sets. Consequently, the method is able to construct an *exact* inverse image of the output-space polyhedron.

Three-Stage Rule Induction

Following the investigation of network-inversion based rule induction methods, we have proposed a novel *three-stage approach* to rule induction [1]. This approach can be considered

a generalization of neural-network-based rule induction methods. It consists of the following stages:

1. Induction of an accuracy-optimized auxiliary model
2. Decision region connectivity analysis of the auxiliary model
3. Generation of the comprehensible descriptive model

Three-stage rule induction approach is motivated by Van De Merckt's *two-functional model*. The noise filtering function is performed by the auxiliary model induced in step 1, the disjunctive bias of the description generation process is realized by *decision region connectivity analysis*. In contrast to two-functional model, the three-stage approach realizes the disjunctive bias independently of any particular auxiliary model used for noise filtering. This gives it higher flexibility as it allows choosing the auxiliary model with respect to the problem at hand.

The proposed three-stage method has several advantages over direct rule-induction methods. The use of continuous auxiliary model together with its higher-level descriptions obtained in Stage 2 allows *late*, *context-dependent* and *dynamic discretization.* Since the induction of the auxiliary model is optimized with respect to its statistical properties, the noise of the input to rule induction process is reduced. Another advantageous property of the three-stage method is its modularity. The method stages are to a great extent independent. Techniques used in Stage 1 and Stage 3 might be therefore varied, depending on the problem at hand. Besides serving as a rule induction technique, the three-stage method can be used to derive comprehensible descriptions and visualizations of existing black-box classifiers.

Conclusion

We have reviewed methods for network function inversion and identified two methods most suitable for the task of rule induction. In order to improve flexibility of the method, we have then generalized the rule induction method based on network function inversion and proposed a novel three-stage rule induction method. The key property of the method is the application of decision region connectivity analysis to obtain a multiple-level view of the classification model (and relationships in the data), and careful utilization of this knowledge to guide the generation of its comprehensible description. We employed some of these ideas during the analysis of medical data [3]. There is a great chance that such an approach might improve on rather blind search process that classical rule induction algorithms perform. Whether this really is the case has to be verified by further research.

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Experiments and Simulation of BR(r) Scheme

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This abstract describes a simulation of BR(*r*) scheme [1] as a part of the GASTON Large-scale File System project. This file system (FS) uses a data replication to increase reliability and data availability [2]. To easily synchronize all data replicas, a tree-topology overlay replica network (RN) for every data object is built over a system network (SN). For scalability reasons, each node keeps only local knowledge about network and thus a single RN node failure causes an RN fragmentation. A BR(r) scheme is a method, whose task is to reconnect all the network fragments and enable multicast communication among replicas of a given data object to continue even after a node failure.

The BR(*r*) scheme is based on the following principle. A bypass ring (BR) of radius *r*, centered in the node *c* is a virtual ring connecting selected RN nodes in the distance *r* edges from *c*. BRs of radius r_{max} are created around every RN node and are used for connecting tree fragments in case when this node fails. The node failure is detected by one or more its neighbor-nodes who become repair initiators. Using REPAIR messages they create a bypass cycle tightly surrounding the failed node (or a cluster of failed nodes), and makes the connection among the tree fragments. In order to avoid cycles in the restored tree, a distributed repair algorithm determines a single edge to be omitted from the cycle.

We use some helpful software to create the BR(*r*) scheme implementation. The basis is a network simulator NS-2 that forms a platform for the entire GASTON FS development. NS–2 [3] can simulate many network protocols and environments; the topology is described in OTcl scripts and the simulator is implemented in C++.

The aim of the previous work [4], which is now being reassumed, was to use NS-2 to develop a DFS agent. Various needful modules are now supposed to be hung on the agent to set the FS working. Each module attaches its own packet handler, an OTCL command handler and a timer handling routine. The agent then calls them upon every occurrence of such an event. The agent, modules for a simple replica management and the TAPESTRY substrate for data location and routing are already completed. BR(*r*) scheme is implemented in C++ as a module attached to the agent to increase fault-tolerance of the system.

The NS-2 simulator processes an input OTcl script and calls the appropriate command handling routines. The script describes the RN topology built over TAPESTRY substrate. The physical topologies are created by either BRITE or TIERS network generators. The RN is constructed using utility *brite2tap* for the generation of the DFS agents on the selected nodes and utility *brite2tree* for the creation of the RN itself among the agents with given parameters. By analogy, utilities *tiers2tap* and *tiers2tree* are used with physical topologies generated by TIERS. Both generators are widely configurable and their outputs can be easily converted to OTcl using the mentioned utilities.

The BR module is attached to the DFS agent by the following way. A *DAM_BR* class implementing BR(*r*) scheme is inherited from agent's abstract class *DAM_FaultToleranceManager* and implements three elementary virtual methods – handlers. A method *processPacket()* is appointed to process incoming packets, a method *processCommand()* to execute OTcl commands and *tick()* serves as a timer handling routine. All these methods first have to be registered by the agent, who is then expected to call them in case it can not treat them itself. Besides these methods usually implemented by every module,

the class *DAM_BR* includes a method *makeFailSafe()*, which is called from the TAPESTRY system network module when adding or removing a node – a RN neighbor. Its goal is to update BR records concerned with the change of the topology during the repair process. Finally, method *initiateRepair()* is called whenever a neighbor failure has been detected. It sends a REPAIR messages to both BR directions and thus initiates the tree recovery.

To verify the functionality and to find out the repair process features, there are about 20 measurements prepared in advance. They focus on the failed area topology change and its properties, the repair process network overhead, the time of the reparation, the maximum size of repairable cluster, the probability of a successful repair and others. The majority of these quantities are showed in the resulting graphs in percents, expressing the rate before and after reparation. On the x-axis appears the most frequently the number of fragments of the decomposed tree (NFDT), the average branching factor (ABF) of the failed area, the number of failed cluster nodes, etc. It is desirable to take some measurements with a certain parameter. This is usually the number of repair initiators (nodes initiating the repair concurrently) or the reconnection method. For the measurements we use physical topologies of Waxman type generated by BRITE, hierarchical IP topologies created by TIERS and random topologies. The networks are used in sizes of 50 to 500 nodes where a specified percentage of them become TAPESTRY nodes in the RN. One generated network is able to run multiple successive simulations. The node failure and its reparation are controlled by the OTcl script, which assigns the failure at a particular moment. The failed node then chooses some of its neighbors that join the failure (a cluster arises) and it also determines which children of theirs become the initiators. The NFDT then depends just on the probabilities of these selections and in addition on the ABF of the failed area.

From the measurement results we have obtained so far (they concern particularly the recovered tree topology changes), we can see several repair process features. The properties of the newly created topology correspond to our presumptions, whether the measurement was concerned with the RN (bypass edges) or the SN. In both cases, it was confirmed that the tree recovery with LRM reconnection method [1] nearly preserves the number of the network edges and that depending on the NFDT it linearly increases the area diameter and preserves the network's ABF. All these properties are independent on the number of repair initiators.

Contemporarily, the important measurements proving the correct functionality of the BR module have already been completed. The module works according to the expectations and is able to become a part of the GASTON FS. The performed experiments confirm the BR(r) scheme to be a simple, flexible and efficient method for a multicast failure recovery.

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A Concept of Survivable Trees and its Application in a Fault-Tolerant Multicast

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The general term *survivable network* indicates the inherent capability of a communication network to continue to provide service or fulfill its mission in the presence of failures of network components. A survivable network leaves users of such a network unaware of failures as long as it can guarantee the survivability and thus it adds a level of abstraction to the system. In this paper we briefly summarize results of an ongoing research in the area of failure recovery of tree-topology communication networks [1]. We introduce our concept of survivable trees, identify restrictive characteristics imposed by large-scale network infrastructures and propose vital properties of a general solution of a tree recovery mechanism for a survivable tree applied in a fault-tolerant multicasting.

For the concept of survivable trees, we consider an underlying communication substrate of an arbitrary topology with routing capability, on top of which an overlay tree-topology network, modeled as a graph $T = (TM, CE)$, is built. TM is a set of tree member nodes and CE represents a set of virtual edges of T. A message transmission over a virtual link consists of a sequence of transmissions over one or more links in the substrate.

For scalability reasons, nodes from TM set dispose only a local knowledge of topology. Thus, even a failure of a single tree-node causes the tree to be partitioned into several fragments as the distributed knowledge is broken. Let FC be a nonempty subset of TM and $<FC>$ be a connected vertex-induced subgraph of T. A failure of FC in T is a vertex set removal of set FC from T, $T \setminus FC$, such that $T \setminus FC$ is partitioned into fragments T_i; $i = 1, 2, \ldots, card(A_T(FC))$, where $A_T(FC)$ is a neighbor set of FC in T; FC is called a failed cluster of nodes.

We define a *survivable tree* as a tree-topology communication network capable to deliver a message in a timely manner to all its correct member nodes even in the presence of failures in the tree. In order to achieve this goal, a survivable tree employs a fault-tolerant scheme responsible for failure recovery in case of failures. Should T be a survivable tree partitioned after a failure of a faulty cluster FC into fragments $T_1, T_2, \ldots, T_k$. A *failure recovery* in T is then a process of reconnection of $T_1, T_2, \ldots, T_k$ into a single restored network $T' = (TM \setminus FC, CE')$ with two key properties: (1) *correctness* - the restored network is acyclic and (2) *completeness* - all the tree fragments in each partition of the underlying communication substrate are eventually connected together.

The characteristics of the computing environment are very important for the design of failure recovery mechanisms for survivable trees. The trend in networked computing environment points towards large-scale unbounded network infrastructures. Taking into account the restrictive nature of the characteristics of such environments makes the proposed mechanisms easily applicable in other (bounded) environments as well. The characteristics in question include (1) *characteristics of a distributed system* (asynchronous communication, no global clock, autonomous behavior of nodes), (2) *no central authority* in the system supervising the proper functionality, (3) *no global knowledge* about number of nodes and their identities, (4) *unrestricted failure pattern* and (5) *unlimited size* of the system.

In such an environment, survivability property of survivable trees, perhaps as a part of Quality of Service (QoS), can hardly be absolute or infinite. It is rather considered to be a *parameter* to be achieved in tree networks while keeping correctness and completeness. A trade-off between survivability and costs is to be chosen when deploying a survivable tree. In this respect, survivability is closely related to the notion of fault-tolerance. On the other hand, a fault-tolerant scheme used to implement a survivable tree has to be able to offer a trade-off according to specific needs and requirements of a user.

The functional characteristics of a tree network *T* itself also play a significant role for a failure recovery. The network attributes depend largely on the desired use of the tree and its application. The restrictive characteristics include (1) *group model* (any node may become a member of *T*, unlimited number of communication trees in the system), (2) *direction of traffic* generated by a single or multiple message sources in *T*, (3) *tree adaptation* reflecting group changes or optimization requirements, (4) *local message routing* in *T* based on local decision of nodes en route, (5) *real-time operation* (no off-line mode) and many other attributes.

These characteristics represent the worst case and the most restrictive properties of the environment and the tree network. Of course, not all applications using tree communication structures employ trees of this kind and the three characteristics are somehow relaxed. However, in many other applications, particularly large-scale data sharing or data storing systems exploiting overlay multicasting [2], the tree networks exhibit all these attributes, which then must be reflected by the respective properties of the failure recovery mechanism.

Some of these properties are of key importance in the concept of survivable trees. *Multiple failure recovery* capability allows a successful recovery from multiple failures in the tree ($card(FC) > 1$). *On-line recovery* is the ability of the scheme to perform a failure recovery while the communication in the rest of the tree continues and other failures may occur (simultaneous failure recovery of several distinct failures in the same tree is possible). *On-the-fly recovery* enables the failure recovery to be performed while the traffic in the tree goes on, even through the nodes performing the recovery. *Optional level of fault-tolerance* allows to choose a level of fault-tolerance provided for the tree a thus possibly find an optimal trade-off between survivability and costs. *Protection selectivity* denotes possibility of choosing a fault-tolerance level individually for each node in *T* and allows the survivable tree to provide a stronger protection against failure of more important nodes in the tree.

As most of these properties are required by the characteristics of the real environment and needs of applications, the concept of survivable trees becomes indispensable. As a practical solution, we proposed a simple and efficient failure recovery scheme for survivable trees meeting all the required properties [1]. It has been successfully integrated into the data management of *Gaston*, a large-scale distributed file system [3].

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BR(r) Scheme: A Solution for Survivable Trees

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This paper presents BR(r) scheme designed for recovery from node failures in survivable trees. The *survivable tree* is defined as a tree-topology overlay communication network capable to deliver a message in a timely manner to all its correct member nodes even in the presence of failures in the tree. BR(r) scheme is a straightforward extension of BR(1) scheme proposed for a single failure recovery in multicast trees [1]. First, essential principles of BR(r) scheme are introduced in this text. Next, the process of node failure recovery in the tree is briefly described and finally, the paper deals with the fundamental properties of a failure recovery required by the concept of the survivable trees and shows how they are achieved in BR(r) scheme.

The concept of survivable trees considers an underlying communication substrate of an arbitrary topology with routing capability, on top of which an overlay tree-topology network, modeled as a graph $T = (TM, CE)$, is built. TM is a set of tree member nodes and CE represents a set of virtual edges of T. A message transmission in T over a virtual link consists of a sequence of transmissions over one or more links in the substrate. There is no global knowledge about T membership; TM nodes dispose only a local knowledge of their neighborhood. Thus, a failure of a cluster of adjacent tree-member nodes, denoted FC, causes T to be partitioned into $k = card(A_T(FC))$ fragments $T_1, T_2, \ldots, T_k$ as the distributed knowledge is disrupted; $A_T(FC)$ is a neighbor set of FC in T. The mechanism of recovery of FC failure in a survivable tree is required to be *complete* (all the tree fragments are eventually connected together) and *correct* (the recovered tree is acyclic).

BR(r) failure recovery is based on redundant virtual cyclic structures, called *bypass rings*, providing alternative paths to eliminate failed nodes, reconnect the fragments and reroute the traffic in the tree, similarly to [1]. Construction of the bypass rings is based on partial order of nodes in the tree inferable from their identifications. In a partially ordered tree, there is an order defined for neighbors of every node $n \in TM$ such that $\mathrm{ID}(n_1) < \mathrm{ID}(n_2) < \ldots < \mathrm{ID}(n_k)$; $n_1, \ldots, n_k \in A_T(n)$; $k = deg_T(n)$. As it is assumed that every node in T is assigned with a unique ID from a totally ordered set of identifiers, it is possible to build the partial order and consider T to be partially ordered. A bypass ring in tree T, denoted $BR_T(n, r)$, is a graph determined by its center node $n \in TM$ and radius r. It consists of *bypass edges* (redundant virtual links) connecting all $k = deg_T(n)$ tree branches of node n, such that the initial node of each bypass edge is a node in branch i, the terminal node is a node in branch $i \oplus_k 1$ ($i = 1, 2, \ldots, k$; $\oplus_k$ denotes operation + modulo k) and both initial and terminal nodes are in the distance r from the center node n.

Rings $BR_T(n, r)$ of radii $r = 1, \ldots, r_{\max}$ are constructed around selected nodes in T. The tree together with the framework of all redundant links forms an *extended tree* $ET = (TM, CE \cup BE)$, where BE is set of all bypass edges. An integral part of BR(r) scheme is also a *bypass routing algorithm* capable of routing messages in ET cyclically through nodes in $A_T(FC)$ - the set of closest neighbors of FC in T. The algorithm is based on local decision of each node en route determining the next bypass edge to send the message along.

The failure recovery is performed in the following steps. (1) BR(r) *scheme initialization* creates the framework of bypass edges and thus builds ET. (2) *Failure detection*; a node

failure is always detected at a tree-neighbor node of the failed node first. (3) *Designated nodes (*DN*) discovery* is a process of searching in $A_T(FC)$ for nodes eligible for initiating bypass cycle construction and it is initiated separately by each node detecting a failure. (4) *Bypass cycle construction* is initiated autonomously by all DN nodes found by DN discovery. The task of this phase is to construct a bypass cycle $BC = <A_T(FC)>$ – a sub-graph of *ET* induced by $A_T(FC)$. *BC* is an essential virtual structure forming a base for the tree fragments reconnection. (5) *Leader link election* is performed simultaneously with the *BC* construction. Exploiting nodes' IDs, it chooses a single edge of *BC* that will not take a part in fragment reconnection and thus prevents a cycle forming in the restored tree. (6) *Tree fragment reconnection* is a process of constituting new tree core edges connecting tree fragments. It is based on results of the leader link election. (7) BR(*r*) *scheme reconfiguration* adapts the redundant link framework according to changes in the topology of the tree after the fragment reconnection. A detailed description of BR(*r*) failure recovery can be found in [2] and [3].

Completeness property of the failure recovery is ensured as bypass rings connect all branches (the potential fragments) of the center nodes and thus the bypass cycle involves all the fragments caused by the failure. The scheme can recover the tree from failure of clusters with the diameter less or equal to $2(r_{max}-1)$. Correctness property is ensured by leader link election, which chooses (in a distributed way) a single edge of *BC* to be omitted from tree reconnection and thus prevents the cycle forming while keeping the completeness.

The concept of survivable trees requires the failure recovery to exhibit several more properties besides completeness and correctness. BR(*r*) scheme enables the *multiple failure recovery* if $r_{max} > 1$. Cardinality of recoverable *FC* is proportional to r_{max}. *On-line recovery* can also be performed as the scheme preserves locality – each recovery affects only a closest neighborhood of the failure and thus simultaneous recovery of several distinct failures in the same tree is possible. *On-the-fly recovery* is provided as well since the bypass routing algorithm can route also data messages and thus the traffic in *T* may continue when the recovery is in progress. *Optional level of fault-tolerance* and *protection selectivity* is ensured through r_{max} parameter of bypass rings and possibility to construct bypass rings around selected nodes only. Thus an optimal trade-off between survivability and costs can be found.

We have briefly described BR(*r*) scheme and its bypass rings as the fundamental structures for failure recovery in tree-topology networks. As the scheme meets the required properties, it can be employed as the failure recovery mechanism in survivable trees. There are lots of applications of this concept. As an example, it is implemented in a model of a large-scale file system [4] to increase fault-tolerance of its data management. Numerous experiments are now carried out to evaluate practical properties of the scheme.

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Formal Description of The Adaptive Web System

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Since 1997 term Web Engineering has been appearing. This term represents application of systematic, disciplined, qualified attitude to development, performance and maintenance of web applications. Beside the contemporary Internet, the Web Engineering discipline [1] deals with development of new conceptions and technologies for the web. One of them is adaptive, personalized web [2]. Adaptation of web behavior to user's specific object and needs is perspective realm of the Internet evolution. Adaptive web systems can be effectively used in many cases. As the example we can give E-learning [3], adaptation of web to the disabled users or personal navigation on web. The aim of this work is contribution to development of theoretical base in the adaptive web systems realm. Formal description of problems is needful for installation of unified communication platform in this scope. Further, it will be used as the basic theory for automated implementation of adaptive web systems.

Adaptive web system monitors behavior and characteristics of particular user. Based on them, the system compiles resultant, adapted, document from larger universal source document. Then, adapted document is produced to user. The basic motivation for creating adaptive web systems is the difference between individual users. For this reason, it's suitable to prepare specific adapted document for each user. This document should correspond to user's qualification, capability, preferences and his specific needs. For example, we can adapt user interface of document, its information content and layout, topology of hypertext or another features. The characteristic of particular user is stored in system via user's parameters. There is a wide spectrum of user's parameters and we will not deal with individual sorts of them on this general level. We just specify them formally.

The adaptive web system compiles adapted document for particular user. Its inputs are values of user's parameters and universal source document, called document data source. The document data source is divided into blocks. The blocks fold up from elements. During compilation of adapted document, particular behavior of element is determined by value of control signal. The way of element's reaction on control signal (for example if the element will be displayed whole, modified or will not be displayed) is described in element metadata. There is a metadata and one or more control signals assigned to each element. This set creates the complex element, which is basic building unit of adapted document.

The elements are divided to feedback elements and non-feedback elements. As an example of feedback element, we can give a question in some test from interpreted theme, a choice from several ways of arrangement of information on the screen or a time counter, measuring time spent in individual sections of document. Like the elements, we divide user's parameters to feedback and non-feedback too. The feedback in adaptive system is represented by link between feedback elements and feedback user's parameters. Using feedbacks, adaptive system gets and gives precision to values of user's parameters.

Run of adaptive system can be characterized as a sequence of iterations. The iteration of adaptive web system is current state of user's parameters values and resultant adapted

document. We can imagine the iteration intuitively as one time shot from adaptive web system run. Then, description of adaptive system is divided into static and dynamic part. In the static part we deal with compilation of adapted document from document data source according to values of user's parameters (creating of one iteration). This part begins by some action on client (user) side. There follows a processing of feedback, possible change of user's parameters values, compilation of adapted document and producing compiled document to user. In the dynamic part we deal with sequence of iterations and time aspect of problem.

In the dynamic part of description, we define system history in given iteration, which is set of all iterations preceding this iteration. Next, we define user's parameters iteration, which is current state of parameter values. The user's profile is a set containing current state of user's parameters in given iteration and selected parts of user's parameters history in given iteration. It specifies data, which we store for particular user in adaptive web system.

Formal description of adaptive web system is needful for installation of unified communication platform in the realm of adaptive web. Hereafter it is necessary as a basic theory for setting standards in this scope and next theoretical research. Ideas outlined in this article, formalized by theory of sets and mathematical logic was published on mathematical conference [4]. The next step, intimately connected to formal description of adaptive web system, is the support of automated implementation of adaptive web. To fulfill it's purpose effectively, this support must fit to several requirements. In the first, it must be compliant to architecture of contemporary web and web protocols, but, along with it, must be platform-independent. The second requirement is consistency with the formal description of problems. The third claim is being easy to understand for the end-users, which will implement adaptive webs using this support. The part of research in this realm is the beginning pilot project of adaptive web. The aim of the pilot project is to get the feedback related to used implementation support and designed formal description. In the future, there are many iterations waiting for the whole system, that will lead to its improvement and increasing its effectivity. Equally, we can't exclude that new possibilities and rightfulness will be disclosed. They could be included to the formal description consecutively.

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Classification of the Attacks on Network Protocols

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Network protocols allow communication over a network environment. Usually this environment is considered to be insecure. In a typical network environment, there are three aspects of information security. These aspects are: security attacks, security mechanisms and security services. Security attack is an action which compromises the security of transmitted information. The security mechanisms are methods to detect, prevent or recover from security attacks. The security service is a service which employs one or more security mechanisms to enhance the security of the transmitted information.
Group called "security services" includes following items : Confidentiality (warranting that stored or transmitted information is accessible only by authorized entities), Authentication (warranting that the identity of the origin of the message is correctly identified), Integrity (stored or transmitted information and system assets are modified only by authorized entities), Non-repudiation (sender or receiver cannot deny the transmission that came through), Access Control (information resources are controlled) and Availability (authorized parties must have an access to network resources they are allowed to).

Classification of the attacks
One possible categorization of the security attacks is to consider the effect of the attack on the normal flow of information: Normal flow of information is from the source to the destination. The state when transmitted information is destroyed or has become unavailable is called Interruption. Interruption is an attack on Availability. Example of an attack to Availability is for example Denial of Service (DoS) or Distributed Denial of Service (DDoS). This type of attack usually results in a crashed server. As a result, the server is no longer capable of offering services. Thus, the attack denies these services to the public.
If an unauthorized entity gains access to the system assets, sensitive or confidential information then it's a case of Interception. Interception is an attack on confidentiality. If an unauthorized entity gains access and modifies information, then it's a case of Modification. Modification is an attack on Integrity. Example of an attack to integrity is a replay attack. Replay attack is a passive capturing of data and its subsequent transmission to produce an unauthorized effect. Another type of attack to Integrity is modification. A legitimate data is altered, delayed, or reordered to produce an unauthorized effect. If an unauthorized entity inserts fake objects into the system it's an act of Fabrication. Fabrication is an attack on Authenticity. Example of an attack to authenticity is a masquerade. An entity pretends to be another entity. The purpose is to obtain extra privileges.
Another possible categorization of attacks on protocols is division on passive and active attacks. Passive attacks rests in eavesdropping of communication and subsequent analysis. The unauthorized entity is able to determine location and identity of communicating entities, size of the messages and their frequency. These information can be used for guessing the nature of communication. The active attacks include replay attack, man-in-the-middle attack, denial of service, modification and others.

Security Mechanisms

In order to detect, prevent, or recover from these security attacks, we use security mechanisms. There is no single mechanism which will provide all the security services or perform all the functions mentioned above. A variety of mechanisms are used to detect and/or prevent certain attacks, and to provide certain functions and services However, most security mechanisms use methods and tools which are provided by cryptography.
Traditionally, cryptography was used by the military and diplomatic services for secure communication. Secret-key cryptography offers only techniques for encrypting while public-key cryptography offers techniques for encrypting , authenticating data and exchanging keys over an insecure network. Cryptographic techniques provide the methods and tools required to establish the security services of a network.

Security using cryptography
Protection assets against interception is done by encryption. Cryptographic algorithms provides confidentiality. Protection against modification is made by digital signatures provide authentication of data and user identity. Access control also protects against interception and modification. Data origin authentication is provided by message authentication codes (MAC), digital signatures, and hash functions.

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3D Graphics in Adapting XML

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Our research is focused on creation of a suitable file format for virtual world specification. As a basis, the XML was chosen. Above the lowest XML layer lays an integrated data adaptation layer. When creating 3D graphics for the virtual worlds, two aspects were selected as the most important – consistency of stored data and isolation of independent concepts. Beside 3D graphics data, the file format must be able to store for example data for physical simulation, audio processing, or user interaction. Current systems for virtual world creation focus more on concrete concepts and less on their independence thus limiting extensibility. They usually define static core functionality that quickly becomes outdated due to the fast development in computer industry. Adapting XML on the other hand focuses on extensibility, defining rules for cooperation (data sharing) and provides mechanisms for concept isolation. This makes it suitable as the base layer for extensible virtual world languages.

The state-of-the-art technologies dealing with virtual worlds, structured data storage include VRML, XML, XML Schema, X3D or MPEG-7.
These technologies mapped the territory of virtual world specification and provided partial solutions of our problem. Our system is based on their best features:

- Transparent structure,
- Selection of most important concepts,

while it tries to eliminate the problematic ones:

- Missing references support in parser,
- Missing custom atomic types,
- Poor isolation of concepts,
- Monolithic architecture.

To accomplish this, we employ following techniques:

- References are processed in parser. Their existence is transparent for client code.
- Type-libraries – a type-library is a module cooperating with the parser providing means for storing, parsing, serialization and validation of atomic types. No atomic types are defined by the parser – there are only custom atomic types in type-libraries. A type-library with standard types is available, but it is not mandatory to use it. This solves the problem with suitable atomic types.
- Adapting engine – adapting engine is a layer above the parser that extracts the relevant bits of data from the whole file and creates a "writable view" on the data. The adaptation engine isolates the concepts and therefore allows componentized system architecture instead of monolithic one.

The adapting XML inserts a new layer between XML parser and the application. The new layer is called adapting engine and its task is to adapt the data in the XML file using converters. The new typed and adapted DOM is similar to the XML DOM interface. But

instead of using simple elements, the elements implement two interfaces – a common interface and a type-specific interface.
Using the common interface, the element can be serialized or de-serialized from a string representation in the XML file. Also, the element can be uniquely identified using this interface.
The type-specific interface provides access to the internal data For example, if an atomic type represents a triangle mesh, it can have methods for manipulation and rendering of the mesh. Each part of an application receives suitable data through the typed and adapted DOM. This separation is a way to achieve one of our primary goals – the separation of concepts and minimization of dependencies.
The components in the application can cooperate at different levels [1]. Among others, they may use the file in the file system and serialize access to it or they may use the typed and adapted DOM. In the later case, there is a need for a global change notification handling – the adapting engine must be able to notify its clients of changes in the data structure. This is accomplished by a Subject-Observer pattern employed at element or file level of granularity.

XML defines one atomic type – a string (CDATA). For some applications, this may be not suitable. They require multiple atomic types optimized for different tasks. These applications would usually encode these types into a string. But it has a negative effect – the parser is unable to validate the contents of elements of this type and application must do it manually. Each application that uses this type must provide the validation code on its own. It would be desirable to prevent the code duplication by moving it into a shared type library. This type library is then used by the adapting engine. The library needs to be written in a full featured programming language that is able to interoperate with the adapting engine. In adapting XML, the type libraries contain definitions for custom atomic types. Therefore it is possible to validate any data type during parsing.
Ordinary XML stores data in a simple tree structure of elements and attributes. For 3D graphics data an acyclic graph is the native data structure (for example vertex coordinates or material definitions are shared among multiple elements). Today, the acyclic graph is reconstructed manually in each application. The checking code may be eliminated from the applications if the feature is moved into the parser. To accomplish this, a convention is defined in adapting XML. Instead of any element, a reference element may be used. The relative location is specified using the XPath syntax.
The problem of data adaptation may have different complexness. Sometimes it is enough to ignore portion of the data, rename data fields or fill missing fields with default values. Alternatively, the conversion may be very complex. In adapting XML, two kinds of converters are defined: scripted converter and native converter. Native converter resides in type ligraries, while scripted converter is part of the data file.

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The MMS Portal

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This multimedia-messaging portal (MMS Portal) is a new member of a family of products from the Research and Development Centre (RDC). It is a pilot project dealing with multimedia messaging service (MMS), which is a rather new service provided by 2.5G mobile networks. The MMS Portal unites the possibilities of MMS as a new form of communication with the advantages of Internet.

MMS

Multimedia Messaging Service is the next step in the evolution of messaging services for mobile networks. It is the successor of the Short Messaging Service (SMS) and the Enhanced Messaging Service (EMS). Over time, SMS has become a very successful service for the second-generation of mobile networks. It enables to transfer an alphanumeric message up to 160 characters. MMS should take all advantages of the SM service and extend it to multimedia (e.g. images, video sequences, sounds, etc.).

MMS is built on protocols and technologies that are common to Internet. For instance, it uses MIME, SOAP, SMIL, e-mail, WAP and many other technologies. In fact, it also uses the SM service itself. A special binary short message is sent to a mobile phone where a new MMS will be delivered. This SMS triggers a download of the MMS from a multimedia service centre (MMC). The WAP protocol is used for downloading.

Although the multimedia messaging service was meant for the third generation of mobile networks, it has been implemented already in 2.5G networks. Since the MMS is designed for transferring of multimedia information, it needs to be based on a broadband bearer service. In case of 2.5G mobile networks the GPRS (General Packet Radio Service) is used for this purpose.

MMS Portal

The MMS Portal was developed as a web application offering the options to create and to send MMS messages. A user can compose a MMS message using uploaded images, sounds and texts or select predefined images from a gallery that has been already integrated into the application.

It runs on the TOMCAT server. This application consists of servlets, JSPs and JavaBeans and its structure is based on a standard Model-View-Controller (MVC) architecture.

MMS Gallery and MMS Editor

This application consists of two parts: gallery and editor. In the gallery predefined MMS messages are stored. These messages are ready to be ordered and sent. The user can also employ these messages in new compositions. All images from the gallery are secured by a watermark.

A MMS Editor represents the second part of the MMS Portal. By making use of this editor the user can define a new MMS message. Only its creator can order a delivery of a newly composed message.

Supported media formats

Generally speaking, the MMS message is a set of slides. Each slide has a specific duration defined. One slide consists of an image supplemented by sound and text information. Diverse media information are combined into an intact message by means of a SMIL (Synchronized Multimedia Integration Language) script. Detailed specification of the SMIL can be found in [1]. In this script the essential parameters (e.g. positions, times, durations) for each element in the message are specified.

Our MMS Portal supports almost all media formats described in the Conformance document version 2 [2]. This document specifies the minimal requirements for MMS handsets and therefore it should guarantee the compatibility among all devices on the market. The following media formats are supported in the current version of the portal:

- Images - GIF, JPEG, PNG
- Audio - AU, AIFF, WAV

Interfaces

The MMS Portal is connected to the mobile network over two interfaces. The first interface creates a connection to the MMC. All MMS messages exchanged between the application and the mobile network are transported over this interface. This interface is also known as the MM7 interface. The protocol used within the MM7 interface is implemented by a special library that is usually delivered by the mobile network operator to all third parties' developers. The other interface is intended for SMS messages. All mobile originating (MO) messages, mobile terminating (MT) messages and delivery notifications (DN) to and from SMS-C are transported over this interface. This interface is based on the XML/HTTP protocol and is implemented by a special library that has been developed in the Research and Development Centre.

Sending of MMS

When a user wants to send a MMS message, the message must be selected from the gallery or created in the editor. Then the MMS Portal generates a unique ordering number for this MMS. Consequently, the MMS can be ordered from the portal by sending an ordering SMS with a specified format. This SMS is sent to a shortcode number that was assigned to the portal by the mobile network operator. When the portal receives this ordering SMS, the MMS is sent to the subscriber number (MSISDN) specified in the SMS.

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Access to Bibliographic Databases for Engineering Disciplines

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This project has been a part of the Ministry of Education funded programme called **LI Information sources for research and development.** The core goal was to provide end users with an easy access to high quality information sources. Czech Technical University in Prague was a project contractor and the participating partners were these Czech universities: Masaryk University Brno, Technical University of Liberec, Brno University of Technology, VSB-Technical University of Ostrava, Charles University in Prague, Tomas Bata University in Zlin and University of West Bohemia in Pilsen.

The goals of the project have evolved over the course of its development. As a result of the initial phase of the work on project a group license agreement has been signed and purchased. This was one of the most important steps to achieve the proposal target which enabled the academic community of participating universities an easy access to four selected most valuable commercial databases (Compendex, Iconda, Inspec and Metadex) via the Dialog Corporation unified search interface. The web interface is easy-to-use and does not require knowledge of commands. Therefore it is suitable for both advanced and novice searchers. The license agreement conditions have changed in 2001 since the Cambridge Scientific Abstracts (CSA) decided not to use Dialog Corporation for distribution and use of its products. The CSA Materials Sciences Collection with METADEX is now available via the Internet Database Service (IDS), the CSA own web interface. By the end of 2002 the users were offered another interesting source: the IEEE Computer Society Digital Library. It provides online access to 22 magazines and transactions and over 1,500 selected conference proceedings. All the licensed electronic sources will be available to the users at least till October 2004.

A possibility to search bibliographic databases and to use new full-text sources was not the only goal of the project. The libraries of participating universities provided additional services such as delivery of full-text articles or other types of documents found in databases through inter-library loan (ILL) services from Czech libraries or from abroad if no Czech library could supply the request. Another useful service has been set up in 2002 when Dialog launched a new e-journal linking service. The links added to bibliographic records with abstracts provide a hyperlink directly to the full-text electronic article record by a partner publisher or journal aggregator. This service offers a streamlined method for retrieving the full-text of an e-journal article that an organization subscribes to. Most of the members of the project provide access to electronic journals either on an individual or consortium based subscription. The subscription manager has been used to set up journal links according to different subscription groups in order to enable end users to access to journals their university subscribes to. Full-text articles from selected journals published by Dialog partners, i.e. Springer, Elsevier and Wiley, have become accessible immediately to the users as a result of searching bibliographic databases Inspec and Compendex.

A technical support and assistance to the project was made by the project contractor, by its Information and Computing Centre staff. The research and development work had to be undertaken in the area of usage statistics and users control. The first task was to establish and maintain authorisation server and to control users' accounts. An application proxy has been used to provide an access to Dialog Corporation. This enabled a different ways of access to authorised users, either from participating universities campuses or from remote off campus workstations connected to the Internet no matter where located. Such solution provided an opportunity to track the usage of available information sources and to improve collecting statistical data reported by IP addresses or based on a personal authorisation which is used by three project members (CTU, VSB-Technical University of Ostrava and University of West Bohemia in Pilsen). The rest of the participants use an IP addresses access control only. Usage statistics is very important as it can help to make decisions on different things concerning the information provision to library users. Unfortunately usage statistics reported by the providers was not reliable, up-to-date and comprehensive enough. Therefore a software tool for statistical data collecting has been developed. It allows to collect data about number of sessions, number of queries (searches) and number of items examined (viewed or downloaded or printed) by each specific database, by each institution, by individual accounts and by time period. Access to statistical reports (tabular statistical data with graphs) is provided via web-based reporting system and is restricted to authorised users. The set of collected elements was adopted in order to follow the requirements of International Coalition of Library Consortia (ICOLC).

Significant cost savings have been made during the work on project. In addition to its core goal this allowed to: expand the range of product offerings, expand the number of participants, buy 48 PC workstations located and used in participants' libraries to enhance access to databases and other information sources provided, and obtain 296 foreign books valuable to the research and development community.

As a conclusion we can say that the project has been beneficial to the research and development staff. Well identified and selected bibliographic databases linked with full-text articles and supported by additional services made information easier to find, obtain and use. Evaluation of the project has shown that direct access to full-text articles should be supplemented by copy ordering and inter-library loans as a significant number of information searchable in the databases is still not available electronically. Usage statistics data evaluation has shown that ideally end users should use core bibliographic databases for the optimal searching and then access the most relevant hits through tight integration with full-text services and ILL functionalities (e-journal linking, electronic document requests and delivery).

Through the work on project the research team has gained considerable experience about the importance of preparatory work when it comes to negotiations concerning the license agreement as well as to implementation of services, marketing and training, technical matters etc. The governmental funding was essential to the project success as it has been obvious the universities would not be able to pay for the subscription to such a large scale of high quality services through their ordinary budgets. The Ministry of Education has opened a new funding programme 1N. The experience gained through the work on the project helped the research team to develop a continuing project proposal build on documented needs and realistic expectations and apply for funding for next five years.

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CTU Libraries – Subject Information Gateway

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The project objective was to enable both students and academic staff a qualitatively new way of access to general information about CTU libraries and to information resources and services provided by the libraries. A new libraries website intended to be a subject information gateway is simply called "CTU Libraries". Its primary goal is to facilitate navigation and use of all the services provided. The second goal is to create web documents easy to maintain and update.

Present web pages of CTU libraries have been created for several years. With an increased amount of information and services the pages have become not well arranged and difficult to use. All the important information could not be put on the home page. Therefore some useful information has been hidden thanks to the pages complex hierarchical structure. Restructuring the pages and their complete redesign have become the only solution how to create the web site better and make it easy to use – and useful.

An analysis of users needs and behaviour was the first step of new web pages development. Another necessary thing was a detailed analysis of a present web structure, all the resources and services provided as well as analysis of all the individual HTML documents, their content, structure, and code.

An important part of this initial stage of building a new website was to analyse reported statistical data (web access logs). As the web environment provides an opportunity to measure the use of information it was easy to determine which information is being accessed and used. Usage tracking helped us to improve the site and to organise web site content better to meet its users needs, motivations and expectations, and their technical requirements and abilities. A decision concerning the best scheme and structure has been one of the most important steps in reorganising libraries web site content. An effective and stable information architecture concept is essential to design for future growth of the site as well as for some necessary changes of its content.

A detailed analysis of present web pages and a proposed web site content helped us to determine four topical top-level categories for organising information: **Services, Resources, Information Education,** and **Information for Librarians.** This was very important as organisation schemes as well as the content structure are closely related to navigation and labelling. All the above mentioned elements of information architecture make the site content useful: it can be found, pleasant to use and easy to understand. The top-level categories areas are divided into several subcategories. These subcategories should be either documents or links to deeper documents. The main navigation system of the web site hierarchical structure is designed to allow users to easily navigate across categories. Users can move quickly to required document thanks to the complementary navigation provided and alternate access options, such as quick links, breadcrumbs, site index, what's new page etc. The organisation of the web site content can be easily scanned thanks to the home page design.

Services
The content of this top-level category includes the general information about CTU libraries. Users can move quickly to required services like checking loans or electronic documents delivery service. They can find opening hours of the libraries or contact information (library staff directory) there. Unified general information about libraries is supplemented with the information specific to the certain library if necessary.

Resources
The content of this category provides general information about available resources. It also serves as an access point to searching the resources. Subcategory Catalogues includes links to a Union Catalogue of CTU Libraries (books), to a subscribed journals database, to a catalogue of standards etc. Subcategory E-Resources provides information about licensed commercial databases and electronic journals and to important information how to access them. Subcategory Free Information Sources includes a large collection of external web links topically organised. Subcategory CD-ROM Applications provides information and links to networked applications distributed to authorised users from the CTU CD-ROM server.

Information Education
This category provides information useful for students. It includes a link to an online Information Training Course for users who want to learn more about information searching and retrieval, about library services, different types of documents, bibliographic references etc. Students can find information about lessons and additional information concerning information education and literacy, too.

Information for Librarians
This section of CTU libraries web site provides information useful especially to librarians, but not only for them. It informs about CTU Libraries and their history, includes CTU Libraries annual reports, information about professional activities and past or future events. A Directory of Czech University Libraries which is maintained by CTU Computing and Centre staff can be found there, too. Password protected working materials for cataloguers are also located in this category.

A new web site of CTU Libraries was build and designed to comply with W3C recommendations, XHTML 1.0 and Cascading Style Sheets (CSS). Designing with standards make the web site accessible for all browsers and platforms and easier to maintain. Accessibility and usability issues have been seriously considered, too. Attention has been paid to layout, typography, consistency issues, and clear writing style. Navigation is supported by a visual graphic design and helps a user not to get lost in a large collection of documents and links.

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Development of New Equipments for Teaching Automatic Control

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Automatic control is an indispensable branch of all engineering specializations. These days, all engineers and technicians need to know about control engineering. The increasing use and sophistication of automation in modern engineering systems has created the need for students of all engineering specialization and academic levels to have more than just appreciation of the theoretical principles involved in control engineering. Therefore a common course "Automatic Control" is delivered for all students of Faculty of Mechanical Engineering CTU in Prague in the third school year. It is also important for students to have practical skills and abilities, usually only gained through experience. This can only be gained by "hands-on" use of equipment. Practical training as a component part of the course is realized in the laboratory of Automatic Control that is one of the laboratories of Institute of Instrumentation and Control Technology (IICT), see [2], [3].

The laboratory models serve for practicing the fundamentals of logic, analog and digital control. To arouse interest in control engineering the old laboratory equipments are in successive steps removed and substituted by new ones. Laboratory equipments and software have to be user friendly, flexible and reliable. The new apparatuses are manufactured in IICT with the help of students but design, development, manufacture and testing of an appropriate experimental physical model is always long-term thing.

The experimental models in the automatic control laboratory of IICT are controlled objects linked to the controllers. Most of equipments use PCs with standard I/O interface cards for data acquisition and control. Microprocessor based platforms as control elements are less frequent and PLCs are used in laboratory apparatuses for practicing logic control.

The apparatuses called "Bathyscaph", "Air Levitation", "Ball & Ellipse", "Rail Vehicle on an Inclined Plane" rang among the most interesting new original laboratory models. The developed experimental models are directly controlled from MATLAB simulation environment via special acquisition cards. All the mentioned models are suitable for design and verification of mathematical descriptions of these physical models and for derivation of appropriate automatic control algorithms based on classical and modern control technologies.

The laboratory model "Bathyscaph" demonstrates the movement of the hollow cylinder (bathyscaph) in the water tank. The average density of the bathyscaph (and the air closed inside) is almost the same as density of the water. When the pressure over the water surface is changed, the volume of the air inside the bathyscaphe will change. That means the average density of the bathyscaphe will change slightly above or below the water density and that will move the bathyscaphe up or down. The movement of the bathyscaph depends on the pressure over the water surface. The pressure of the educational equipment is controlled by PC. The basic control is to maintain the position of the bathyscaph at the desired position. The second one is designed specifically for the study and practical investigation of basic and advanced control engineering principles.

The next laboratory model "Air Levitation" consists of a ball which is raised by the air flow. The ventilator supplies an appropriate amount of air, so that the ball is maintained in the

desired horizontal position. The position is sensed by an ultrasound sensor. The controller generates the actuating signal assigning the ventilator performance. The basic control task is to control the position of the ball freely levitating in the air flow. The "Air Levitation" system is a nonlinear dynamic system with one input and one output designed for studying system dynamics and experimenting with number of different control algorithms on classical and modern control theory.

The laboratory model "Ball & Ellipse" consists of an ellipse pivoted at its centre such that the slope can be manipulated in two perpendicular directions. A servo system is used for tilting the ellipse. A steel ball rolls freely on two parallel tensioned wires which have the ellipse contour. The ball position is sensed by a transducer. The "Ball & Ellipse" system is a dynamic system with two inputs and two outputs. The basic control task is to control the position of the ball rolling on the ellipse railway. This two-dimensional system with astatism demonstrates control problems associated with unstable systems.

The last laboratory equipment "Rail Vehicle on an Inclined Plane" consists of a rail vehicle running on two moving rails (continuous belts). The tilt of the rails, their speed and the speed of the vehicle may be changed by PC. The position of the vehicle is sensed. The basic control task is to control the position of the vehicle.

All the mentioned laboratory equipments use MATLAB/SIMULINK environment for system analysis, control algorithm design, simulation and the Real-Time Toolbox (Humusoft) for using MATLAB in real time, data acquisition, signal processing and on-line control. The introduced educational equipments are lightweight and compact so they are easy to move around.

Descriptions and photographs of the mentioned apparatuses together with other new ones constructed for practical training of control engineering can be found in [1], [4].

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Risk Analysis in Designing and Realization of Information Systems

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Process of design and implementation of information system is very difficult despite of there are plenty of a sophisticated methods of design that whole project divide into smaller simplified subprojects that advise designer how to go step by step. There are many of well-considered techniques that help designer to solve individual steps. Indeed neither the best processes aren't quality guarantee, therefore even nowadays many of projects result in failure including the biggest ones. In technical literature there are many of examples such failure from which is necessary to moralize.

Used methods of design and implementation information systems are known already several decades. It is necessary to face many risks during design (time, cost, quality, security etc.). The methods does not contain the ways how to face them, eventually how to remove them or the accent is laid stress on the basic.
The goal of the project was to analyze the risks and make the design, how to face the identified risks. Therefore applicable design should be specialized in stages of design information system in which the possible risks may be found and especially in ways how to face them.

Risk is possible appearance of any phenomenon that may cause failure or serious problems or damage. For estimation risks is necessary unambiguously determine, what is exactly success. Success of system is for every corporation a little bit else but it is possible to formulate expectations such as: system should increase efficiency of company's workers, should obtain a competitive advantage and make for company other strategic purposes of development.
For risks estimation are most often used following techniques:

- Determination of a list of events (technical, commercial, intern, extern), which may cause unwelcome effects.
- Qualitative methods based on score (big influence / insignificant influence, influence valuation of some factor of rate 1 to 10 etc.) or they are based on flow chart of the project.
- Quantitative estimate techniques of probability and influence relevance of risk factor to common planning characteristics like time and costs.

Process of design and implementation of information systems was divided to individual stages according to life cycle. Every stage contains many defined actions, their goal is to make project easier and clear up the project. Every methodology has these procedures differently elaborated, but the principles are same. Every stage was analyzed respecting individual activities and techniques of stage according to methods mentioned above.

Various corporations have various aims and therefore the design of IS/IT may have different risks. But in every stage it is possible to find public risks of failure. The most important risks were identified and prioritize in every stage. With individual activities were cleared up the reasons why and in which case they could became risks. It was described how it is possible to avoid the individual risks or how to reduce them, possible methods solving any action so that the risks are minimized. With some activities where it depends on an individual situation and is not possible exactly describe which method to use, was recommended what is bad way or what is unsuitable way. List of identified risks is supplemented with list of critical factors of individual stages, because non-performance of critical factor is a serious risk. The biggest critical factors are:

- Human factor – fluctuation, inadequate abilities, poor or too late training, inadequate qualification and experience or inability teamwork.
- Management – inappropriately scheduled goals, badly scheduled dates and cost, change of manager, inability of leading a project, badly chosen partner, mistakes in the economic contract.
- User – weak support of cooperation, absence in a public work, change the IS lays too big requirement on the users, incorrectness or unreliability of data.
- Hardware – delay in installation, insufficient system performance, unsuitable property, provider failure, breach of contract, weak support by users.
- Software – delay in installation, unsuitable for the hardware, incorrect or unsuitable function, poor documentation (especially of negative properties), poor support by provider, mistakes in configuration etc.

Design and implementation of information systems is firstly about peoples and about understanding and cooperation of two parts that create the system by teamwork. As every difficult process also design and implementation of information system has self risks and critical points. Generally, the process is divided into information strategy of the company, opening study of the system, analysis and design, implementation, loading and system operation and servicing.

As the biggest risks it is possible to specify the opening stages i.e. scheduling, these are in the whole process so cardinal. On their bases the system conception is continued in the following stages so that if there are mistakes in the bases, if we stay in this terminology, then is almost sure that it is impossible lead the project to the successful end. The bases are global company strategies and consequential information strategies. These are the pointers on the forward way, they give sense and target to company activity. If these strategies are wrongly created than we cannot expect benefit from the IS/IT.

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XML data Integration and Querying

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XML has emerged as the leading language for representing and exchanging data not only on the web, but also in the enterprice. The advantage of XML as an exchange model, makes it the best candidate for supporting the integrated data model.

Because of frequent requirements to integrate and analyze data from multiple resources, we present a logical formalism for describing specifications of semantic mapping between a unified global interface and a multiple of data sources through a logical mediated schema. The mediated schema is virtual in the sense that it is used for posing queries, but not for storing data.

Many diverse solutions to data integration has been developed, most of them are based on common mediator architecture [1]. Mainly, they can be classified into *structural approaches* and *semantic approaches*. In structural approaches, local data sources are assumed as crucial. The integration is obtained through a virtual global schema that characterizes the underlying data sources. Paper [2] describes structural approach, in which XML is used as a data model. A view definition langauge is provided for the mediation engineer to define an integrated view that specifies how local data sources are integrated to the system. On the other hand, semantic approaches assume that enough domain knowledge for integration is contained in the exported conceptual models, or 'onthologies' of each local database. This requires a common ontology among the data source providers. F-Logic[4] has been developed to help the data integration from semantic perspective.

Our goal is to leverage the techniques for specifying mapping in XML data integration, extending them beyond the Metadata Integration Assistant Generator for Heterogeneous Distributed Database [3]. This approach is called DDXMI (for Distributed Database XML Metadata Interface). The master DDXMI file includes database information, XML path information, and semantic information about XML elements and attributes. A tool is implemented for Meta-users to do the Meta-data integration, producing a master DDXMI file, which is then used to generate queries to local databases from master queries. This tool parses local DTDs (Document Type Definition), each of which is a text file consisting of a set of rules about the structure and content of XML documents. It lists the valid set of elements that may appear in an XML document, including their order and attributes.

The DTD mechanism has numerous limitations. A basic and major limitation is that a DTD is itself not a valid XML document. Therefore it must be handled by XML parsing tools in a special way. Furthermore, DTDs support a very limited capability for specifying data types. Also, DTDs are quite limited in their ability to constrain the structure and content of XML documents. In addition, they cannot handle namespace conflicts within XML structures or describe complex relationships among documents or elements. They also are not modular, and can not derive new type definitions on the basis of old one. For these reasons and others, the World Wide Web Consortium (W3C) is working to replace DTD mechanism with XML Schema. An XML Schema Definition (XSD) is an XML-based grammar declaration for XML documents. XML Schema allows very precise definition for both simple and complex data types, and allows deriving new type definitions on the basis of old one and many other features.

We propose a novel approach for integrating XML data sources of diverse formats by introducing XML Schema. A mediation layer is proposed as a component of the architecture for XML data integration and querying. Such layer manages two important tasks: XML schema integration and XML data querying. Using XML Schema as the grammar language for XML data sources was investigated and formulated in our approach. JDOM was used for parsing and combining related schema objects from multiple XML data sources into a single logical view (global view).

The architecture of our system consists of three main units: XML Mediator Interface (XMI), XML Query parser, and XML Query Translator. We assume that all database sources contain XML datal, each source is associated with its XML Schema definition. A global XML Schema Definition is designed in which all the needs of end user are included and all local elements are represented. For each source, the XML Schema is parsed and its tree structure is constructed to generate the path for each node starting from the root. Thereafter, a GUI is generated for each source to assign an index number for each element agrees with its global element. By gathering the same indices of all sources elements with its corresponding global element, then the XMI is created.

When a user query is posed over the integrated global schema, called *a global query*, is automatically decomposed to sub-queries, called *local queries*, which fit each local database format using the information stored in mediator by the query translator. The mediator contains the path information and functions to be applied to each local database, along with identification information to be used for query decomposition. If there are paths for the global query, these paths are parsed by the query translator and replaced by corresponding paths of each local document, by navigating the XMI document. If not, an empty query is generated for the corresponding path in the local query, which means that this query cannot be applied to that local database. Each generated local query will be sent to its corresponding local database engine, which will execute the query and return the result for the global query.

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Inverse Kinematic - Jacobian Inversion Method in a Plane

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There are two main approaches when animating articulated structures, e.g. human bodies, etc. [1].
The first approach is known as Forward Kinematics. The movement of the structure is derived from the movement of each part whereas the second approach, called Inverse Kinematics, works in opposite way. It deduces the movement of its parts from the desired movement of the complete structure.
It is clear that Inverse Kinematics is more natural way of animating articulated structures. Nobody wants to care about the setting up the movement and position of each part. The only thing that the animators want to do is to set up the trajectory of the end point of the articulated structure. But sometimes some constraints are required for inner parts of the structure.
It is easy to imagine that the complexity is higher and in many cases leads to more than one solution unlike the Forward Kinematics.
Such multiple solutions are avoided by reusing previous states of articulated structure. We can say that Inverse Kinematics works in iterative mode unlike the Forward Kinematics which can be solved exactly without using previous states.

Solving Inverse Kinematics

Several methods exist for solving Inverse Kinematics. Among the most known of them are Jacobian Inversion [1], Jacobian Transposition [2] and CCD (Cyclic Coordinate Descent) [3]. All of them are based on iterative model.
We have focused on Jacobian Inversion method because is based on mathematic model only. The method is described using equation [1]

$$\vec{x} = \vec{f}(\vec{q}),$$

where $\vec{q}$ is the status vector (angles between neighboring segments) and $\vec{x}$ is position of the end of the structure, so called "End Effector" (EE). For solving Inverse Kinematics problem we need invert transformation which is not unique therefore we use iterative model based on differentials [1]

$$d\vec{q} = \mathbf{J}^{-1}(\vec{q}) \cdot d\vec{x}, \tag{1}$$

where $\mathbf{J}_{ij} = \frac{\partial f_i}{\partial q_j}$ is matrix called Jacobian ($\mathbf{J}^{-1}$ is inversion matrix related to $\mathbf{J}$).

Standard Jacobian Inversion

Standard Jacobian Inversion employs equation (1). Important part of this equation is Jacobian. Jacobian is in general rectangular matrix with number of rows equal to the number of degrees of freedom of EE (concrete number varies on used space, e.g. in 2D it is 3 – 2 translations and 1 rotation; in 3D it is 6 – 3 translations and 3 rotations). Number of columns is equal to the number of segments of the structure and also corresponds to the size of status vector.

Due to the fact that Jacobian is in general non-square matrix there is the problem with its inversion. It is not possible to use classic method, e.g. method based on Gauss elimination. In such a case Generalized Inversion based on Singular Value Decomposition must be used.
However a drawback is non-existence possibility of control of the inner parts of the structure. The control is taken only over the end of the structure.

Extended Jacobian Inversion

Due to the problems described in previous section we tried to extend the Jacobian to be a matrix with guaranteed rank at least n.
In this method $2(n-1)$ rows corresponding to $n-1$ pairs have been added to the original Jacobian. Each pair consists from 2 neighboring segments and is treated as independent structure. So in every added row there are two non-zero items in corresponding columns (in row i non-zero items are at columns i and $i+1$). Added rows are linear-independent.
Such technique has several advantages in comparison to standard method. First the Jacobian's rank is guaranteed to be at least n. To be able to use standard matrix inversion, e.g. Gauss elimination method, it is necessary to apply Least Square method first to obtain matrix with rank exactly n. Next the inner parts of the structure can be controlled whereas standard method enables only control of the EE. And thus we can put some constraints on the whole structure and also its parts. Finally the complexity remains $O(n)$ computation steps to create Jacobian as standard inversion.
The future work should concern with definition and description of constraints to achieve desired behavior of the structure as a whole not only of the end of the structure.

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Error Analysis of Orient3D and InSphere Tests

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On today computers we have to take in account finite arithmetic when performing any computations in both integer and floating point arithmetic. Using floating point arithmetic causes rounding errors during computation.
The Orient3D and InSphere tests are methods to determine mutual position of a plane vs. point and sphere vs. point in 3D. These tests are very useful in computer graphics algorithms for instance in Delaunay triangulation.
Tests are based on determinant evaluation where input data are coordinates of points in 3D. There is no restriction on values of coordinates of input points and thus floating point is being used for evaluating of determinants. But only sign of the determinant is significant to resolve mutual position. We need to know whether $D > 0$ or $D < 0$ or $D = 0$. In some cases floating point arithmetic is not able sufficiently to solve the problem of mutual position. For example when matrix of determinant is ill-conditioned then round-off errors can cause incorrect result compared to exact evaluation [1].

General Error Analysis

To be able to solve such problems it is necessary to focus on errors propagation during computation. Therefore we have to consider exact numbers to be in interval [4]

$$x - \varepsilon(x) \le \bar{x} \le x + \varepsilon(x)$$

in floating point arithmetic, where x is known value and $\varepsilon(x)$ its absolute error bound, shortly written $\bar{x} = x \pm \varepsilon(x)$. Following formulas give us results of error bounds for addition and multiplication.

$$\varepsilon(\bar{x} \pm \bar{y}) = \varepsilon(x) + \varepsilon(y),$$
$$\varepsilon(\bar{x} \cdot \bar{y}) = |x| \cdot \varepsilon(y) + |y| \cdot \varepsilon(x) + \varepsilon(x)\varepsilon(y).$$

The first formula can be generalized to sum of arbitrary number of numbers.

$$\varepsilon\left(\sum \bar{x}_i\right) = \sum \varepsilon(x_i).$$

Since the tests are based on determinants we will focus on error propagation when evaluating determinants.

Error Analysis of Matrix Determinants

It is convenient to use recursive definition of determinant without being worried about complexity because Orient3D test uses determinant of range 3 and InSphere test uses determinant of range 4. According to the determinant definition we obtain formula for upper error bound of the result

$$\varepsilon(D,n) = \sum_{j=1}^{n} \left(|x_{1j}| \cdot \varepsilon(d_{1j}, n-1) + |d_{1j}| \cdot \varepsilon(x_{1j}) + \varepsilon(x_{1j})\varepsilon(d_{1j}, n-1) \right),$$

where x_{1j} is value at first row and column j, and d_{1j} is value of corresponding sub-determinant. Sub-determinant's error bounds are computed in the same way.

Orient3D and InSphere Tests

When evaluating error bound of the tests we can use determinant's error bound but it is necessary to replace all $\varepsilon(x_{ij})$ with error bound of corresponding formulas [1].

We also have to find error bounds of the input values. Due to the floating point with double precision arithmetic usage we know relative error of data that is $\delta(x) = 2^{-54}$ according to the mantissa length. Absolute error bound can be obtained through the following formula $\varepsilon(x) = |x| \cdot \delta(x)$.

When we have computed the error bound of the test (Orient3D, InSphere) we can easily determine whether the result of the test, computed in floating point double precision arithmetic, is exact enough or not. It can be obtained from followed inequality

$$-\varepsilon(D) \le D \le \varepsilon(D).$$

If the absolute value of the test is less than its error bound the result can be either negative ($D - \varepsilon(D) < 0$) or positive ($D + \varepsilon(D) > 0$) or equaled zero. In such a case the result cannot be accepted and more precise method must be used [2, 3].

Any arbitrary precision library (special software which provides optional length of computer word) can be used for exact evaluation of the test in case of computation failure using floating point arithmetic. Advantage of this approach based on error bounds as opposed to using arbitrary precision library only is the fact that arbitrary precision library is software and thus is much slower in operation compared to hardware floating point arithmetic. Therefore it is useful to combine both methods to acquire good performance and sufficient precision.

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Generating Semantic Web Content Directly from Data Source

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It is well known that the World Wide Web has become a huge source of information. Today it contains millions of pages on every subject. Accordingly we have to deal with the problem of finding and maintaining information on the Web. This problem is complicated by another fact. Most Web content today is presented only for humans to read and understand. Machines – software agents [3], web crawlers [3] and search engines [3] – can hardly understand semantic information on Web pages. That means they can help only a little with, for example, searching for a proper piece of information. In other words, for computers the Web content is only data, not information.
There are several initiatives for trying to improve the situation. One idea is the Semantic Web [1], which would give more structure and computer understandable meaning to the data on the WWW. The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation [1].

The three basic technologies for the Semantic Web are XML (eXtensible Markup Language), RDF (Resource Description Framework) and ontologies. Using XML syntax we can add structure to our documents, but this structure still doesn't express meaning of content. For this task there is RDF, which uses XML tags to write triples. By these triples, a semantic is formulated like an elementary sentence consisting of subject, verb and object. In this way we can make assertions that a subject, e.g. 'person' or 'scientific paper', has a property, e.g. 'is a friend of' or 'is written by', with a particular value, such as another 'person'. Ontologies were added to the concept of the Semantic Web to formally describe terms used in metadata. Ontology defines not only terms and relations between them, but it also offers a set of inference rules, which allows a software agent to deduce new facts from those asserted in metadata.

Realization of the Semantic Web is still in its very early stage and wide spread is only to be achieved [2, 3]. Its success also depends on mass creation of semantic data that is expected to cover existing Web by machine-readable meaning. To reach this goal, several applications have been designed [4]. These tools are intended to allow manual and/or automatic annotation of existing Web resources.
These approaches often assume that data sources are static, while large amount of information on the WWW is dynamic [2] and data are often stored in relational databases (RDBMS). Generally, web presentation (e.g. HTML pages) is created from these databases and metadata are generated from this presentation.

In our work, we are trying to shorten this process and bring metadata creation closer to the data source. We are examining the possibility of generating RDF data directly from relational database, concurrently with creation of HTML presentation.

We suppose that data in database are in 'classic' relational schema, thus they don't represent particular RDF triples. Mapping from database structure to RDF document (or fragment of RDF document) is made according to a given ontology. Of course, this mapping is generated with the help of a human web site maintainer. This requires special mapping tool.
This kind of SQL/RDF interface would allow the provider of a web site run various semantic web services in addition to traditional web pages.
Let us imagine a university web site, where there are web pages about teachers, students, educational activities and research projects. This presentation is not very suitable for machine reading, but all data are stored in the relational database, where they are better structured as in a HTML documents. We can use these facts to generate RDF metadata directly from the relational database. Ability to pump RDF information from database allows various agents (humans or machines) to query database as it was RDF document. Then agents can browse this information and due to the ontology infer new facts from those asserted in the database.
Obviously, RDF data suits a software agent but not a human reader. To enable a human to browse this kind of information (asserted as well as inferred facts), there must be another interface, from RDF to HTML, again based on ontology. This issue is one of additional tasks in our research.

Discussed approach doesn't suit annotation of large static text documents. However, there are a great number of dynamically generated web sites intended to cooperate with their surroundings or to provide information about well structured domain, for instance electronic libraries, human-resource databases, community web portals, e-shops and so on.

In the future we are going to focus on an implementation of simple semantic web application over data source used as base for common web presentation. The next big challenge is creating a formal methodology for mapping relational database structure to RDF metadata according to a particular ontology.

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Wrapped Butterfly and Gossiping

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Parallel computing is still very important and popular. Large and time consuming problems are in focus of parallel computer scientifics. Communication operations are very important in parallel computers with distributed memory. They are the only ways how to exchage data among processes.

Collective communication operations frequently occur in parallel computing, and their performance often determines the overall running time of application. One of the fundamental communication problems is gossiping (also called total exchange or all-to-all non-personalized communication). Gossiping is the problem in which every processing unit p wants to send the same packet to every other p. Said differently, initially each of the n processing units contains an amount of data of size h, and finally all processing units know the complete data set of size $n*h$. Gossiping is used in all applications in which the processing units operate autonomously for a while, and then must exchange all gathered data to update their databases. Many aspects of the problem have been investigated for all kinds of interconnection networks [2].

We are considering wrapped butterflies, *wBF*. They form a parametrized class of networks. The k-th network has $k*2^k$ nodes of degree *4*. The nodes are indexed by two-tuples (i,j), $0 \le i \le 2^k-1$ and $0 \le j \le k-1$. They are connected by straight and cross edges. Straight edges connect nodes $(i,*)$ into i lines. These lines are connected by cross edges. Nodes $(*,j)$ we call rows.

In the telephone communication model, a processing unit can communicate with only one of its neighbors at a time, but it can both send and receive during this communication. In this paper we assume this communication model. We also assume that in one communication round two communicating processing units can exchange all available data. This is called the unit-cost model, which is considered in most theoretical papers on gossiping.

In the unit-cost telephone model we are considering, giving a gossiping schedule of length l, amounts to giving a sequence of l matchings: matching i gives the set of edges that are used in communication round i. In our case we will work with a small set of matchings M_i. To represent a long regular sequence of such matchings, we use the following notation for regular expressions. A term $[x]^k$ means that x is repeated k times. A term $\{xy..\}^k$ means that the regular expression is starting with x, is of length k, and is composed from x and y which are used alternatingly. A term $\{..xy\}^k$ means that the regular expression is ending with y, is of length k, and is composed from x and y which are used alternatingly.

Even more, for gossiping we define two following operations: Going-straight down or up means using only straight connections, moving up or down. Distance x is covered in x rounds. Braiding up or down means using alternating using straight and cross edges, moving up or down. A distance x is covered in $2*x$ rounds.

For gossiping in wBF_k we use four matching, covering all edges of wBF_k exactly once. We denote them as follows: M_0 contains all edges between $(i,2*j)$ and $(i,2*j+1)$, M_1 all edges between $(i,2*j-1)$ and $(i,2*j)$. Hence, together M_0 and M_1 contain all straight edges. M_2

contains all edges between *(i,2*j)* and *(i+2^i,2*j+1)*, and *(i,2*j+1)* and *(i+2^i,2*j)*, M_3 all edges between *(i,2*j-1)* and *(i+2^i,2*j)*, and *(i,2*j)* and *(i+2^i,2*j-1)*. Hence, together M_2 and M_3 contain all cross edges.

Gossiping in wBF_k, $k \geq 4$ and is even, can be done in telephone model in *5*k/2-2* rounds using $[M_0M_2M_1M_3]^{k/2-1}M_0M_2M_3\{M_1M_0..\}^{k/2-1}$ that improves result presented in [2].

Wrapped butterfly *wBF* is vertex symmetric network. It is possible to describe gossiping for any node and due to this symmetricity this description holds for every node. Without loss of generality, we describe gossiping for node *(0,0)*. Gossiping starts by braiding using sequences M_0M_2 and M_1M_3. Each of these sequences doubles number of informed nodes on every next row. After *2*k-2* rounds braiding stops. In this moment matching M_3 is used which caused that one complete one row is informed by packet from source node *(0,0)*. More exactly, all nodes at row *(*,k-1)* are informed. Going-straight operation continues. Packet is distributed by matchings M_1 and M_0 in next *k/2-1* rounds until all nodes are informed. All together we need *2*k-1+1+k/2-1=5*k/2-1* rounds.

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Methods for Modeling and Rendering Atmospheric Phenomena

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Two main approaches to modelling and rendering clouds and other atmospheric phenomena are currently used in computer graphics - physically based techniques, and ontogenetic techniques. The physically based techniques attempt to simulate the meteorological processes that are responsible for atmospheric phenomena. Ontogenetic techniques try to capture the visual appearance of clouds without simulating actual physical processes. This paper describes an efficient implementation of selected ontogenetic algorithms for modeling and rendering clouds and other atmospheric phenomena that are described in details in our work [1]. In that work we firstly explained physical processes responsible for creating clouds. We described types of clouds, which could be seen in the nature, and conditions at which any type of cloud could occur. We also brought together an overview of existing physically based and ontogenetic methods for clouds simulation and rendering. Finally we implemented a method, that uses cellular automata [2] for realistic cloud modelling. We implemented a rendering method that computes single scattering of light [2]. Both methods are computationally quite inexpensive, thus simulation and rendering is performed at almost interactive frame rate. Next, we implemented an algorithm for rendering shafts of light (visible beams of light passed through gapes among clouds) and an algorithm for displaying real-looking sky. We have extended all these algorithms with the aim to achieve a higher speed of simulation. These improvements are introduced in the following text.

We implemented a method for simulation of cloud evolution based on cellular automata. The simulation space is divided into voxels that represent cells in the cellular automaton. At each cell, three logical variables representing a vapor, a phase transition factor, and cloud being are evaluated. A cloud evolution is simulated by applying simple transition rules at each time step. Since every variable is stored in one bit, simulation is performed using boolean operations and is memory efficient. The nice feature of boolean operations is that on 32 bit machines up to 32 logical variables could be calculated at once. Also, for further speeding up of this algorithm we rewrote all boolean operations into assembler language, that gave us about next 15% speed up of simulation. Disadvantage of this method is that a continuous density distribution of clouds that is required for rendering cannot be obtained directly, but it must be computed by smoothing binary distribution obtained from simulation.

For rendering of clouds we implemented a method that uses a splatting algorithm. In this method we utilized a *metaball* for density distribution visualization. A metaball is defined by its center, radius, and the density at the center of the ball. The rendering algorithm has two phases. First, the attenuation ratio of light caused by passing through the clouds is calculated. The shadows of the clouds on the ground are also calculated in this step. In the second phase, the image is generated using results obtained in the previous step. Advantage of this method is that we were able to easily incorporate a graphics hardware support for time demanding computations. Unfortunately, in the first pass of the algorithm, the attenuation ratio is obtained by reading pixels back from the frame buffer. This is a method's bottleneck, thus we read a well defined bigger group of pixels, instead of reading either single pixels or the whole

frame buffer. The speed up is recognizable especially in the case when the scene is viewed from directions that are not parallel with voxel space containing metaballs.

An algorithm for rendering shafts of light [3, 4] works as follows. We render a number of virtual planes that are perpendicular to the viewing ray. The higher number of such planes is, the better image quality is achieved, but computing time grows linearly. For every point on the plane we determine if it lies in the shadow. We compute it using a shadow texture for every virtual plane. A shadow texture is created as follows. A viewpoint is placed at the position of the light source. Depth values of all objects are written in the depth buffer. Then every virtual plane is rendered in white color using read-only information from the depth buffer. This creates a shadow image in which visible parts of the virtual plane viewed from the light source are rendered in white. This image is read back and projected on virtual plane. Virtual planes are finally rendered from user's view using additive blending function. Novelty of our approach is that we use multitexturing with combination of graphics hardware register combiners (NVIDIA cards) for rendering virtual planes. This speeds up their rendering almost twice. Disadvantage of this method is that it shows visible artifacts caused by impossibility to render clouds along with virtual planes, because both rendering algorithms use alpha channel of frame buffer differently. That is why the discussed algorithm for displaying shafts of light is not suitable for shafts caused by semitransparent objects.

We plan to remove unwanted visible artefacts that occur during rendering shafts of light. Better algorithm could use a hardware accelerated rendering directly to the texture, which will avoid time-consuming transferring of frame buffer into texture and even avoid writing to the alpha channel. Next, we would like to focus on faster rendering of clouds. The slowest part is finding an attenuation ratio of the cloud, especially reading values of the pixels from the frame buffer. Current extension of algorithm does not give us a sufficient speed up. That is why it is necessary to find a method, which would avoid such reading. Our attention will be also oriented towards using new features of modern graphics card. Those cards have introduced a sophisticated control of rendering process based on fully programmable vertex shaders. By utilizing these features, not only rendering, but even simulation phase itself could be computed on graphics hardware.

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ALU for Modular Arithmetic

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Modular arithmetic, or finite field arithmetic, is becoming widely used in a number of fields. First of all, we should mention cryptography, where modular arithmetic plays a significant role in public key cryptosystems, key exchange schemes, digital signature systems, and so on. Other uses involve systems for solving systems of linear equations exactly, capable of finding the correct solution even in ill-conditioned cases.

The primary, long-term objective of our work is to develop fast and efficient hardware algorithms for performing the elementary operations in modular arithmetic, integrate them into a fully functional arithmetic unit for modular arithmetic, and implement the design on FPGA and ASIC platforms. The resulting ALU should support all elementary operations in a finite field GF(p); that is, addition, subtraction, multiplication and inverse modulo a prime integer p.

In our previous works [1–3], we have primarily concentrated on algorithms and hardware architectures for computing one of the mentioned operations, the modular multiplicative inverse. The modular inverse of an integer $a \in [1, p-1]$ modulo the prime number p is defined as the integer $x \in [1, p-1]$ satisfying the condition $ax \equiv 1 \pmod{p}$. Often, the notation $x = a^{-1} \bmod p$ is used.

The modular inverse can be calculated using a number of algorithms; for example, the extended Euclidean algorithm, modified Kaliski's algorithm [2], or the recently proposed left-shifting algorithm [4].

Since the modular inverse is the most complicated operation the arithmetic unit is expected to handle, we have based our choice of algorithms on this operation. As we have found, the recently proposed left-shifting algorithm is the fastest, compared to other considered algorithms. Its corresponding hardware implementation is more complex than that of other algorithms but it is well suited for implementing the other operations as well. We have taken this hardware architecture as the basis for our current design of the modular arithmetic unit.

Modular multiplication is similar to integer multiplication, except that a modular reduction is performed at the end of the calculation. More precisely, given the integers $a,b \in [0, p-1]$, we are looking for an integer $x \in [0, p-1]$ such that $x \equiv ab \pmod{p}$. It is covered by a number of algorithms; however, many of them utilize special encodings of numbers, or particularly special architectures. We have used a straightforward approach and implemented an algorithm that performs a sequence of integer addition, binary shifts and modular reduction until the desired result is found. This algorithm has an important advantage – the hardware for computing the modular inverse is able to multiply with only a few modifications.

Modular addition and modular subtraction again resemble their integer counterparts, with the reduction modulo p performed after the respective integer operation. Described more precisely, given the integers $a,b \in [0, p-1]$, we are looking for an integer $x \in [0, p-1]$ such that $x \equiv a+b \pmod{p}$ in case of addition and $x \equiv a-b \pmod{p}$ in case of subtraction. We have again implemented the computation in a straightforward approach. In the first step, the

required operation is performed in integer arithmetic. Then, the result is reduced if it falls outside of the required range. Again, these two operations can be added to the hardware architecture with only a few additional modifications.

The final hardware architecture supports the algorithms for all four described operations. It has a "butterfly" structure. The "master" part contains the register P (holds the prime modulus *p*), the work registers U and V, an adder/subtractor unit, a left-shift unit, and several multiplexers. It is able to load the contents of the register P, the operand to the inversion operation or one of the operands to the other operations; add or subtract U and V; shift U, V or the result to the left.

The "slave" part contains the work registers R and S, the output register Y, an adder/subtractor unit, a left- and right-shift unit, and again several multiplexers. It is able to load one operand to the multiplication operation and two operands to the addition and subtraction operations; add or subtract R, S, P and V (only a subset of combinations is possible); shift R, S or the addition/subtraction result to the left or to the right; store the final result into the output register Y.

The remaining parts of the hardware architecture are the test logic and the finite state machine (FSM). The test logic evaluates contents of the work registers and results of the arithmetic operations; its outputs are used by the FSM to control the progress of the computation.

We have described the hardware architecture in VHDL, the industry standard for describing digital hardware. The design can be readily implemented in a suitable target platform. We have tried synthesis for the Xilinx Spartan II FPGA, using several different settings and various word sizes of the architecture. The results show that the designed hardware is fully functional.

The current design can still be improved in a number of ways. Our future work will concentrate on the search for more efficient, hardware-oriented algorithms for performing the individual operations, design of a faster and more optimized arithmetic unit, and fine-tuning the design for implementation on various FPGA and ASIC platforms.

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E-Business Application Development Technology Review

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The development tools are determinates by platform they are using for. This paper compares basic technology of each reviewed platform. Specially these parts of platforms used for E-Business application development. The platform compared in this paper are Microsoft .NET [2] and Java 2 Platform, Enterprise Edition [3].

The heart of .NET platform is its core called .NET Framework. Summaries fundamental and characteristic of .NET Framework, it is application run time environment consist of independent object oriented libraries, supporting databases, communication protocols, process, threads and I/O operations. Furthermore it offers tools for web services creation. Thanks to object oriented structure of Framework and robust definition of data types, it is a platform offers using set of different languages. Example exception raising unification results in their independent generation and processing. Types are native represented as classes and they are free to extend as well. Additional the core of the platform is capable to detect illegal type manipulation etc.

ASP.NET offers new kind of E-Business application implementation, which is similar to the known model used for Microsoft desktop application development in few last years. It is based on event control programming called WebForms. This extension didn't force any change of currently web-based application standards; only try to use all of these together effectively. Finally application based on this model separates presentation and application logic into two independent layers. This ASP.NET advantage is possible to use only with connection to the some powerful tool like VS.NET or WebMatrix are. Summarize web application development nowadays; application logic is placed directly into HTML pages or is linked there. These pages are interpreted through application servers and the result is getting back to the user as a pure HTML. With this model had been working ASP.NET predecessor ASP. The highest benefit of ASP.NET is separation of layers - application and presentation are separated into two different parts. ASP.NET terminology calls that as Code behind. Further part of .NET technology extending the E-Business application world is ADO.NET. It is used for data access and managing. A characteristic of ADO.NET is using XML in design and data transferring and representation. The concept of ADO.NET is split into several objects with different, but compound functionalities. DataReader has access collections of records. It is forward-only cursor in general. DataSet and DataAdaper together access transferring data from source to data cache on client. They are also able to work with data on client after server-client connection is closed. DataSet and DataAdapter may store data structures, which we used to call relation data stores. One of the main advantages of DataSet is independency on data source, even particular tables can fill different sources also insist of XML files.

J2EE platform defined in few sentences is extension of Java standards with advanced methods of programming, which are documented with couple of standards. These standards are handling compatibility and also support development and live cycles of application. The

Java source is interpreted into Byte Code, which is translating through special programs of Java platform. Java platform consist from two parts, first JVM handling the HW linkage and Byte Code interpretation, second standard library classes called Java Core API. Affection of interpreted languages, slow speed, Java trying to solve through Just in Time compilation, which is also available within .NET platform. Base unit in J2EE E-Business application structure are servlets and JSP pages (also using with same extensions like BC4J from Oracle). Servlets are CGI for Java platform. They running on the server which is middle tier between client http requests and application or database placed on web server. Servlets reads data sent by user including information in request. Then servelt makes results for these inputs. This process can be handled by several ways for example by RMI or COBRA application calling etc. If we are using servlets, JVM is also running and handles every request through Java thread. If there is a several request for one program, together several threads are active handles every on them separately, however only one class copy of servelt exist. Servlets uses very sophisticated tools for syntactic analyzes of HTML, decoding and headers setup, session and cookies support. Servelets are parts of Java platform, this adventure offers to use them on the most of application servers including Microsoft IIS. Also JSP pages are based on servlets, furthermore they make rapidly E-Business application development process easier. JSP uses sets of special marks with different meaning, which are placed directly into HTML code. It offers place there application logic. Each of mark has special functionality logic. A JSP directive defines global settings and offers crating new user customize marks. Using special sign is possible to insert declarations, scriptles include Java code and an expression writes content into out objects. As I wrote above, JSP are extension of servelets - demonstrating on live cycle of JSP page. When we store JSP page into the server and it is requested, than JSP is translated into the source code of servelt. Lastly I will describe Business Components for Java, which are sets of technological Java and XML resources offers better and faster E-Business application development. If we want to compare BC4J with some parts of .NET it has to be ADO.NET who has a similar functionality. It means that it is resource for data processing. BC4J is OpenSource technology, which is based on Java standards as JavaBeans and CustomTags are.

The main differences between these technologies are visible within application layer, where their resources produce same results using different philosophy (for example BC4J and ADO.NET). In general there are no significant differences between these technologies. Any of them doesn't offer new key point for E-Business application development, though the user interaction is different with using each of them. Developer has to choose concept, which is much closer to his knowledge's and personal priority.

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Web Application Development Tools

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Focus on the E-Business platform technology details; there are large differences between basic development practices for each compared development platform (J2EE, PHP, .NET). This paper contains summary of these key differences instead of using metrics.

Every platform is much more powerful when the development suite its used. Significant example is .NET; Visual Studio is presented like a part demonstrating power of whole platform. To demonstrate the differences it is better overview specify parts used within E-Business applications. This comparison use practices learnt on developing reference application (Electronic WebShop) per three application tools. Parts of the review are Microsoft Visual Studio.NET [1], Oracle 9i JDeveloper 9.0.2 [2] a Macromedia Dreamweaver MX[3].

Data presentation logic is part, which all E-Business applications have to use expect Web Services. .NET platform which is using by VS.NET helps better then other to developer connect application logic with presentation layer, furthermore the content presentation is effortless as desktop application models use. .NET automatically generate JavaScript at the client side providing faster functionality on the client. Splitting presentation layer between two independents layers is also used in Jdeveloper. This tools offers through special wizards generate complete middle tier contents encapsulated data. These are used with presentation logic same as application logic. Compare these two different methods, .NET and Jdeveloper is very lump. Jdeveloper model is clearer for advance developer, but VS model is easier to understand to beginner. On other side is Macromedia development tool, where splitting layers has prepared developer by himself. Next specific part is data generating. The significant differences are also between presentation resources. As VS and jDeveloper offers predefined modules cooperating with whole platform (BC4J, WebForms), Dreamweaver only helps predefined code using some kind of macros. The most important part of web-based application is data connectivity. All of these tools offer its own way how to helps developer. More complex and useful is object model using within Jdeveloper and VS. Macromedia only helps predefined part of code into the HTML. Object, which referred to connection, should be change by request. Thanks these points are application using Jdeveloper and VS data independent to data sources. Same difference is for application coding. VS and Jdeveloper offers much more powerful technology background to specify all needs of developer. It means cut off some programming, because of tools will helps to do that.

For the electronic small business application solutions, realized by one developer, it is recommended to use PHP technology - Dreamweaver. Using these resources is possible with base knowledge of programming, communication protocols, databases and HTML. Complexity in designed applications needs powerful solutions. For that reason, tools like VS.NET or Jdeveloper are recommended to use.

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Securing Data in Untrusted P2P Environment

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In last decade as Internet has rapidly evolved from a pure academic interconnecting network to an everywhere present medium. This rapid pace opened an idea of using the Internet as a large distributed file system. As the effort to achieve this goal started not long time ago, only simple applications have been deployed so far. The idea behind is to incorporate many machines connected to the Internet to create a large, virtually file system providing transparent and fault-tolerant file access while securing data against both unauthorized access and nature disaster. In this paper we shortly summarize the data securing schema used in the Gaston distributed file system project [1] to address human threats.

The simplest way how to participate in any kind of society is just to come and join. In this project we adopt this idea as well while preserving as much freedom as possible. Thus the system is build upon peer-to-peer (P2P) principles which have proved to be nearly ideal for this kind of service. The introduced freedom and openness of the system, however, brings several negatives to the system design, which are of the indispensable importance. Let's imagine people being connected into the system, who might want to get access to resources that they are not authorized to. The threat results from one the most important architecture features of the system - the use of arbitrary computer that its administrator connected to the system. In that case machine's free storage is reserved for use by other users and thus their data are exposed to the administrator (the same way applies to local data on a single i.e. not Internet-connected computer).

Nowadays, several cryptographic solutions can be applied - both, patented and public domain; however we do not discuss this patent related difficulties here. Briefly said, symmetric cryptography is to be used to achieve data confidentiality and at the other side, asymmetric algorithms assure data authenticity and consistency as well as user authorization.

Distributed nature of the system implies usage of a "differential" update modus of data exchange to reduce network traffic and increase overall system performance. Adopting this schema, the elementary data object subject to the system activity (e.g. file, directory, picture, etc.) [2] evolves in time, creating a concatenation of discrete updates as they have been applied to the object. To achieve data object consistency as well as reasonable performance of file operations meta data is attached to pure data object. A modification table is used to keep track of all changes applied to the data object so far and can be viewed as a contents page of a book.

Since data object is exposed to many man-caused threats it is not only encrypted but also digitally signed to prevent unauthorized changes in the data. In the current state of the system, only a single signing key is used, so either a single user or a community of users all sharing the same digital signing key can access the data to change it. Every update requested to the object is verified using the corresponding public key since only the authorized user can generate the valid signature and after that the digital signature is placed into the data object. This mechanism not only ensures user authorization but also assures data object consistency, since all parts of the object (the modification table, original data and all updates stored in the object and corresponding to the modification table) are subject to the process of signing.

Data confidentiality is assured by means of symmetric cryptography algorithms such as IDEA, AES, 3DES etc. however choosing a particular algorithm is not mandatory since

every algorithm provides such a level of confidentiality the user has selected. Due to performance requirements the best available security level provided by the particular algorithm cannot be reached. This restriction comes from the generic behavior of cryptographic algorithms where data are mixed as much as possible to make it difficult to decrypt data without a specific key. This, in reality, means that as much as possible amount of original data is used to calculate every encrypted unit of data so modification of data object would result in very expensive operation. Hence we propose to use fixed-length data block schema, in which the data block is the unit of the encrypt/decrypt operations. Though, this approach will decrease the level of data security (besides it is hard to define it exactly), it will not significantly decrease the overall performance of the system.

The previous mechanism itself can only detect unauthorized modifications in data objects. To recover these situations data object replication has been proposed in the overall system design. Using this feature, data object in the proper form is with very high probability present in the system and when needed, it can be looked up and be available to the user. Malicious object modification without storing valid signature can be handled by two ways. The first one is a reaction to a remote file system failure, where due to an unknown error data has been corrupted. In that case the node characteristics is updated to reflect the situation and its credit is decreased. This does not imply that the node is immediately removed from the system due to its unreliability; it just means that the node storage quality has decreased. The other handling of the incorrect signature is caused by unauthorized modification and is handled with a more serious effect to the overall system. In this case the malicious node should be marked both as unreliable and dangerous to prevent similar attacks to other data stored (or to be stored) at the node.

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Authority Records Files Development – Next Phase of CTU Libraries Participation

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The creation of National Authority File in CNL started in 1995. The goal of this activity is to create and maintain a system of national authoritative headings for personal names, corporate names, and uniform titles based on international standards and recommendations (Unimarc/Authorities). This is very helpful from an international point of view. Authority control on a national level facilitates an international exchange of data and makes easier access to national databases. CTU libraries have participated in the National Authority File project, a co-operative project of the Czech National Library (CNL), since 2002.

The objective when creating and expanding authority control for personal and corporate headings is to bring precise search performances in bibliographic databases (i.e. library catalogues), to get the user to the uniform authorised form used to co-locate bibliographic records. This means: one person – one authority record. The same can be applied to corporate names. The principle is to choose the name by which a public identity is most commonly known as the authorised heading. There is also the need to facilitate national and international co-operative efforts in attaining authority control. Among other prospects, it would help to reduce costs by automating and simplifying the process of derived cataloguing.

The presented project goal was to continue in a co-operative effort in creating and using the National Authority File (NAF). Main activities focused on creation of new authority records as well as on harmonisation of CTU local database authority records with the records in a NAF.

Creation of authority records for persons from CTU

CTU librarians focused on a creation of authority records for persons of CTU academic staff in 2002. They used personal data from the CTU information system which contained information about the most of the university staff. An authority file containing 2,485 records has been built up and loaded into the NAF. During this process every record was checked and compared with the NAF records. The procedure had shown that the NAF database contained only 314 identical personal authority records before. As a result of this first phase of creating personal authority records a decision was made it would be efficient to continue this activity next year.

The project goal for 2003 was to create authority records of persons from CTU who either died or left the university. As a source for personal data a CTU archive card file was used. A creation of new authority records was a bit complicated because of the nature of the traditional paper card information. The time period for the data created and added to a personal authority file was 1945-2001. To support the creation of records and to be able to compare them with existing records in the NAF efficiently a software tool for analysis data

had to be developed. All the new records were checked and analysed then. Some of them had to be corrected, some created again. As a result of this 446 records were created and 57 of them were imported to the NAF database in 2003.

Creation and harmonisation of authority records for CTU corporate names

A local CTU database contained records with CTU corporate headings – the names of faculties, institutes, departments and other parts of CTU. These headings had to be checked with the NAF records. CTU corporate names headings were compared with the standardised forms of corporate names in the NAF. If a CTU corporate name was found there an authority record file was downloaded and imported to a local CTU database. The next step was to harmonise the headings towards the authority record, remove duplicates etc. Most of downloaded records needed corrections and changes because the current data in the CTU database were more complete and accurate. As a result of the CTU organisational changes during past years a lot of new records had to be created. The project expected it would be necessary to create about 140 records. The creation of authority records for corporate names was more complicated and has taken longer than was expected. After transferring the records to the NAF database additional changes and corrections had to be done. The librarians involved in this activity needed detailed instructions and training. It was necessary to discuss the methods and techniques for corporate name authority records creation before the procedure started. All the records were checked again and then transferred to the NAF database through the Z39.50 protocol. Using this way 300 corporate names authority records were created.

Harmonisation of authority records for personal names with the NAF

This was a continuation of a previous work done during the first phase of the project. Nearly a half of a database – records for the names with initial letters from A to L – was checked and harmonised in 2002. Checking the records continued in 2003. Thanks to the retrospective catalogue conversion nearly 300,000 records were added to the database during this year. This caused some inconsistencies in the local authority file database. Therefore the authority records checked before had to be revised and corrected. The total number of checked and harmonised records during 2003 was 75,000. The procedure used the same methods and techniques as in 2002.

The project achieved all its goals. New authority records were added to the National Authority File. Some of the existing records data were corrected thanks to the unique CTU archival source. A complete CTU corporate names authority file is one of the benefits of the project. Harmonised personal names authority file is also very important.

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Communication Security in Multi-Agent Systems

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Both, research and application development in the area of multi-agent systems currently undertake a rapid expansion. In order to use the multi-agent technology in real applications, it is inevitable to implement security, integrity and authenticity of inter-agent communication. Various security systems, developed for different applications have been used in multi-agent systems (MAS). Alternatively, MAS are designed with respect to the specific communication security requirements. We propose the architecture and implementation of the security system, which implements authentication and secure FIPA-compliant information exchange among the agents.

Basic requirements on interaction security among standalone entities and set of recommendations how to implement them regardless a programming language can be found e.g. in [1]. Communication security in multi-agent systems can be implemented either by the message encryption (security against monitoring by undesirable side) or message signing (assuring of message content's integrity). In some cases it is not necessary to secure whole message but its parts only. Our proposed approach attempts to avoid disadvantages of existing security systems in MAS and suggests a set of improvements e.g. allow communication among the agents using security and already existing (unsecured) agents, minimize the number of messages and amount of transferred data necessary to ensure the security or enable agents to generate new security keys in the case of suspicion of their misusage.

One of most obvious problems with implementation of security systems in MAS is that the solutions are mostly created ad-hoc without respect to the existing standards. This makes impossible interoperability among systems implemented by different designers. Therefore we also emphasized on creating a solution that will comply with standards of the FIPA organization [2]. We have decided to extend the FIPA ACL message structure with a new X-Security slot. In this slot we specify, how the message content has been signed/encrypted, what certificate (pair of keys) was used, etc. This approach allows portability between different types of platforms. Using this mechanism, chaining and storing of signed messages are also possible, unlike using SSL (Secure Socket Layer) where only one-time communication channels are opened.

Either the whole message content or just parts can be signed / encrypted. Agents can exchange both secured and unsecured messages at the same time. This means, that agent not using a security package can use current form of ACL Message without any restrictions.

In the proposed approach the dedicated central authority is required to administer an important part of the security mechanisms. This authority issues appropriate licenses – certificates. Agents use issued certificates to prove their identities and execute security related actions within the system. Function of the central authority is in the proposed system implemented by the Security Certification Authority (SCA). SCA is a standalone, application independent agent that allows certificate registration/deregistration and provides other agents in the community with these certificates. Certificate contains mandatory information requested by the SCA and may contain additional information supplied by an agent. Information requested by SCA is agent's identification, public keys (and their description), and requested validity time and security level in MAS. SCA verifies these data and stores them into the certificate. SCA can't guarantee validity of optional data, but can assure their

constancy (originality) when providing other agents with the certificate. SCA signs whole certificate and thus allows receiver to verify the integrity of contained data. If agent needs to send encrypted message to another agent, verify signature of received message or check the security level, it asks SCA for particular certificate.

On the agent's side security service is provided by the security module that is put between the agent's core and communication layer. Incoming messages are withdrawn from the input queue. These messages could serve for security management (e.g. required certificates); they could be secured (e.g. by encryption, signature, etc.), or unsecured that are passed directly to the agent's core. Security module uses SHA with DSA algorithm for message signing and RSA algorithm for message encrypting. Module is composed from several standalone units. First of them provides methods for encrypting, decrypting, creating and checking the message signature. Second ensures the connection with SCA and exchanges certificates with other agents. Third unit maintains database of received certificates, private keys and session keys. This unit provides them to other units. Storing the certificates in the database allows us to minimize the number of messages exchanged in the system and overrides the problems with the temporary SCA inaccessibility. During this phase the agents are allowed to provide their certificates one other. Even though the agents can't register the new certificates anymore, the already existing security links are not affected. Last unit provides interface between security module and agent's core, which is necessary e.g. to configure the module's behavior or when partial encryption is required.

Described security system has been implemented in Java as an extension of the JADE multi-agent platform [3]. It has been included and successfully tested within various application domains and projects e.g. Agent Exchange system - model of an agent trading environment and a test-bed for modeling various market situations or ExPlanTech project – technology for production planning and supply chain management.

The result of our implementation is a system that avoids some disadvantages of the current security systems and provides the user universal security module that can be included into the common agent and Security Certification Authority, which issues and manages appropriate certificates. Whole system complies with up-to-date standards in the area of multi-agent systems.

More detailed description of the above outlined principles and algorithms can be found in [4].

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Database in Web Environment

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Under the term „engineering“ is generally understood the systematic application of the scientific knowledge during design and creation of the economically effective solutions of the practical problems. If we apply the engineering definition to the web area, too, then we can define the term web engineering as an application of the systematic, disciplined and qualified approach to the development, operation and maintenance of the web applications.

The basis of the present web applications is a three-layer model. The web-client interface is considered as the first layer and the web viewer (Internet Explorer, Mozila, ...) is most spread of them. The client cooperates with the second layer that is a web server relevant to the web application. The web server supports the application programming (CGI+API DB, PHP, ASP, ...). Application operating in the second layer needs to cooperate with some data source stored either in the form of „real“ database systems or non structurally in various formats and on various platforms. Then, the third layer is mostly database system in which data information of the application is stored. The communication between programme logic and a database system is presently provided by the ODBC, JDBC or by the special API interface of the relevant application interface to the database system.

And what is the reason for the access to the web information via the database system? The reason is quite simple and follows from the essential feature of the web engineering. We want the data to be safely stored, to be up to date and its actualization to be running without the administrator interference. All of these advantages are introduced just by the usage of databases on the web.

In today’s world, where a huge quantity of information arises in every moment, the technologies are inseparable tool for the effective data storage, processing and re-searching. Based on the information technology and above all database evolution, several types of databases arise. Undoubtedly, the relational databases, termed as RDBMS (Relational Database Management Systems), are of the most spread ones. For example, MySQL (http://www.mysql.com/) can be indicated as their representative. The object databases, termed as ODBMS (Object Oriented DBMS), are the second (no less important) group. The GameStone database is their representative. But today, both groups begin to penetrate and present databases try to accept the better features if both groups they are termed as ORDBMS (Object Relational database). They can be represented by the Oracle database (http://www.oracle.com), that enables both relational and object data access with its advantages and imperfections. Beside the basic and most known types of databases, there are a great number of systems that solve data processing by their own way. As an example, we can name the Cache database (http://www.intersystems.com/cache/technology/) that is termed as post-relational database. Cache is a data storage that is able - under specific circumstances - to access the data by relational and object way. However, the XML databases with their native XML structure are developed presently. Apart from databases, that are the hugest data storage, it is possible to store the data into the specific structure files, for example HTML, PDF, XML (the most number of formats are standardised by the W3C organisation) etc.

All of the above mentioned ways of the data saving are comprehensively called data storages. The group of the data storages will never be ultimate, as the new ones are developed and others are abolished all the time. Besides all of the above stated distinctions between

particular data storages, presently it is necessary to consider the platform, on which the system is built, and not only the OS (operational system), but the data access protocol, too.

By both of the areas combining, that are during last years rapidly manifested thanks to the research in the given areas, the critical point seems to be the providing of the universal data access to the data storage from the web (Internet) environment. The usage of the ODBC and JDBC interface is a modern trend of the data access solution from the web environment, but it presents great problems not only by the fact, that it is restricted to the SQL language (on top of it the SQL is presently different on every database system), but it is rather ineffective due to the necessary access via other means, for example the driver of the particular database. There are several (4) types in the case of the JDBC, in addition several of them require the access simultaneously via both the JDBC and the ODBC. The direct interfaces enabling the data access – API – exist for most of the data storage, but the interfaces are very specific and support only various levels of the data access. Present research tries to solve particular problems, e.g. static pages converting into the databases, but the global view still lacks. Presently, the methods of the various content connecting of the data storage are developed at the expert workplaces, presently, the effective transformation of one type of data storage to other, that preserves the advantages of the relevant data sources, is discussed. It follows from the facts stated above, that the universal model by means of which the easy access to data without necessary knowledge of the data storage specification is missing.

The research target is to develop the universal model of the data source by the access to the heterogeneous data spaces and heterogeneous types of information on the Internet/web. The databases are the main area of the data sources. However, the access to the databases is very difficult due to the diversity of their character, different data view and data access. This is the reason why only proper developed model of the data source enables easy and above all unified view to the data sources, stored both in the classical types of databases (relational) and in the specialized databases (object, XML etc), and in the other data sources. It will be the question of the interface between the data source and the user (human, computer) that removes the diversity in the data access and ensures the user friendly means of the cooperation with the data source. The model formalism will include the non standard methods of searching, such as approximately, context and non text information searching. The concrete result of the proposed project is, except the searching model design, the experimental system for the design test and the presentation of the research results at the important conference. The model implementation, testing procedures and evaluation on the selected data sources will be the part of the research procedure.

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Enhancement of Education in the Area of Data Interfaces

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The idea of extending the education of data communication with the principles of MIDI data interfaces is based on the fact that until now there has not been (after abandoning the telex technology) education of any data interface using the principle of electric current loop. The said gap in education is going to be filled with a very practical type of a trivial data interface.

The basic idea that stimulated the development and standardization of MIDI interface was to find a solution for interconnection of various (especially electronic) musical instruments so that they could functionally collaborate, thus multiplying their particular properties and possibilities, not only for the purpose of playing music but also for the subsequent processing and preparation of data. The data transmitted over the interface, however, are not an audio signal, but rather control data corresponding to events (called "messages" in MIDI terminology) initiated by playing the musical instrument (for example pressing or releasing the key on the keyboard). This basic concept was later incorporated in the technical standard MIDI 1.0.

When designing the MIDI standard in the beginning of the 80's, its authors took into account the following conditions:

1. Parametric transmission of information;
2. The parameters are transmitted in the form of messages;
3. Limited number of transmitted parameters (eight types of messages);
4. Low baud rate (and transmission speed);
5. Serial transmission of data;
6. Simplex transmission over a single cable (two connecting cables are needed for duplex transmission);
7. Single-current electrical circuit is used for expression of characteristic states;
8. Various topologies for interconnection of particular devices (star, tree, point-to-point, ring etc.);

These criteria led to the definition of a MIDI standard that had been finished until the middle of the 80's. The said standard was later refined by so-called "General MIDI" standard that is used especially for electronic musical instruments of the lowest class (concerning both quality and price). The MIDI standard itself defines mechanical, electrical, functional and protocol characteristics.

From the mechanical point of view, the MIDI interface consists of three different 5-pin DIN connectors marked IN, OUT and THRU. The "IN" connector serves for input of MIDI data, the "OUT" one for output. The data coming to the "IN" connector are copied to the "THRU" one. The interconnection of devices is usually implemented using shielded pairs between OUT/IN (or THRU/IN) connectors of different devices.

The electrical properties are generally given by the fact that the MIDI interface is a current loop. The logical state "0" is represented by the current of 5 mA; the logical state "1" is represented by absence of the electric current. Serial arrhythmic transmission of data with modulation speed (baud rate) of 31.25 kBd is used. In order to eliminate ground loops between the interconnected devices, the grounding pins of the connectors should not be connected with the grounding of the appliances and the MIDI input of an instrument should be electrically separated by a fast optical separator.

A word (byte) is composed of one start bit, eight data bits and one stop bit. Parity bit is not used. The message consists of one to three bytes; it is a basic block communicating comprehensive information. Some examples of MIDI messages are: note on (information about pressing the key on a keyboard; subsequently, information about dynamics of the stroke is transmitted), note off (information about releasing the key on a keyboard), controller (information about a change of some parameter – loudness, stereo weight, number of the sound bank, special effects like portamento, tremolo or chorus, parameters of ADSR envelope etc.), selection of a program (information about the number of a stop, i.e. timbre), common pressure sensitivity (informing about the pressure that acts on the pressed keys), bending of a tone (relative shift of frequency of the tones), system reset.

By incorporating the MIDI interface theory to the courses dealing with data interfaces we have enriched the education with a neglected type of data interface – electric current loop. The education is not limited to theory – thanks to the fact that MIDI devices are becoming more and more affordable we could prepare a laboratory measurement with practical demonstration of MIDI interface work as well as analytical work and measurements making our students familiar with the protocol, message format and other properties of the MID interface.

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Genetic Algorithms Use for Making Plate Digital Terrain Model

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Digital terrain model (DTM) is important for the civil engineering, for viewing buildings influence on their environment. Therefore it is need for effective model terrain output.
The raster model is the easiest type of DTM. A terrain relief is described by array of vertical coordinates of points. The points are located in a regular raster.
The polyhedry model is the next type of DTM. For polyhedry model a landscape is parceled in smaller plane areas (usually triangles, quadrangles), so as to adjoin to a terrain relief to the nines. The terrain relief is replaced by regular polyhedron with triangle or quadrangle faces.
The plate model has the most effective output . A terrain is parceled smaller areas. No only plane ones. They can be anyway curved.
One of the problems to make the plate model is curvature of the terrain plates so as to continue one another fluently.
Quadratic area is the most used method of the terrain plates curvatures. The area can be written by equation:

R1: $z = ax^2 + by^2 + cxy + dx + ey + g$

This area is running for all border points of the plate. First derivation of the terrain is continuous at a border of two plates. These two rulles give a set equations. By that of we can get expressions of several of the area parameters (*a,b,c,d,e,g)*. We can to replace the expressions to right and left derivation of altitude along the arbitrary trajectory at the border of the plate comes.
There are used triangular plates even quadrangular plates. Fluent curvature of these plates problem is difficult. Sometime it can be insoluble.
It rise the teoretical problem to continue these plates at least to the best fluently. That means difference right and left derivation of altitude along the arbitrary trajectory at the border of the plate comes to be the nearest to 0.
One of the optimization way to the best fluently continue plates is to use evolution computing methods.
It is possible to use GA (Genetic Algorithms) for finding the best curvature of approached areas.
We want to find such parameters, for which all four function are the nearest to 0.
We can use GA for finding the optimal parameters.
We will generate a lot of terrain models by this way. We will choose one model from their along some criteria.
It is several problems of to make GA:
To find applicable parameters representation,
invent applicable crossing operator and mutation operator.
We need to find system of make first solving generation, system of selection and current generation projection to next generations. We need to find stop rule for this GA.

Than we are finding expectations of crosssing and mutation by experiments, so that next generation will be improving.
We will choose the best of generated individuals set models from their along some criteria.
We will choose the most fluently model: such plates witch *fi* values are the nearest to 0.
The plates of the choosen model must hold:

$f_i() \in <0,R>$.

R will be determined by experiments.
The alghoritm for model finding must be effective, to run generating DTM for resonable time. It will be necessary to provide a lot of experiments for various types of terrain areas and to set GA and its parameters.

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Practical Application of eSupport at CTU in Prague

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This paper summarizes basic prerequisites for utilizing the recorded lectures of technical subjects and their placing on a streaming server. It also deals with technical background and problems of on-line streamed lectures.

One of the recent activities of the Department of Telecommunication Engineering at the FEE (CTU in Prague) is focused on recording the lectures of the selected courses and their subsequent placing on a streaming server. The procedure is supplemented with the possibility of live transmissions over the Internet. These activities could be brought into life thanks to collaboration with the CESNET association.

The goal of our project is also verification of the students' attitude: will the full-time students (who are regularly physically present at lectures) be interested in such innovative eSupport tools and will the said tools help them make their study better? In this sense, we do not talk about one or two separate lectures but rather about the whole cycle covering the entire semester.

The key point of the technical implementation is the idea that the recording itself must not disturb the students in the auditorium nor the lecturer. The teacher must be given optimum conditions and must not be stressed by the technology used for recording and streaming.
The workplace consists of three parts. The first one ensures taking of the picture, editing and real-time recording (using a DVD recorder). The second part performs computer processing of the output signal for streaming. The streaming server represents the last one. Students can watch the resulting record very simply – the link to it is placed on our Department's web portal (http://www.comtel.cz).
By determining the concept of the workplace we focused on minimization of the time needed for post-production routines, number of stuff needed for operation of the system and number of operations needed for deployment and moving of the workplace. So we came to the idea of "transmission trolley" – special compact workplace that integrates all necessary components in a connected (i.e. prepared) state, which is mobile and robust. Selection of dimensions respects the conditions given in the faculty building – we can use any elevator.
Regarding the technology used for recording, we enforce the idea that most of the activities necessary for acquiring the complete record (including its conversion into a format suitable for streaming) should be performed during the lecture. Other time losses given by post-processing (either artistic – i.e. editing etc. – or technical – i.e. preparing versions in various formats) are undesirable as they would make the whole process longer, i.e. more expensive.

The scene is photographed by two cameras – one of them taking the lecturer; the second one the blackboard / whiteboard / screen (if the lecturer uses non-electronic materials) for formulas, pictures etc. drawn by the teacher, and it also takes the auditorium, for example, when there are some questions. The lecturer has a laptop computer with electronic materials for his lecture; the computer is equipped with a VGA-to-video (base band) signal converter

(either internal or external); the video signal is the third tributary signal for editing. The voice of the lecturer is transmitted to the editing device by radio waves from an on-head microphone (microport; the particular implementation respect the wish of the lecturer). The editing workplace takes care especially of proper and functional combining of the tributary signals. The resulting signal is recorded (archiving) and also taken to the second part of the workplace.
The second part is in fact a powerful computer that performs real-time A/V-to-digital signal conversion, preparing the signal suitable for streaming over the Internet. The streaming itself is handled by a streaming server (the third part of the system). At the same time, the recorded version is prepared that is placed on the streaming server for permanent use immediately after finishing the lecture.

At present time (January 2004) we have collected the materials covering three study courses for full-time students in magister stage (Transmission Systems I, Transmission Systems II, Program Control of Switching Systems), one course for doctoral students and a series of irregular lectures that are organized by RDC (Research and Development Center for Mobile Communication). We assume that evaluation of this experiment will be performed after closing the winter semester and according to its results we will develop our activities in this area in the coming period.

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Reasoning Based Filtering of Graphical Data

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Nowadays there are needs for storage of graphical information together with its description ([2][4]). An additional description enables searching for specific graphical data. It also allows graphical data to have semantic information that describes used objects and relations among them and that are usually not available directly from the graphical data.

Such a description can be successfully used to improve clarity of graphical presentation by means of *semantic filtering* ([3]). Semantic filters help a user find required information by filtering out information that is not necessary in the particular situation. The semantic description is used to specify filters by means of the user's regions of interest (ROI). User can specify objects and relations and their combinations to get only the most important information. The objects and relations refer to the particular description.

The filtering process using semantic filters has several drawbacks and there are some tasks that cannot be sufficiently solved using this approach because the filtered data contains unimportant information or in a worse case misses some important information. The semantic filters need rich and well-structured descriptions to specify particular requirements. However, all necessary information hardly ever appears explicitly in any description. In addition, such a system is not Turing-complete and cannot use recursive definitions of semantic filters.

We have developed a system that enables us to derive new information and use the new information for a more flexible filtering of the graphical data. Suppose the required data can be well addressed and filtered, there is the possibility of a better management and visualization of the data, since a user need not be bothered about unimportant data in a particular situation.

We want to introduce a way to process semantic information about graphical data – especially derivation of new relations – by means of *logic programming* (LP) known from artificial intelligence. The important features to accomplish are flexibility in different environments and a simple declarative way of requirement specification while supporting advanced features to solve many classes of problems. As far as we can see the LP is the most suitable tool for representation of relations and declarative specification of rules. The well-known representative of LP is the Prolog language. A detailed description of LP can be found in [1].

One of the main motivations for our work was the requirement to filter out information that can be described by a composition of an arbitrary number of relations in a description (using recursive definition).

The description of graphical data can be both semantic and structural. We do not distinguish between them because the structural description can be handled as a special case of the semantic description.

In the simplest case, the semantic description is composed of objects and binary relations among. Since all relations in the description that we use are binary (relations between two objects), we can represent the description in the form of a graph. Vertices of such a graph are objects of the descriptions and edges correspond to relations. The edges of the graph are oriented, so the graph is generally oriented too.

There are two kinds of relations that can be obtained from a graph – explicitly defined relations and implicit ones. Implicit relations can be seen from the description graph but they

are not explicitly defined. If we knew that some relation is, for example, transitive, we could see its closure from the graph, but not so for another program where we do not know about the transitivity. We can use our knowledge to define the missing relations. The knowledge can be represented by logical rules that describe how to obtain new relations from the existing ones. The original description together with rules can be used to enrich the description by the derived relations without much additional effort.

As we saw in the previous text, the description can be represented in the form of a graph. This is a significant advantage, because there are many different algorithms known for graphs and there are many useful and proven theorems about graphs. The graph algorithms can be a big help for derivation, because if all relations (including the derived ones) are defined among the specified objects that do not change, the derivation of new relations is simple addition of new edges to the graph.

General graph algorithms are mainly needed when the required relation cannot be defined as a composition of the fixed number of relations. This can be, for example, accessibility among objects using a given relation (e.g. transitive closures), paths in a graph, spanning tree construction, etc.

Programming a general graph algorithm is not easy in a straight way. Because we use LP, the LP program uses relations (represented by predicates) needed to perform the graph algorithm directly. There is no simple way to pass a relation to the algorithm. For example, this problem is solved by meta-programming in Prolog. This solution requires a lot of experience and it is an error-prone way of programming. We need a way to specify *meta-rules* – general rules that can form specific parameterized instances. If we pass relations (or more precisely predicates) to the meta-rules, we obtain concrete rules that use the relations directly.

We wanted to introduce a suitable way to define meta-rules. We defined so-called *templates* and we integrated them into our reasoning system. Creating templates is quite easy and straightforward process, but still requires an experienced user or an expert for programming them. Many predefined algorithms allow a user to not care about creating templates, but to use them in rule and query specifications.

Templates are similar to standard rules. In addition, the names of relations (predicates) can be passed to the templates and then each symbol name in the template body that is equal to the one in the template head is replaced by the real passed parameter. This process can be done in the same time as the unification of clauses or can be handled similarly to the macro-expansion.

The derived relations then can be used for many different purposes including hiding the unimportant data during visualization, highlighting the most important data (in a particular situation) and to derive another required data. Sometimes visualization of the description alone as a graph can be useful for general overview.

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Video Coder based on Vector Quantization

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Although today we still see an expansion of information technologies and rising speed of computing technics, the idea of data compression is still very actual. Especially in data - type video - where we impact on need of processing large amount of data very fast on the incoming side of the communication chain. The redundance and irrelevance reduction was very well solved by the MPEG 1-2 designers. But in today's multimedial society with demand for integration of large number of communication services into possibly most complex system we also search for ways how to speed up the data transmission. One of the possible solutions could be the usage of Multi-dimensional Vector Quantization. The Vector Quantization already found it's use in static images and textures compression, sound and speech compression applications, in construction of psychoacoustic models and other specialized branches. We would also like to aim on usage in video – MPEG 4, 7, 21 standard [3]. These standards are very generally (open) defined and their implementation, as well as the usage is very variable.

We have performed an experiment with a short color video-sequence using the VQ on a video stream formed by "I" frames. Some of the advantages from the static pictures can be applied on the video-sequence. The codebook is formed by specially designed set of subblocks of the particular frames of the sequence. The overall concept of the coder is designed as a vector quantization with adaptive codebook. The codebook is generated for the input video-sequence by alternative algorithm of uniform reduction of the codebook set. The input variables of the vector quantizer are vectors formed by subblocks of 4x3 pixels of the frames of the input video-sequence. Because we reason about color input video-sequence, the dimension of the quantized vector is 36 (three planes – R, G, B). In the experiment we are using first 100 frames of the video-sequence (25fps – 8 s.). This approach can of course be modified by an alternative image analysis, for example to follow the method until the frame cut.

The original Voronoi cells, often used in VQ, needn't be calculated, because we are using the mean square error (pattern recognition approach) to calculate the Eucleidian distance between the researched vectors. The adaptive codebook generating iterative algorithms for VQ are based on idea of compressing static images and textures and they have a strong feedback to the original image. These can efectively reduce the quantization error. In case of video data we need to reconsider the usage of VQ to achieve comparable results with these techniques. If we were using the same method like in GLA, LBG algorithms [1],[2], the coding times would be extremely long. Especially the structure of the coder is very important. There are still many approaches to MPEG 4 [3] that could be useful when applying the advantageous VQ characteristics.

The compression times are still too high, but with the progress gradient in the information technology we will soon be able to use faster coding devices. The reduction of the transferred information can also bring new view on UMTS technology and usage of fast video applications. In the conclusion a comparison with other often used compression methods is performed. There are significant positive characteristics, that can bring the vector quantization a step forward in the compression algorithms.

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Non-photorealistic Rendering for PDAs

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Our research is aimed on using non-photorealistic rendering on PDAs for faster and more comprehensible displaying of 3D scenes. We use Macromedia Flash technology to transfer and display pre-rendered 3D scenes from a desktop computer to a PDA. User interaction with the scene is possible. This technology allows platform-independent 3D scene browsing on a PDA without need to install any specialized plug-ins.

PDAs – Personal Digital Assistants – are miniature portable computers that fit in a pocket and thus can assist their users virtually anytime and anyplace. These devices are recently becoming widespread, undergoing a similar boom as the mobile phones. Although their capabilities are rapidly increasing, PDAs still lag considerably behind the desktop computers. Except lower processor speeds and memory sizes, the PDAs also lack specialized hardware for accelerating 3D graphic rendering. Fast 3D graphics still did not find its way to this new, mobile platform.

3D models and scenes are displayed on a 2D screen by means of rendering. The quality of the rendering is usually measured by its fidelity (how much the rendering resembles a photograph of a real scene). Rendering method that strives to produce results unrecognizable from a photograph is called photorealistic rendering (PR). Inventing and implementing such methods is one of the ultimate goals of computer graphics research.

Photorealistic rendering can produce very sophisticated results, bur unfortunately it is way too slow even for most desktop computers. It is practically impossible to generate PR image on a PDA, such rendering would require resources the PDAs do not possess.

Non-photorealistic rendering (NPR) provides means of trading image quality for speed. The speedup is achieved by giving up the task of creating an artificial photograph. A simpler image is generated instead, for instance one that resembles a pencil drawing. The NPR renderings have three important characteristics: they are more comprehensible, consume less memory and shorten the rendering time.

NPR has also a psychological advantage: the NPR images often better hide small errors caused by the rendering process, than their photorealistic counterparts. This happens because NPR images resemble fast sketches done by people. The hand-made look and feel of the rendering makes the user to be more forgetful about small imprecision and mistakes in the rendering.

In order to make the PDAs display scenes of high complexity as fast as possible, a client-server approach was chosen. The scene is pre-rendered on a server – typically a desktop computer. Pre-rendered data, simplified by the means of NPR are transferred on the client – the PDA – by means of Macromedia Flash.

Part of the calculations is done using ActionScript directly within the client. As the user browses the 3D scene, new data are requested from the server and streamed to the PDA. These data contain additional geometry information, pre-computed animations of moving

through the scene as well as arbitrary multimedia information, such as sound clips, images or annotations.

Macromedia Flash was chosen due to its wide availability on nearly all platforms. Most users do have Macromedia Flash installed so no additional downloads are necessary for using system. This is a very important advantage. Nowadays, many technologies for transferring 3D data over internet (such as VRML or ViewPoint) suffer from the fact that users are not willing to install and run special software in order to be able to browse 3D data. These technologies thus have only few users. Flash SWF format on the other hand became a de-facto standard for interactive vector-based presentations. SWF is also optimized for transferring vector data over internet, which is precisely our concern.

We used several features of Macromedia Flash in order to minimize the data transfer. Multiperspective panoramas as described in [4] were used for outdoor scene backgrounds. These panoramas are being displayed using affine transforms in object placement tag, consuming only several bytes per frame. Indoor scenes and objects are simplified by method described in [3] and transferred as key framed animation using shape blending tags of Macromedia Flash. Interlaced streaming of data is used to provide illusion of faster system response. See SWF Format Specification by Macromedia for more details concerning SWF – the Macromedia Flash file format.

The results we obtained proved that interactive 3D graphics on PDAs is possible even without a specialized plug-in. The performance of our system unfortunately turned out to be relatively low – the bottleneck is the Flash Player implementation on the PDA, which seems to be far from optimum. For example - a simple animation of 100 randomly moving lines runs only at approximately 30fps on a 400MHz Intel PXA255 processor. This makes our system usable only for highly simplified scenes. The simplification is fortunately often required by the PDA users themselves, since the small PDA displays can provide only a limited amount of information without getting cluttered.

More details about our system are to be found in [1].

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Local Affine Frames for Object Recognition

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The recognition of general three-dimensional objects from 2D images is a challenging task. The problem is essentially this: given some knowledge of how certain objects may appear, plus an image of a scene possibly containing those objects, find which objects are present in the scene and where. Recognition is accomplished by finding a correspondence between features of an image and a model. The two most important issues that a method must address are what constitutes a feature, and how is the correspondence between image and model features found.

What can be considered as the ultimate goal in designing an object recognition system, is to achieve *generality*, i.e. the ability to recognise any object without special user-provided adaptation to a specific task, *robustness*, the ability to recognize the objects under any conditions, and *easy learning*, without requiring special or demanding procedures to obtain the database of models. Obviously these requirements are generally impossible to achieve, as it is for example impossible to recognize objects in images taken in no light conditions. The challenge is then to develop a method which pushes the limits as far as possible, to build a system that is immune to the effects of variable background, noise, image clutter, object occlusions, and illumination and viewpoint variations.

Variations in an object's appearance caused by viewpoint and environment changes are generally complex. Objects with intricate shapes change their overall look dramatically even for small differences in viewpoints. To simplify the situation, we assume that these variations, although complex in general, can be reasonably well approximated by simpler transformations at local scale. Geometric image deformations are locally approximated by 2D affine transformations, photometric changes by affine transformations of individual RGB channels. Such simplification holds for objects where locally planar surface regions can be found, and where the size of such regions is small relative to the camera distance, so that perspective distortions can be neglected.

The proposed approach is based on a robust, affine and illumination invariant detection of local affine frames (local coordinate systems). Local correspondences between individual images are established by comparison of normalised colours in image patches represented canonically in the affine frames. The method achieves the discriminative power of template matching while maintaining the invariance to illumination and object pose changes. The main contribution of our work is the utilisation of several affine-covariant constructions of local affine frames for the determination of local image patches that are being put into correspondence. The robustness of the matching procedure is accomplished by assigning multiple frames to each detected image region, and not requiring all of the frames to match. The structure of our approach is following:

- For every database and query image compute *distinguished regions*. A distinguished region is an image region of arbitrary shape, that can be repeatedly detected over a range of image formation conditions.
- Construct *local affine frames* (object-centered coordinate systems) on the regions. The actual number of the frames depends on the region's complexity. While simple

elliptical regions have no stable frames detected, regions of complex non-convex shape may have tens of frames associated.

- Generate intensity representations of local image patches. The shape of the patches conforms with the local affine frames.
- Photometrically normalise the intensity representations. Each of the RGB channels is transformed to have zero mean and unit variance across the patch.
- Generate discrete cosine transformation (DCT) representations of the normalised local patches.
- Establish correspondences between frames of query and database images, by computing the euclidean distance between the DCT coefficients, and by finding the nearest match.
- From the established correspondences, select a maximal subset of correspondences that are mutually consistent.
- An estimate of the match score is based on the number and quality of the consistent local correspondences.

The method compares well with the state of the art. Object recognition and retrieval results were evalkuated on standard public image databases, COIL-100 (mostly man-made 3D objects, no object occlusion nor background clutter), FOCUS (planar logos, no occlusion but significant background clutter) and ZuBuD (a database of 200 real-world buildings). The achieved results are superior to any results published. The experiments are described in detail in [1,2,3,4].

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Preparation of the Course Multimedia and Computer Animation

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Computer animation (CA) and multimedia cover a wide area of technologies used by a lot of applications in the contemporary world. Taking into account the field of entertainment (games programming and film industry) we can meet CA applications also in visualization of industrial processes and simulations. CA applies information from different scientific areas as computer graphics, robotics and physics in general. This discipline builds its own knowledge base for several years and it cannot be covered by near disciplines (typically computer graphics) as it is usually done during educational process at our department or in some literature.

Therefore a development of an original educational program that will give compact information about the field of CA to the student is the actual topic. That is the main reason, which motivated the author to develop activities leading to preparation of such the course at the *Department of Computer Science and Engineering*.

Over-viewing the situation in the world we can found that the universities offering courses in the field of computer graphics also offer special courses focused on the area of CA. The most European top is the laboratory (known as MIRALAB) at the University of Geneva led by prof. Nadia Magnenat-Thalmann. This laboratory offers several courses specialized on CA and multimedia. Another example from the USA is Georgia Institute of Technology where College of Computing offers a lot of courses specialized on different aspects CA and multimedia.

Evaluating the situation at the universities in the Czech Republic we can find that CA and multimedia is mostly included in other courses as one of more parts. Therefore the development of a new course focused on techniques specialized to the area of CA and multimedia has realistic background.

The development of the course named *Multimedia and Computer Animation* (MMA) has the simple goal to fill the gap in computer graphics courses offered by the Electrical faculty. The course should give the student overview of selected parts of CA and multimedia from the view of a programmer and also of an animator. The student will get information about algorithms, which are usually applied, in video processing or in animation of selected objects (human body, cloth, and hair).

The course MMA is designed so that it will be delivered to the student in two forms. The first one will be represented by classical lectures covering sequentially all the content of the course. The second form will be the practical part of the course. The student will pass this part so that s/he will work on a project concerning a selected topic from the area of CA and multimedia. By this form, the student will practise application of the knowledge obtained on lectures and simultaneously s/he will extend this knowledge to a desired level necessary to fulfill requirements of the project. This part also offer student to participate on research activities of the *Computer Graphics Group* (CGG) at the department.

The content of the course itself is divided into two basic parts. The first one - *raster animation* covers topics concerning raster video-formats, DVD technologies, video editing, and video processing.

The second part covers classical *vector animation* techniques and algorithms including inverse kinematics, dynamics, particle systems, animation, and modeling of the human body, facial animation, animation of cloth, typical algorithms as collision detection, and level of detail. This part also includes programming methodology for animation control systems used in virtual reality and additional techniques such as motion capture and motion editing.
Several points characterize the current state of the course preparation project:

- all the materials necessary to cover whole content of the course has been completed – this includes, first of all, books and other literature,
- the content of the lectures is completed in the text form from which the presentation slides are sequentially generated,
- the multimedia laboratory built in 2001 as part of Computer Graphics Group at the Department of Computer Science and Engineering has been upgraded to meet the most of requirements of the course and of the student projects,
- several development environments has been prepared for students working on the projects concerning video-processing (library Alegro, plug-in API and SDK for Adobe Premiere) and vector animation (3D animation environment Twister),
- several demonstration applications are prepared for students to show how selected algorithms or techniques work,
- strategic partners have been contacted from the area of DVD production, movie production, and collaboration of partners from the CGG staff has started,
- development of website of the course has been started ([1]).

The expected results are in the best way valuable from view of the student. As the topics and solutions are partially taken from the real environment of the Czech movie production (commercial and non-commercial)[1], it can be expected that the content of the course can be useful for each engineer leaving the university and which plans to work in the area producing movies, DVDs, or various multimedia applications.
The future development of the course should be influenced by a progress of needs of the industry. Thus the next directions will lead to equipment and technologies used there. It is, first of all, software equipment with Maya[2] modeler on the top.

[1] CGG several years collaborates with a company *Digital Media Production* and collaboration with *Film and TV School of the Academy of Performing Arts* in Prague is in plan.
[2] Maya is a complex modeling and animation system used widely in the professional area.

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Gearbox Diagnostics Using Advanced Methods of Signal Processing

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The application of advanced classification methods is one way to improve the performance of inspection systems used at transmission production line. This paper describes the application of advanced signal processing methods in gearbox diagnostics. The classification is based on the Self-organizing feature map algorithm (Kohonen neural network). A database containing diagnostic signals from nine manual automotive transmissions was created. The performance of the proposed system was tested using vibration data from the database.

The inspection process of manual automotive transmission can be divided into three main parts [4]. The first part of inspection system involves acquiring appropriate signals containing diagnostic information. Vibrations of gearbox housing and acoustic noise produced by tested gearbox are the most frequently used signals in the transmission diagnostic. These signals supposed to be mostly correlated because acoustic noise is created by vibration of each surfaces of gearbox housing. In this project vibration signal was acquired by reason that the vibration can be easier acquired than acoustic noise at industrial environment. The papers [1] contain more information concerning the transducer placement selections and data acquisition.

In the second part of the inspection system, the raw vibration signal is preprocessed and condition indicators are computed. Up to this day several condition indicators were investigated. In 1977, Stewart introduced condition indicators FM0 and FM4 for evaluating the health of a gear. These condition indicators are single valued functions of the vibration signal that indicate if the signal deviates from an ideal model of the signal. FM0 increases if a periodic signal contains a local increase in amplitude. FM4 increases if a signal contains a local increase in amplitude or local phase change in a periodic signal [4]. In 1993, Zakrajsek and his colleagues introduced condition indicator NA4 to detect onset of damage. Then Zakrajsek applied condition indicators M6A and M8A, investigated to detect damage of surface by Martin, to damage detection in gears [4]. All mentioned condition indicators were tested for aircraft application [4]. The application of these indicators for automotive transmission was one aim of this project.

In the third part of the inspection system, the computed features are passed to the classifier that makes final decision about health condition of tested gearbox. Even today simple classification methods are used. For instance classification according to threshold value is one of the most frequently used in transmission diagnostics. However this method is not optimal for diagnostic system at transmission production line. During the production the setting of gearing parameters may be changed. This results in change of the threshold value. And a finding of optimal threshold value is a very time consuming task. Therefore we substitute this time consuming task by another approach based on neural network. The final decision about health condition of tested gearboxes was made according to clusters analysis.

The database containing vibration data from ten gearboxes was created to test the performance of the proposed diagnostic system. The vibration data was acquired during the simulated test drive on the test bench. The database contains gearboxes in a various health

condition. After the database was created, the mentioned condition indicators FM0, NA4, FM4, NB4, M6A, M8A, ER and amplitude features rms value, crest factor, kurtosis and skewness were computed. All these indicators were computed from the raw vibration signal and from synchronous averaged signal. Before averaging the raw vibration signal was re-sampled. Therefore the slight speed changes during the test do not affect the results. Each used condition indicator was evaluated according to its ability to discriminate one faulty gearbox from all others tested gearboxes. The results from this competition follow. The rms value of vibration signal from faulty gearbox was at least three times higher then rms value for referential gearbox. ER, FM4 and ER also had higher value for faulty gearbox then for referential gearbox [3]. However differences were lower then for rms value. The final step in our project was to choose an appropriate classifier for this application. Our approach was based on neural network and cluster analysis. Therefore we used the Self-organizing maps as a classifier.

The setting of used maps follows. The map size was 4 x 3 neurons. The shape of map was sheet. A hexagonal lattice type and a Gaussian neighborhood type were selected. The vectors composed from three condition indicators (rms value, kurtosis and skewness) were passed to the proposed classifier. The condition indicators were computed for four gearboxes from the database. The first one was the referential gearbox. It works well during all the tests. The second one was the representative of group faulty gearboxes. This gearbox worked noisily during the simulated test drive on the test bench. Later the gearing for the first gear was measured. It passed out because of toothing dimension. The other tested gearboxes worked well during all the tests. The results of the classification were shown at visualization of the unified distance matrix of the trained map. The U-matrix visualizes distances between neighboring map units. A strong boarder separated the faulty gearbox from all other tested gearboxes [2].

At the end we assume the main results from the project. At the beginning the database containing diagnostics signal (vibration and acoustics noise) was created. Then the review of condition indicators for gearbox diagnostic was done. Features of each condition indicators were test on the data from the database. At the end complete diagnostic algorithm based on self-organizing maps were done. The performance of the proposed diagnostic system was tested.

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Implementation of Basic Arithmetic Operations in FPGA

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Almost every design of digital integrated circuit utilises arithmetic units. Architectures of arithmetic units in microprocessors and ASICs in general are well known and verified. The same is not true for FPGAs. There are arithmetic operators available in HDL languages, but their translation to hardware implementation is not standardised. Designers have to rely on synthesis tools and quality of results varies. Furthermore, the operators mentioned above take only fixed-point operands. Need for library of arithmetic units is substantial. Particular characteristics of these units have to be compared and delivered together with the library to support future design decisions.

The main goal of our research is implementation of floating-point arithmetic operations, however we focused on fixed-point addition and multiplication till now. Exploring fixed-point arithmetic operations is a necessary step before implementing any floating-point units, since majority of floating-point units consist of fixed-point operations.

There are many well-known structures of fixed-point adders and multipliers [1], [2], [3]. Our research compares FPGA implementations of several selected structures. Two main objectives of the research are: first, to compare the structures themselves and second, to see how can these structures be implemented into a concrete FPGA. First objective follows the idea of proving or disproving "well-known paradigms" about characteristics of a particular structure, i.e. to see how these characteristics change or not when given structure is implemented into FPGA. Second objective aims to explore properties of FPGA architecture itself.

Since there are many different FPGA chips from different manufactures, it is impossible to make conclusions that would be valid for any FPGA. We met a decision to use Xilinx Virtex II FPGA family. There are several reasons for that. They posses a number of features important for implementation of arithmetic operations, for example fast carry chains, embedded combinatorial multipliers etc. This seems to be a trend in contemporary FPGA architectures. Furthermore, it can be said without making any thorough market research that Xilinx FPGAs are among the most often used FPGAs nowadays. Important role in the decision also played availability of software CAD tools for this FPGA family at our department. CAD tools themselves are another factor that affects results of the implementation. Comparing different tools was not our aim. Nevertheless, it is interesting subject for further research.

Fixed-point Addition

For addition, one of the basic arithmetic operations, exist several structures of implementation. The structures explored in our research were selected from the most basic one (Carry-ripple Adder), the one generated by synthesis tool (Leonardo Spectrum in this case), to more sophisticated ones, such as Carry-lookahead Adder. Our objective was to implement adders so that they can be used interchangeably. All of them use the same number representation and the same interface. Two's complement number representation was chosen, as it is the most frequently used one. Adaptation to majority of other number representations is possible and usually simple. Each adder has two input operands of user-defined width, 1-bit

carry-in input and 1-bit carry-out output. This seems to be generic interface, which also allows straightforward implementation of subtracter or overflow flag.

Results of our research show that the best adder structure is the one generated by synthesis tool in both time and area criteria. Utilisation of fast carry chains available in Xilinx Virtex II FPGA proved to be the reason for that. Any techniques to speed up addition by cutting the carry chain did not bring any improvement in speed, but led to increase in occupied area.

Fixed-point Multiplication

Implemented structures of fixed-point multiplication can be divided according to computing mode they use into two groups. First group consists of multipliers working in serial mode. In serial mode the bits of the result are computed one by one in each clock cycle. There are several structures that speed up the computation process by either speeding up addition (Carry-save multiplier) or decreasing number of computation steps (multipliers with Booth recoding). Parallel mode multipliers make up the second group of implemented structures. Here, in contrast to serial mode, all the bits of result are computed in parallel. The basic structure, the Array multiplier, can be improved by implementing a tree structure such as Wallace tree. Pipelining techniques were also incorporated into some of the structures.

The implemented structures were compared towards time and area criteria again. The parallel mode structures provide shorter response time, however they also require significantly larger space in terms of CLB slices. Structure that uses embedded combinatorial multipliers, and is generated by synthesis tool, showed to be the fastest, and it consumes smallest number of CLB slices. On the other hand, for bit-widths larger than 18, limited number of combinatorial multiplier blocks are consumed very rapidly and additional area increases.

The serial mode structures proved to have advantages for applications that require small area usage with short clock cycle. They provide reasonable response time even for relatively large bit-widths (up to 32-40 bits), on a very small area. This allows the opportunity to exploit the parallelism between a large number of serial-mode multipliers in the single FPGA.

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Efficient and Secure Data Manipulation, Exchange and Synchronization Using XML

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When I would like to talk about efficiency in data manipulation, exchange and synchronization, I mean not wasting resources. For me in this case was the most valuable resource human work, time to develop working application. In the human work resource is also included the ability to easily extend designed application (well-documented features and documenting with minimal effort).

Security does not meat that I would build "absolutely" secure system because such a thing is not possible. It means that would build system as much secure as I can and then I would document all known or possible security leaks that this system has.

I had a task to develop such a system, which consists of multiple nodes that build hierarchy. This hierarchy should be flat and natural. Other attribute of my starting point was existing system mainly text and SQL based. So the whole task was kind of reengineering.

Tools and technologies used in this process were XML as an integration element, web infrastructure for data exchange in a batch and instant messaging as a real-time report and management tool. All of the tools came from open source, both old and new system work on a Linux machine as a main operating and development platform.

XML is suitable for almost any kind of data manipulation. However, in many applications use of XML is somehow artificial. Nature of XML is in its simplicity and self-documentation capabilities. XML has its root in widely used HTML standard.

As I already mentioned the system consists of multiple semiautonomous systems. Each of these systems collects data and does some computation on them then sends these data are over network to other node/nodes. Next node can reiterate this process repeatedly, until all requested information produced.

In more details, the distributed nodes were network-management a service nodes. The service nodes are offering certain number of services (like SMTP, POP3, accounting, WEB hosting, DNS hosting, etc.). Offered services conform to AAA (Authentication, Authorization and Accounting). All "A" should be covered by system. For security reasons no user information should not be present in service nodes and only minimal information that is necessary for operation. Any other configuration is security risk. Therefore, the essential information I distribute from main node to the serving node. I call this main node administrative or trusted because it manages other nodes and its data are trusted. The computation done by each node is not important for further interaction so I will not explain it in more details here.

Choice of XML was necessity because it protects structure and offers simple debugging facilities. All services have its configuration template (in a language of XML it is called XSD or DTD).

Original system has grown from single system by steadily adding new functions. Such process lead to unmanageable set of semi working parts that duplicated functions and even information. To keep the old system working and in parallel create new one I have replaced parts of the old system with new ones with the same functionality, but better structured.

Even the old system used web server for management but no distribution or coordination was present. Therefore, I moved the unnecessary data from the service node to management node and consolidated them. At first, I have created transport agents that post data from service node thru HTTPS to the management node. The management node stores the data. The next step was duplicating the existing processing activity to management node cleaning it and/or re-implementing utilizing new environment and processing power. When has time proven that new management node is producing the same outputs as the old system, it was easy to remove old stale components.

HTTPS protocol is used for posting data between service and management node, with verified authenticity with certificates and public key interchange. The XML signing and normalization was not used because it is not yet stabilized and well understood. Nevertheless, it might be subject of further improvements, when necessary.

Last part of the system is real-time reporting. By employing Jabber, instant messenger, anybody can watch the whole distributed environment. In addition, appropriate person could be according to predefined rules informed. Jabber lives at the top of XML so it offers every advantage of this language built. Including namespace addition and embedding other XML documents or fragments, support for internationalization and localization.

Some service nodes in this environment have such basic software equipment on them that they cannot provide direct XML support (among them are routers, wireless access points, switches, etc.). To translate from native representation of non-XML nodes I use XML agents. These agents provides compatible interface for the rest of the system to manage the non-XML node. The cost of that is the agent.

I think that XML is well-established standard and can be used without need of large and hardly maintainable frameworks. These frameworks may be used only when complexity of system and number of involved persons goes beyond a small team. In such a case, the need of breaking systems into smaller ones should be checked twice.

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Multiuser Cluster of Workstations Based on Debian GNU/Linux

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Clusters of PC Workstations have become a very popular platform for performing long CPU-intensive computations. Today's commodity PCs offer excellent performance for a relatively low price.

Anyway, a proper software environment is needed to fully utilize the computing power of workstation clusters. An important part of the software is formed by a queueing and scheduling system, which assigns workstation resources to individual users. One of the most popular software solutions for this task is PBS (Portable Batch System) [1].

In this article, experiences with a real Linux cluster are described. The cluster runs in a multiuser mode and uses OpenPBS for scheduling jobs to workstations. Most of the jobs are parallel applications written by students of parallel programming course using MPI (Message Passing Interface) library [2].

The last year, we have used NPACI Rocks Cluster Distribution based on RedHat Linux [3]. Although Rocks showed very good performance, there were some difficulties caused by a large number of proprietary patches to various software packages. Many of the Rocks software components (including the Linux kernel) were formed by very old releases and there were problems upgrading them to up-to-date versions. This, along with a lack of documentation, caused problems to cluster administrators. Moreover, this also posed high security risks.

To make the cluster administration easier, we have developed UpStarTer [4], a new cluster managing system, which supports clusters consisting of one frontend (master) workstation and a number of computing nodes. This is a frequently used configuration in many places. Beside standard Ethernet switch, fast Myrinet network can be used to connect the computing nodes.

Unlike other cluster management tools, UpStarTer is based on Debian GNU/Linux, which is a very flexible and easy to maintain Linux distribution with powerful packaging system.

UpStarTer consists of the following software packages:

- FAI (Fully Automatic Installation), an automated installation tool for Debian, needed to easy the installation process of a large number of workstations;
- OpenPBS, the job queueing and scheduling system;
- MPICH, a popular freely available MPI implementation; and
- Myrinet drivers and Myrinet port of MPICH, provided by Myricom.

The main part of UpStarTer is an installation program which installs all of the above packages and configures them. Besides, it helps a lot with the configuration of a base operating system to prepare it for cluster usage.

The installation process begins with installing a standard Debian GNU/Linux distribution on the frontend machine. Then, the cluster installation program is run, which handles the following tasks:

- all of the workstations are automatically detected;
- IP forwarding is configured to provide Internet access to the workstations;
- NIS and NFS servers are configured to share a common filesystem and user accounts;
- DHCP and TFTP servers are set to allow network booting of the workstations (PXE);
- FAI is used to automatically install all of the workstations; and
- the software packages (mentioned above) are installed and configured.

After the installation program terminates, user accounts can be created on the frontend machine. The users are then able to login to the frontend and submit their jobs using PBS commands. The computing nodes (workstations) are hidden from the users and the jobs are scheduled to them according to rules set by the administrator using standard PBS manners.

Unlike Rocks, UpStarTer does not require users to have a login privileges for the computing nodes. Thus, PBS can be configured to provide exclusive access to the nodes. Thanks to underlying Debian GNU/Linux operating system, new software packages can be installed easily when needed.

The system was tested on a cluster consisting of sixteen uniprocessor computing nodes connected by 100MBit Ethernet switch and by a fast Myrinet network. One extra SMP node, equipped with two processors, was used as a frontend to the cluster.

The cluster was monitored for one month (December 2003). During this period, more than 10000 jobs were executed, originating from 120 different users. Each of the jobs required from 1 to 15 nodes and up to one hour of real time for its execution.

The total CPU time consumed by all the jobs was 4623 hours. The total sum of real time used (multiplied by the number of nodes for parallel jobs) was 7622 hours.

Our experiences show that the proposed cluster system can provide a powerful high-performance environment to a large number of users with high demands for CPU resources.

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Second Order Sliding Mode Control Design for Time Delay Systems

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Time delay systems identified as anisochronic state models used for the second-order sliding mode control (SMC) design also include distributed delays, in general, and an anisochronic state feedback

$$u(t) = -\int_0^T d\mathbf{k}(\tau)\boldsymbol{x}(t-\tau) \qquad (1)$$

combined with the sliding mode principle presented in [4]. The benefit of this combination consists in an insensitivity to controlled system perturbations and in achieving the desired feedback system dynamics. As shown in [4] the perturbations are considered as parameter and structure uncertainties included in external disturbances.

The idea of a higher-order instead of the first-order SMC was originally proposed in [3]. It has been presented in papers [1,2] a proposal of the second-order SMC of time delay systems developed analogously to the first-order sliding mode control of time delay systems. Unlike the usual scheme of the first-order version the first derivative (speed) du/dt of the control variable is assessed in the second-order SMC scheme as follows

$$\frac{du(t)}{dt} = \begin{cases} \left[\frac{du(\boldsymbol{x})}{dt}\right]^+, & \frac{dm(\boldsymbol{x})}{dt}m(\boldsymbol{x}) \geq 0 \\ \left[\frac{du(\boldsymbol{x})}{dt}\right]^-, & \frac{dm(\boldsymbol{x})}{dt}m(\boldsymbol{x}) < 0 \end{cases}, \forall\, t\,. \qquad (2)$$

Therefore the control variable u is not discontinuous but continuous variable. In accordance with the first order SMC scheme a parallel model of the control system is applied prescribing its desired behaviour, to be followed by the controlled process

$$\frac{d\boldsymbol{x}(t)}{dt} = \int_0^T d\mathbf{A}(\tau)\boldsymbol{x}(t-\tau) + \int_0^T d\,\mathbf{b}(\tau)u(t-\tau) + \mathbf{f}(\boldsymbol{x},t)\,. \qquad (3)$$

The model of the feedback system consists of both the process and the feedback controller models adjusting the control action amplitude. The process model is supposed to be identified as time delay system described by a low order anisochronic state model, favourable for the control synthesis. This synthesis is based on a dominant pole assignment performed by the help of the Ackermann formula with functional extension computing the matrix $\mathbf{k}(s)$ in Laplace transform of (1), where s is complex variable of Laplace transform. Unfortunately, the computation of the matrix $\mathbf{k}(s)$ usually requires to invert a delay factor $e^{-s\tau}$, and such

inversion results in an anticipative operation, which therefore is unfeasible. To overcome this failure the Smith-like control scheme is to be applied [4]. The mismatch between the process and its model, known as perturbations $\mathbf{f}(\boldsymbol{x},t)$, is rejected by the sliding mode technique. The second-order sliding mode is proposed to suppress the usually encountered chattering, arising as parasitic oscillations in the first-order version of the SMC, see [4]. Then, due to the integration in the sliding mode feedback a favourable filtering effect is obtained in the control action. In addition the known advantage of the second-order SMC it is easy way to remove a wind-up effect, as the saturation limit of the control variable is reached, but also to reduce the chattering by the limited integrator, as mentioned above. Next, a longer sample period of employed numerical method also leads to a reducing the chattering [2]. In case of the second-order SMC the requirement of sliding accuracy results in a shorter sample period than in case of the first-order version. Finally, the second-order SMC scheme applied to the time delay systems control is tested on a laboratory heat transfer plant control.

Future research focused on the second-order SMC of time delay systems is going to be dedicated a reduction of the second-order SMC scheme. Since the reduction of the complexity of control algorithm is also needed when using the control algorithm based on an ideal relay control principle known as sliding mode control. Apparently the reduction of the second-order SMC can be carried out analogously to the reduced-order SMC based on the first-order SMC which is regularly used in time delay systems control.

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Execution Engine: The Virtual Processing Unit for Driving Physical Experimental Systems

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To drive a physical experimental system (PES), one requires a basic mechanism that would deliver commands to each of the subsystem of the PES, flexible and adaptable enough to easily maintain various changes of configuration and experiment type, scalable enough to be able to run on a single computer for smaller PES, as well as on more cooperating computers for larger PES (or perhaps to allow a remote control of the PES), and reliable enough to assure that the critical parts of the experiment would survive some deliberate or unexpected break of communication, and that the experiment could continue even without operators terminal attached, and, on the other hand, that the experiment could be monitored from more terminals at a time. Execution Engine (EE) is a Virtual Processing Unit (VPU), matching exactly these requirements.

Unlike CPU, this is a software construct, with variable instruction set, extendable modules, and flexible routing mechanism allowing the communication with the modules and between multiple EEs. Even though from another point of view it can be considered a variant of interpreting translator (a.k.a. interpreter).

EE can obtain instructions from two types of sources. First type of instruction source is an incomming streaming buffer, which is exactly one for each EE connection (either to an external module or another EE). This allows to execute instructions sent by another EE (as from the PES operator's computer for instance) or by an external module (which usually is an interface to the device driver of some PES subsystem, but is not restricted to that). Second type of instruction source is a local memory block, which allows to execute instructions previsously stored in EE's local memory, and, though, instructions from these types of instruction sources can be executed even when EE lost the connection with the outer world.

Each of the instruction sources together with its resources forms a (virtual) context. That makes the sources more or less independent of each other. One can say, that each context is simillar to a process of an operating system. And EE provides a feature, that may be considered a variant of priority based cooperative multitasking. Cooperative multitasking was chosen, because there are not supposed to be more, completely independent jobs running on one EE at a time (the only job should be driving the PES).

Most instructions of almost every CPU are operating with registers, because they are on-chip hardwired and thus accessed really fast compared to the memory access. EE does not have any hardwired registers, it operates only in the memory. So there is no big reason to have any extra registers to operate on, as accessing them wouldn't be much faster than accessing the memory. Yet, still, EE defines some global and some context (local) registers, mainly used for controlling internal EE mechanisms (such as routing, event handling, branching etc.), but there ase also some general purpose ones.

EE is not designed to run on just one type of CPU architecture. Therefore it can operate in both little- (x86, Alpha, …) and big-endian (Sparc, PowerPC, …) environments. Different implementations of EE can operate with different endianness. And it is left up to the programmer to deal with it properly, especially during the communication between two EEs

with different endianness, but also during interaction with external devices through external modules. One can place an endian converting filter to one end of the communication channel, however, there can be difficulties with deciding what should be converted and what should not. Best and easiest way to deal with this is to run the whole system in one chosen endianness, and it should be chosen wisely to prevent unnecessary slowdown by unnecessary internal EE endian conversions.

All the memory assigned to the EE as its memory space lays in one CPU address space, so that it is possible for EE to operate with addresses as only with offsets in one address space in operating system. Standard instruction set of the EE also has addressing modes simmilar to those of an ordinary CPU. Nonetheless, EE instructions defined in additional instruction sets are not really restricted to this.

As mentioned earlier, EE has a variable instruction set. By default all implementations of EE have at least the standard instruction set, which in fact is somewhat simillar to the assembler language of a CPU with some more complex instructions closing to those of language one level higher (such as C). All of these instructions are interpreted from their binary form, so that there is no need to place a rather complex parsing code to each EE as it would be if the instructions were represented by a human readable text. Instead these translators can be placed perhaps only to the operator's terminal, so that the operator can both monitor and enter the instructions by hand if he wishes to. (But a graphical user interface is preferred, so that the operator would not require the knowledge of the EE programming at all.)

The way of executing EE instructions allows EE to have interrupts and exceptions (sometimes also referred to as events) implemented very simply as virtual contexts (processes) with high virtual priority, because contexts are scheduled after each executed instruction. So it is only a matter of creating some low priority contexts and letting their priority be risen when the event occurs. This mechanism is present in the EE as well as for instance the barrier mechanism (used to synchronize more contexts), which is based on the same principle.

Also one of the most important features that EE provides is the routing mechanism. It is used to create delivery paths (tunnels) accros the network of EEs, which allows communication and distant driving of all the parts of the system.

Execution Engine was designed within the project INDECS to form the skeleton of the system for driving the neutron diffractometer KSN-2 placed at the research reactor LVR-15 at Řež near Prague. However, it is not limited to this, and can be used to drive many other systems.

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Additional Congestion Control Mechanisms and Their Impact on the TCP End-to-end Performance in Long Distance Networks

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Due to the worldwide boom in the IT industry the amounts of transferred data in networks steadily grow. The majority of this communication can be classified as bulk transfers. Almost all these bulk transfers are carried by the TCP/IP which is the most widespread transport protocol. Todays modern networks allow each end host to communicate with other local host or with a distant recipient using a considerably high bandwidth. For any communication inside a local network there are usually no obstacles for utilising all the available bandwidth. But, for long distance networks with bandwidth * delay product greater than 64 KiB, the TCP protocol starts to limit the available throughput and exacts the usage of TCP extensions from both communicating host.

These extensions have caused several problems and their present state of implementation still contains some oddities. Detailed info about their behavior, settings, and related effects can be found in [2]. Unfortunately, the end-to-end performance, even for correctly and carefully adjusted extensions, might not be ideal. Surprisingly, modern TCP implementations such as in Linux 2.4.x or 2.6.x are more predisposed to this behavior than the standard ones. The resulting performance loss can be appreciable, for example one halve of the available throughput, thus the detailed analysis of causes of this effect is required.

For the proper TCP performance measurement and offline traffic analysis the method described in [1] was used. Due to the complexity of all mutually intertwined mechanisms in modern TCP stacks and resulting difficulties a reverse approach was used instead of the pure simulation. First, packet headers from a real connection over a long distance network with the performance loss were captured. Then, the cause of the performance loss was identified as a prematurely started congestion avoidance phase. This was the consequence of the congestion window threshold which was set too low to reflect the real state of the network path. For normally working congestion control mechanisms which is regarding the common Mathis's model this situation shouldn't occur. One known exception might be caused by the physical packetloss-rate. A physical packet-drop cannot be distinguished from a congestion-caused dropping. Hence, the congestion control mechanism reacts too early and fixes the threshold low. But, further experiments have shown that the physical packet losses are minor so that alternative causes had to be identified.

In general, for any improper threshold change, the standard AIMD congestion control mechanism must be blamed. Unfortunately, in modern TCP stacks, more mechanisms may influence the congestion control in parallel. In Linux 2.4.x and 2.6.x, there are used the ECN, CWV, CWND moderation, CWR, txqueue-triggered CWR, limited transmit, and a mechanism for undoing the congestion control steps, all in addition to the stock AIMD. Further, some of these mentioned mechanisms aren't RFC compliant or contain some deviations from the standard behavior. Implementation of these mechanisms had to be inspected and the result of this effort can be found in the document [2].

Six different aspects influence the effect of the poor end-to-end performance. The first is the physical packet dropping and was mentioned before. This is believed not to be the

primary cause in most cases, but must be preventively considered too. The second aspect are packet drops caused by the network congestion. These losses inform the congestion control mechanism that the available bandwidth has been exhausted. But, this information may be delayed due to queueing at congested node and the freeing of a congested segment might be delayed as well. Hence, the subsequent slow-start might still enter a congested state especially in the case of some time-variant crosstraffic along the path. Third cause is related to the transmission queue, which is a specific add-on, implemented in modern Linux kernels. This queue is capable of congestion signaling and has no limitating bottleneck at its input. Hence, this queue may easily overfill. This overfill triggers the congestion window reduction. Congestion window reduction itself is the fourth possible culprit. Original AIMD, used in Reno or NewReno TCP stacks, leaves the network empty after the Fast Retransmit phase. Then, after one halve of the round-trip time expires, transmission continues at a halved rate. Congestion window reduction is transmitting continuously. This approach avoids the burstness of the flow after the recovery, but can contribute to fix the congested state as in the second case. The fifth culprit are the discrepances in the application scheduling and in the incoming sequence of acknowledgements. Both effects lead to possible burstness. This burstnes should be normally intercepted by the congestion window validation mechanism, but this mechanism works with a hard-grained scale unable to cover short bursts. The last cause is the timeout computation. The implementation in Linux 2.4.x deprecates the former RFC-compliant 1 second minimum and allows to use five times shorter timeouts. This behavior is responsible for higher sesnitivity of all TCP retransmissions.

It is obvious that all these mechanism cooperate in parallel and their investigation on a pure traffic basis cannot be sufficient. Hence, a kernel patch was developed. This patch incorporates two independent sections. The first one serves for the system-wide or per-socked based AIMD parametrisation and CWR/CWV masking. These parameters can be adjusted even during the connection lifetime. This modification was necessary to screen out the possible impact of physical losses. This tunable AIMD is also a suitable probe for the available bandwidth along the network path. Common methods, such as RUDE/CRUDE generators, may give incorrect results due to their different sensitivity to packet losses in comparation with the TCP. The second part contains a block of dedicated event-counters on a per-socket basis. These variables are intended to count important events during the socket lifetime. Some events also reflect the current congestion control stage. The counters are accessible via the setsockopt/getsockopt interface directly from the application program. This solution provides good opportunity for synchronised acquisition of necessary data without the need for any third-party code. These patches are now available for kernels 2.4.x and also for 2.6.x.

This research has contributed to better understanding of the 2.4.x's TCP functionality in LFN environments. Four distinct proposal for performance-loss improvements, based on measurements, were proposed. They are now simulated in ns-2 and will be also implemented in the 2.4.x and 2.6.x kernels for real measurements. This is a work in progress leading to improved congestion control technique which is the final aim of this research.

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The Finite State Machine in Fairy Tale World

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Once upon a time there was a sweet little girl. Everyone who saw her liked her, but most of all her grandmother, who did not know what to give the child next. Once she gave her a little cap made of red velvet. Because it suited her so well, and she wanted to wear it all the time, she came to be known as Little Red Cap.

One day her mother said to her, "Come Little Red Cap. Here is a piece of cake and a bottle of wine. Take them to your grandmother. She is sick and weak, and they will do her well. Mind your manners and give her my greetings. Behave yourself on the way, and do not leave the path, or you might fall down and break the glass, and then there will be nothing for your sick grandmother."

Little Red Cap promised to obey her mother. The grandmother lived out in the woods, a half hour from the village. When Little Red Cap entered the woods a wolf came up to her. She did not know what a wicked animal he was, and was not afraid of him.

"Good day to you, Little Red Cap."

"Thank you, wolf."

"Where are you going so early, Little Red Cap?"

"To grandmother's."

"And what are you carrying under your apron?"

"Grandmother is sick and weak, and I am taking her some cake and wine. We baked yesterday, and they should give her strength."

"Little Red Cap, just where does your grandmother live?"

"Her house is a good quarter hour from here in the woods, under the three large oak trees. There's a hedge of hazel bushes there. You must know the place," said Little Red Cap.

The wolf thought to himself, "Now there is a tasty bite for me. Just how are you going to catch her?" Then he said, "Listen, Little Red Cap, haven't you seen the beautiful flowers that are blossoming in the woods? Why don't you go and take a look? And I don't believe you can hear how beautifully the birds are singing. You are walking along as though you were on your way to school in the village. It is very beautiful in the woods."

Little Red Cap opened her eyes and saw the sunlight breaking through the trees and how the ground was covered with beautiful flowers. She thought, "If a take a bouquet to grandmother, she will be very pleased. Anyway, it is still early, and I'll be home on time." And she ran off into the woods looking for flowers. Each time she picked one she thought that she could see an even more beautiful one a little way off, and she ran after it, going further and further into the woods. But the wolf ran straight to the grandmother's house and knocked on the door.

"Who's there?"

"Little Red Cap. I'm bringing you some cake and wine. Open the door for me."

"Just press the latch," called out the grandmother. "I'm too weak to get up."

The wolf pressed the latch, and the door opened. He stepped inside, went straight to the grandmother's bed, and ate her up. Then he took her clothes, put them on, and put her cap on his head. He got into her bed and pulled the curtains shut.

Little Red Cap had run after flowers, and did not continue on her way to grandmother's until she had gathered all that she could carry. When she arrived, she found, to

her surprise, that the door was open. She walked into the parlor, and everything looked so strange that she thought, "Oh, my God, why am I so afraid? I usually like it at grandmother's." Then she went to the bed and pulled back the curtains. Grandmother was lying there with her cap pulled down over her face and looking very strange.

"Oh, grandmother, what big ears you have!"

"All the better to hear you with."

"Oh, grandmother, what big eyes you have!"

"All the better to see you with."

"Oh, grandmother, what big hands you have!"

"All the better to grab you with!"

"Oh, grandmother, what a horribly big mouth you have!"

"All the better to eat you with!" And with that he jumped out of bed, jumped on top of poor Little Red Cap, and ate her up. As soon as the wolf had finished this tasty bite, he climbed back into bed, fell asleep, and began to snore very loudly.

A huntsman was just passing by. He thought it strange that the old woman was snoring so loudly, so he decided to take a look. He stepped inside, and in the bed there lay the wolf that he had been hunting for such a long time. "He has eaten the grandmother, but perhaps she still can be saved. I won't shoot him," thought the huntsman. So he took a pair of scissors and cut open his belly.

He had cut only a few strokes when he saw the red cap shining through. He cut a little more, and the girl jumped out and cried, "Oh, I was so frightened! It was so dark inside the wolf's body!"

And then the grandmother came out alive as well. Then Little Red Cap fetched some large heavy stones. They filled the wolf's body with them, and when he woke up and tried to run away, the stones were so heavy that he fell down dead.

The three of them were happy. The huntsman took the wolf's pelt. The grandmother ate the cake and drank the wine that Little Red Cap had brought. And Little Red Cap thought to herself, "As long as I live, I will never leave the path and run off into the woods by myself if mother tells me not to."

Finite state machine representation of the wolf behavior will be presented at poster section.

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Multi-Agent Systems Visualization

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The extension of our research on analysis of a single agent or agent communities combining advanced methods of visualization with traditional AI techniques is presented in this paper. Even though this approach can be used for arbitrary Multi-Agent System (MAS), it was primarily developed to analyze systems falling into Artificial Life domain. Traditional methods are becoming insufficient as MAS are becoming more complex and therefore novel approaches are needed. In this paper we present an overview of our recent visualization tools suite. Our newest techniques allow visualization of changes of the MAS along with their quality and context. This transparent approach emphasizes MAS dynamics by providing means for discovery of changes in its tendencies or in behavior of either single agent or agent communities. A simulated artificial life environment with intelligent agents has been used as a test bed. We have selected this particular domain because our long-term goal is to model life as it could be so as to understand life, as we know it.

As a testing MAS we have used the Artificial Life Simulator (ALS) [4] developed at CTU, Department of Cybernetics, Prague. This Java based MAS allows to setup a complex environment inhabited by agents with arbitrary internal architecture. ALS has been used for numerous simulations; most of them fall into the Artificial Life domain. ALS records agents' activity together with various characteristics and exports this data via XML to be later used in a visualization tool. Our testing ecosystem contained various static objects and agents (creatures) living in the environment. Agents' objective was to survive and fulfill some subsidiary deliberative tasks in parallel. We used 8 types of static objects: water resource, food resource, tree (shelter), flower (increase agent's interest), trap, playroom (boredom reduction), light and post office (for agents performing deliberative task of delivering post messages among post offices and agents) during our tests. We used 3 types of agents: two types of prey agents (blue and red) and predator agents. All these agents had CZAR [4] internal architecture.

Architectural components common to most agents are sensors, actuators, Internal State Model (ISM) and Action Selection Mechanism (ASM) and various optional blocks as planning, sequencing, memory etc. Sensors and actuators differ domain by domain in purpose and complexity. Regardless of their purpose, agents have a perception layer, which transforms feedback (information) from MAS (other agents, objects, ambient environment) to their internal representation and an actuation layer, which transforms agent's internal representation of actions to physical actions. These physical actions may be considered as communicative or non-communicative acts. Then there is usually a set of control blocks, which transform perceived inputs into motivations for an agent to make decision. These motivations (action stimuli) are combined in ASM (Action Selection Mechanism), where the best action is selected in order to maximize progress towards its (time varying) goals. Data used for the analysis include agent's state (selected properties of its control blocks), motivations and selected actions. During the execution of MAS, selected agent's parameters are being recorded by State Observer into an external XML file (for each time step) and later imported into our visualization tools.

It is obvious that looking on a system of agents from one point of view doesn't provide enough information for sufficient analysis. Multiple interlinked views with different levels of detail have proven to be a successful approach to solve this task. Our research has resulted in development of various incorporated Visualization Analysis Tools (VAT) [1] [2] [3], which provide means for seamless analysis on various levels by the utilization of modern visualization methods and standard AI techniques.

On the lowest level of our analysis tools, a selected agent is being analyzed with high level of granularity [2]. However, single agent does not reflect the behavior and characteristics of the whole multi-agent system, which is our primary goal to visualize. Several difficulties are arising: many agents, parameters and actions, dynamic system, inter-agent communication and reciprocal popularity etc. All these features influence both the behavior of the whole agent community (local-to-global) and every single agent (global-to-local) as well. All the higher levels of our analysis tools are focused on visualization of multiple agents [1] [3].

We see that the key information to understand MAS lies in identifying changes in its tendency – changes in behavior of single agents, community or environment. To facilitate these challenges, the visualization tools we have developed were added new visualization methods, which help us to study the trends of the MAS in a broad context. VAT level 1 focuses on visualization of agent's internal state (its properties), visualization of its action selection mechanism and relationships (or correspondence) between agent's state and resulting actions – agent's behavior. From VAT level 2 on, the system works with multiple agents. These methods present agent's state in context to its position, other agents or surrounding environment.

Our future work plans include application of our visualization tools suite in neighbour science disciplines, such as medicine (trends prediction), neural networks (adaptation visualization and analysis) and biology.

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Project Methodology Management Analysis

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In this day and age it is really impossible to carry out any project without proper management. The strictly established documentation rules, assembly of a project team, determination of the scope of the project, quick and accurate communication between the project team members and other people (company management, respondents…); these are some of the many basic attributes included in one term: methodical project management.

Using any project management method as a basic condition will help you to reach the previously specified project goals in time and utilize the planned resources effectively. Sometimes the methodical management of projects is not applied, and we can see examples where the methodology is used, but it is modified for their specific purposes. It will not be known whether the level of modification to the methodology is correctly set (estimated) or not, until the end of the project, at which time the main problems escalate, which are created by incorrectly establishing the rules in the initiation stage of the project.

There are many projects where numerous methods are used concurrently. But a combination of "the best of the best" doesn't have to be a condition of quality project management. Different methods may have procedures that are excellent within the one methodology, but become inapplicable when combined incorrectly with others.

The project management methodology analysis investigates and evaluates all risks related to the methodology rules that may have an impact on the final project outputs or even on the business of the company. Current statistical surveys show that there are no projects these days being carried out without any project methodology. But we still don't know whether or not the level of usage of these methods is suitable, effective and sufficient to reach the project goals.

This type of analysis is the goal of my project, which is the basis of my dissertation. The project is currently in process and will be completed by the end of 2004. The project steps are described below:

1. The summarization of inputs for questionnaire investigations with RAC Questor®

There have not been any analyses carried out similar to this in the Czech Republic. This analysis is aimed at the current status of project management methods used in the companies and public organizations.

The RAC Questor® methodology and set of tools forms a sophisticated environment satisfying the needs of organizations that require information about the state of the organization in different areas for the support of management and control processes.

The basis of RAC Questor® is an integrated environment for the creation and filling out of prepared questionnaires and their subsequent evaluation, which includes execution of professional conclusions and relevant recommendations, all together generating a professional system of support for questionnaire surveys.

The tool has been borrowed with the kind permission of Risk Analysis Consultants.

2. Creating a hypotheses structure for the set of questionnaires according to the theory of creating Q-modules in RAC Questor®

The structure of a Q-module is created from three basic items: questions, answers, hypotheses, which are separated to hierarchical levels. The tool allows you to create the hypotheses that are confirmed by answering specific questions. The relationships between the answers and hypotheses may be set up for quantitative or qualitative evaluation.

The hypotheses are defined against the relevant project risks. This means that the questions investigate the quality of project action completion and whether the risks will affect the goals (if so, the impact will be determined).

Example:

Hypothesis: The project plan has been created

Relevant risk (if the hypothesis is not confirmed): Project deadline will be postpone

Question(s): Has the project schedule been created? (Yes/No)

Is the project schedule continuously updated? (Yes/No)

…

The points given in the evaluation are used as a quantitative input in confirming the hypotheses and for the measurement of project risks depending on how the methodology is used.

3. Creating a Q-module for questionnaire investigations, definition of questions and building questionnaires

The questions are organized into a structure in compliance with the Q-module theory contained in the tool. The Q-module is created with a Czech and English version. Although the Q-module is being created specifically for my dissertation, it can also be used in practical situation.

4. Distribution of questionnaires to specified respondents from government and commercial sectors

The questionnaires are given in electronic version to respondents from various commercial companies and public organizations. The respondents have been chosen in advance and the questionnaires have not been distributed anonymously.

5. Processing the answers from the questionnaires in RAC Questor® and evaluating the answers

The questionnaires will be processed in electronic version within the tool and the evaluation will be calculated. The measure of risks will be determined according to the answers assessed.

6. Making conclusions for the dissertation

The analysis is currently being completed now and will be finished by the end of 2004. Therefore the results and conclusions are not yet known. However, they will be presented in my dissertation “Risk Analysis in Project Management” in June 2005.

Integration Laboratory of Switching System and Data Transmission

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At the Faculty of Electrical Engineering on Czech Technical University in Prague was established and modernized in passed years laboratory equipment for teaching and development in sphere of communication technologies (switching system and data transmission).

Areas including problems of communication technologies are teaching at the Faculty of Electrical Engineering on the Czech Technical University in Prague in many learning now, whereas basic dividing of large findings is making at the Department of Telecommunication Engineering (K13132) traditionally to this section: transmission systems, switching systems, data transmission. Number of laboratories of the Department of Telecommunication Engineering, which are step by step renovated and innovated, serves for education of specialized subjects.

Direction of project, which is supported by grant of Foundation of Higher Education Development, was built up integration laboratory of switching system and data transmission, which includes whole communication descriptor from study to NGN and mobile communication services and make it possible to top preparation of students as in traditional telecommunication disciplines. Connection of laboratories with basic communication infrastructure is possible to present whole branch in complex view at whole linked telecommunication network in sequence to local computer network and information technology. Wholly new communication distribution was installed in whole pile, where are important laboratories of the Department of Telecommunication Engineering. Laboratories of the Department of Telecommunication Engineering dispose of number of modern equipments, which have been obtained in frame of cooperation with external firms, which have been found fully use in frame of project: multiplexers SDH, optical line termination, concentrators ADSL, digital branch exchange, terminal equipment ISDN, modems, routers and other networks elements. Laboratories have been completed by new access multiplexor VDSL (Very high speed Digital Subscriber Line).

Laboratories our department has been especially equipped of modern measurement equipment to accomplish to hereinbefore mentioned direction and estimation most expansive equipment. Purchase of equipment only from capital resources of department is unreal in regard of their high price. At the same time practice required, that graduates have been prepared at least partially for work with current measurement technique. Laboratories have been completed by following equipments: data and signalling analyzer (SS7, ISDN-PRA, V5.X, GSM, V.24, X.21), 4-chanell oscilloscop, analyzers of data interfaces (Ethernet, IP). Whole mentioned equipments have been used to practical education already in winter semester in year 2003 to completion existing exercises in subjects Switching systems 2 and Transmissions systems 2.

Wholly new exercises originated for subjects Switching systems 1, Transmissions systems 1 and Telecommunication systems. We introduce several examples of concrete innovations.

For diagnostics of telecommunication equipment and networks are used analyzers, which are provided with needed interface E1 and with functions for verification their function and signalling monitoring. Portable analyzer has been provided in terms of project for electric interface E1 with description SunSet E20. LCD tangent display very transparent and didactic effectively shows block function of equipment for generation selected stream and receiving. Analyzer serves to generation and plotting of signal PCM of first order for intention of digital telecommunication equipment, as well as multiplexers, exchanges, digital transfer switches etc. Beyond he makes it possible to testing data interfaces V.24/V.28, X.24/V.11 and V.35 with help of additional adapter. The additive software options make from device the power-full protocol analysis: bidirectional mesage tracing and full protocol decode allow for easy trouble-shooting at the A and A-bis interface. The SunSet E20 decodes SS7 at the A and A-bis interface for the BSSAP (DTAP, BSSMAP), as well as SS7 (MAP) at the inter-MSC/database (VLR, HLR, AUC, EIR). It also decodes the full range of error messages. An intuitive screen display makes even the most complex message content easy to understand. A rich collection of filters enables technicians to identify trouble quickly by selectively capturing information.

Laboratory of switching systems has been completed by new access multiplexor VDSL (Very high speed Digital Subscriber Line) V-16 IP DSLAM from Lucent Technologies. VDSL provides transmission speeds far higher than ADSL - up to 70 Mbps downstream and 40 Mbps upstream. So you can offer a wide range of cutting-edge, high-value services, including video-on-demand, broadcast TV and super-high-speed Internet access. A native packet architecture simplifies provisioning, start up and monitoring for students projects a testing in laboratory.

Equipments is also used in bachelor period of study to performance of submission of semester projects and in engineering period of study to performance semester and thesis. Students of postgraduate study have these equipments at disposal and they can use it to performance of experimental or thesis.

Attained results are exhibition of successful inovationon on the Department of Telecommunication Engineering CTU FEE in Prague, as well as example of effective utilization of financial resources of school with support of grant agency.

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Inovation of Learning for Telecommunication and IT Sector

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Areas including problems of telecommunication technologies are teaching at the Faculty of Electrical Engineering on the Czech Technical University in Prague in many learning now, whereas basic dividing of large findings is making at the Department of Telecommunication Engineering (K13132) traditionally to this section: transmission systems, switching systems, data transmission. The data transmission section is learned for students of department of information technology (IT) now in "Data transmission" seminars and on next period in "Telecommunication systems principles" course.

The "Telecommunication systems principles" curriculum will intend for the entire branch of IT and Internet, i.e. for about 60 students every year. The curriculum is primarily offered to the students of the 3rd year, at the beginning of Bachelor stage, and it takes 2 hours of lectures and 1 hours of seminars a week. At present time we can eyewitness mutual convergence of areas telecommunication technologies and IT (ICT), as well as that of information and telecommunication technologies. This development must be reflected in the education, too. Students will be successively introduced to the following technologies: transmission systems, access systems, network applications in data transmission and videoconferencing areas, GSM cellular networks. Students will obtain the basic knowledge in a fundamental functional principles of the telecommunication systems, the digital transmission systems and signal processing theory. The main subjects are physical media parameters, access and backbone network technology, for example PDH (Plesiochronous Digital Hierarchy), SDH (Synchronous Digital Hierarchy), ATM (Asynchronous Transfer Mode), xDSL (Digital Subscribe Line) and ISDN (Integrated Services Digital Network).

Besides selection of the content we have to choose methods of teaching as well, which is not trivial task at all. Some students learn the fundamentals and continue in a different branch (Computer Technology, Software Technology etc.). Our goal (and responsibility) is to harmonize the contradictory demands, as for the first group of students is this course the first and the last one dealing with telecommunications, while for the rest it is just an introductory overview before the following ones. Analysis and preparation of content and teaching methods to be applied in "overview" curricula is a good starting point for further development of pedagogy, and this fact applies to our Department as well. More curricula of such nature are about to be started in connection with rebuilding of the study plans and their diversification to Bachelor and Master stages, according to demands of other branches than Communication Technology (departments of Computer Science, Cybernetics and Control Technology). We make use of our experience from this curriculum in preparation of other ones.

When teaching this type of curricula, we encounter also problems concerning staff and rooms. It is necessary to ensure lessons for quite big crowd of students, which is extremely difficult with limited number of teachers and auditoriums. Distance education is a seductive idea, but it is eligible just for the introductory theoretical parts. If the students should make familiar with real technology, they simply must come to the laboratories. Software simulation is usable, but it cannot fully substitute the experience with real system and its application in a telecommunication network.

Direction of project, which is supported by grant of Foundation of Higher Education Development, was built new laboratory workplaces in laboratory of transmission system and data transmission, which includes whole communication descriptor from study to NGN and mobile communication services and make it possible to top preparation of students as in traditional telecommunication disciplines. Connection of laboratories with basic communication infrastructure is possible to present whole branch in complex view at whole linked telecommunication network in sequence to local computer network and information technology. Wholly new communication distribution was installed in whole pile, where are important laboratories of the Department of Telecommunication Engineering. Laboratories of the Department of Telecommunication Engineering dispose of number of modern equipments, which have been obtained in frame of cooperation with external firms, which have been found fully use in frame of project: multiplexers SDH, optical line termination, concentrators ADSL, digital branch exchange, terminal equipment ISDN, modems, routers and other networks elements. Laboratories have been completed by new access systems SHDSL (Singel pair High bit rate Digital Subscriber Line).

Laboratories has been especially equipped of modern measurement equipment to accomplish to hereinbefore mentioned direction and estimation most expansive equipment. Laboratories have been completed by following equipments: function and noice generator, ADSL analyzer, balance/unbalance probes. Whole mentioned equipments will be used to practical education already in summer semester in year 2004. Equipments is also used in bachelor period of study to performance of submission of semester projects and in engineering period of study to performance semester and thesis. Students of postgraduate study have these equipments at disposal and they can use it to performance of experimental or thesis.

Attained results are exhibition of successful inovationon on the Department of Telecommunication Engineering CTU FEE in Prague, as well as example of effective utilization of financial resources of school with support of grant agency.

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Authoring of Multimedia Presentations in Web Environment

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Our age offers us a lot of technologies including the Internet and mobile communication networks on one side, and powerful graphics and audio tools on the other. A large subset of these technologies is tailor-made for multimedia materials that present an arbitrary content to unlimited number of viewers worldwide. As the technologies progress in their development, they allow for ever-increasing complexity of their applications. Currently, the development of advanced multimedia applications calls for the acquisition, storage, and the management of large amount of resources of various types (textual, graphic, acoustic, etc.). In order to maintain their consistency, formalism in the acquisition of resources and management must be introduced and maintained during the whole process of development of the multimedia application.

We present a new method of structured acquisition and management of the multimedia resources. Our approach is based on the paradigm of uniform descriptors. A uniform descriptor is a collection of properties of a logical unit it represents. It may describe an elementary resource (a text, an image, a video clip, etc.) that was acquired, a group of resources (a thematic unit), or a relation of these resources. The properties may be both semantic (what a resource contains) and technical (what technology may be used to acquire the resource, what technology is suitable for its presentation, or in what conditions the resource has been acquired). As we allowed a descriptor to nest in another one, the uniform descriptors may be used to form a hierarchical structure that reflects the semantics of the whole application.

In order to formally represent the uniform resource descriptors, we have developed a formal language based on the XML standard [1]. It allows for the notation of the uniform descriptors legible by the authors, as well as by the application itself. The reasons for this selection are relative simplicity of the XML standard and possibility to describe large amount of data with complex structure. Another advantage of the use of the XML is its support from the application domain. There are a lot of libraries directly usable in processing of the XML and thus they may accept data description that meets the XML standard. Using XSLT, the XML descriptor is convertible to other formats, which is useful for unconstrained exchange of the data.

The key feature of our approach is the reusability of the hierarchical structure of uniform descriptors: once created during the design of the application, it may be used in its later production steps (the resource acquisition and editing), as well as during the run time of the application (the resource presentation). This results in substantial reduction of the resource management effort during the production and maintenance of the resource base.

We employ our approach in our contribution to the project *Virtual Heart of Central Europe* (VHCE) [2, 3]. The goal of the project (supported by the European program Culture 2000) is

to implement a compact set of presentations of important architectural rarities of the participating cities (Prague, Bratislava, Graz, and Maribor). The presentation covers their history and current status in the cultural context of the contemporary Europe. The target platforms are the web environment and DVD. This emphasizes the need for a uniform content description independently employed in both target platforms.

We have verified the usability of our approach during the evaluation of the resources that has been acquired in the early phase of the VHCE project. In this phase, 17 participating student volunteers were to author or retrieve public domain media of different types (text data, photographs, 3D models, both rendered and shot video, and sound samples).

The students were instructed how to create the uniform resource descriptors conforming to our format in their submissions. They have collected and described more than 11 gigabytes of data with more than 1000 photographs and 100 movie clips covering five important architectural solitaires in Prague.

To facilitate the evaluation of the completeness and quality of their submissions, we created a web-based application which allowed to browse the uniform resource descriptors and the resources acquired, and also to warn about inconsistencies in the description, should any resource described (or its preview) be missing from the data submitted. The application displayed the resources in their hierarchy which allowed us to evaluate also the proper context of every resource acquired. Thanks to this automatic checking tool, we were able to quickly find the inconsistencies in data.

Our future work is to develop a special data maintaining application implementing a user interface front-end for the creation of the XML data descriptors and manipulating the acquired data by means of this descriptor. The target date for the final presentation of the VHCE project and the dissemination of results is the mid of April 2004.

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Rendering The Acoustic Response of Virtual Scene

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With the growth of the power of the computers available for the 3D applications, the spatial sound became a human-computer interaction modality as important as the computer graphics. The spatial sound output allows the user to hear how the sound – emanated from different sound sources in the virtual scene – is distributed through the environment in the virtual scene. The user may thus explore the spatial and material properties of the environment. (A short overview of the spatial sound perception may be found in [1, 2].) The key contribution of the spatial audio is the improvement of immersion in the virtual scene. The spatial audio may be used in both virtual and augmented reality applications, such as multimodal collaborative and/or training systems, or independently, such as a subsystem of a navigation tool in virtual scenes for the visually impaired users [3].

Currently, there is a lot of technologies that support the spatial audio synthesis and output from the applications designed for widely available operating systems and platforms. These technologies include various hardware components (such as Creative Labs' SoundBlaster Live! sound cards) that directly support the rendering of the spatial audio primitives (echoes, reverberation, etc.), and numerous software libraries that allow to control the hardware according to the context of the application (such as OpenAL with the EAX extensions). On the other hand, there are commercially available software tools designed for evaluation of the acoustic properties of architectural structures, such as concert halls, stadiums, etc. (ODEON, Ramsette, etc.) However, none of these tools and technologies were designed and used for automatized production of the sound tracks for the rendered visual output.

We made an effort to fill this gap. Our goal was to design and implement a system that would process a dynamic 3D scene created in an external authoring tool, calculate its acoustic response, and write the result to specified output files in desired format and quality to be later used as the sound track of the rendered video [4]. This paper gives a brief overview of the system implemented.

The scenario of the use of our system may be as follows: (1) An animated scene is modeled and rendered using the external authoring tool (we have chosen the 3D Studio Max for its wide availability). (2) An output video file is rendered. (3) Some objects in the scene are defined to represent sound sources or sound receivers. (4) A sound signal for every sound source in the scene is prepared. (5) Our spatial audio rendering system is used to create one or more files with the spatialized sound signals according to the model of the scene. (6) Using any post-production tool, the video file and the audio files created during the steps 2 and 5 respectively are combined into a single audiovisual output file.

One of the primary functionality requirements was the support of dynamic scenes, ie. the scenes where any object may change its position and orientation in time (6 DOF animation). In order to be able to use already known algorithms of the virtual acoustics which are defined for static scenes only, we have decided to process the dynamic scene as a sequence of static frames obtained as the snapshots from the dynamic scene. The output signal is then the aggregation of acoustic energy received during the particular frames by the virtual sound receiver.

To model the phenomena of the sound propagation, we used the framework of geometric acoustic where the propagation of sound is described using the sound paths from the sound source to the sound receiver. Each sound path represents a trajectory along which the sound energy is transferred. The total time delay, attenuation and the Doppler shifting coefficient is investigated along each sound path.

The rendering pipeline in our system consists of the following blocks: (1) the scene parser, (2) the dynamic scene representation, (3) the shutter, (4) the static scene representation, (5) the sound propagation model, and (6) the spatialization block.

The scene parser reads (and the dynamic scene representation allows to keep in the memory) the whole scene hierarchy and its animation, as defined in the external authoring tool, as well as the acoustic signal of every virtual sound source in the scene.

The shutter block takes snapshots of the scene in evenly distributed time points. The static scene is described using the boundary scene representation model where the velocity vector is stored for each vertex. This allows the sound propagation model to calculate also the correct Doppler shifting in the scene along the sound paths involving the objects in motion.

The sound propagation model uses a hybrid method of the simulation of sound propagation where the early sound reflections (received between 0 and approx. 0.1 s after the sound source starts) were found using the beam tracing algorithm while the late reverberation was determined using a statistic model based on the Sabine's formula of the reverberation time. The output from the sound propagation model is the list of sound paths contributing to the generalized impulse response of the virtual sound sources in the scene.

The spatialization block performs the spatialization of the raw sound signals of the virtual sound sources. The spatialization is the process in which the impulse response of the environment is applied to a sound signal, usually by means of a convolution. Since we were to consider the Doppler frequency shifting of the individual sound paths, we decided to generate the output in the time domain.

We have implemented our system as an application for the Microsoft Windows XP operating system. Our development platform was Microsoft Visual C++ 6.0. To perform the time consuming DSP computation, we made use of the Intel Signal Processing Library 4.5. Our implementation was verified by means of various subjective tests, as described in [2].

Our future work includes functional and performance improvements of the system implemented to model also the sound diffraction using the uniform theory of diffraction [1] and also to perform in real time conditions.

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Cryptographic Hardware Scalable Arithmetic Unit

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1. INTRODUCTION

Modern algorithms based on the elliptic curve discrete logarithm problem, e.g. the Elliptic Curve Digital Signature Algorithm (ECDSA), need significantly shorter keys (e.g. 160 bits) to achieve the same level of security in comparison with the classical RSA algorithm (that needs 1024 bits). This fact is very important in applications such as chip cards, where the size of hardware or energy consumption is crucial.

For cryptographic purposes, elliptic curves over finite fields are used. We focus on curves over GF(2m), where point coordinates are expressed as m-bit vectors. ECDSA is based on scalar point multiplication over a point on a given elliptic curve.

Implementation of operations depends on basis representation of the field GF(2m). There are two common families of the basis representation: polynomial basis and normal basis representation. For more details, see [2]. In this work we focus on the normal basis representation.

The following operations must be implemented over elements of GF(2m):

- addition
- multiplication
- inversion
- squaring

Addition over elements of GF(2m) is simple and is implemented as a bit-wise XOR. Squaring in normal basis is realized by rotation (cyclic shift) of argument one bit to the right, so it is very simple and is performed in one clock cycle. Multiplication is based on matrix multiplication over GF(2m). In hardware, special unit (multiplier) is necessary. The best known algorithm for inversion in normal basis is the algorithm of Itoh, Teechai and Tsujii (ITT) [3] based on multiplication and squarings.

As we can see, the main problem is an efficient implementation of a normal basis multiplier. Other operations are either simple or based on multiplication.

2. PREVIOUS WORK

Massey and Omura proposed a multiplier [3] that employs the regularity of equations for all bits of result. If we construct an equation for one bit of a result, equations for other bits can be derived by rotating bits of arguments [2]. In this multiplier, one bit of the result is computed in one clock cycle and registers holding arguments a and b are rotated one bit to the right between cycles. The computation of m bits of the result takes m clock cycles and hence this multiplier is also called bit-serial.

Agnew, Mullin Onyszchuk and Vanstone introduced [1] a modification of the Massey-Omura multiplier (in this paper we call it the AMOV multiplier). They divided the equation for each bit into m products. All bits of the result are successively evaluated in parallel; the computation is pipelined.

The amount of hardware is the same as for the non-pipelined Massey-Omura multiplier, but the critical path is short and constant (it does not depend on m) and so the maximum achievable frequency is higher. This multiplier is widely used.

The computation of an inverse element (inversion) by the ITT algorithm [3] is usually controlled by a microprogram [4]. When implementing the ITT inversion using classical AMOV multiplier, additional registers and data transfers outside the multiplier are necessary.

In this work we present a modification of the AMOV multiplier. This modification allows an efficient implementation of both the multiplication and ITT inversion algorithms. In comparison with the microprogrammed inversion, no additional registers or data transfers outside the multiplier are necessary. We also introduce several improvements of this multiplication/inversion unit. We employ digit-serialization of multiplication and speed-up the iterative squarings by using long-distance rotations. These improvements lead to increased performance and better performance/area ratio.

5. IMPLEMENTATION

The proposed multiplier/inverter has been implemented in the Xilinx Virtex300 FPGA using the Synopsys FPGA Express synthesis tool and Foundation 3.3i implementation tool. Its functionality has been verified in the ModelSim simulator.

6. CONCLUSIONS

A pipelined version of the Massey-Omura multiplier modified for easy implementation of ITT inversion algorithm has been presented. The performance of this multiplier/inverter can be improved by employing digit-serialization and by speeding-up the iterative squarings.

The multiplier/inverter has been implemented in Xilinx Virtex 300. Without speeding-up the iterative squarings, the shortest computation time has been obtained for digit width D = 6. The use of “long distance” rotation blocks further speeded up the design and benefited higher digit widths.

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Optimization of Shifter in Normal Basis Aritmetic Unit

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1. Introduction

The problem presented here appeared during the design of finite field arithmetic unit (AU) for a comparison study [1], which discussed trade-offs in hardware for Elliptic Curve Cryptography [4]. The unit used normal basis representation, and therefore the inversion algorithm of Itoh, Teechaji, and Tsujii [3] was chosen. The algorithm computes the inverse by repeated multiplication and squaring. In normal basis representation, squaring is realized as rotation (circular shift). The arithmetic unit then comprises a multiplier and a shifter.

To achieve fair comparison in the cited study, the arithmetic unit had to be scalable. As area and performance were the main measures, we needed to adjust the area of the AU to obtain given performance and vice versa.

Besides this motivation, we also considered system optimization scenarios as in [2], where the top-level optimization process works on a set of blocks with parametric performance and (in this case) power consumption.

Our AU design is dominated by the multiplier in both area and time. Moreover, the multiplier has a natural scaling parameter, namely the digit width. We consider the design of the multiplier to be the primary task. This leaves us with the design of the shifter as a dependent task. that is, the shifter shall be optimized in the context of the dominating block. Our aim is to develop a procedure where the digit width controls the design of the entire AU.

Surprisingly, the problem of optimum shifter design exhibits a rich structure and complex solution space. Although the solution presented here is heuristic, proving some problem-specific theorems played a role in decomposition of the problem.

2. Implementation and results

The optimizer uses dynamic programming and genetic algorithm.

The optimizer was implemented using the GAlib C++ library. A number of experiments has been performed, with *m* in range interesting for elliptic curve cryptography, that is, from 160 to 250. The following facts were observed:

1. Where a brute force optimum solution was available, the algorithm gave an identical answer.
2. Any realized rotation s_i in an optimum solution was identical to some given rotation k_i, although even slightly sub-optimum solutions did not have this property.
3. The left side of the equation was less than *m* in all optimum and some sub-optimum solutions.
4. When the above observation was exploited to simplify the evaluation procedure, the search space became disconnected, and more time was needed to achieve equivalent results.
5. Neither the brute force nor the described algorithm gave any optimum or sub-optimum solution violating the tentative assumption.
6. With population size of 100, the algorithm required circa 3000 generations to converge at m=160, rising to 4000 at m=250.

7. Infeasible individuals were rare.
8. The running time was below 20 minutes on an office-grade PC.

3. Conclusions

We have presented a process, which optimizes a block (the shifter) in the context of another, dominating block with strong interdependences in area and time of computation. The optimization criterion used can accommodate estimations obtained experimentally from design tools.

The size of practical instances of the problem is limited. This enabled us to solve a part of the problem exactly, and do so even repetitively inside the genetic algorithm.

We simplified the process further by approximating the results of the space domain problem. The approximation was inspired by proofs valid in special cases, and was found feasible during testing the algorithm.

The results also show that formally proving certain properties of the circuit can dramatically reduce the search space. On the other hand, we have found that the construction of such proofs can be difficult even for very simple blocks.

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Web Services

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In this project were solved two web systems. First of them was an evidence PhD students of branch Geodesy and Cartography. Second system is PhotoPa – database of Czech historical monuments.

The system of evidence PhD students was developed for easy and well-arranged evidence of students PhD studies of branch Geodesy and Cartography. For final entering the data about students were chosen language XML and a form XHTML 1.0 Strict. The form is served by CGI script, which generates XML file. Script is written in C++ and uses method "Post" for communication between form and CGI script. Then is XML file processed with parser. Parser is written in C++ and its base forms free spread parser expat from James Clark. This parser is able to change the XML file. In this case are XML files exported to XHTML 1.0 Strict. After foundation or changing, XML data is automatically called parser, which will carry out new export to XHTML. This cause that data on XHTML pages are still actual.

There are many historical monuments in the Czech Republic and most of them have been documented photographically. But hardly any can be use in photogrammetry because of absence measuring attributes. The aim of PhotoPa system is a collection such photo documentation which would be sufficient for future geometric interpretation of a monument. To fill the PhotoPa system are being used students' projects of course Photogrammetry, Geodesy and Cartography, Faculty of Civil Engineering in Prague. In PhotoPa system has been saved over 180 monuments which photographs were taken during 2001 and 2002.

An idea to make such project came at the end of year 2000. The aim was definite – application of students' project to create a database of most threatened and unused historical monuments in Czech Republic. Students choose one object in CR (a list of listed buildings is recommended http://www.supp.cz/html/publikace/seznohrpam), this object is geodetic located by GPS and than transformed into Czech co-ordinate system S-JTSK; photo survey uses an elementary photogrammetry method by digital cameras. A survey of geometric parameters is determinate by a tape.

The PhotoPa system consists of two sections. The first part is web system for registration of objects. The registration has to be completed during opening course. Every student fills a form consisting of user's name and a password, name of a project, e-mail for further communication and student's personal identification number; after completing the form every user obtains unique ID in the form YEAR- XX (e.g. 2002-052) and his chosen project obtains ID in the form P-YEAR-XX (e.g. P-02-052).

The registration is important to obtain unique ID for student and object. Another reason of registration is agreement of teacher, which should avoid duplication and selection inappropriate object (too large for a term project). A teacher also handles with system through web interface. He has possibilities to send e-mail, to accept projects, to make a list of registered object, etc. All web pages of PhotoPa project are completely valid XHTML 1.0 Strict a standard of W3C consortium. The second part is a local application for a data collection from students.

The PhotoPa program – input monument data, is made for structured data acquisition (text and graphic as well) about monuments in CR. The program is written in C++ with use graphic library VCL. The source text compilation and link modules was made with

C++Builder 6. The final program PhotoPa is possible to launch in operation system with win32 architecture. The application is free.

After starting the program we'll see the main screen of the application. We can maintain application either by instrumental slat, where the icons which bring the most commonly used orders are placed or by the main menu of the application, were all orders are available. Now lets look at each order in details. At the first phase you can create a brand new project. You'll use this possibility in case you have just started your project. In case your project is being worked out you have a chance to open it. In both cases the next window will open. Because it is MDI application, you can have more than one project open at a time. Project window is the most essential form of whole application. This is where the process of recording the data in goes on. The window consists of few folders: Student, Object, Analysis, Bibliography, Object Description, Measuring Tools, Photos, Measuring, Technical Report and Evaluation (teacher). These 9 respectively 10 folders contain all information about the project necessary to record. Last folder appears only if the application is started by a teacher who evaluates the project. After filling all necessary forms in open application and after saving the project is generated XML file. We have had around 250 monuments saved in XML files in these days.

Our work and work of all students would be useless if hid the achieved data and didn't show them to public. We are currently working on this – doubtlessly the most important – part of the project, because real data which whole public system can be built on are available.

The PhotoPa system won a significant award on international conference FIG in Paris. The grant was praised as the only one in a section TS 26 Best practice in facility management.

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The Precise Encoding and Processing of the Direct Position and the Geographic Information Aspects According to the International Technical Standards

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The international technical standards in the branch of geomatics are able to be applied with success in geodesy and other related fields of activities. The present position of geodesy in the branch of geosciences forms pressure on the increasing interoperability in the broad spectrum of geotechnologies. The benefits of participation between geodesy and other technical sciences or information technologies can not be fully honoured because there are many specific methods and technologies in geodesy. The main subject of geodesy and other geosciences is in common: Objects and phenomena directly or indirectly related to a location on or near the surface of the Earth. That is the main idea of the project: Implementation of the standards from the related branches (mostly geomatics) to describe the geodetic datasets and allow the easy cooperation.

The geomatics standards can be applied for geodetic data management, processing, analysing, accessing, presenting and transferring in digital/electronic form between different users, systems and locations. These activities are also linked to appropriate standards for information technology. European Committee for Standardization (CEN / TC 287) has created the set of the European Prestandards and CEN Technical Reports (CR documents). The frame of standards was prepared in 1993 and most of the standards were published in 1998 or 1999. The standards cover the whole area of GIS activities and published numerous application schemas (the result of the data description process for a specific field of interests) can show the basics of the formalism used in geoinformation modelling. The chosen conceptual language EXPRESS (ISO 10303-11) can be the main disadvantage of the standards from the present viewpoint. This language has been developed for the purpose of information modelling and description in area of the industrial automation systems and integration as a part of ISO 10303 STEP standards (Standard for the Exchange of Product Model Data). The International Organization for Standardization (ISO / TC 211) began with the geoinformation / geomatics standards development later and a lot of government or professional organization have been participating on the process. After the accomplishment of the process, the wide and complex range of the geographic and related tasks will be described. The standardization process covers the technical, information and quality technologies, conformance tasks and also the qualifications and certification of personnel. The first standards were published in 2000 and today around 10 standards is completed and published.

The technologies and functional standards (with focusing on the task of spatial referencing and operations, temporal referencing, semantics and quality aspects) were analysed to test the conformance requirements and to find the ideal schemas for geodetic data techniques in the project. The semantic aspects according to the standards can precisely model the reality and the relations between the geodetic elements. Semantic schemas can also describe the additional information for future classification, testing and creating process analysis of the elements. For various services, the metadata of the geodetic datasets should be

recorded in the standard form. Most of these informations are today available but none in the easy accessible form. The spatial referencing was the main purpose of the analysis. The recommendation for the spatial schemas allows describing various reference systems based on the various datums, parameters and coordinate systems. The definitions comprise the wide area of geodetic applications from the image coordinates to geocentric systems. The definition of the N-dimensional systems allows describing the height as the physical parameter. The standards also put requirements for the coordinate conversions and transformations. It makes enable precise description of the coordinate values origin. Standards for the temporal aspects of the geographic information present the time as a dimension analogues to any of the spatial dimensions and show the way to describe the dynamic phenomena. The existing geodetic datasets record the temporal dimension with using the time stamps but the complex description is not possible. The adaptation of the standards for the geoinformation allow that. Quality aspect in geodesy is presently characterized by the positional accuracy and the related parameters. It is enough but only for the specific use. For the general use, the quality indicator should be completed by the evaluation of the reliability, completeness, homogeneity and logical consistency.

Not all the geoinformation technologies can be used without lost of the precision, but most of them are prepared with respects to the specific (geometrical or physical) character of the geodetic measurements. The technologies makes easy some of recent problematical steps in geodetic electronic data exchange, such as coordinate referencing and coordinate manipulations descriptions, and geodetical sensor descriptions.

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Pattern Matching in Huffman Coded Text

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Over the last years, the amount of data to be processed and stored grows rapidly. It is therefore natural that there is need for faster and better algorithms and approaches for storing and processing data. The pattern matching in compressed text problem attempts to help in both these areas. The data are stored using data compression (and therefore the data are stored more efficiently), and when the data are to be searched, an algorithm for pattern matching in compressed text is employed to do the work.

A Huffman coding is a code that assigns each symbol binary code of variable length. The code is assigned according to symbols probabilities. These probabilities may be determined during the first pass through the text, or may be static.

The pattern matching is a mean to locate a pattern in a text. There are many pattern matching problems, ranging from the simplest exact one pattern matching (finding exact occurrences of one pattern), through exact multiple pattern matching (finding exact occurrences of multiple patterns) and approximate pattern matching (finding occurrences of pattern(s) with mistakes), to the most general regular expression pattern matching (finding occurrences that correspond to a given regular expression). All pattern matching problems are described in the 6D pattern matching problems classification. All pattern matching problems can be solved using finite automata.

The problem of pattern matching in compressed text is defined as finding of all occurrences of a pattern in a text, using only the pattern and compressed form of the text. There are several algorithms performing pattern matching in Huffman compressed text. These algorithms suffer from some disadvantages, for example solve only multiple pattern matching problem, or may produce false matches. Our approach to pattern matching produces exact matches and is capable to solve any pattern matching problem (according to the 6D pattern matching problems classification).

Our approach is based on finite automata. The algorithm runs in two phases, the first is the preprocessing phase, the second is the pattern matching phase itself. As the second phase is performed using common pattern matching algorithm (with small extensions), the first (preprocessing) phase is more interesting. During this phase, an automaton for pattern matching in Huffman coded text is constructed. At the very beginning, only the pattern matching problem and the set of patterns to be found is given. Then a pattern matching automaton is constructed (the exact algorithms of construction of the pattern matching automata for given pattern matching problems are quite well known). Then, the pattern matching automaton and the Huffman tree (used to compress the text) are used to construct the automaton for pattern matching in Huffman coded text. This is done by replacing each state of the pattern matching automaton by the whole Huffman tree, and by replacing the transitions of the original pattern matching automaton. One of quite important properties of this algorithm is that if the original pattern matching automaton is deterministic, the resulting automaton is also deterministic.

The most important problem of the above process is that the resulting automaton operates over the binary alphabet. The computers in practice usually operate over larger units (bytes, etc.) much faster than their operate over bits. To make the whole algorithm run faster, common technique called “alphabet expansion” can be employed. The main idea of this

technique is to replace (e.g. binary) alphabet by some larger alphabet. A transition performed for a symbol from this larger alphabet replaces two (or more) transitions for symbols from the original alphabet. Although generally it is not necessary that all the transitions for symbols for the larger alphabet replace the same number of original transitions, in our case it seems natural. If eight original transitions are replaced by one, we get transitions for bytes, getting faster operation.

The first phase of the algorithm run time depends of the pattern matching solved. The second (pattern matching phase) runs in time dependent on the length of the compressed text. Therefore, the algorithm runs faster than the trivial algorithm (decompressing the compressed text and then pattern matching the plain text).

The presented algorithm allows solving all the pattern matching problems. The algorithm runs in time dependent on the size of the compressed text.

Although many problems in the field of pattern matching in compressed text are solved, many are still unsolved. Our work and approach can be used as a base for another algorithms and generalization. In particular, the pattern matching in text coded by adaptive Huffman coding (a variant of “static” Huffman coding described above) is still unsolved. The finite automata also provide a good basis for pattern matching algorithms, using other compression methods.

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Achievement Tests Lifecycle Assisted System (ATLAS)

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Achievement tests as a part of learning process were not constructed and used in the past almost at all, but its popularity has been growing during the last decade. The main reasons might be for example quite easy construction of achievement tests (AT), simple correction and classification. Due to the illusory simplicity AT have been overused, but only in reduced forms. According to those objections AT are criticized very often.

The ATLAS should help to cope with many difficulties in the course of the AT lifecycle. The lifecycle consists of basic steps as follows: *aim specification*, *selection of used methods*, *test construction*, *collection and proceeding of results*, *evaluation*, *classification* and *diagnostics*. Every well prepared and potentially successful AT is supposed to pass through all mentioned steps or nearly all of them.

Passing the whole sequence of above mentioned steps manually is very time-consuming and tiring. As a consequence, some of the steps are not often done as well as they should be or even worse they are totally omitted. Because of that, a lot of important and useful information that the most time-consuming steps provide are missed. For instance, the large spectrum of information is given by the diagnostics. The proper usage of that step allows to improve not only the testing, but also to enrich the learning process in general.

The project of the ATLAS is built as a complex system for full support of AT. Inner structure of the system leads to an accomplishment of main AT requirements such as:

- *aim specification* - with relationship to a subject matter of the curriculum with respect for its structure, sequence and time dividing,
- *knowledge structure discovery* - not only the quantity of separated items, but also the relations between them,
- *gradation of difficulties in tasks and questions* - the simplest tasks should come first, the most difficult ones at the end; ordered by used aim taxonomy (e.g. Bloom, Nimierek, etc.),
- *wide spectrum of tasks and questions* - all parts of used taxonomy, not only a passive knowledge reproduction,
- *interconnection with the learning process* - results of AT should be used for student correction and also for learning process improvement.

The system should support an evolution of AT leading from the first draft up to well prepared and tested standardized AT. There is usually a long journey for the AT to achieve all demands that are required. That journey mostly consists of some iterations in construction of AT and its diagnostics [1]. The time-consuming diagnostics needed in standardization process is provided by the ATLAS. Thus, the number of iterations and time spent with standardization could be decreased. There are some demands for standardized AT as follows:

- *validity* - correspondence between its content and purpose,
- *reliability* - credibility of results and consistency of results,
- *objectivity* - to find out real knowledge, freedom from prejudice,
- *sensitivity* - ability to differentiate between "good" and "bad" student.

In addition, the standardized AT should be *easy to use*, *time-saving* (in dependence on the range of tested knowledge) and also *economical*.

The ATLAS is projected to cover and to support all main kinds of cognitive AT [2]. The plenty kinds of AT could be divided in several groups according to following criteria: *measured type of performance* (speed / level of knowledge), *quality of adjustment* (standardized / semi-standardized / non-standardized), *motivation* (results / presumptions), *phase of education* (input / running / output), *range of topic* (mono-thematic / poly-thematic) and *interpretation of performance* (relative / absolute). Enumerated criteria illustrate high variability of the system. Its possibilities also cause probable high usability of the ATLAS.

A lot of question types should be used to achieve better results in testing and higher quality of AT. Questions (tasks) in AT can be divided into two principal groups [1]. The first one, that is used more frequently, is called "closed" and it contains a range of questions from *binary* (dichotomy) through *selections* to *matching* and *ordering* ones. The second group is called "open" and it contains questions with brief answers (*complementary*) and wide answers (*essays*). All types of questions but essays are projected in the ATLAS.

A special subsystem which allows using classic paper tests with limited testing methods and functionality is planned to be incorporated in the ATLAS. It should realize to print test papers properly and it should also realize a successive scanning and a recognition of results (filled-in papers).

A modularity of the system offers its stand-alone parts to be applied anywhere inside the AT lifecycle chain. A utilization of parts outside the ATLAS is enabled by specified files using XML or CSV. That utilization could be exemplified by a classification subsystem where needed type and method can be chosen. Another example could be a diagnostic module that could be used separately for any evaluated test.

A growing popularity of AT (and a testing in general) calls into existence of efficient system which should help to create AT effectively and to keep their high quality. A developing system such as the ATLAS intends to satisfy those requirements.

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Two-dimensional Pattern Matching

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A two-dimensional exact pattern matching is a generalization of one-dimensional (*i.e.* string) matching. Suppose we have a *rectangular* digitized picture *TA*, where each point is given a number indicating, say, its colour and brightness. We are also given a smaller rectangular picture *PA*, which also is digitized, and we want to find all occurrences (possibly overlapping) of the smaller picture in the larger one. We assume that the bottom edges of the two rectangles are parallel to each other. This is a two-dimensional generalization of the exact string matching problem that has been described in detail in numerous tutorials and textbooks. All string matching problems can be categorized using six dimensional classification given by *Melichar* and *Holub* [4]. It has been shown that there exist automata solving problems from every such category. Moreover, it has been shown by various authors that there exist pattern matching automata for above mentioned pattern matching problems searching a pattern in a text in time linear with the length of the text.

Firstly let us mention some notions of 2D pattern matching: 2D rectangular objects we call *pictures*, every picture (a word of a two-dimensional language [3]) consists of elements (symbols, letters of some finite alphabet *A*) organized into rows and columns. Every picture has its *origin*, which is its leftmost and topmost (upper left corner) element. This is very important property of every picture, because it determines picture's orientation.

The two-dimensional pattern matching problem is to locate an ($m \times m'$) pattern array *PA* (not necessarily a picture) inside an ($n \times n'$) text array *TA*.

A two-dimensional occurrence of pattern array *PA* in text array *TA* is then

- exact, when *PA* is included in *TA* as a sub-array,
- approximate (with *k* errors), when *PA* is included in *TA* as a sub-array with at most *k* non-matching positions.

Note that *position* of a two-dimensional occurrence of *PA* in *TA* is a pair (i,j), such that $PA=TA[i \,..\, i+m-1; j \,..\, j+m'-1]$. The origin of *PA*, $PA[1,1]=TA[i,j]$.

Possible outputs of 2D searching are all positions of origins of a pattern array in a text array; or the origin of the first occurrence; or simple answer *yes*/*no*, *i.e.* whether *PA* is in *TA* or not.

As has been proved in [4], all one-dimensional pattern matching problems can be solved in the worst case in asymptotically linear time. Motivation for finding a solution working in linear time in two-dimensional case (linear with respect to the size of the text array) is similar to the one-dimensional case. Namely it is the fact that so called *trivial algorithm* of 2D exact pattern matching has $O(|TA||PA|)=O(nn' \cdot mm')$ asymptotic time complexity.

The trivial algorithm for two-dimensional exact pattern matching is analogical to the one in one-dimensional case: we are given above-mentioned 2D arrays *PA* and *TA*. Assume their sizes are ($m \times m'$) and ($n \times n'$), respectively, and without loss of generality let hold $m \geq m'$ and $n \geq n'$. The trivial algorithm repeatedly verifies for each element of the text array whether there begins an occurrence of the pattern array or not. Asymptotical time complexity of this single check is $O(|PA|)=O(m^2)$ and it is done $O(|TA|)=O(n^2)$ times. Therefore overall asymptotical time complexity of such algorithm is $O(|TA||PA|)=O(n^2\, m^2)$. We clearly see that there cannot be an occurrence of *PA* in elements of *TA* such that $TA[i,j]$, $i>n-m+1$, and $j>n'-m'+1$, but

asymptotically it does not matter if we make such an enhancement and do not check an occurrence there or not. Because in this algorithm we are interested in the exact occurrences, we also see that checking for an occurrence will end in the moment the first non-matching element is found, thus usually it will end prematurely. However, consider following situation: let *PA* consists of all zeros (0) and in the bottom right element is single one (1). Let *TA* consists of all zeros (0). At this moment, we can end our deliberation stating that this is the worst case, where every element of the pattern array *PA* inevitably must be compared with appropriate elements of the text array *TA*, and even in case we are interested in the first occurrence of *PA* in *TA* we have to check elements of whole text array.

Now let us turn our attention to 2D pattern matching using the finite automata. Such approach allows reusing some of already known and thoroughly studied 1D pattern matching automata in the new area of application. First automata based two-dimensional exact pattern matching algorithm is due to *Bird* and *Baker* [1, 2]. A natural way of solving any generalized problem is by reducing it to a special case whose solution is known. It is therefore not surprising that not only above mentioned algorithm, but most solutions to the two-dimensional exact matching problem use exact string matching algorithms in one way or another. Suppose each pattern row is taken and all its occurrences in the text rows are found. The pattern rows can be treated as a set of strings, they represent a *dictionary*. The *dictionary matching problem* has been solved using the finite automaton by *Aho* and *Corasick* in 1975. This fundamental result has been immediately reused by Bird and Baker in 2D pattern matching for preprocessing the text array. The result of such preprocessing is new text array, whose elements are determined by run of the AC-automaton in rows of *TA*, precisely each element of the original text array is replaced by the number (label) of active state of the AC-automaton after reading this element. Since all the patterns in our dictionary are of the same size (no row is prefix of another), the size of the output is linear. Moreover, the dimension of the problem is effectively reduced and 1D pattern matching in columns of the preprocessed text array can be used. For this pattern matching the Knuth-Morris-Pratt automaton is used and it searches for 1D pattern composed of appropriately ordered labels of final states of the AC-automaton from the previous step. Ordering of these labels corresponds with the ordering of rows in the pattern array. Assuming again $m \geq m$', $n \geq n$' and $n > m$, this method has asymptotical time complexity $O(m^2+n^2+m+n^2)=O(n^2)$, that is linear with respect to the size of the text array.

Our future work is to find applications for at least some types of 1D pattern matching automata described in 6D classification model [4] for 2D pattern matching exact and approximate.

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Wide-band Parameters Prediction for Mobile Systems Channel

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Current trend in indoor prediction is showing a shift from empirical models to complex deterministic models due to the decreasing computation cost and increasing demand for a wide-band prediction that is by empirical model reduced. State-of-art models are usually based on a ray-tracing algorithm with many stochastic features, Bertoni [1]. As it is from a ray-tracing description obvious the time-complexity is very high due to obstacle visibility verification during a ray propagation. That is why the number of traced rays is limited and together with it the prediction dynamic range too. To partly accelerate the prediction, the obstacle visibility pre-calculation could by applied, Wölfle [2]. Both current concepts - empirical and physical - have shortcomings and actually are not able to fully satisfy increasing demands for the mobile channel parameters prediction required by rising third and fourth generation of UMTS incorporating adaptive antennas or MIMO systems. However, combination of physical models with statistics is to yield significant benefit. A new approach called Motif Model suggested by Klepal [3] aspires to be such model. This poster briefly deals with exciting wide-band channel parameter predictions as directional impulse response prediction and channel capacity prediction for MIMO systems are.

The prediction of a floor excitation by launched Dirac impulse becomes crucial along with a MIMO systems design and implementation. Such excitation can accurately characterise the wide-band communication channel and it serves for the site-specific directional impulse responses prediction e.g. The Motif Model compared to a common Ray-Tracing gives much higher dynamic range of prediction (~100dB) from level of dominant signal paths to the level of the weakest paths, which behave almost as a background noise. A comparison of impulse response measurement and prediction proves excellent Motif Model accuracy [4]. The Motif Model algorithm is very fast. It took 15 minutes to predict directional impulse responses in every element of the floor plan (15 thousands). Time complexity depends on resolutions, which were 0.5 ns and 1 deg, respectively.

On the basis of such impulse responses prediction a MIMO channel matrix can be estimated e.g. and site-specific wide-band capacity of MIMO channel can be calculated. Along the corridor, where direct signal path is dominant, the MIMO capacity improvement is low. In contrast over the rest of floor, where a reach multi-path propagation exists, the MIMO capacity improvement is much higher.

The ideas behind the Motif Model algorithm seem to be very general. If a full electromagnetic description of the motifs were used, the Motif Model could also be applied in various other electromagnetic areas. The key aspect of prediction accuracy inside buildings is the incorporation of all significant obstacles to the model input. The Motif Model can predict naturraly the radio signal strength and other parameters of communication channels such as impulse response at high speed and large dynamic, while high accuracy is preserved. The Motif Model does not neglect any of the electromagnetic wave propagation phenomena. From this point of view the Motif Model can be considered more physical than optical models.

Today, while the ray-tracing models fail in a prediction of wide-band parameters with large dynamic, for the Motif Model algorithm it is nature feature in contrast.

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Signaling System No.7 and NGN

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This contribution provides an overview of the protocols developed for signaling within IP telephony networks with the special scope for use of signaling system No.7. Although voice transmission over IP networks is of primary concern of IP telephony, much is also to be done in the area of signaling. The voice and data transmission is really outside the scope of this contribution.

All of the switching intelligence in IP telephony is provided by a controller, which sits in a more regional location. The controller supports all of the devices within its defined zone. The controller provides call control functions, instructing the devices on how to handle a specific call. Controllers use a signaling protocol to communicate with these devices, as well as a signaling protocol to communicate with one another. All of these protocols are based on IP as the transport. In order for these devices to communicate with devices in another network, there must be some device that provides a bridge. This requires yet another level of signaling. If calls are to be sent to the PSTN, SS7 is the only accepted form of signaling. A signaling gateway provides the bridge between IP networks and the PSTN. While signaling system No.7 is a packet-switched protocol, some adaptations are necessary to work in IP network environment.

It is important to understand that SS7 is not necessarily being replaced by new IP signaling protocols. Rather, SS7 is being modified to meet requirements of IP networks. When one looks at the ISUP and TCAP protocols, it becomes obvious that the services brought by these two protocols are not easily duplicated by any other protocols. They have been developed many years to support telephony services. TCP/IP does not have any comparable protocols to support these functions. Creating new IP-based protocols to replace ISUP and TCAP would be far too complex and time-consuming. It makes far more sense to modify SS7 to support IP networks than to create new replacement protocols. This is not to say that SS7 may not someday be replaced entirely. The telephony network, as we know it today, is undergoing dramatic changes. These changes may render SS7 obsolete some years from now. In the meantime, work continues on modifying SS7 network to interoperate with IP telephony networks.

SS7 uses many timers at levels 2 and 3 to maintain the integrity of each „link“, network element and to guarantee delivery of all messages. TCP/IP does not provide the same functions as MTP. Specially link management, traffic management, and route management. These functions must be emulated in the IP networks to allow SS7 to work.

Standards are now focusing on emulating the services of SS7 levels 2 and 3 so those three functions mentioned above can be provided seamlessly regardless if signaling messages come from the PSTN or IP networks. There are a couple of different thoughts about how SS7 is deployed in these networks. Some vendors use software stacks enabling SS7 in their solutions. Many have found out that these software stacks are not dependable and often result in failures. For this reason, many vendors have began to migrate away from software stacks and partner with vendors to provide more telco hardened platform for SS7. Signaling Transfer Points STPs that support the function of signaling gateways can now be found. These are also being used as front ends to controllers and other entities in the IP network.

Another concept still in its infancy is billing through SS7, rather than creating billing records at the edge of the network. In legacy networks SS7 provides a much efficient method for collecting call data used for billing purposes and eliminates the need for generating this data in switching equipment, collecting the data from these switches, and processing the data at some central billing center. The same advantages exist in IP telephony networks. By centralizing this process using SS7, the edge devices responsible for actually generating phone calls and routing them through the network do not need software to generate call details records.

Regardless of the architecture used, there is one critical factor to consider when designing signaling over IP networks. Latency is a critical issue in IP networks and the round this time for messages to traverse the network must be closely engineered. An SS7 message should experience no more then 100 ms round trip time to prevent expiration of level 2 and level 3 timers.

The biggest issue with IP telephony is lack of standardization. Although there are some preliminary standards being adopted and deployed in IP networks, there still is not a standard for SS7 transport through an IP network. The signaling protocols currently being used allow carriers to communicate within their own networks, but when connections to the PSTN must be made, they are left with no solution. There are basically two functions that have been defined for signaling protocol work, adaptation, and transport. The purpose of the adaptation protocols is to emulate the services provided by the MTP, maintaining link management, traffic management, and route management. The transport function provides a reliable transfer of signaling traffic across the network. The IETF is currently defining a new protocol that will be a peer to IP called SCTP (Simple Control Transmission Protocol).

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Visualizing Manipulating Activities of Human Operator in Virtual Reality

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We present a virtual reality (VR) tool, which allows to display the activity of a human operator performing a routine which involves manipulation with objects. This tool represents a presentation module of the running EU project ActIPret. The project stresses mainly the cognitive vision aspects and aims at interpretation and understanding of expert activities for teaching and education purposes. The task of the virtual reality module is to display a symbolic activity plan to a user.

The project objective is to develop a cognitive vision methodology to interpret, understand and record the actions of a person handling objects in a real world scene. The input information about the activity is a video sequence. Human(s) and object(s) in it should be recognized and tracked. The main scientific challenge of the project is to find the methodology which allows to perceive activities, decompose them into individual actions and to create the formal description of an activity plan.

The cognitive abilities have to be demonstrated in the following simplified setting. The expert should demonstrate the particular activity first and it should be learned. The ActIPret system should perceive expert's activity and represent it in the activity plan. When the trainee attempts to perform the activity, the system should perceive it and, by comparison with the stored expert activity plan, provide hints.

The VR presentation module is one of the possible ways to utilize the symbolic activity plan for educational purposes via repetitive reviewing the actions of avatar (virtual human).

Learning and perception is tested in ActIPret scenarios which encapsulate the activity. The insert CD scenario is the simplest one used in the project. The scenario comprises the activity of inserting CD into a player (human operator opens the CD player, selects a CD, inserts it in the player and closes the player). Even though this might look like too simple problem, from the VR point of view, the scenario includes all aspects a testing example should have. The animated avatar interacts with other objects in a scene by moving the CD between locations and changing the state of the CD player(open/close).

It is obvious from the description of the testing scenario, that VR model of human manipulating activity consists of three parts – geometry of the scene, motion and interaction description. The task of the VR presentation module within the ActIPret is to define, create and present these three parts of the model. To achieve this we can use the ActIPret output (activity plan) and the data that is available to other modules within the ActIPret framework. The use of such data for VR tasks is not its main purpose so they require special techniques, especially in case of the human animation as we will mention later.

Reconstruction of the scene will be the less complicated part of the task. It was decided to create the models of all the objects in the scene for each scenario manually and assemble them automatically to form the observed scene. The scene has to be well structured and some of the object must implement some functionality (CD player's response to button push). As we can see in [1] there is no automatic method of scene reconstruction that would meet these requirements and no ambition to develop one in ActIPret.

More interesting problem is the motion description part. There can be a lot of motion in the scene that is relevant to the activity. This motion can be basically cathegorized in a master-slave fashion. Thus the motion description becomes a human animation task, because all the motion depends on the motion of human. Human operator either activates the functions of the objects or translocates the objects, no other kind of motion is relevant to the purposefull manipulating activity.

Our human animation task is specific, because ActIPret system only keeps track of the motion of operators hands. We have tried to approach this limited information problem by using the inverse kinematics (IK) algorithm and model of human body with realistic joint rotation constraints.

Finally the human-object interaction description problem is closely related to the previous. The ActIPret activity plan should keep the information about such interactions and our task is only to interpret this information at our VR system.

The experimental VR presentation module has been written in Java language and uses the EAI (External Authoring Interface) to control the VR scene that is defined using the VRML standard. The humanoid avatar we use is compliant to the H-Anim 1.1 standard. This program tool is capable to load the VRML description of the manipulating activity and view it. The functions common at animation viewing utilities (start, stop, pause&restat) have been implemented. Implementation of these functions for VRML animation is based on previous work of the author [2]. The user can also chose from multiple viewpoints including the avatars eye viewpoint. These are listed by particular activity description, because different viewpoints are necessary for good explanatory description of different activity. The VR presentation is further enhanced with a "head-up display" showing additional textual information to the user.

We have selected the data that describe the manipulating activity sufficiently to be presented in VR. This data include the list of objects (including the human) represented by their VRML models, the locations of these objects in the scene, the human animation data represented by the set of H-Anim compliant VRML interpolators, the formal description of human-object interaction events and other (viewpoints, textual hints). We have created the VRML prototype that encapsulate this information and finally we have created the program that can load this prototype, interpret it and present the modeled activity to the user.

We have also been looking for ways to convert the data available in the project to the form we have defined for the VR presentation. The IK algorithm for realistic human animation using the trajectory of the hand has currently been tested. For the future we plan to use the activity plan to obtain the information on human-object interaction.

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Reconfigurable Designs in FPGAs

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Field-programmable gate arrays are configurable VLSI devices that can implement various logic functions. Classical SRAM-based FPGA chips introduced in 1984 were designed to be configured only once at the beginning of their operation (at power-up) and to enable a designer to improve the functionality (or correct bugs) after a device had been shipped to the end user. This factor together with the possibility to personalize an FPGA in the field has resulted in their increasing popularity.

Now, almost two decades later, the current FPGA technology has introduced the concept of dynamic reconfigurability. At present devices that support limited or full dynamic reconfigurability are available, for example, the recently introduced devices from Xilinx (VirtexII-PRO, SpartanIII), Atmel (AT6000, AT40K, AT94K), and Chameleon Systems (CS2000). On the other hand the supplied design tools still follow classical design cycle that is not suitable for dynamically reconfigurable designs.

The major challenge it to provide facilities for developing dynamically reconfigurable systems with much less effort and specialized knowledge than is required now. From the published literature it is clear that current design tools do not directly support dynamic reconfiguration. The support is desirable on two levels: an automatic partitioning of an input circuit that was designed as a classical static circuit, and features for obtaining suitable bitstreams (FPGA configuration files).

Dynamic reconfiguration (DR) enables a designer to increase the functionality of his design: he may increase its functional density, perform error recovery, or modify itself. The price a designer has to pay for all that is an additional DR control logic that keeps track of the state of the DR part of the design, ensures proper unloading and loading of DR modules (d-modules) and performs context-sensitive storing and restoring of corresponding sequential elements.

Let us divide the reconfiguration related issues to these groups: the reconfiguration cycle, reconfiguration controller, save/restore logic for sequential elements, interface management, and bitstream management.

Reconfiguration cycle

An actual reconfiguration of a device is performed through reconfiguration cycles. One cycle consists of five independent phases: first, all interface ports between a static part and the active (loaded) d-module to be removed should be disabled. Next, sequential data of that d-module should be saved, then the d-module can be replaced with another d-module (chosen by the reconfiguration controller), finally sequential data should be restored and interface ports should be enabled.

Reconfiguration controller

The reconfiguration controller is an overhead logic added to a user design that takes care of the reconfiguration process. The controller is usually implemented either as a finite state machine inside an FPGA, or as a computer programme executed by an attached microcontroller. Its complexity may range from a simple automaton that loads a certain

bitstream to a device when said so to a complex state machine with many input signals and internal conditions.

Save/restore logic

The save/restore logic can be viewed simply as a set of registers located in a static part of a design that are responsible for keeping last values of flipflops in a d-module before it was removed, and multiplexers that connect proper flipflops in the static part and in the loaded d-module.

Interface management

Interface management is responsible for treating connections between the static part and loaded d-modules. Two approaches are possible: either to define as many ports as there are different ports used by all d-modules, or to take the maximum number of ports used in one d-module and to introduce multiplexing of the ports.

Bitstream management

The problem with bitstream management is mainly how the configuration information is stored or generated. Two choices are either to store a bitstream (generated in advance by the design tools) inside an FPGA, or to store it in an external memory. The latter case is likely to be used together with the reconfiguration controller executed in a microcontroller.
This paper discusses dynamic reconfiguration achievable using current FPGA technology. An analysis of implementation issues has been presented and desirable features of future generation of CAD tools have been discussed.

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FPGA Modelling for High-Performance Algorithms

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Timing-driven physical design algorithms belong to the leading edge of today's FPGA design technology. They take an input circuit and transform it so that delays along the most critical signal paths are minimized. An essential requirement is a model of a target device that supports timing simulation of the implementation. One does not usually talk about topological models on the mapping level, but frequently used are such models on the placement and routing levels. As the detailed logical structure of today's FPGAs is rather complicated and the placement/global routing algorithms have to deal with a huge amount of data, it is desirable to reduce the number of descriptive elements and thus obtain results in less time.

This research was formed by three parts. The first part introduced theoretical aspects connected with FPGA modeling. The second part tested the aspects on two FPGA global routing models that had different levels of abstraction: a complex global routing model that retained routing properties of the target FPGA (also known as the wire-type model) and its simplified version (also known as the global routing model) that was similar to abstract 2-dimensional mesh models often used in academic research. The third part examined three delay estimation methods supported by the models and used them to objectively compare the quality of the models. The following text presents key aspects of the research.

FPGA models are usually represented by a directed global placement and routing (hyper)graph, we will stick to the terms global or detailed routing graph in the following text. It is necessary to incorporate into the graph physical properties of the modeled FPGA, namely the direction of signal propagation and its delay; this can be done by directly incorporating orientation in the model by using a directed graph, or by incorporating orientation properties in the placement/routing algorithms that use an undirected graph. Other important properties include area constraints and delay propagation; these are considered by using valued graphs, where each vertex and edge has an assigned capacity and type. A global routing model is a graph derived (reduced) from a detailed routing model; the detailed model is a one-to-one representation of a real FPGA. The vertices in both graphs have an input degree and an output degree. It is assumed that a global routing model contains fewer elements than a corresponding detailed routing model.

Easy model reductions are those that can be done without affecting routability properties of a model. *Difficult reductions* alter routability of the model. This may result basically in wrong routability assessment, wrong area estimation, and wrong operating frequency estimation. It may also cause the placement/routing algorithm arrive at invalid or suboptimal results.

To be able to analyze *the effects of model reductions*, we have first defined their creation using terms from the graph theory and then introduced metrics that analyze routing properties of the resulting routing models.

Modeling errors are caused by a changed topology of the global routing model with respect to the detailed routing model. Since the aim is to generate an optimal solution using the global routing model that will be optimal and valid with respect to the detailed model (= the targeted FPGA), the best measures to assess a global routing model against a detailed routing model are its *routing unambiguity* and *routing fidelity*.

Routing unambiguity reflects the degree to which a route given in a global model determines a specific route in a detailed model.

Routing fidelity is a degree to which a global routing model is able to reflect the detailed topology of a route in a detailed routing model. It is a number from the interval **< 0 ; 1 >** that reflects suitability of the global routing model for signal delay estimation, where the reference is the detailed routing model (we assume that the detailed model itself is suitable for delay estimation).

Delay modeling is essential for timing-driven algorithms. In the past, signal delays were determined mainly by delays of logic resources. From the 0.5um process generation signal delays are determined by routing resources. This fact stresses the need for a high-quality routing delay estimation in all phases of the design process.

To *generate a good placement* in terms of critical signal delays it is necessary to be able to model with a good precision topologies of signal nets. Any delay model is not perfect and produces imprecise values. A delay estimation error is usually evaluated against some reference values, which are usually determined using a *SPICE* simulator, or using a simulator provided by a manufacturer. To be able to assess different delay models, we need to introduce *delay estimation error*. Delay estimation error translates absolute delay values into a space of relative errors. A good delay model produces delay values with a 0% error. Delay models can be compared according to the *distributions* of their delay estimation errors. A simpler option is to derive a set of useful *statistics* from the distributions. Suitable candidates are *entropy*, *mean error*, *standard deviation*, mean *absolute deviation*, *median error*, *error range*, and *correlation* of a model.

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Face Detetection and Tracking in Images/Video

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Face detection is currently very popular research area. It attracts attention of researchers due to its wide applicability, e.g. in security systems, video signal compression, intelligent human-computer interfaces, people activity monitoring, biometric measurements, etc.. Nevertheless, the problem is not solved sufficiently yet.

Recent results in face detection have shown advantages of methods based on learning from huge training sets. In facial image processing, enormous amounts of training examples are typically easily available. However, speed of *training* determines the size of practically manageable training set and consequently the quality of found solution. Another important aspect of each face detector is its *detection* speed. In many applications, real-time performance is required.

In typical face detection system, the speed of training is not considered as a problem. Therefore, it lasts from few seconds up to weeks depending on a training method. The main objective of most training methods is the classification error minimisation. However, it was shown that larger the training set used during training, better classificator can be trained with lower classification error. A faster training method can therefore explore larger training sets and find better classificator.

The speed of detection has always been taken into account. Recently, several real-time face detectors have been proposed. One way of reaching the speedup is to use some fast detection heuristic (e.g. the region has to contain a given percentage of skin colour) rejecting majority of possible regions in the image and running the classifier only on the remaining small portion of regions. Another, recently often used method is to separate the classifier itself into smaller parts and running them sequentially on each region. If the first part does not reject the region, the second part is run, if the second part does not reject the region, the third part is run, etc.. When some part accepts the region as a searched object, the following parts do not need to be evaluated. One such face detector, running in real-time, has been proposed by Viola and Jones [1]. They built a cascade from classifiers trained by the AdaBoost algorithm.

In our research the speed of training and detection have been explored. Different approaches for decreasing computational complexity of both problems were examined in connection to the AdaBoost training algorithm and in close relation to the work of Viola and Jones.

At first, several obvious solutions have been tested and the results were summarised in the technical report [2]. The tested approaches were training randomisation, using different weak classifiers (LDA), and pruning of the weak classifier set. None of these “easy” methods lead to a worthful improvement.

To speedup training and detection phase, specific properties of the training algorithm, AdaBoost, have to be used. The AdaBoost algorithm works in cycles. In each cycle one weak classifier is chosen (from a given set) and combined with previously selected ones. It has been shown that the AdaBoost algorithm selects a new weak classifier to be independent in precisely defined way of the previously selected one. We proposed the *totally corrective algorithm* that extends this independence to all previously selected weak classifiers [3]. The motivation for this step was to add weak classifiers with classification information not

included in already learned classifier. The totally corrective algorithm minimises the same classification error upper bound as the AdaBoost algorithm, but more aggressively. The result was 20 % speedup in both training and detection compare to the Viola and Jones method and four-fold shortening of the classifier.

Our second modification is related to the Viola and Jones cascade building. In their cascade building, every classifier was trained on the data not rejected by the previous classifiers. However, the classifier was trained from scratch. Our idea is to use knowledge of the previous classifiers and combine it into the currently built classifier. This modification leads again approximately to 30 % speedup in training and detection and 25 % shortening of the classifier. Furthermore, it can be combined with the totally corrective algorithm. The results will be published on one of the upcomming conferences.

To test our detectors in real scenarios, a real-time system was implemented and connected to the input of a camera. It is used to study the weak points of the detector.

The main result of the work supported by the grant was the speed improvement in training and detection of the face detector based on the AdaBoost algorithm. Both proposed techniques allow about 20 % and 30 % speedup and create shorter classifiers. The latter property facilitates hardware implementation, the former opens scope for the increase in the search space, e.g. the range of scales at which faces are sought.

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High Performance Computing Web Portal

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The project objective is to build up a web portal solution that will take specific demands of the Centre of High Performance Computing (HPC) into account and will be optimal for this purpose.

The basic requirement for creation of dynamically and graphically attractive web portal has been the necessity to offer to its users both sufficient volume of information concerning HPC and support services for communication, searching, data storing and also the possibility of the personal web presentation. The further important requirement has been to facilitate the portal administration. The management of the portal will be accomplished through www interface to be understandable even for less technically qualified administrators. Apart from providing with publicly available information the portal will also include internal information for employees and partly will integrate the internal web applications and utilities.

At present web portals represent the main practice how to integrate available information resources of an organization and to make them accessible through a unified environment, most commonly the web interfaces. There is a great spectrum of commercial solutions on the market. These meet different requirements of the customers, from basic information services up to large-scale implementations of the enterprise information systems that integrate different database resources and application processes. Although these commercial products represent high-quality modular solutions that can be tailored on client demands, at the same time this is also rather expensive solution that can be used meaningfully with larger or more ambitious portal implementations as far as the performance or the security is concerned.

Web portals distributed under GNU licence are another option to the commercial products. In that case the implementation consists mostly of the configuration of the portal and of the data supply. In frame of searching of the initial, for us the useful portal, the following free GNU web portals have been tested:

- php-nuke.org, php-nuke.net based on PHP
- PHPgroupware from php.net
- JetSpeed based on JSP (Java server pages) from apache.org
- Jahia.org based on JSP
- Altoweb from Altoweb.com, Weblogic from Bea.com (also JSP)

From the point of view of our requirements we have detected the following problems during the testing of the above web portals:

- Difficult integration of the post system with the web interface access
- The portals support PHP4 or JSP only
- Not all the required services are supported
- Difficult kernel adaptation
- Unsufficent modularity

Because of the above mentioned drawbacks we have come to the decision that it will be the most convenient to program our own tailored portal. There has been the further reason for own solution, namely the fact, that the initial requirements imposed to the HPC portal had not been fully defined and could be changed during implementation itself.

The solution of the web portal has been based mostly on GNU software. We have used the Unix-like Debian Linux as the operational system. PHP has been chosen as the script language for the portal construction, MySQL as the relation database for data-storing and the Apache server for the dynamic web-pages representation.

At the first stage of the portal creation we have implemented an information module that creates the very heart of the portal through which public, user and also information for employees are presented. After more detailed analysis we have proposed inner data representation (hierarchic structure of the documents, access rights, own html tags definition, bilingual support, etc.) and we have implemented it to the database. For the client communication it has been used so called „session" that serves to authentication and authorization of the www client in frame of the whole portal. The standard Linux firewall has also been applied for better security of the whole portal. During the process of construction of the portal cascade styles have been used to facilitate modification of the portal representation. Under close collaboration with future administrators the interface for the content management has been proposed and integrated directly into the web pages. This has involved text editing functions, editing of further document attributes (rights and location of documents), uploading and administration of non-text documents (pictures, enclosures and scripts). After technological completion of the information program unit data from the existing and now unsatisfactory static webs have been transferred to the portal structure.

At the second stage of the portal creation we started step-by-step to implement complementary and supportive services for users, in particular the full-text searching over the portal texts and the communication application of type discussion forum. Moreover, for registered users we offer to use e-mail post, ftp storage services and area for their personal web presentation. For that purpose standard GNU software will be used (WU-FTP, SendMail). Owing to the fast (1 Gb/s) portal connection to the academic backbone CESNET the portal will be used as a ftp archive of GNU software concerning HPC.

At the present advanced stage of the implementation process of the portal the choice of the programming of the less capacious extensive nonunified portal has appeared to be optimal, while it facilitates effectively to realize functional and design modifications of the portal, which were not successfully intercepted in initial requirements and which arisen during implementation or using itself. The portal programming itself also makes possible combine effectively heterogeneous GNU software for the provision of standard services.

The web portal is located at the URL http://www.civ.cvut.cz .

Modern Tools for Reconfigurable SoC Design

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System-on-a-Chip (SoC) is usually referred as a complete electronic system on a single silicon substrate, [1]. Such a system incorporates processing elements, application specific IP cores and storage elements to implement custom functionality tailored for a particular application. Although the SoC used to be a domain of the ASIC design, the advances in deep submicron IC technology have enabled to create programmable devices (FPGAs) with sufficient capacity and fast enough to provide an alternative to the traditional SoC design, usually called System-on-a-(Re)programmable-Chip (SoRC, SoPC).

Systems-on-a-Chip have always been the heart of embedded systems, i.e. complex systems dedicated for a specific application (or a small set of applications) with strict requirements on performance, power consumption and low cost. The example of the concrete embedded system may be a disk controller, an automobile engine controller, a cellular phone or a set-top box. The design of such systems is usually characterized as HW-SW co-design, because it encapsulates design of both hardware (PCB design, SoC design) and software platform (firmware, device drivers, RTOS, control applications, etc.). Such a design process is inevitably too slow, complicated and error-prone to satisfy the permanent needs for shortening the time-to-market. One possibility that meets these requirements is based on the technology improvements and IP reuse methodology, thus shifting embedded system design into the field of SoC design, i.e. implementing as big portion of the overall system as possible into a single chip. Using the modern programmable devices as the hardware platform for embedded systems is only the consequence of the requirements for rapid prototyping and first-time-success implementation.

As presented earlier the traditional embedded system design consists of several independent flows (PCB, SoC and SW design flows) that are verified separately and meet only in the point of system-level implementation thus increasing the risk of multiple system redesign cycles. This traditional flow is inappropriate for SoPC embedded system design and has to be modified to adopt key SoC design principles such as thorough verification necessary for first-time-success implementation. This requires evolving new design tools that supports tight co-operation of HW and SW flows, and new methodologies for flexible HW/SW design partitioning.

An example of a modern tool that addresses these needs is Embedded Development Kit (EDK) by Xilinx Inc [2], [3]. It represents an attempt to create a framework over the existing design tools for CPU based embedded systems. It is a set of individual tools consisting of processor hardware platform tailoring utilities (used in connection with existing HW design tools, e.g. Xilinx ISE), software application development tools (e.g. GCC compiler) and a verification/debug tool chain (support for 3rd party verification tools, e.g. ModelSim; support for in-circuit debugging). EDK also provides interface to invoke these tools and to enable their co-operation. Moreover, it also provides a wide range of predefined standard peripheral IP cores, with device drivers and libraries for C programming language, available for rapid system development.

The design flow introduced in EDK consists of three major parts: hardware, software and verification platform creation. A specification files (simple text files) are used to define each of these platforms. In case of hardware platform, the specification file defines the embedded processor(s) (currently Microblaze or PowerPC), the peripherals and the bus architecture, specifies address space for instruction/data memory and for individual peripherals, etc. The software specification determines driver and library customization parameters for peripherals, processor customization parameters, standard input/output devices, interrupt handler routines, and other related software features. Finally, the specification for verification platform allows the user to choose the hardware simulation models (simulation libraries) and the level of simulation abstraction (behavioral, structural, timing). After providing these specification files together with sources for user-defined HW/SW components and after setting EDK environment properly, the user may invoke individual tools (or the complete tool chain) to implement complete SoPC system.

Our first benchmark application was a character terminal incorporating standard PS2-compatible keyboard, LCD display, UART and two 8-bit general purpose I/O. Microblaze CPU core and all peripherals including programmable interrupt controller and watchdog occupy 62 % of CLB slices available inside XC2S200E FPGA. Overall design can run at 64 MHz. Software portion of design is a simple interrupt routine that translates the character scan code received from the keyboard to ASCII code, displays the character on the LCD and sends it over serial line to host computer. Program and data memory occupied approx. 80 % of available Block RAMs inside FPGA. The whole application was verified on the Digilab D2E development board.

Design and verification of the benchmark application lasted for more than one month for experienced designer. It was due to relatively long learning curve of the EDK and many bugs in the early release (ver. 3.1). However, this may improve with later releases and after gaining sufficient experience with the tool. On the downside, complexity of the application is limited because the SW portion must fit inside available Block RAMs. Application that is more complex must use external memory for program or larger (and more expensive) FPGA.

We plan to continue our experiments in two directions. Firstly, we would try to incorporate different CPU cores within EDK framework. CPU cores such as DOP [4] may use limited memory resources more efficiently and more complex applications would be possible to implement in the same FPGA. Secondly, the methodology to embed a coprocessor for accelerating the time-critical portion of application is developed. It may allow more efficient HW/SW decomposition for computation intensive applications.

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Adaptive Order Linear Predictor for Speech Compression Algorithms

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It is known that the speech compression can increase performance of many applications as a speech transmission and storage. Best algorithms in sense of maximal compress ratio are based on loseless tube model of human vocal tract. This model leads to linear all-pole filter and its excitation. Parameters of this model are estimated from speech and used for speech synthesis. From human anatomy is determined minimal order of all-pole filter in the model. It is given by the most complicated vocals and its value is 10. However order of 10 is not necessary every time. Necessary order depends on each vocal, whether it is voiced or not, etc. In our work we are trying to minimize overheads by estimating necessary order of the all-pole filter and to use reduced model for synthesis when it is possible.

Our approach is capable to reduce bitrate generated by compression algorithm twice in average or quality of synthesized speech can be increased for standard bitrate.

For implementation was used recursive least squares (RLS) lattice algorithm on the contrary to the batch estimation of the state of the art. The lattice modification of RLS was used because of nested order property. When order of 10 is computed, then RLS lattice provides all solutions from 0^{th} order up to 10^{th} order. This algorithm was advanced by estimation of the most probable order of model for each speech data frame, this estimation is based on Peterka's theory. For speech data, probabilities of orders are continuously estimated starting from 0^{th} order and ending by 10^{th} order. Then the speech is divided into frames and in each frame the order which is reaching maximal maximal value was used as order of the model. Only necessary model parameters were transmitted.

This way was bitstream reduced approximately by 50 %. Quality of the synthesized speech decreased, but in comparison with RLS of 5^{th} order which produces same bitrate, the speech was understandable.

In future work we will try to implement better decision rules for order estimation. Usage of RLS algorithm is providing possibility of adaptive frame length. This possibility will be analyzed too. Complete algorithm will be implemented in field programmable gate array (FPGA) as IP core.

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Re-usable Open Web-based Learning Systems Built Using Web Services

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Introduction

In accordance with the European Union's "Programme for the Effective Integration of Information and Communication Technologies (ICT) in Education and Training Systems in Europe (2004 – 2006)" and mainly its key aims (Promoting digital literacy, European virtual campuses, e-Twinning of schools in Europe and promotion of teacher training, Transversal actions for the promotion of e-learning in Europe) many educational institutions are focusing ever more on the emerging possibilities of Information and Communication Technologies (ICT).

Past experience gained at the Institute of Instrumentation and Control Engineering of the CTU's Faculty of Mechanical Engineering showed several interesting observations regarding the use of ICT in the learning process.

Following are the critical elements in designing a web-based learning system:

- Interoperability
- Content management
- Support tools (forum, calendar, real-time chat, audio and video communication)

Interoperability

In an ever more globalized world, such as the one at the beginning of the 21st century, it is a desirable feature of most of the computer-based systems to be interoperable at a certain level with other computer-based systems. With recent spread of the Internet, most current learning systems are based on a client/server architecture, where the client party connects to the server using a regular web browser and a standardized HTTP protocol. In this way interoperability between different clients and a single server has been achieved. However, it is also desirable to connect such system to other systems, thus allowing the information contained in each one of the systems to be shared. Most currently used e-learning systems are based on proprietary solutions, which means that it is very difficult (if not impossible) to connect information contained in them with information contained in other such systems. Web services architecture seems to be a very good approach allowing overcoming of this drawback, for it is based on approved, well-known and popular standards (TCP/IP, HTTP, XML, SOAP).

Content management

Independent of what actual solution is chosen for the implementation of a learning system one of its most critical aspects is the content. Commercially available e-learning solutions (for example WebCT) usually address this issue by developing their own Content Management System (CMS). Such system then makes (sometime inseparable) part of the entire learning system. The disadvantage of this approach is that the content inserted into such e-learning system is then "closed" inside the system and unavailable for other use than by the (registered) users of such system. Even though this may be sometimes useful (and necessary) often times there is no need to restrict the scope of the target audience and therefore the technology becomes the (undesirably) limiting factor. Extensible Markup Language (XML)

has been a favorable advance in the recent years and most of the current content is already being saved in XML, however the inability of other systems to connect to such locally stored documents makes the advantages of the use of XML data in such systems practically useless. Exposing this data by the means of web services is a goal of a project currently taking place at our institute. With the advantage of web services, not only theoretical data is exposed, but also laboratory experiments and mathematical MATLAB models.

Support tools

Effectiveness of the learning process is greatly dependent on the accompanying tools that the student has at his/her disposal. Informal interchange between students is one of the critical and often forgotten aspects. Sufficient communication between the teacher and the students must also be enabled and encouraged. These and other features (like calendar, audio and video streams, etc.) are often missing in the common e-learning systems. There exists a large number of open-source Community, Content and Collaboration Management Systems (C3MS) that are perfectly suitable for enabling such features in a web-based learning system.

Implementation

All the three critical requirements have been merged together and formed a goal to build a "re-usable open web-based learning system". The "re-usable" criterion has been selected, because the fundamental principle of the approach is to share once digitized knowledge with the "outside world". For this reason web services have been chosen as the underlying architecture. The "open" criterion expresses the desire to build the solution preferably on an open system (available under GNU General Public License or similar), thus avoiding the high costs of a commercial system and also allowing others to contribute to and draw from such system. The "web-based" criterion expresses the fact stated above that most current learning systems are based on HTTP client/server architecture. Finally, the system is a "learning" one, because its main aim is to help people use ICT during the learning process.

Several C3MS are being considered for the basis of implementation of this system, among which are Typo3, PhpNuke, PostNuke, Mambo, Drupal, CMSInfo, OpenCMS, Redhat CMS, Zope, Midgard and others. Experience was also taken from the OpenCourseWare project of Massachusetts Institute of Technology, implemented with Microsoft Content Management System 2002. Several application server solutions are also considered to host the web services – among them Apache Jakarta Project, Microsoft .NET platform, Java 2 Platform Enterprise Edition (J2EE), as well as simple web server (for example Pinknet Web Server) with an ISAPI extension. Pilot version of the system will be launched in the coming weeks.

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Computational and Performance Testing on an Experimental IBM Opteron Cluster System

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When Opteron from AMD and Itanium from Intel were released onto the 64-bit processor market in the summer of 2003 [1], computing systems based on these processors joined RISC systems delivered by IBM, Sun-Microsystems, Hewlett-Packard and others. Opteron and Itanium, running Linux (Red Hat Enterprise Linux AS 2.1, SuSE Linux Enterprise Server) and Windows (Windows Server 2003) operating systems, are aimed at creating low-cost, high-performance clusters. These clusters can threaten high-end RISC systems with their performance-cost ratios. Opteron and Itanium support a lot of memory per processor, have quick memory and CPU access and fast communication between processors. Opteron is superior to Itanium because it runs 32-bit applications in the native mode. Itanium runs 32-bit applications only in the emulation mode, so applications run more slowly there than on Xeon or Opteron. In late September 2003, an experimental IBM Opteron Cluster System (IOCS) was delivered to the Computing Center to assemble, install and run functional application and performance tests on [2]. The Cluster System is referred to as IBM @Server 325. The hardware configurations of IOCS and of ThinkPad notebook are in Table 1 (below):

Machine	HW	Nodes	Type[GHz]	RAM/Cache	LAN[Mbps]	HDD[GB]/AI
IOCS	64-bit	2x4	Opteron 1.6	(2/1)x4 [GB]	(2x100/1T)x4	(15/2xATA)x4
ThinkPad	32-bit	1	Centrino 1.5	0.8/0.1 [GB]	1x100/1T	50/ATA

IOCS was split into three independent virtual servers (Opt12, Opt3, Opt4) in Table 2:

Machine	SW	Nodes	OS Linux	OS Kernel	JRE/Java2
Opt12	32-bit	2x2	RedHat9	2.4.22+openMosix-1	gij/gcj-3.2.2
Opt3	32-bit	2	RedHat9	2.4.22	gij/gcj-3.2.2
Opt4	64-bit	2	SuSE ES	2.4.19-SMP	IBM 1.3.1
ThinkPad	32-bit	1	XP2002 SP1	5.10.2600	Sun 1.4.1

Apart from the experiments [2], we were interested in Java performance, especially Java threads [4] in multi-processor environments, were the main focus. Java threads are the union of “old” thread paradigms and a modern object-oriented programming language. The threads are easy to use on single and multiple processor machines with shared memories, which enable a parallelism of applications. If the operating system is able to schedule application threads on available processors, the application runs faster by the number of working processors.

A test problem was the parallelization [3,4] of a single thread program, which counted discrete sinus values (y=sin(x)) on the interval <0,360> and then stored them into a matrix. The idea was to split the interval into several chunks, assign chunks to threads and run them parallel to each other in order to decrease the computation time. Three versions of scheduling were proposed and implemented: static, self and guided-self scheduling [3]. Input values of the program were the number of iterations (200), threads (1-12), rows (2000) and columns (200) of the matrix. An implementation phase and preliminary testing were carried out in JBuilder8 IDE on the ThinkPad notebook.

Four types of test environments were utilized, as seen in Table 2. However, the application should have been scale based on the number of available processors. The positive time decrease Δ was obtained only for Opt12. Opt12 (Opt1 and Opt2) was joined by OpenMosix to behave like a SMP machine. The performance of Opt12 was two times better than the performance of Opt3, by two or more threads. The Opt4 server was sixteen (thirty) times faster than Opt12 and sixty times faster than Opt3, because 64-bit SuSE ES was installed on Opt4, but no improvement of two and more threads was achieved on Opt4. When the number of threads was greater than four, the parallel run time was around the same as for one thread. Comparing ThinkPad 32-bit Centrino to "32-bit/64-bit" Opteron, ThinkPad was five times slower than Opt4 and more than three times faster than Opt12. Confusion lay in the fact that ThinkPad was an one processor machine, but Opt4 and Opt12 were two and four processors machines, respectively. The run times ranged from 9.9 to 300 seconds, as shown in Table 3. The results were calculated as averages of ten independent runs.

Machine	**Threads[#]**	**Basic[s]**	**Schedule[s]**	**CPU/Mem[%]**	**Δ[%]**
Opt12	1|2-12	300|164	300|157	99/12	52-54
Opt3	1|2-12	300|299	299|298	98/15	0
Opt4	1|2-12	10|9.9	9.9|9.8	96/22	0
ThinkPad	1|2-12	49|48.5	59|58	99/32	0

In the experiments [3], we used several JRE and Java compilers; no constraints, errors, problems or compatibility issues were experienced. Classes created by newer compilers showed slightly better performance when the number of threads was increased. In scheduling mechanisms, there were no differences in the speedup, which was unexpected. Java threads were processor demanding (96-99% of CPU resources), but not memory demanding (12-49% of memory resources). Every thread or the same number of threads was mapped onto one processor. Matrix representation phenomenon of "rows vs. columns" was also measurable with a difference of three percent in the total run time. Java threads in combination with a "32-bit" Opteron are "too" expensive of a choice due to a lack of performance for this high price. For multi-thread applications, cluster systems without an OpenMosix-like feature cannot be used efficiently. However, RISC SMP systems [3] still have an advantage, as they freely distribute threads to processors and share memory pools over their distributed memory counterparts, OpenMosix libraries are a challenging approach to decreasing disadvantages of distributed memory clusters for use in multi-thread Java applications.

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Speeding up Evaluation of the Erlang-B Formula

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Theory of queuing systems is often used in telecommunication network planning, particularly for dimensioning various network elements. When concerning telephone networks with a voice traffic, then the Erlang-B is probably the most important formula. It is used for dimensioning of the loss systems classified as M/M/N/0 according to the Kendall's classification. Its aim is to determine the probability of loss B based on the offered traffic and the number of circuits. Nevertheless utilization of this formula is based on several assumptions and in practical applications their fulfillment has to be carefully examined by measurements. It is often necessary to evaluate the Erlang-B formula with a prescribed accuracy and moreover, as it is used repeatedly in some applications, the speed of the evaluation has to be considered as significant. This article is summary of various improvements made to speed up the numerical evaluation of this formula.

In the basic form its parameters are integer number of circuits n and offered traffic A. Although possible, direct evaluation of B according to the definition would be time consuming. Therefore, a recurrent form of the formula is used widely.

$$B_N = \frac{\frac{A^N}{N!}}{\sum_{i=0}^{N} \frac{A^i}{i!}}$$

Basic form of the formula

$$B_{N+1} = \frac{A \cdot B_N}{N+1+A \cdot B_N}, B_0 = 1$$

Recurrent form of the formula

$$I_N = 1 + \frac{N}{A} \cdot I_{N-1}, I_0 = 0$$

Reciprocal recurrent formula

First obvious, but very important improvement is evaluation of reciprocal value of B instead direct usage of recurrent formula. Due to constant offered traffic A during the evaluation it is possible to multiply by the reciprocal value 1/A instead of dividing by the value A and thus completely eliminate dividing. This accelerates the evaluation significantly. It is also possible to substitute the incrementation of a temporary variable with 1/A for multiplication N(1/A) and further speed up the evaluation.

It is necessary to evaluate the probability of loss for non-integer number of circuits in several applications, e.g. when dimensioning systems with overflow using Wilkinson two-parametr method. A generalized version of the formula is available for a non-integer number of circuits.

$$B_x = \frac{A^x \cdot e^{-A}}{\int_A^\infty t^x \cdot e^{-t} dt}$$

Loss probabilty for non-integer number of circuits

$$E_{x,approx} = \frac{1}{(1+A)((1+A)^2+A)} \cdot x^2 - \frac{A+2}{(1+A)^2+A} \cdot x + 1$$

Rapp's approximation of loss probability for 0<x<1

Various approximations are often used instead of direct evaluation of generalized formula. The most popular is probably the Rapp's approximation. The approximating function is directly used in the interval <0..1>. For x>1 a fractional part of the loss probability is determined. The final value of the approximation is evaluated using recurrent equation which is also valid for non-integer number of circuits. When employing reciprocal recurrent formula

the Rapp's approximation is very fast due to its simplicity and it is linearly dependent on the number of circuits.

Another promising approach is using expansion of incomplete gamma function, which is part of the generalized formula for non-integer number of circuits, into continued fraction. Cruicial problem of this method is finding out sufficient number of terms of the expansion to reach certain prescribed precision.

$$\Gamma(1+x,A) = e^{-A} \cdot A^{x} \cdot \left(\cfrac{a_1}{b_1 + \cfrac{a_2}{b_2 + \ldots}} \right)$$

$$a_{2n} = -x + n - 1, b_{2n} = A, a_{2n+1} = n, b_{2n+1} = 1, a_1 = 1, b_0 = 0$$

Expansion of the incomplete gamma function to continued fraction

Above mentioned expansion into continued fraction is converging for all A>0 and x>0 (both conditions are valid for the real systems). Nevertheless, the convergence for x>A is slow, and therefore it is often time consuming to obtain a result with an appropriate accuracy. In these cases, it is advisable to evaluate it for number of circuits A-1+θ, where θ is fractional part of x. The final value of the loss probability is evaluated utilizing the recurrent formula. Using this expansion formula for probability of loss can be derived.

Various methods to evaluate continued fraction “from the beginning” were examined, but most of them had problems from the point of view of numerical stability. Finally was successfully employed modified Lentz's method. However according to real measuring even in the most optimized implementation it is slower than Rapp's approximation in conjunction with recurrent formula. And so the next step led towards evaluation “from the end”. First of all some comparisons of speed of real implementations of Rapp's approximation and evaluation of continued fractions were made assuming that the number of expansion terms is known in advance. Continued fraction method is faster in area bounded with conditions n>20, A>100 and simultaneously A>n+20. At the same time theoretical computational complexity of the two above mentioned methods was compared. Both procedures indicate that there might exist opportunity to speed up the evaluation.

Further studies of dependence of terms number on offered traffic A and number of ciruits n showed that it is increasing rapidly as n or A approaches A=n as has been previously remarked on. It also has to be denoted that in most practical applications A is less than n to serve offered demands with sufficient loss. Therefore it is possible to find out such number d=A-n, for which is the speed of evaluation using Rapp's approximation and continued fraction the same. Consequently the continued fraction might be used to compute A-d+θ, where θ is fractional part of x and for the rest to A recurrent formula might be used. Another approach to fastening is finding approximation of dependence of number of terms on A and n. Unfortunately the function is not known in analytical form, it is only possible to compute numerically values for particular pairs of A and n. The character of the approximating function also has to be sufficiently simple and so it is not clear whether this approach would lead to positive results.

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Automatic Correspondences in 2D Imaging for 3D Model Reconstruction

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Many computer vision algorithms include a robust estimation step where model parameters are computed from a data set containing a significant proportion of outliers. The RANSAC algorithm introduced by Fishler and Bolles in 1981 [1] is possibly the most widely used robust estimator in the field of computer vision. RANSAC has been applied in the context of short baseline stereo, wide baseline stereo matching, motion segmentation, mosaicing, detection of geometric primitives, robust eigenimage matching and elsewhere.

In a classical formulation of RANSAC, the problem is to find all inliers in a set of data points. The number of inliers I is typically not known a priori. Inliers are data points consistent with the 'best' model, e.g. epipolar geometry or homography in a two view correspondence problem or line or ellipse parameters in the case of detection of geometric primitives. The RANSAC procedure finds, with a certain probability, all inliers and the corresponding model by repeatedly drawing random samples from the input set of data points.

The structure of the RANSAC algorithm is simple but powerful. Repeatedly, subsets are randomly selected from the input data and model parameters fitting the sample are computed. The size of the random samples is the smallest sufficient for determining model parameters. In a second step, the quality of the model parameters is evaluated on the full data set. Different cost functions may be used for the evaluation, the standard being the number of inliers, i.e. the number of data points consistent with the model. The process is terminated when the likelihood of finding a better model becomes low.

RANSAC is popular because it is simple and it works well in practice. The reason is that almost no assumptions are made about the data and no (unrealistic) conditions have to be satisfied for RANSAC to succeed. However, it has been observed experimentally that RANSAC runs much longer (even by an order of magnitude) than theoretically predicted [4]. The discrepancy is due to one assumption of RANSAC that is rarely true in practice: it is assumed that a model with parameters computed from *an uncontaminated sample* is consistent with *all* inliers.

In this work we propose a novel improvement of RANSAC exploiting the fact that the model hypothesis from an uncontaminated minimal sample is almost always sufficiently near the optimal solution and a local optimization step applied to selected models produces an algorithm with near perfect agreement with theoretical (i.e. optimal) performance. This approach not only increases the number of inliers found and consequently speeds up the RANSAC procedure by allowing its earlier termination, but also returns models of higher quality. The increase of average time spent in a single RANSAC verification step is minimal. The proposed optimization strategy guarantees that the number of samples to which the optimization is applied is insignificant.

The improvement proposed in this paper requires no extra input information or prior knowledge, and it does not interfere with other modifications of the algorithm, the MLESAC

(Torr and Zisserman, CVIU), R-RANSAC (Chum and Matas, BMVC'02) and NAPSAC (Myatt BMVC'02).

The experiments in [2] showed, that the number of detected inliers increased, and consequently the number of samples drawn decreased. In all experiments, the running-time is reduced by a factor of at least two, which may be very important in real-time application incorporating a RANSAC step. It has been shown and experimentally verified that the number of local optimization steps is lower than logarithm of the number of samples drawn, and thus local optimization does not slow the procedure down. Four different methods of local optimization were tested and the efficiency of method 5 is almost 1. The proposed improvement allows to make precise quantitative statements about the number of samples drawn in RANSAC. The local optimization step applied to selected models produces an algorithm with near perfect agreement with theoretical (i.e. optimal) performance.

All details of the proposed algorithm can be found in [2].

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Matching Algorithms in Computational Stereoscopic Vision

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Computational stereoscopic vision gained a big interest of researches over the last four decades due to its importance in computer vision. The core problem of stereoscopic matching is: (1) to find correspondences between binocularly visible regions in the input 2-D images and (2) to detect occluded regions (i.e. regions that are not visible in all the input images) and ambiguous regions (i.e. of low texture, with repetitive patterns, specularities, etc.). The results are typically presented in a form of disparity map, where the disparity represents the shift between the corresponding points from the input images.

In local stereo methods, the correspondences are typically found based on the small rectangular image windows neighbouring the point of interest. Over these neighbourhoods a statistics (such as SSD, SAD, NCC, etc.) is computed and pixels with the most similar neighbourhoods are assigned as the corresponding pair. In order to produce accurate results, the matching features—contents of the windows—has to be as stable and discriminable as possible. By stability we mean the independence on various image distortions, by discriminability the ability to recognize correct match. Thus, the definition of the point neighbourhood determines the quality of the resulting disparity map.

In our research, we are designing stereo matching algorithm for 3-D scene reconstruction, i.e. finding the 3-D model of the scene from a set of uncalibrated 2-D images. Consequently, the requirements to our results are: no (or low) false positive and mismatch errors, which is paid by lower density of the results. To fulfil these requirements, we have come to the conclusion that the matching has to be computed over jointly discriminable and stable features, i.e. that both the input images contribute equally to the matching features definition. However, it is impossible to get such features in the input images due to various distortions. Therefore, we pose the matching problem in the *disparity space*, which is a set of all tentative pairs. Since the disparity space contains all the possible correspondences, we can map the real spatial point neighbourhood in the scene to the point neighbourhood in disparity space defining our matching features. However, these features cannot be selected without having first any matching hypothesis, which led us to division of the matching process into two semi-independent phases, where the first one searches for the reliable matching features, while the second one establishes the matching over these features. In our approach, a *Stratified Dense Matching* [2,3], we propose a four-step algorithm: in the first step, pre-matching, the high-similarity pairs, *pre-matches*, are selected. In the second step, the connected structures of these pre-matches are traced out, creating the good-quality matching hypothesis we call *disparity components*. To capture even small disparity variations we allow the disparity within one component to vary. In the third step, for each pre-match its matching neighbourhood is adapted to its corresponding disparity component over which a new similarity value is computed. In the last step, the final matching is established using the new re-computed similarities. Our approach is independent on selection the matching algorithm, however, due to our application requirements we have applied the Confidently Stable Matching approach [4] for the final step.

Our neighbourhood definition: (1) allows varying disparity resulting in non-rectangular windows, (2) determines the neighbourhood shape directly by the hypothesised solution, (3) avoids any explicit surface model, and (4) allows to capture slanted or curved surfaces, discontinuities and even small scale differences.

We have tested our algorithm on various benchmark, real and artificial images. For a detailed study we have performed a ground truth evaluation [1], which showed that our approach improves the matching accuracy 1.8×, matching density 3×, and occlusion boundary detection 2× as compared to the same matching algorithm [4] with fixed-size rectangular windows in the input images. In a rigorous evaluation study [3], we have demonstrated that proper image modelling in disparity space is crucial for the accuracy of the matching since it considerably improves the quality of the results.

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Adaptive Communication Systems with Spatial Diversity

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The utilization of spatial diversity has been shown to provide significant gains in achievable data rates in wireless communication systems. We attach desired additional degrees of freedom commonly by installing multiple antenna elements on both the transmitter and the receiver side. Intuitively we endeavour to obtain more independent signal paths between transmitter and receiver and thereby increase the reliability of reception. In [1] was shown asymptotically linear growth of the channel throughput with the number of transmitter antennas. Since the channel is unknown at the transmitter the fading can be mitigated by some of channel coding techniques proposed e.g. in [2] or [3]. However enabling channel state information (CSI) can bring us further increase in spectral efficiency. Due to time variant nature of mobile wireless channel the non-adaptive system would have to be designed to the worst channel condition which is surely very non-effective. It is clearly very suitable to match the transmit scheme (power, rate, symbol period, coding scheme, etc.) to the actual channel state and thereby get the higher spectral efficiency. The CSI is commonly estimated at the receiver and fed back to the transmitter by an independent feedback channel or by the same channel with duplex mode (TDD). Due to the high attraction of this theme the theoretical performance limits have been investigated by the authors from the whole world in recent years.

We have focused on the more practical issues encountered implementing the system. Due to high complexity of optimal algorithms for coding, decoding, parameter synchronisation in these multidimensional systems overwhelm majority of built simulations runs in offline mode. Our aim was to get a step closer to the reality. Therefore the simulation in real-time environment (SPW Cadence 4.8.2) was built and the impact of practical systems limitations was investigated. This software package enables creating a real-time simulation which (or its only parts) can be directly translated to the language of hardware implementation VHDL used for programming of ASIC and FPGA.

Now we proceed with the brief system description. The system for complex envelopes with flat fading MIMO (Multiple-Input Multiple-Output) channel can be described by following equation

$$\mathbf{y} = \mathbf{G}\mathbf{x} + \mathbf{n}$$

where $\mathbf{y}$ and $\mathbf{n}$ are output respective noise complex vector of size $N_R \times 1$ and $\mathbf{x}$ is $N_T \times 1$ complex input vector. $\mathbf{G}$ is $N_R \times N_T$ matrix of channel coefficients drawn from complex Gaussian distribution (Rayleigh flat fading model). We decompose the channel using singular value decomposition (SVD) to the set of parallel independent subchannels.

$$\begin{aligned} \mathbf{y} &= \mathbf{U}\mathbf{D}\mathbf{V}\mathbf{x} + \mathbf{n} \\ \mathbf{U}^H\mathbf{y} &= \mathbf{D}\mathbf{V}\mathbf{x} + \mathbf{U}^H\mathbf{n} \\ \tilde{\mathbf{y}} &= \mathbf{D}\tilde{\mathbf{x}} + \tilde{\mathbf{n}} \end{aligned}$$

where **D** is a diagonal matrix. The number of subchannels is equal to the number of non-zero eigenvalues in **D**. Hence the adaptation techniques developed for single-input single-output channels [4] can be used in advance. We exploit discrete rate continuous power adaptation with the instantaneous maximal BER as the limiting condition. Our aim is to maximize average spectral efficiency subject to total mean (sum of powers over all antennas) transmitted power constraint, which has substantial impact on battery stand-by time in mobile devices. Commonly used modulation with good spectral efficiency was exploited (BPSK, QPSK,16-QAM, 64-QAM). A simple channel estimator based on the preambule insertion and data-aided estimation was implemented on the receiver side. An influence of estimation error on the system performance can be easily observed as well as the impact of delay in the feedback channel relative to the channel dynamics.

As the by-pass product the very flexible channel model was constructed. It can simulate a wide spectrum of mobile communication channels. The correlation between antennas on both the receiver and the transmitter side and even between individual paths in frequency selective channel can be simulated. The channel dynamics is also easily adjustable.

In conclusion we can say that the real-time simulation of MIMO adaptive communication system was built. This complex system provides an insight to the future generation of mobile communication systems and represents the next step on the way from theoretical considerations to the real implemented systems.

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Theory and Robotics Artificial Life Applications for Mobile Robots Control

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This paper gives a concise overview to innovated lectures *"Mobile Robots and their Control"* (agents in general) inspired by *artificial life* (AL) approaches.
A major goal of AL research is to *gain insight into both life as it is and life as it might have been*. As such, AL issues span potentially a very broad range, from the role of chaos and prebiotic chemistry, to the emergence of animal intelligence. The drive towards self-preservation applies to all levels of complexity: genes, cells, multicellular structures, plants, animals, group of animals, societies, and species. Behavior-oriented ALife approaches focuses upon the behavior of organisms of the complexity of animals. Systems of this complexity are called *agents*. When several of them cooperate or compete, we talk about *multiagent systems*. The idea of the bottom-up approach in simulation and building of the *mobile based-based* intelligent robots has been used during the recent few years in different ways. In Artificial Intelligence, the classical *deliberative* paradigm of viewing intelligent tasks as *reasoning* processes on *internal representations* of knowledge only has been shown to be unrealistic for embodied autonomous intelligent robots - agents. The new paradigm of *emergent functionality* views intelligence as an emergent attribute of interactions of agents with their environments and with other agents and focuses on models of intelligence that share certain common characteristics with biological information processing systems. In its context, the behavior-based approach allows to achieve higher-level cooperation among simpler systems by creating societies of robots [1], [2].
Agent technology covers wide spectrum of applications including enterprise, process control applications, and research areas such as artificial life, mobile robotics, nanotechnology and many others. Agents should provide satisfactory level of autonomity, adaptivity, proactivity and of social based. The term mobility covers a huge set of capabilities, the robot must be able to do. How to get wheeled robot from place A to place B, if there are rocks and a deep stream between these two places? It may be a tremendously hard task. The mobile robot must be able to solve situations that may be totally different from each other, must react on wide range of stimuli and from simple tasks, such as reflex reactions on emergent stimuli, to highly complex tasks as deliberative planning. Simply said, based of a physical mobile robot or a complex artificial life entity, which are able to survive and adapt in highly complex environment, has to be more complex then based of their specialized software agent counterparts [2].
The existing biological systems (with their capacity to continuously preserve and adapt themselves) provide solid base for designing of such types of agents. Ethologists have stressed that an animal's based can only be understood and only makes sense in the context of the particular environment it inhabits [4]. Such system tries to satisfy a set of time-dependent goals or motivations. Interaction dynamics between an agent and its environment leads exactly to the appointed emergent structure or the emergent functionality. Although each biological system brings a large amount of evolutionary baggage unnecessary to support intelligent behavior, the study of animal behavior can provide models that can be successfully

operationalzed within a robotic system. The basic animal based (such as instincts, reflexes, reproduction, predator avoidance, nesting etc.) suffices for modeling of simple life forms, but for the ones with deliberative thinking and planning doesn't. It is obvious that more complex biological systems are hybrid from their nature. Starting from the simplest living forms, which are mostly reactive, continuing with complex ones, which demonstrate deliberative or based features and finishing with human, who is capable of very sophisticated deliberative thinking and planning. Furthermore, the biological systems persist their internal state and moreover they are forced to keep and attain this state, which is called homeostasis. An intuitive decomposition of such biosystem into three controlling parts is: a *deliberative part* responsible for willed based and planning, a *reactive part* being responsible for automatic based and a *homeostatic part*, which keeps agent's internal state.

In the year 2003 new educational activities in innovated lectures of "*Mobile Robots and their Control*" were prepared and realized [1]. We aimed at an alternative teaching that made clear practical aspects of the multidisciplinary knowledge. During the education it will be demonstrated advantages and disadvantages of the based controlled mobile robots in simplified world. The course organization is conformed primarily to the practical view. Entire topic of the course covers an important background for the mobile robot design.

Some basic issues are illustrated in more practice detail after a brief overview. We deal with essentially problems of intelligent mobile robots control inspired by artificial life approaches. The elementary tasks are linked into the feedback control order: the locomotion control, the neighborhood estimation from sensors and the motion of real robots based on changing scene finally. Each part of lecture and seminar clears up one simple problem domain. We deal with locomotion initially. We present several executive components and feedback control methods. Next part is oriented on sort of available sensors. Some mechanical, infrared and ultra-sonic sensors are compared and tested. In the last some useful auxiliary IT methods in the control of robots are summarized. To conclude every part, students are given the individual homework to master the current topic [3]. Syllabus and detailed lectures notes (working version) of innovated subject with plenty of Alife interactive simulations are published on Internet pages http://cyber.felk.cvut.cz/gerstner/eth, in order to utilize our teaching experience for the all persons concerned in Artificial Life applications.

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Speedup of Computation using Accelerators

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The aim of our work is to create a methodology for the connection of numerical accelerators to master systems. This methodology will involve rules for computation of the fitness criteria of several ways to connect the accelerator to the master system.

Accelerators are devices used to speed up the computation in the areas of computer graphics, signal processing, cryptography and more. We use them in order to accelerate a computation, which would take too long when performed by a universal processor (CPU), or when we want to offload the CPU, freeing its computing power for other tasks.

The goal of the acceleration is to achieve an actual speedup. By this we sometimes assume that, by using an accelerator, we get an advantage over the case when we would not have used it. However, that does not always hold. We pay for the advantage of acceleration with other disadvantages that come from the structure and other properties of the system. Namely there are limited throughput and considerable latency involved.

Nowadays the universal processors are so powerful, that, in most cases, it pays off to use more CPUs or computers rather than to use an accelerator. An exception to this is the case, where a peripheral device is involved, e.g. graphic or network adapter.

The acceleration can be performed in different scale. We can use acceleration in these particular fields: Firstly, embedded systems – the most tightly coupled, the lowest latency. Typical case is the voice compression in digital telephones. Secondly, workstations and PCs – the accelerator is connected to some standard interface, e.g. PCI bus. High throughput can be achieved, but latency causes considerable problems. Typical example is a graphic accelerator. And thirdly, application servers – the accelerator is connected via a standard interface to the server and additionally the communication between the clients and the server must be considered. This communication is done typically through a local area network.

The partial aim is to derive for a selected algorithm the minimum amount of data for which the accelerator can achieve a speedup of the computation. This amount data depends on the speed of the accelerator, the speed of the central processor and the properties of the interconnection (latency, throughput). The result will be a formula for the lower limit of the amount of data in order to the computation to achieve a certain speedup. The derived formulas will result from the Amdahl's law [1] which states that the overall speedup $Sp=1/(1-fp+fp/p)$, where fp is the fraction of the execution time of the original program that is now implemented in hardware and p is the speedup of this accelerated part of the computation. Other researches on this field are [3,4].

The generalization of the attained knowledge to other algorithms will follow. The algorithms from the field of numerical computation and cryptography are the candidates for further study.

The ultimate goal is to create the methodology for the attachment of numerical accelerators to the master systems. The resulting speedup will be derived from the quantitative parameters and the structure of the given system. This way we get the estimate of

the effectiveness of the accelerator, depending on the way of its attachment to the master system and on the way of communication with the accelerator.

Our experiments have shown that not only the interconnection but also the operating system issues contribute to the latencies in the system. This causes additional overhead and thus diminishes the overall performance. We have used a PCI accelerator board with a field-programmable gate array (FPGA) Xilinx Virtex xcv300-4, which acted as the PCI interface and also contained a simple application. We used a simple application performing a dot product of two 1024-element, 32-bit integer vectors. The results show an unacceptable communication overhead. The CPU is capable of performing ca. $530 \cdot 10^6$ MAC operations per second, whereas the communication via the PCI bus achieves $33 \cdot 10^6$ integers per second. In this case, the software implementation of the algorithm runs faster than the accelerator, which is limited mainly by the PCI bus and by the OS-dependent overhead (device driver – application communication).

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Development of Higher Order Nonlinear Neural Units for Evaluation of Complex Static and Dynamic Systems

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Assessment of real, complicated nonlinear dynamic systems is usually available through characteristic parameters evaluated from corresponding input and output signals. These signals are usually obtained by measurement experiments. The correlation dimension, Lyapunov exponents, and Kolmogorov entropy, are some of special characteristic invariants used for assessment of complicated signals including bio-signals (heart rate, ECG etc.). However, it has been shown that to evaluate these characteristic invariants requires relatively huge amount of data which is great limitation for practical implementation. For example, one-hour recordings of heart rate were shown to be generally too short for proper saturation of correlation exponent and thus for evaluation of correlation dimension [1] [2]. This fact becomes even more problematic due to the fact that multi-attractor behavior seems to be intrinsic to the dynamics of cardiovascular system (Vitkaj, PhD. Thesis, 2002). Moreover, the evaluation of these invariants does not provide an investigator with any simple and useful analytical description of the dynamics for further development of advanced solutions.

Conventional artificial neural networks (NN) (with neurons with linear aggregation function) can be well used to solve problems with systems showing highly complicated (chaotic) behavior that is observed with nonlinear dynamic systems. That is such conventional (NN) can serve for prediction and thus for some diagnosis purposes. However, an important limitation on conventional NN when applied to a complicated (nonlinear) either static or dynamic systems is their complex mathematical structure of a network output. A linear aggregation (synaptic) operation at every neural input passes through nonlinear, usually type of sigmoidal, output (somatic) operation. For this reason, it is difficult to obtain an explicit mathematical description of a model and the output function is practically not useful for further analytical solving of the problem. Thus, conventional NN architectures with internal structures of conventional artificial neurons are inappropriate for analytically useful input-output mapping, i.e. for obtaining mathematical description of a problem from trained neural network.

According to some of the knowledge achieved during the research of heart rate variability such as:

- powerful capability of conventional neural networks for heart rate prediction; however, without obtaining a useful mathematical description of a problem leading to further utilization for advanced solutions,
- limitations of common techniques on evaluation of characteristic nonlinear invariants (correlation dimension, Lyapunov exponents,…), i.e. the need for relatively long recordings of bio-signals (heart rate, ECG,…), especially when they display multi-attractor behavior,

the concept of novel neural units, Higher Order Nonlinear Neural Units (HONNU) [3], was found as promising direction for the field of nonlinear dynamic systems where cardiovascular system also belongs to.

So far it has been dealt mostly with Quadratic Neural Unit (QNU) and Cubic Neural Unit (CNU), their modifications and subsets, which can be also called HONNU [3]. In brief, the major difference of HONNU against artificial neurons used in conventional NN is a nonlinear synaptic operation (aggregating function) of neural inputs. In case of QNU and CNU the synaptic operation is represented by quadratic and cubic polynomial (respectively) consisting of neural inputs, synaptic weights and bias.

It should be mentioned that the nonlinear somatic operation (transfer function) resulting in neural output may or may not be necessarily introduced. Its introduction may significantly alter between two main possible concepts of the use of HONNU's that is in networks or as a standalone unit (identifier, controller, nonlinearity eliminator…)

With the implemented dynamic back-propagation learning algorithm, a standalone HONNU is theoretically capable of nonlinear dynamic system identification (approximation) with minimum number of parameters and is well suited for pattern classification and NN control applications as the latest results show [3]. The implementation of a nonlinear operation into somatic operation together with back propagation learning algorithm provides an artificial neuron with general capability for nonlinear function as well as dynamic system approximation. Based upon the natural principle of back propagation, weights are forced to converge during the adaptation if the general form of synaptic operation includes the solution as its subset. In principle, a quadratic neural unit is capable of identifying a nonlinear system or approximating it with the Taylor polynomial of second order. Similarly, a cubic neural unit is capable of identifying a nonlinear system or approximating it with the Taylor polynomial of third order and so on.

The development of HONNU for dynamic applications, such as for the dynamics of cardiovascular system in this case, introduces also novel promising solutions into system identification and control applications in form of adaptable fast state-feedback neural controller with online system identification [3].

Currently, the development of dynamic HONNU and special stable dynamic back-propagation learning algorithm has been leading to the design of original technique for assessment of dynamics of nonlinear system using minimum number of network parameters with extended options for system monitoring and further diagnosis. Currently, this technique is at the stage of experimental investigation.

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Simulation of Human Visual System for Image Quality Evaluation

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This work deals with design of the Human Visual System (HVS) for image quality evaluation. The reason for image quality evaluation is increasing use of the image data compression. These compression techniques are very often used in multimedia communications. That is the main reason for image quality assessment is determination of the acceptable quality for that services.

For image quality testing is often used these methods: subjective, objective and testing with HVS models. Subjective quality testing is based on many observers that evaluate perception image quality. Subjective tests have a very strict definition of the observational conditions given by unified recommendation of ITU-R 5003. Objective quality testing is given by mathematical approaches that rise from transmission theory. Very often is used Signal to Noise Ratio or Mean Square Error. Objective image quality evaluation is faster and cheaper than the subjective one, but has bad correlation with human perception. The third way how to assess the image quality is usage of a HVS model. These models are nowadays very popular because they are faster and cheaper than subjective quality testing and have better correspondence with the human perception than the objective one. These HVS models can model only some parts of the human vision that we need. Majority of these HVS models requires a tested image and its corresponding matching reference (original image) in order to determine the perceptual quality between them. There are two groups of HVS models. The first group comprises one-channel models that computing selected features with the whole entire image. The second ones are multi-channel models based on neuron response of brain cortex that is known as it's selectivity to spatial frequencies and orientation. These models decompose image into spatial frequency bands and orientations. Then, separate thresholds are set for each channel in order to classify perceived image details. At the end of the processing the channels are weighted and summarised in order to get a number that represents the overall image quality.

A series of testing images were prepared with various compression ratios and compression methods (JPEG, JPEG2000, DCT, fractals and wavelet). The used scenes were selected with emphasis on textures, natural scenes, faces and contrasts areas. These images were tested by subjective, objective and HVS model methods described above.

We have designed a special laboratory for subjective testing with respecting ITU 500.3 recommendation for image quality testing. We select *Double Stimulus Continuous Quality Scale* test that is especially useful for compare a pair of pictures.

We used MSE and MAE for objective testing.

For human visual system testing we implement used two models of HVS. The first one we derive and implement from already published models [1, 2, 3, 4]. This one has 60 channels that are weighted to get one value that describes the image quality. The second one that we design consists of 31 frequency- oriented channels that are weighted by JND difference metrics [3].

Results of the testing are represented by comparison of used methods especially with HVS testing. Resulting graphs are dependency of the image quality on compression ratio. All results was normalised to range from 0 to 100 so they can be compared. Subjective testing was set as a reference and all ather results were compared with it. Both models that we have design and implement are comparable with other methods and can be used for image quality evaluation. Testing by human visual model is easier and less time demanding than with objective testing.

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Separation of Signals by Neural Networks

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Quality of signals is one of important parameters that every scientist, which deals with processing of signals, wants to improve. Current progress of information technology, telecommunication and similar branch is very quickly going in advance. Therefore we want to use only superior signals (signals without noise, damage and so forth). So that we would use new technology and we do not have to grapple with wrong input signals. Signals, which are used, can be stored in data warehouses or large databases but also they can be used in real-time. Just real-time process of signals is very "hot" topic at this time. By the way, very "hot" topic is also separation signals with minimal information about signals. This is known as Blind Signals Separation.

Real-time process of signals or blind signals separation [1] is solved by mathematical methods, exactly by adaptive filters or similar techniques. This process is quite good described in [4]. The basic idea utilizes setting of filters for concrete record environment. For other environment, the filters have to be reconfigured.

Our main idea of processing exactly separation of signals is completely different. This is based on artificial intelligence. Especially we are concentrated on artificial neural networks [3]. Utility of the neural networks is quite hopefully in separation of signals because of its adaptation. The main power of neural networks is in learn-ability and just it is very important for processing of signals with minimal information. This is typically task for neural networks without using of external information; these neural networks are named self-organizing neural networks (or also unsupervised learning neural networks). They do not use learning information from external teacher. Learning of these neural networks is based on adaptation in record environment.

For our experiments, we use speech of several speaking people. Easy example is explained next (this is well known also as "cocktail party problem"):

> *"We can imagine a group of people who are sitting in a room and speaking simultaneously. We are also member of speaking group and we want to obtain speech from only a person who is speaking important speech for us. We must quite concentrate on this person. Human ability of speech recognition can exactly focus on speech from one person and other noise is eliminated."*

Our question is: "Is it possible to separate the mixed signals (speech) from each other by machine?" We use mathematical gadgetry for pre-processing and self-organizing neural networks for routine of process. The mixed signals are firstly pre-processed by FFT (fast Fourier transformation). The values of signals in frequency domain are used as input data for self-organizing neural network. These values (the peaks) in frequency domain have much better characteristics then in time domain. Self-organizing neural networks cluster together the peaks, which are very similar between them. Just similarity means the main idea of our solution. These clusters with similar peaks represent the separated signals. After clustering of

all peaks, the clusters with the values in frequency domain are transformed back to time domain. For our practical usage, we need only one important signal. Other signals can be deleted or not used. The power of this solution is based on independency of type of signals. In fact, our solution is self-learning band-pass filter based on self-organizing neural networks with FFT pre-processing of input signals.

We prepared several experiment with artificial prepared signals. These signals were mixed in an audio program in a computer. Other experiments use audio signals from real environment (e.g. speaking person and noise, speaking man and woman together and so on). By the way, in terms of this project we created the database of the observed signals. These signals are from real environment (e.g. speaking people in the garden, phoning person in ridden car and others). The results of this project are applicable and our hypothesis was accomplishment that neural networks exactly self-organizing neural networks can be used for separation of mixed signals.

In conclusion I would like to devote my acknowledgement to my supervisor Doc. Ing. Miroslav Šnorek, CSc. for helpful advices and support during solving of this project. I would like to also thank other people from Neural Computing Group for helpful advices. The results of this project are quite perfect therefore they will be used as main part of experiments in my dissertation thesis.

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Software Support of Conceptual Design Process

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The analysis and the background

From a purely white-collar point of view, Conceptual Design Process (CDP) could go on some database in a network of retrieval and composition procedures. However, this is a rather administrative image. CDPs differ in their internal structure and the computer support for their components is also different. The analysis of conceptual design processes underlines the following criteria by which various CDPs can be compared with each other by means of their most important characteristics:
P1. Translation of the initial specification into CDP. **P2**. Decomposition of Functions and Structures.**P3**. Proper method for forming of conceptual constructions. **P4**. Verification of the correctness of the CDP result function. **P5**. Way of modelling the emergence of novel solution.
The whole field of various CDPs may be decomposed according to types of designed systems, into three classes:
A) Conceptual design of Configurations (flats, buildings, parks, allocation of machines in halls, …). **B)** Conceptual design of technological components, machines and devices (holders, attachment tools, frames, bicycles, cars, paragliding sets, refrigerators, heat pumps). **C)** Conceptual design of systems (control systems, technological systems, transport systems, telecommunication systems).
In work [1] there has been done deeper analysis of software support systems for CDPs as a synthesis of criteria P1-P5 and A) – C). Systems which are near to the result of our project (it will be referred in the second section) are the following ones:
GALILEO [2] is a knowledge-based CDP support system. The kernel of the system is a knowledge base which contains atomic and partial essential structures of the type "*Required function* $\Rightarrow$ *Means of its realisation*". The principle of CDP lies in decomposing the global function of the designed system (included in the specification) into subfunctions. The verification process takes place during designing, and its efficiency is limited by the content of the library of elements and parts and by the implemented constraints.
AIDA is described in [3] as an AI system for computer support for Conceptual Design of complex systems. It is based on a combination of three AI tools: Case Based reasoning for suggesting the initial proposals, Rule-Based Reasoning to assess these proposals and their functional qualities (i.e., small computations and checking points), and Constraint–Based Geometrical Modelling for visualisation of the proposals. These tools are developed as

independent modules. One of published applications of AIDA is dedicated to Conceptual Design of Aircraft.

GPAL (Green Product All Life-Cycle) is a CAD system that integrates conceptual and detailed design. The kernel of the system consists in four modules: • functional element library, • a knowledge-based "Function to Form" mapping mechanism, • an assembly model, • a module for geometric reconstitution of functional carriers based on default geometric reasoning [4].

MMforTED [4] was developed to support the acquisition of several ontologies for reasoning about an artefact from different viewpoints. The system works with a hypertext browser which enables the designed object (situation, system) to be identified with pre-formed models. Browsing through the network of models induces simultaneous changes of views. The system integrates model-based reasoning, ontological engineering and hypermedia and web-based instruction.

The proposed system

The proposed system for SW support of CDP has been developed within the framework of the research project supported by GA CR. Comparing with SW systems referred above our system is more oriented in the design of unique systems and its facilities and abilities use more from cognitive approaches to problem solving. The main Menu contains the following items:

• *Soft means for Conceptual Design:* - Conceptual Design OMT and UML means. - The measurement of Formation Energy. - Conceptual Design with Emergence Solution.

• *Conceptual Design based on components.* - The Formation and the Edition of Components. - Synthesis systems from components. • *The Simulation and the Verification of the designed systems.* • *Conceptual Design of Configurations.*

The surface of the program system is developed in DELPHI. From this upper level are controlled modules which works in various program environments (C++, Visual Prolog) and software systems (Rational Rose Enterprise Edition, Simulink/MatLab).

The procedures and operations in items of software system are not self evident and they are associated with special theoretical and methodological parts.

All needed information about the system and its additional tools are available in the Final Report of the project.

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Adaptable Publish/Subscribe System

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The publish/subscribe paradigm is a loose communication scheme for modeling the autonomous interaction among participants in event systems. On the contrary to the classic interaction models like request/reply, publish/subscribe provides three levels of decoupling: time, space and data flow. Participants remain anonymous one to another, because the whole business logic is provided by sophisticated mediators called brokers. Brokers assure data storage and delivery. This interaction is also known as the full decoupling [1].

In this contribution we focus on communication among participants of a publish/subscribe system using IP Multicast running on top of the UDP/IP. In the following text we discuss the advantages of the IP Multicast communication in CORBA that gives us a powerful mechanism to increase the performance of interactions among CORBA objects. Consequently, we improve efficiency of a publish/subscribe system having CORBA Notification Service as a communication middleware. This way, we achieve much more adaptable publish/subscribe system in comparison to the standard CORBA Notification Service.

There are some academic projects covering multicast communication, e.g. the Horus project or the Ensemble project (http://www.cs.cornell.edu/Info/Projects/), public domain projects, e.g. the Javagroups Project, (http://www.javagroups.com), as well as commercial products, e.g. the JRM Service (http://www.cs.rit.edu/~hpb/JRMS/). The project most closely related to the MIOP is probably the Fault Tolerant CORBA [2]. More specifically, a great part of MIOP object model is a subset of the object model of the Fault Tolerant CORBA. MIOP might be considered as an extension of the Fault Tolerant CORBA supporting the multicast.

The purpose of CORBA MIOP (Unreliable Multicast Inter-ORB Protocol) [3] is to provide a common mechanism to deliver CORBA GIOP messages via multicast. The default transport specified for MIOP is IP Multicast, which will provide the ability to perform a connectionless multicast. This requires that IDL operations in MIOP have one-way semantics as opposed to possible bidirectional interoperation in IIOP. MIOP also enables multicast-unaware clients to communicate via so called IIOP gateways allowing interoperation via standard IIOP.

The current CORBA object model specifies that a single object reference will map to a single object implementation via an object key. The MIOP object model does not specify an object key but a group identifier that can be associated to multiple ObjectId values, which in turn can be used to activate implementation objects. Since the delivery semantics of CORBA messages over MIOP are one-way with no reliability of message receipt, it is possible to have an application sending CORBA messages via MIOP with no receiving applications present.

Object groups in MIOP represent a collection of participating CORBA objects. An object group in MIOP consists of group identification information as well as network communication information. Typically, object groups are managed by the Multicast Group Manager (MGM). The MGM serves the purpose of creating and managing multicast object

groups as well as transport resources. Creation of the multicast group can result in the assignment of multicast destination endpoints at which senders multicast their messages and receivers accept them.

Unlike the mapping of active objects interaction via IIOP (Map of Active Objects - MAO), the concept of object groups in MIOP allows nonexistent objects to be silently ignored. This feature has been designed because object groups encapsulate objects within the multicast group and not within the ORB or object adapter (some objects are maintained by ORB_1, some objects by ORB_2, etc.) This loosening of restrictions gives us a powerful mechanism to manage the objects if we have configured them effectively along the adapters of particular ORBs. While ORBs interacting via IIOP protocol miss time decoupling [1], one-way interaction (though having some other disadvantages) supports this requirement to the utmost.

Unlike the proprietary solutions supporting multicast in ORBs (mostly based on the configuration of ORBs (IONA's Orbacus (http://www.iona.com/products/orbacus/), MIOP provides a CORBA Multicast API. A single MIOP multicast address may be associated with more than one object group. This allows a process to listen to messages for more than one group at a single multicast address. This feature allows the mapping of n addresses to m objects in an arbitrary way, which is the main idea of loose interaction within ORBs. Based on this idea we can partition ORBs to groups, which can interact with one another using group communication techniques. We can call them clusters of ORBs. An ORB (and its objects) may be inside a single cluster or may be part of more clusters (if it belongs to all of them due to managing the appropriate object groups). Two brokers, which do not belong to any cluster may be isolated or may interact using IIOP.

We chose The Community OpenORB Project 1.4.0 (http://openorb.sf.net) for implementation of the MIOP protocol. The choice is justified by two main arguments. First, the OpenORB is a pure java implementation. Second, this ORB is one of the two most advanced open source implementations of CORBA. In particular, The Community OpenORB follows the BSD-like license. There is no fully functional implementation of MIOP yet, both among commercial ORBs and open source ORBs, except the TAO CORBA, which is in the early phase.

Our future work will be concentrated on finishing the MIOP implementation and on the implementation of ROMIOP (Reliable Ordered Multicast Inter-ORB Protocol). Since the ROMIOP specification is in the phase of initial submission, we will implement it partly according to the specification and partly experimentally. After finishing the implementation of both protocols we intend to test their performance and to compare the results with IIOP. Then, we will focus on new multicast technologies, especially on SSM Multicast in the context of CORBA interoperability. Finally, we intend to perform tests to compare CORBA Notification Service supporting multicast with other proprietary messaging technologies.

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GIS for Creation of Geodynamic Model of Mining Areas

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The north Bohemia brown coal mining area has changed seriously within last 150 years. The reason of the fact were the ground mining activities lasting from the second half of the 19th century and open mining activities since the second half of the twentieth century. All these activities are already finished and the landscape can be regarded as stable. Changes of land morphology, of hydrology, of road and railway network, of urban areas, and in climate are phenomena characterizing the geodynamic model. Their development in time steps since the first half of the 20th century defines the time development of the model. The model was created in the region where half of the area was dedicated to ground or open mining activities.

Changes in land use, land morphology and in climate were studied for the period from the second half of 30s of the 20th century till the end of the century. The changes were derived from maps and aerial photographs. These changes showed the dynamic evolution of the region. High percentage of the changes was found to be due to various mining activities - ground one from the 19th century till 1960, open mines and dumps in the neighborhood from 1960 to 1975. The evolution of the region was called a geodynamical model due to narrow relations between mining activities as a result of geological conditions and changes in the land use and morphology. The analysis was performed in GIS.

The data used for the model can be divided into surface and subsurface input data. The surface input data were formed by hydrological information layer with situation in maps in 1934, 1960, 1975, 1989 and 1999 years and aerial photographs from 1938, 1953, 1968, 1982, 1999 years. There were many changes caused by new river beds due to open mines, by newly existing water basins covering far larger area, where large open mines were transformed into these new water basins.

The vegetation layer represented by forest areas was the second class helping to model the evolution of the region. The forest areas covering now six times larger area than in 1934 year are a proof of successful reclamation of large regions in those locations where due to unsufficiently consolidated dumps no important anthropogenic activities are allowed.

Anthropogenic layer summarizes urban areas, roads and railways. Urban areas in all mining areas were completely removed including ground mining areas. New urban areas were built in ground mining areas 15 years after closing last ground mines. Changes in road and railway network caused by mining activities and especially railways serving mining activities were only temporary.

Digital elevation data were vectorized from maps (1:5000 scale). They are not accurate enough to show inbreaks, whose size is to small to be mapped in topographic maps of the above mentioned scale. These features were implemented into the system from mining maps.

The second group of input data was formed by subsurface data. These were geological maps showing the fact that the mining activities occurred in superimposed clays. However, the exact information about the brown coal bed is in the mining map only. Quarternary data in the form of the quarternary map bring updated information concerning inner and outer tailings. Hydrogeological data map the reclaimed areas as one class. Mining maps were very important input data with the information about inbreaks, with the information about brown coal bulk with the contour lines of their upper and bottom layers. This information enabled us to verify the occurrence of inbreaks in relation to the depth of the upper layer of the brown coal bulk. The mining map was an exact source of the mining evolution - of end of mining activities in individual locations.

The geodynamical model was divided into the geodynamical model of three different regions - undermined areas, dumps and open mines and neighborhood of mines. Three temporal phases were defined for all these regions. These are before mining period, mining period and after mining period. Geodynamical model of undermined areas can be characterized by built-up areas removal and by new short temporary railways to ensure the material transport. The land use and land cover in the period of mining is formed by agricultural and forest activities. The first period after mining activities is a period when inbreaks occur, when land depression is often filled by water creating new water basins, when industrial railways and roads are removed. The period of future tens of years is a period of land consolidation when large areas are covered by new forests.

Geodynamical model of dumps and open mines has the first time period the same as undermined areas. During the mining activities the area of mining slowly changes its place continuing till the end of profitable excavation. The period of the first five years after mining brings new water basins in abandoned pits, removal of industrial railways and roads serving only for mining activities. The period of tens of years is a phase of continuing reclamation with the final step - biological reclamation. The land consolidation, the forest enlargement and more important and larger recreational locations (due to new water basins) are typical for the period. The land reaches a new shape attractive even for leasure time losing marks of industrial regions.

The geodynamical model of neighborhood regions are touched by new industrial railways and their removal. Their changes are not so important and visible as in the previous type of area.

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Section 4

ELECTRICAL ENGINEERING
&
INSTRUMENTATION

Digital Loudspeaker

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Transducers with the direct digital-to-analog conversion (usually shortly called „digital transducers“) were theoretically described at the beginning of the eighties and at the same time first digital transducer prototypes were presented. Since then, some theoretical work has been presented and only a few new systems have been introduced.

The grant entitled „Digital Loudspeaker“ had for a goal launching research in this field in the Czech Republic both theoretically and practically. Research of various types of transducers has a long tradition in the Department of Radioelectronics where the author and his team work.

The work we did in the course of this grant project was aimed at development of the first model of a digital loudspeaker along with the theoretical research associated with its design.

The first theoretical step was prepared in the earlier stages of work, i.e. choice of the transducer type associated with the choice between the transducer array type (number of transducer fed by one bit is proportional to the bit weight) or the divided membrane type (the size of the membrane section driven by the bit signal is proportional to its bitweight). As there were many possibilities, having searched for cost effective and easy-to-handle solution, at this stage of research we opted for piezoelectric transducer type in the form of a thin piezoelectric buzzer with a 12.5 mm base to which a thin circular piezoelectric transducer is attached which will constitute an element of a transducer array. Other possibilities are discussed in [1,2].

The further step comprised the analysis of the transducer array layout. From the two most convenient array shapes – circular and rectangular we chose the latter one with the view of the foreseen application along with the micro mechanical technology, i.e. fabrication of miniaturized microphones on silicon wafers. An analysis of various arrangements of bit transducers in the field was performed and described in detail in [3]. Following arrangements of transducers were tested (the field always having a square shape): A) the square is divided in two rectangles, one of them is also divided into two squares, the process continues in the same way. B) bits filled in rectangles of one length with the shortening other side, all of them making a square. The last rectangle with the side of one bit is accordingly divided into subsections. C) transducers fed by the most important bit are situated in the square in the middle of the field and remaining bits are arranged in approximate squares around the centre. D) Transducers fed by the most important bit are situated near the field edges and other bits are situated accordingly along with lowering their bit weight. E) random distribution of all bits. These arrangements were tested by calculation of a sound pressure in front of the transducer field at various points, where contributions from all transducers add and produce reconstruction of original analog acoustic pressure. The testing points were chosen both on the acoustic axis of the loudspeaker and off-axis, where the resulting analog signal was expected to have much more distorted form. The reason for different results are different temporal and path differences with which „digital“ signals from elementary transducers reach the given point. Although there were differences in calculated signal form for different transducer arrangement in the loudspeaker, they weren´t found crucial and therefore the choice of the trasducer arrangement can be made according to other demands.

The first prototype of a digital loudspeaker using piezoplastic transducers was made. Piezoelectric transducers were grouped on 2 separate printed circuit boards, one holding 63 transducers for the group of six least significant bits and the other holding 64 transducers for the seventh bit, for the time being the most important bit.

The transducer (actuator) with the direct digital-to-analog conversion needs as a primary signal source the series digital data stream in standard AES/EBU, SPDIF etc. formats. For experimental purposes we also need the analog input and variable multiple output. For these reasons the development kit Xilinx CoolRunner-II, the programmable logical field was used. The decoder enables AES/EBU, IEC-958, S/PDIF and EIAJ CP340.1201 data stream transformations, being sampled up to the frequency 96 kHz at I2S interface, which is the standard data bus for communivation between integrated circuits used in multimedia. The programmable logical field itself serves for changes in quantisation and resampling decoded audio data and for distribution of DL source signals to final power stages.

For realization of this power stage a monolithic integrated dual audio power amplifier TDA2822M from ST Microelectronics was chosen. Reasons for this option were small dimensions, two channels per chip, high output current (1A max), few external components and low price. There are also some disadvantages, such as fixed gain, only asymmetrical operation and necessity of parallel channel connection in case of heavy load, but these are not essential for the first version (prototype) of actuator.

Measurements were focused on all catalog parameters with respect to our application, such as slew rate, input/output impedance, cross talks (in case of sinus and rectangular input signal etc). Consequently ability of amplifier to operate with heavy capacity load with accent to nonlinear distortion, heat dissipation according to output power (respectively output current) and differences between individual amplifiers to provide the same conditions for all bits were investigated.

In the course of this project we prepared the first model of the transducer with direct digital to analog conversion, made of piezoelectric buzzers along with the source of paralel signal necessary for driving the loudspeaker. The other types of arrangement will be studied in future projects, for which the work carried out within the framework of this grant project laid fundaments.

Future work comprise considering other types of transducers used for the transducer array, usage of a pressure system with a waveguide to improve efficiency of the system, and study of the digital loudspeaker with a segmented membrane.

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Sensors with Implanted Layers for Using in Microsystems

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We present properties of piezoresistive sensor with implanted strain gauges [1]. In this paper is described methodology of measurement and modeling of these sensors with the aim to use that structure as mechanical sensor. Static parameters and temperature range of their usability have been measured on realized samples. We compare sensors based on implanted strain gauges and sputtered thin-film strain gauges as well. The basic function of the semiconductor strain gauge is based on transforming the changes of dimension in certain direction to change its electric resistance. Deformation of measured object causes the change of strain gauge dimension. It allows measuring of plenty nonelectrical quantities such deformation, bending, force, acceleration etc.

Gauge factor depends on many parameters, for example: concentration of impurities, geometrical dimensions, thickness of layer, on used material for thin-film layer, etc. When evaluating electric characteristics of implanted resistors into Si substrate, it is necessary to consider the influence of PN junction that is created between the implanted area and the substrate.

The software package CoventorWare has been used for design of mechanical and thermal characteristics of the structure. The tools enable design, modelling and successive modification of designed MEMS structures. For successful simulation, it is necessary to input all material constants correctly. There have been realised Mechanical, Piezoresistive and Thermal simulations [3].

Mechanical simulation calculates bend of the cantilever and value of mechanical strain on the surface of the cantilever caused by this bend.

Piezoresistive simulation calculates magnitude of voltage on meander at constant current in dependence on cantilever deformation caused by effective force.

Thermal simulation, results of this simulation are data on mechanical strain arising in connection of cantilever with base due to different thermal expansion of material of base and Si.

The electric model of the piezoresistive cantilever is designed such as way that it accounts for the temperature of the resistor, the change of resistance in dependence on the load and influence of reverse voltage. Si cantilever was cut from Si wafer and was bonded to the base from Kovar by epoxy resin EP310. Length of the cantilever (to the point of fixation) is $l=21\ mm$, width $b=2.5\ mm$ and thickness $h=440\ \mu m$.

There are three types of sensors with different used material for active sputtered layer. Sputtered layers: NiCr:N, $CrSi_2$ (made in TTS) and CrSi:N (made in SEZAM). By Nitrogen doping is achieved long term stability and compatibility with contact system (gold).

There have been measured a number of parameters of realised samples in dependence on mechanical strain and temperature and reverse voltage and junction capacity

as well. From the measured values there have been calculated further parameters like values of piezoresistive coefficients, coefficients of deformation sensitivity, deviations from linearity, hysteresis and temperature coefficients of resistance. There has been measured dilatation of kovar. Calculated coefficient of thermal expansion is λ_{kov}=17.18e-6 1/°C. This value is more than three times higher than coefficient of thermal expansion of silicon. It causes mechanical tension at point of fixation at high temperatures [2].

The results acquired from performed simulations show distribution of mechanical tension along x axis of the cantilever with acting force on the end of the cantilever as parameter.

The main goal of this work was comparison between two types of piezoresistive sensors and their characterization. Measured and calculated characteristics of Si cantilevers with implanted strain gauges exhibit very good linearity, low hysteresis at load and very high sensitivity, but it can be used only for low temperatures (under 140 °C).

Samples with sputtered thin-film strain gauges shows high temperature stability and wide temperature range, but their sensitivity and G-factor are much worse than samples with implanted layers. This technology is suitable for making sensors for high temperature applications.

CoventorWare simulator of COVENTOR Inc. can be used for design quality verification. Simulation results have corresponded well with measured values

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Modeling of Electromagnetic Couplings in Microsystems

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Electromagnetic couplings

Parasitic electromagnetic couplings result in the transfer of interfering energy from the interference source to the interference receiver. Inside the IC's the principal sources of interference are usually the clock circuits, output drivers and other circuits with low output impedance. The most frequent receivers of interference are the input circuits, flip-flops and circuits with high input impedance. The parasitic couplings can be classified according to the prevailing kind of coupling to: galvanic, capacitive, inductive and by radiated electromagnetic field.

The galvanic coupling appears always when there exists some real-character mutual impedance between the interference source and receiver. This kind of coupling can be found in power supply and grounding lead systems of the IC's.

The inductive coupling is based on the electromagnetic induction principle. It depends strongly on the circuit arrangement, like the area of current loops, the speed and magnitude of current variations and permeability of the environment. This kind of coupling dominates in low impedance circuits and therefore it only appears very rarely in the IC's.

The parasitic coupling through radiated electromagnetic field appears between the interference source and receiver when the physical distance between these systems is large enough to prevent both the capacitive and the inductive coupling. The distance between the interference source and receiver in the IC's is usually small relative to the equivalent wavelength of operating signals.

The capacitive coupling is the predominant type of coupling in high-impedance circuits, like NMOS and CMOS IC's [1].

Frequency characteristics of interference sources

The digital circuit signals in the time domain can be characterized by: voltage levels, basic period T, pulse width t_1, duration of leading and lagging edges t_r and t_f, respectively. The most important parameter in terms of the capacitive coupling is the duration of the leading and lagging edges.

A break frequency f_2 can be found on the frequency characteristic, above which the amplitude of the spectral components drops by 40 dB per decade [2]. The break frequency f_2 is the frequency representation of the duration of leading and lagging edges of the signal. Increasing the slope of the leading and lagging edges shifts the break frequency f_2 higher and the power of high frequency spectral components of the signal rises. Further we introduce the important conversion equations between the time and frequency domains of the digital signal.

Transfer function of the coupling

In order to make possible a quantification of the frequency characteristic of the capacitive coupling, it was necessary to rearrange the capacitive coupling equivalent circuit to a form from which it was possible to derive the coupling transfer function P. The resistor R_1 represents the internal resistance of the interference source, in this case the internal resistance of the gate. The resistor R_2 represents the internal resistance of the driver of the inactive part of the line.

The length l of mutually influencing lines acts upon the transfer function P as a relative variation of the capacitances C_S and C_V. It can be told that with changing the length l the frequency characteristic shifts along the horizontal axis but its shape remains unchanged.

Another parameter influencing the transfer function are the values of internal resistances R of the line drivers. A coefficient k was introduced for unequal parameters $R_1 \neq R_2$. The transfer function P has the character of a bandpass filter with characteristic frequency ω_0 and maximum transfer P_0.

The unipolar technology of IC fabrication is based on MOS transistors. By variations of channel width w and length l, it is possible to adjust the channel resistance R_{ch} of the MOS transistor $R \approx R_{ch}$ [3]. In digital systems, MOS transistors are used with minimum channel length $l_1 = l_2 = l_{min}$. The coefficient k can be adjusted so as to reflect the ratio of channel widths of the MOS transistors.

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Apparatus for the Dielectric Constant of Gases Measurement

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This project is a follow–up of the previous research work focused on the capacitive sensor suitable for the measurement of dielectric constant of gases, especially new ecological coolants. Due to the requirements on the feasibility of the connection of the designed sensor to the measured media the optimal solution of this problem has been solved in this project.

Because the tested media could be in some cases technical gases such as argon Ar or carbon dioxide CO2, the designed apparatus has to also provide the easy and safe method to fill and empty the capacitive sensor by the tested medium. Due to the required accuracy of the capacity measurement, in order of attofarads, the measurement principle has to optimal for this task and all applied subsystems have to grant the requirements. In order to fulfill the required conditions, such sufficient immunity against external disturbance, time and thermal stability and accuracy of measurement the most crucial components were appropriately designed and the other were realized by the commercially available instruments with GPIB interface. The GPIB interface was also used to link the measurement system to personal computer in order to acquire and archive the results of experiments. Finally the automated measuring system was designed with the control algorithm realized by means of personal computer.

In order to compare the abilities of all designed components in the system the verification experiments were separately processed on these components by means of the substitutive methods and the best available instruments. Then the system was completed without any automatic control and its parameters were verified again. The given results were compared with the reference results given by different measuring system and by tabular values of dielectric constant of tested media. Finally the measuring system was linked to the controller with GPIB interface.

Because of the extremely high requirements the measuring system has to be also immune against the parasitic properties of the capacitive sensor. This problem has been solved out by the measuring method sensitive only on the capacitive component in the general impedance of the sensor. The effects of the resistive component are eliminated by means of the suitably designed measurement method when as the phase sensitive coherent demodulator is used in order to determine the measurand. Then the automated system sets the parameters of the exciting signals in order to achieve the state of equilibrium. In this case when only capacitive component of impedance is balanced the quadrature equilibrium is reached. Further only theoretically the state when the capacitive component is completely balanced can be achieved. When the residual error signal would be less than the certain limit, its value could be neglected, otherwise this error signal should affect the results of measurement. Because the required accuracy, the resolution of the measurement system should be in order of attofarads while measured capacity is in order of picofarads, the residual error signal

(unbalance signal of system) parameters were used in the result calculations. Due to these methods the used measurement system can be classified as the semi-balanced system with the quadrature equilibrium.

When the complete measurement system was verified, the final experiments on the ecological coolants were processed. Firstly the capacitive sensor was filled by carbon dioxide CO2, and then by argon Ar and the tabular values of their dielectric constants were used to calibrate the sensor and measuring system. Straightly after this calibration the sensor was filled the sample of the ecological coolant R12 and closed up by the gas valves. The dielectric constant of this media was measured for duration of 30 minutes when the constant pressure of the media and its temperature were hold. The pressure of media was equal to normal atmospheric pressure and temperature was equal to 23 degrees of Celsius. Then the previous three measurements were then repeated four times in order to inspect the reproducibility of the measurement results. Next the acquired data were off-line processed and the calculated dielectric constant of the media during all experiment were compared.

As the results the designed capacitive sensor and the measuring system with the mechanical apparatus can be qualified for the measurement of the dielectric constant of gases and provides the easy and safe method to repeatedly fill and empty out the capacitive sensor by means of the realized apparatus. Due to the designed system the physical conditions during the measurement process were held constant, outer disturbance was eliminated or reduced bellow the significant level and the accuracy of measurement is sufficient of the required application. Further the reproducibility of the results was proved by the repeated experiments. The determined dielectric constants of tested media were in good accords to their tabular values for all known tested media.

In the future development the dimension of the capacitive sensor could be reduced by means of its precise machined realization. Also commercially available instruments such as sine wave generators and phase sensitive coherent demodulator could be realized as specially designed subsystems. Feedback controller can be easily realized by small digital system with general CPU. The system is easily transportable and could be applied also in non-laboratory environment.

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Realisation of FIR filter in line CCD sensor

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Abstract: *This paper is devoted to the description of a new CCD linear image sensor control method. This method is used for inherent signal pre-processing or processing in CCD linear image sensor. This new method is suitable for movement compensation, one-frame filtration or two-frame filtration. Because of the similarity between the Non-Recursive Digital Filter with Finite Impulse Response (NRDF FIR) and the new mode was named FIR mode.*

FIR MODE

A FIR mode is one of the non-standard modes of a CCD linear image sensor operation. This mode is used for inherent signal pre-processing in CCD linear image sensor. This mode is based on multiple exposures. A value of each output pixel is determined by values of N_F previous photo-elements, that means N_F exposures are needed to obtain one image. Each exposure has its own integration time with duration corresponding to the coefficients of FIR filter.

The output voltage of CCD sensor in this mode can be described by equation which coresponds to the equation of non-recursive digital filter. The illuminance values of photo-elements are equal to samples of the image (signal) and the integration times are equal to the coefficients of a FIR filter (impulse response). The entire frame integration time is equal to coefficient's sum. When we need to change the frame integration time, all the coefficients must be multiplied by ratio of the old integration time and the new integration time. The number of integration (exposures for one frame) is equal to the filter length.

However, as we can see from the text, only non-negativ coefficients of FIR filter can be implemented directly within the CCD linear image sensor, because the time which coresponds to the filter coefficient can't be negative.

PRINCIPLE OF FIR MODE OF OPERATION

The FIR mode of operation can be made from a simple control unit without complex arithmetic. All the control functions are included in one simple subroutine. This subroutine corresponds to a cycle, which must be repeated N_F times in order to obtain one frame where the N_F is nuber of coefficients of implemented filter.

The sensor must be cleared at the beginning of each frame by the electronic shutter or fast read-out. At the same time, the first coefficient is written to the timer control register. In this case, the timer is used for integration time generation. The control cycle is described below.

After a lapse of integration time (timer interrupt occurred) the charges are transported by the control signal Φ_X to the charge shift register. The transported charges are added to the charges stored there from the last cycle. When the last cycle (exposure) is executed the read-out is processed (the frame is complete), otherwise, the charges in shift register are moved by one position by means of the control signal Φ_L.

The next coefficient is loaded up to the timer control register after the charge is moved. If the coefficient is equal to zero, only the next charge move is processed and after that the next coefficient is loaded. The next exposure begins after the timer is loaded.

After the lapse of the last cycle the read-out is executed. After read-out we have the image of object filtered by the implemented FIR filter.

TWO-FRAME FILTRATION

In many cases is needed filtration by FIR filters with positive and negative coefficients. It can't be done by one-frame filtration, but it is possible to use two-frame filtration.

There is possibility to implement only positive coefficients within the CCD sensor. However, it is possible to split the filter sum to two partial sums. The first sum which represents the positive coefficients (the positive coef. are leave and the negative coefficients are replaced by zeros) and the second sum represents the negative coefficients (the negative coef. are convert to it's absolute values and positive coef. are replaced by zeros).

Realisation of two-frame filtration can be done by two ways. The first is using of two-phase calculation with storing of one frame in memory and the second is using of convenient CCD sensor with two separate read-out circuits (one for even pixels and second for odd pixels).

The first way is split a filtration into two phases and calculate it partially in CCD sensor and in control unit. Multiplications and accumulations are calculated in CCD sensor and subtractions are calculated in control unit. The first phase: the partial sum for positive coef. is acquired in line CCD sensor, and the image samples is stored into a memory after A/D conversion. The second phase: after first phase the partial sum for negative coef. is acquired, in line CCD sensor. The image samples are subtracted from samples stored in memory after conversion in control unit.

The second way is to use of convenient CCD sensor with two separate read-out circuits (one for even pixels and second for odd pixels). The partial sum for positive coef. is acquired in even pixels and the partial sum for negative coef. is acquired in odd pixels. The subtraction can be done by analogue circuits. In this case the pixel size is doubled.

CONCLUSIONS

Advantage of first way is that any CCD line sensor can be used. However, the result of calculation is not achievable in analogue form and the calculation is done by two successive frames that means that calculation is longer two times than in second way. This way is suitable for simple optic gates with simple control units. This method could be used for simple signal processing because only interesting parts of signal can by used for calculation (surroundings of edges and so on).

The main advantage of second way is that the calculation occurs in analogue form and the result is acquired during one frame. There are some disadvantages such as the special CCD sensor is required and the resolution of the sensor is decreased to half. The second way is more suitable for fast systems where the analogue signal processing is used. This way can be used for simple pre-processing where only fast rough estimate is done. This method can be used for fast digital signal processing systems as pre-processing in CCD sensor. The filtered and the original signal can be acquired at the same time by this way.

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Internet Workplace for Magnetic Measurements

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The project of internet measurement workplace for magnetic measurements is aimed to use of modern measurement systems and internet in research and also in teaching of subjects of laboratory nature. A LabVIEW graphical programming language was used for development of Computer Aided Measurement (CAM) system. The CAM system can be controlled from local machine or over the internet via the LabVIEW built-in internet connectivity. The project consists also of a magnetoresistor signal processing unit. This unit is capable of processing signals from different types of magnetoresistors – anisotropic magnetoresistors (AMR), giant magnetoresistance sensors (GMR), and spin dependent tunneling magnetoresistance sensors (SDT). The signal processing settings are controlled by the CAM software. The system was already used in the teaching of undergraduate subject Contactless Measurements at the Dept. of Measurement CTU FEE. The expected system use is also the research in the field of alternated driving of magnetoresistors [1].

The magnetic sensors and measurements are increasing their importance in the modern industrial and home applications (namely reading sensors for magnetic records – computer hard disc, revolution sensors for automotive industry etc.). These widespread applications require sensitive magnetic sensors for middle range (up to 2 kA/m) magnetic fields detection. The demand for this kind of sensors is fulfilled by the improved technology used in AMR sensor production and newly also in giant magnetoresistive and spin dependent tunnelling magnetoresistive sensors. However, for weaker fields detection such as the geomagnetic field there is a need for fluxgate sensors to be used. Hence, the students of the measurement and instrumentation study programme should be familiarised with principles and operation of these kinds of sensors.

The developed system is based on the work [2]. An appropriate measurement system is the main presumption for magnetic sensor testing and application development. The Helmholtz coils are used for the basic measurements. They produce magnetic field corresponding to the current flowing through the coils. Then, the corresponding output signal of the sensor is measured. All the instruments have to be controlled from the CAM software: the power supply, voltmeters, generator and lock-in amplifiers use GPIB interface and current commutator and magnetoresistor signal processing unit uses RS232 interface.

The CAM system was developed with the aim to simplify the user interface in order not to disturb students with unnecessary controls. With this purpose in mind, the CAM system was divided into three different measurement setups with corresponding software modules:

1. AMR magnetometer measurement

The measurement setup is dedicated for testing of AMR, GMR and SDT magnetoresistors with the possibility of alternating driving of these sensors. This measurement setup consists of power supply, commutator and Helmholtz coils to generate the desired field amplitude, developed magnetoresistor signal processing electronics and two voltmeters for precise measurement of current and processed signal from the sensor. The power supply and voltmeters are controlled by the GPIB interface, commutator and magnetometer signal processing unit are controlled by the RS232 interface. The LabVIEW software developed for this measurement setup enables the user to control the field amplitude and polarity and measures the corresponding output of the sensor processed by the signal processing

electronics. This measurement setup allows the user to set the flippping frequency of the AMR sensor as well as other parameters of the signal processing of the sensor output signal (amplification, compensation mode operation, synchronous detection control).

2. MR sensor test

This measurement setup is aimed for testing of the DC voltage output magnetic sensors. The measurement setup consists of simplier setup leaving out the magnetoresistor signal processing electronics unit. This setup can instead control the supply voltage of the sensor (if the sensor is supplied by the GPIB compatible power supply). The output of the sensor is measured by the GPIB controlled voltmeter.

3. Fluxgate sensor test

This measurement setup is aimed for fluxgate sensor testing. The output of the sensor is processed by lock-in amplifier (Stanford Research Systems SR830 or 844). The lock-in amplifier measures the second harmonics of the excitation frequency. The control of the lock-in amplifier is by the GPIB interface.

All measurement setups have in common the ability to display images of the instruments taken on-line from the webcam connected to the control computer. This webcam serves the purpose of visual inspection of the intruments. This feature is especially appropriate when controlling the experiment over the internet. The internet control of the experiment is possible through the LabVIEW web server which displays opened programs within dedicated webpages. The supervisor can control the access to these pages and enables the remote control of the experiment.

Part of the developed system was succesfully tested during the laboratory exercises of the subject Contactless Measurement in December 2003. The wider application can be expected in the year 2004. Moreover, the developed magnetoresistor signal processing unit will be used in the research in the field of alternated driving of magnetoresistors and in the testing of new types of magnetoresistors supplied by cooperating companies.

The system was already used in research when investigating the properties of new construction of the fluxgate sensor [3].

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Inovation of Laboratory Tasks in Electronic Systems Courses

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The main topic of the project was to innovate and improve the quality of content and form in Electronic Systems Courses. For a graduate in our profession it is important to gain not only theoretical foundation through education, but also an adequate practical proficiency. The main aim of the project was to introduce the problems ”Modern filtration”, ”Power supply” and “Using pulse width modulation in actuators of control systems” in the theoretical and practical part of Electronic Systems Courses. Present design and realization of the laboratory tasks in Electronic Systems Courses make possible the important modernization of teaching process and to provide simultaneously the high cost-effectiveness of invest resources for modernization of the subject.

Laboratory task “ Active filters”

Laboratory task consists from two preparations and refills with indispensable measurement devices make possible to teach-in with concrete method of design of different types the active filters and make possible correctness verification of the design. The preparations make possible to compose low-pass or high-pass Butterworth’s or Bessel’s filters from first to fourth order for the specific break frequency. The changes of the parameters correspond to standard possibility of the analogue technology and require the change of the value of a lot of components with guaranteeing your desiderative specificity. Those problems we can solve by means of switched capacitors filters, because the changes of the desiderative frequency properties are reached by change of clock frequency by preservation the values of all components. For teach-in with this forward-looking alternative construction of active filters three preparations for realization switched capacitors filters were made. On these preparations student can verify the properties of different types of filters (Butterworth, Bessels and Elliptic) in practical version. The work with real objects is particularly in this area extremely contributively for student in comparison with computer simulation, where the used models do not correspond to reality.

Laboratory task “ Power supply and DC/DC converters “

Laboratory task consists from two preparations and refills with indispensable measurement devices make possible to teach-in with principle of power supply. In electronics, it is generally considered to be a piece of equipment that converts mains AC into a steady DC. A power supply consists of four stages:
1. A transformer normally steps down the mains voltage to a lower voltage required by the electronic circuit. When there are semiconductor devices in the circuit, the voltage can range from 1V to 30V.
2. The rectifier changes an alternating current to a direct current.

3. The smoother, or filter, is a large capacitor (500 μF to 1000 μF) which is used to smooth, or steady, the DC voltage.
4. The stabilizer irons out all the ripples, so the voltage across the load resistor is kept constant.

The second preparation is DC/DC converter with LM2574-12 circuit with fixed output. The LM2574 series of regulators are monolithic integrated circuits that provide all the active functions for a step down (buck) switching regulator, capable of driving a 0,5A load with excellent line and load regulation. Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation and a fixed-frequency oscillator. The LM2574 series offers a high-efficiency replacement for popular three-terminal linear regulations. Because of its high-efficiency, the copper traces on the printed board are normally the only heat sinking needed.

The features the LM2574 series:

- 3.3V, 5V, 12V, 15V and adjustable output versions
- Adjustable version output voltage range, 1,23V to 37V (57V for HV version) ± 4% max over line and load conditions
- Guaranteed 0,5A output current
- Wide input voltage range, 40V, up to 60V for HV version
- Requires only 4 external components
- 52 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection

Laboratory task ” Using pulse width modulation in actuators of control systems ”

Laboratory task consists from two preparations and refills with indispensable measurement devices make possible to teach-in with principle of the pulse width modulation. Control signal is on the input of the modulator and modulated signal, which control the power switch or the systems of power switches, is on the output of the modulator. The preparations are separated on the two parts. The first part is created from the control system, which contains the modulator with applicable circuits for bipolar and unipolar modulation. The second part contains the logic control and the power circuits, which are contained in half bridge N-channel power MOSFET driver LT 1158.

At the end we can note, that the project contributed not only to equipment of the laboratory of the department of control engineering but also for modernization of applicable subjects.

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Internet-based Differential GPS System

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Differential GPS (DGPS), or actually any Differential Global Navigation Satellite System (DGNSS) in general, improves the achievable positioning accuracy, by correcting the pseudo-distances between receiver and satellites or the receiver position. The correction data are defined by the Radio Technical Commission for Maritime Services (RTCM) standard. These RTCM data can be sent to a mobile GNSS receiver (rover). The validity of corrections depends on the distance between receiver and rover. For providing a service covering a large area, a reference station network has to be introduced, which is able to generate a specific real-time correction for any region. The specific corrections can be transmitted over various communication channels, e.g. via radio transmission (LF, MF, HF, UHF), or a mobile communication network using different communication protocols.

This paper describes use of a HTTP-based system for disseminating RTCM correction data or other kinds of GNSS streaming data to mobile receivers over the Internet, allowing multiple PDA/Laptop/DGNSS-Receiver connections via a Mobile IP Network (GSM/GPRS/EDGE/UMTS). The system, based on cooperation with NTRIP protocol developed by the German Institute of Geodesy and Cartography (BKG), generally consists of four functional blocks: NtripSources, which generate correction data at a specific location, NtripServers, which transfer the correction data from one or multiple sources to the NtripCasters, the major system component. NtripClients finally access data of desired NtripSources on the NtripCaster.

As far as DGNSS and Real Time Kinematic GNSS (RTK-GNSS) is concerned, the system uses RTCM-SC104 standard as the streaming data format. Sufficient precision is obtained if given correction data are not older than a few seconds. The data transmitted can be generally of various format: GPS/ GLONASS RTCM-SC104 v 2.0 corrections messages for standard type of position determination, RTCM v 2.2 data for Real-Time Kinematics measurements, raw data for precise orbit determination, etc. These data can be transmitted in plain format or in a compressed form that leads to more efficient bandwidth use. The basic data streaming is accomplished by TCP/IP protocol stack. Several attempts based on a plain Serial-to-TCP conversion of streaming data on the reference-side (server) and TCP-to-Serial re-conversion on the rover-side (client) have shown the suitability of the TCP/IP protocol for streaming data to mobile IP clients. The concept of NTRIP allows support of numerous networks. The following networks may be consider: IGS (global), EUREF, EGNOS (continental), SAPOS, ASCOS (national) with various purposes: orbit determination, navigation, positioning, precise position measurements, etc. Introducing the real time streaming of GNSS data for these type of networks via Internet as a professional/semi-professional service requires the consideration of some important aspects of the NtripCaster concerning network security, program stability, access control, remote administration and scalability. Therefore already existing detailed tested software is used as core of the NtripCaster: The Internet Radio Server Icecast, licensed under GNU General Public License. All Internet communication, like data input, data output and remote NtripCaster administration can be handled by using one or several ports, thus, the NtripCaster can be easily located behind a protective firewall.

In this project were done several experiments with DGNSS Internet corrections dissemination and reception together with position precision evaluation [1]. As a HTTP stream distributor

was used NtripCaster, experimentally operated by BKG Bureau in Frankfurt. RTCM corrections were received from various NtripServers: Dresden, Berlin, Passau, Torino, Warsaw, Ulm, Milano, Madrid and Barcelona, continually for 24 hours from each of them. Received corrections were supplied to the receivers that were driven from common antenna with the known position. NovAtel GPSCard 751R was chosen as a primary receiver, Garmin GPS 12 was chosen as a complementary receiver. Measuring chain consists of Internet enabled personal computer that acts as NtripClient. RTCM data from this computer are provided to another personal computer that sends data to two GPS receivers and collects and stores position data provided by them. This configuration was chosen for achieving the possibility of statistical evaluation of the measured data. Another tests were done with PDA portable device Compaq iPAQ 3970 supplied with GPRS/GSM CompactFlash insertion card for Internet connection and connected to GPS receiver based on SiRF-II chipset. This configuration was used to test mobility of the application.

Position data were processed offline from each 24h measurement. The stored data (position, time of corrections) were processed in Matlab software for position accuracy comparison with non-differential measurement. Position measured by the Garmin device was provided by receiver with the accuracy of one thousandth of angle minute and that led to horizontal position quantization in the steps 1.2 m × 1.85 m. Garmin receiver was therefore chosen just as a representative sample of the cheaper mass-market receivers and measurements were not done for all chosen NtripServers. The data from NovAtel receiver were evaluated for all NtripServers above. Data were provided in the NMEA format in the time intervals 10 seconds. It was evaluated position error in relationship to known antenna position and to the main value of the measured position for 24-hour measurement. There was also evaluated age of received corrections data. The way of corrections age evaluation corresponds to time of transmission through Internet only with assumption that reference station (providing data to NtripSource) does not extrapolate corrections before transmission. The other contributions to the corrections delay (processing in PC and GNSS receivers, serial link delay) can be considered as negligible. The accuracy improvement was for Garmin GPS12 in the horizontal error 11.47 m for non-differential measurement and 7.9 m for case of Berlin corrections, and 3D error 19.02 m (non-differential) and 15.55 m (Berlin). NOVATEL GPSCard as a higher class receiver provides more accurate position, horizontal error was 2.57 m for Berlin source and 3.67 m for non-differential measurement, 3D error was 5.75 m (Berlin) and 9.02 m (non-differential). Error increased with distance from reference station, for example use of Ulm station led to 3D error 9.13 m. It is also close relationship between corrections transmission delay and position error, therefore possibility of choice of reference station according to position of the receiver and channel capacity.

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Educational HW Laboratory at The Faculty of Transportation Sciences CTU in Prague

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New course ”Introduction to Computer Hardware” has been taught at the Faculty of Transportation Science since 2000/2001. The course is in the category of optional subject and it is recommended for students who study “Automatization in Transportation and Telecommunications” specialization. The subject covers problems of logical circuits, their design, computer architecture, arithmetic etc.. It is very useful for students if they have an opportunity to work in laboratory, to connect some circuits and verify their functionality. Because there were none educational modules, we had to borrow them from Department of Computer Science, Faculty of Electrical Engineering CTU. We decided to establish own laboratory and to buy some educational system.

Educational system, which is used at the Department of Computer Science FEE, is called LABORO 2. It was designed at the department in the beginning of 90’s and made by Laboratories of FEE in Poděbrady town. The system is composed of power supply, waveform generator, non-soldering interconnect field, TTL level switches and set of display elements – LED, 7-segment units. LABORO 2 hasn’t produced yet, because laboratories in Poděbrady were liquidated. We had two possibilities: to design own system, to buy component, to let produce PCBs and to complete it *or* to find other firm, which produce similar system.

RC Didactic manufacturer from Prague was chosen by solvers. This firm has produced educational system for analogue a digital technique for 10 years. Its products are more financial expensive than others, but their attributes are high quality, reliability, mechanical robustness. The architecture of system is modular, user can order arbitrary modules and build-up own configuration. Its possible to order additional components in future. In according to number of students in study group (15), we bought 7 configurations. The basic of each one are these parts:

1. universal power supply +5V, which can be use generally in laboratory
2. plane with power distribution; single modules as boxes can be plugged into plane
3. logic selector with 8 TTL independent output controlled by TTL level switches
4. logic probe with 8 independent input , 8 LED as level indicators and two 7-seg units with built-in decoder

Logical circuits (gates, adders, flip-flop) are realized as programmable universal digital modules (18 pieces). Modules are programmed by plastic cards with drawn symbols of circuits - card is simple put on module. We bought 55 pieces of cards with various functions. Students select modules and cards according to circuit, which they should connect. Naturally, set of wires is part of accessories. To generate waveforms, it’s available set-up generator.

Finally, new laboratory was equipped by modern educational systems. Students will be able to do some experiments with logical circuits and the faculty became independent on FEE. The laboratory is also planed to be used in other courses.

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Contact-less Current Measurement

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In present time, there are many precise current comparators available [1]. The main disadvantage of these comparators is their narrow bandwidth (typically 1 Hz). This is caused by signal processing, that doesn't allow to measure currents at higher frequencies. Several parameters (resulting from generally known block diagrams) must be changed for making measured bandwidth of current wider.

Typically, the excitation frequency of current comparators is lower than 1 kHz. For measuring of currents with frequencies up to 1 kHz this frequency must be higher. The higher, the better, but with higher frequency also losses are getting higher, mainly in magnetic cores of current comparator. Magnetic material of detection cores was changed - a good choice is amorphous material (annealed alloy), which has narrow hysteretic loop and consequently low hysteretic losses. An excitation frequency of 10 kHz is used in realized comparator. A special excitation unit with CPLD EPM3064A is used. This unit allows generation of two signals with frequency *f* and *2f*. It also allows to set phase between these two frequencies.

Mainly the second harmonic (and other even harmonics - the more harmonics, the higher sensitivity) and its changes (in amplitude, frequency and in phase) are important from frequency spectrum of voltage on detection winding. Measuring of this even harmonics is possible with switching type synchronous detector (for example AD630 from Analog Devices). 2^{nd} order low-pass filter is connected to the output of this detector. This detector sets the bandwidth of measured current. Thus cut frequency of this filter is set closed to 1 kHz.

Current comparator works in feedback loop connection. PI regulator with time constant approx. 1 ms is used as a feedback regulator. The ratio of measured currents is 100:1, so to 100 A of measured current corresponds 1 A of compensation current. The PI regulator must supply this current into feedback winding.

This current is the output signal from the comparator and is converted to voltage with current-voltage converter. Shunt resistor of 0.1 Ω is connected to precise instrumentation amplifier AD621 (Analog Devices), its output voltage is proportional to measured current.

Realized comparator has been tested for DC and AC measurements. Full scale error is lower than 0.012 % for DC currents. AC measurements were realized only without electronics, because of some noise generated in excitation winding. This noise is caused by fast switching in generator for excitation winding and will be dealt with soon.

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Resonant Tunneling Diodes - Simulation and Experiment

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In recent years, the resonant tunneling diodes (RTD's) have attracted the attention of scientists due to their high frequency performance up to the terahertz region. It is possible to realise oscillators, mixers, switches and various kinds of functional circuits with RTD structures. Resonant tunneling diodes have undergone intense investigation, both experimental and theoretical, over the past decade and more. Even as a detailed understanding of the operation of RTDs has developed, several controversies have persisted, including the cause of an observed plateau in the negative differential resistance (NDR) region of the current-voltage (I-V) curve, whether intrinsic bistability has been observed and how it manifests, the cause of RTD oscillations, the nature of the tunneling process (sequential or resonant), and the correct lumped-parameter equivalent circuit model for an RTD. Two opposing explanations were given for the plateau. Some researchers advocated extrinsically-induced oscillations caused by reactive elements in the external bias circuit as the sole cause. Others maintained that purely intrinsic RTD operation, such as intrinsic bistability due to charge storage in the quantum well, or discrete states in the emitter accumulation layer, could explain the plateau. Jensen and Buot [1] published transient Wigner function-based numerical simulations of an RTD including both self-consistency and scattering. The mechanism for intrinsic oscillations is the dynamic and self-consistent oscillation of charge in the quantum well and emitter, and the resulting oscillation of the quantum well state energy. Charge accumulation in the quantum well is responsible for the plateau hysteresis and gives a possible explanation for an upwards looping plateau, which is sometimes observed experimentally, but which is difficult to explain by intrinsic bistability alone. Biegel and Plummer analyse the influence of the slew rate on the intrinsic oscillations in RTD using transient Wigner function simulation [2],

In our study we use the transfer matrix (TM) approach including one dimensional self-consistent solution of Schrödinger and Poisson equations in the RTD structure. We analyse the own set of RTD's. The double barrier quantum well (DBQW) structure was grown by molecular beam epitaxy on a semi-insulating GaAs:Cr and undoped GaAs substrates. The DBQW consists of undoped GaAs well with varying thickness (7.1nm, 9.9nm, 10nm) between two undoped $Al_XGa_{1-X}As$ barriers (7.1nm, 9nm, 9.9nm, 10nm, 13nm and 15nm thick). The value of x was 0.386, 0.395, 0.402, 0.405, 0.406 and 1. On the both sides of the DBQW 10nm undoped GaAs spacer layers and 100nm n-GaAs supply layers were grown. The n^+GaAs top and bottom contact layers respectively were 100nm and 500nm thick. Au/Ge/Ni ohmic contacts were fabricated on the anode and cathode layers. The I-V characteristics were measured by Hawlett Packard pikoampermeter/DC voltage source 4140B. The measurements were carried out for different temperatures, that have been changed from 30 to300 K for increasing and decreasing voltage slopes in both directions.

The TM simulation of RTD I-V characteristics shows relatively good agreement with the experimental data and gives a new insight into the physics of RTD bistable behavior. The influence of the structure parameters is analysed as well. The peak valley ratio (PVR) exhibits maximum for barrier thickness equal to 7.1 nm. The measured I-V characteristics exhibit slope in the NDR that depends strongly on the recording speed of the curve and especially on the inductance of the supply lines and on the capacity of diodes. The implementation and computer times for TM approach are lower than for the Wigner function based methods.

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Analysis of Real SI Circuits

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Introduction

The analysis of switched circuits is more complicated in comparison with circuits working in continuous time. During switched filters design is necessary to carry out especially the frequency analysis. Such filters are designed by technique of switched capacitors (SC) and switched currents (SI). There is a number of methods solving this problem.

1. Charge equations method for SC circuits or nodal equations method modified for SI circuits.
2. Solving general linear differential equation of a circuit by a method based on the Fourier transformation [3] or the Laplace transformation [4].
3. General solution of the circuit by transient analysis using program like SPICE. The frequency response is obtained consecutively by Discrete Fourier Transformation (DFT) of output signal samples [1].

A transfer function in Z plane is obtained by the first method. The transfer function describes basic characteristics of idealized circuit. The frequency response of the linear switched circuits with parasitical effects can be analysed by the second method. Parasitical effects are transients performance caused by nonzero resistivity of switches in on-state and by nonzero conductivity in off-state and their parasitical capacitances. The properties of circuits including all parasitical effects and nonlinearities can be analysed by the third method. However this method requires the highest computing power.

Project goals and their solution

The aim of this initiation project was research of algorithms for analysis of real switched current (SI) circuits with intention to select an appropriate algorithm for implementation in mathematical program Maple. The project took into account that a new algorithm would be developed which would be based on possible combination and adaptation of algorithms designated initially for switched capacitor (SC) circuits. The measurement of actual switched circuit should be carried out to verify the functionality of designed algorithm.

The workgroup of grant proposer have extensive experiences in implementation of algorithms in program Maple. Two large libraries of functions were developed in last year [2] and are currently used for education and scientific work.

The first partial goal was the study and the comparison of algorithms appropriate for analysis of real properties of SI circuits. This part involves getting copies of some papers from journals and conference proceedings and the purchase of books. List of interesting papers will be presented on poster.

The second goal was the selection of algorithms appropriate for implementation in program Maple from the aspect of capability of this program, and the analysis of implementation complexity of individual algorithms. Example of switched circuit analysis by

means of selected algorithms will be presented on poster. New version of program Maple (9.00) is available since autumn 2003 so the capability of program has increased especially for our intention.

The third goal was the analysis of possible compound of some algorithms. The algorithms based on solving general linear differential equation by means of Fourier transformation and Laplace transformation (see [3, 4]) seems to be most advisable. The algorithms have common part but they differ in results. The first one provides complete frequency spectrum of switched circuit and the second one provides the semisymbolic transfer function in s and z variables.

The fourth goal was the partial experimental implementation of selected algorithm in program Maple. The example of result from program Maple will be presented on poster.

The last goal was comparison of computation results with measurement of specific switched circuit. This part is delayed but the results should be available in the time of poster presentation.

Conclusion

The project will continue by submiting an application for a post-doc grant at Czech Science Foundation (GAČR). The aim of the grant will be final implementation of above discussed algorithms for real SI circuit analysis.

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Modernization of Linear Circuits Laboratory

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The aim of this project was to prepare working environment for seminars of Linear Circuits (Electric Circuits 3) in bachelor degree courses and related seminars in master degree with respect to required knowledge depth and professional skills of graduates and throughput of this demanding part of electrical engineering study.

Subject Linear Circuits (with new name of structured program – Electric Circuits 3) is the main subject teached in the laboratory. It is one of the basic subjects of study branch Electronics and Communications. The laboratory will be also used for Electric Filters, Analog and Digital Systems and Design of Discrete Systems as subjects of master degree courses. The laboratory will partially support high-capacity basic subject Electric Circuits 1 and 2.

First partial goal is to redesign and rework of student laboratory, including sets of laboratory desks suitable for placement of measuring instruments and one personal computer with demanded connections. The design of these new ergonomic desks is primary task for solving cascading problems. The desk has to make possible convenient work for two students during seminars with enough place for proper notebooks, one PC (monitor, keyboard and PC mouse) for required simulations and calculation and further for placing of measuring instruments set, minimally power supply, multimeter, generator, milivoltmeter and oscilloscope.

Requirements for the student measurement laboratory are given by the set of subjects teached in the laboratory. These requirements influence selection of basic measurement instruments, possibility to add individual special measurement instruments, and selection of gradually added development kits and laboratory modules. Besides the regular use during the study term, the laboratory should also be used for individual project assignments (design, simulation, construction) at different study levels (study term projects, bachelor projects, diploma projects).

Main parts of the project was:

- design of standard measurement equipment set for every workplace, including one PC per workplace,
- design of laboratory desks, choice and placement of necessary equipment (mainly set of measuring instruments and PC),
- spatial arrangement of 12 workplaces
- system of gradual innovation of equipment
- design of new measuring kits for realization filters working in continuous time and selective system based on switched capacitances,
- design of printed circuits and measurement instructions for designed kits,
- modification of relevant web pages.

Main results of the project:

- create a design documentation of laboratory desks, commission and purchase of them,
- completion and placing desks in laboratory,
- construction of AC power network and data network in laboratory desks, interconnects and tests of all laboratory equipment,
- reconstruction of video wiring and computer network,
- allocated grant money were next used to buy new monitors for current PC,
- software reinstallation of current computers and completion of software facilities
- other financial sources were used to buy new chairs,
- realization two types of new measuring kits, including measurement instructions [8].

All these changes allow optimal combination of different types of students' work - laboratory measurement including diagnostic of circuit being worked on, seminar work, and individual project assignments (design, simulation, construction) - and different study levels. We expect that laboratory arrangement will be able to meet requirements of dynamic evolution in this field for at least ten years.

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Educational Support of The Course "Propagation of Electromagnetic Waves and Frequency planning"

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Introduction

Recently wireless local area networks (WLANs) have emerged as flexible communication systems, which have been implemented as an extension or alternation for a wired LAN within buildings. Using electromagnetic waves WLANs transmit and receive data over air interface, minimizing need for wired connection, thereby it enables user mobility in covered area without losing connectivity to the backbone net.

For planning of indoor Wireless LAN systems working in 2.45 GHz ISM band, the signal propagation prediction is needed. Indoor scenarios are usually very complicated and due to moving people rapidly changing environment. Since the WLAN systems use wideband transmission, QoS (Quality of Service) is highly dependent not only on average signal strength in specific location, but also on fading statistics. Due to the multipath propagation, where several waves arrive at the receiver via different paths and with different phases, rapid variations of the received signal envelope occur. Time variations of the received signal and wide bandwidth of the transmission are the reasons why the statistical evaluation of measurement results is necessary.

That is why the indoor measurement project consisting of two measurement methods was accomplished.

Realization

The main aim of this project has been the preparation of practical and theoretical tasks to the upcoming course: „Propagation of Electromagnetic Waves and Frequency planning". Following this tasks, the students will be able to check their knowledge by theoretical prediction of the signal propagation phenomena (WLAN radio interface behaviour) and by direct evaluation by measurement of WLAN network parameters.

The first task is devoted to the deriving of empirical parameters for COST231 Multi-Wall and One-Slope models [1]. These models allow mean signal level prediction for initial coverage planning. A narrowband system was developed at the Department of Electromagnetic Field. This system, consists of a transmitter, portable receiver and two wire omni-directional ground-plane antennas, was designed for 2.45 GHz ISM band. Full computer control is made through the standard serial interface RS232 by the PDA computer PalmIIIx. Values of the signal level are taken automatically every second and are saved in the computer while the receiver was moving along a measured path. The measurement campaign has been performed in several buildings in Prague [2]. Empirical parameters for COST231 One-Slope and Multi-Wall models were optimized based on the measured data and compared with parameters at 1.9 GHz.

The second part of the measurement campaign - the wideband measurement - is focused on the determination of the best WLAN deployment and on the examination how the transmition is influenced by the time and space variability of the environment. The task is split into two parts. In the first part the students will theoretically design the best signal coverage from several access points by special propagation software. Afterwards in the second parts, the signal power level measurement will be performed using commercial WLAN system to investigate statistical distributions of fades. Probability density functions and corresponding service time-availability (cumulative distributions functions) were set and discussed during the project realization taking into account the specific location, the notebook orientation in azimuth and the specific environment arrangement in the near vicinity of the notebook. Using the results necessary power margin and resulting QoS can be determined for WLAN system implementation.

Results

Based on newly constructed tasks, the students will be able to check their knowledge by theoretical prediction of the signal propagation phenomena (WLAN radio interface behaviour and signal coverage) and consequently they will be able to verify results by set of measurements of WLAN network parameters. The results coming from measurement has been published at international conference COMITE 2003 in Exeter (UK) [2] and at conferences Radioelektronika in Brno [3] and Comite 2003 in Pardubice [4].

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Modeling of Real Imaging Systems

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The finding of the optimal model of the real imaging system is constantly actual theme in an area of obtaining, processing, reproduction (visualization) and archiving of imaging data. All imaging data, in analogue and in digital representation, are distorted by the effects of sensing device (optical part and the active sensing unit - sensor), by the effect of compressions (we can treat the compression algorithm as any other imaging system) and at the end by the effect of recording device. For the high-quality reproduction of the image data is necessary work down impact of imaging system.

Specific part of this problem is special imaging systems used for scientific purposes, for example for example for obtaining of the imaging data in medicine and astronomy. Especially in astronomy is evident progress in technology for obtaining of imaging data in invisible parts of spectra – near infrared band and RTG band. The imaging sensors used for those purposes are based on another physical principles than the sensors used for visible part of spectra. In this part of research is necessary to determine criteria of image quality (objective and subjective) and find the model of imaging system which will be respect parameters required to determine this model.

The majority part of an imaging systems consist of the input optic–electrical converter (input optic and sensor) transmission of data (compression) and the electro-optical converter (CRT monitor, LCD display). In this paper is described the imaging sensor modeling and treating the compression methods as an imaging system (for measuring of the objective image quality).

In a standard imaging approach we describe an imaging system by the PSF or the MTF. We can define the response of the imaging system to a point light source (2D Dirac impulse) as the impulse response or the Point Spread Function (PSF). The PSF is frequently used to characterize e.g. the optical blur. The relationship of the imaged object and the original is given by the convolution of the original object with PSF. All parts of the imaging systems, i.e. atmosphere, objective, image sensor, image processing (including image compression methods as well), image display and finally the observer's eye can be described by MTF. The MTF of the whole imaging system based on the above-mentioned equations is than given by the product of all particular MTF.

There are a few approaches how to obtain the Modulation Transfer Function of imaging system (see Fig.1.). At first it is approach based on restoration methods, including deconvolution. Within these methods we use only image data and computational workstation. At second we can use specialized measuring system, e.g. interferometer that enabled to obtain 2D MTF. But this method is exacting in cost. At third there in our approach required to perform a set of 1D MTF (in a lot of angles) computational based on the contrast evaluation within the sinusoidal test pattern projection onto the imaging system. Then we can perform 3D interpolation to obtain a complete 2D MTF. This last approach was also implemented in Matlab and was used within the obtaining results.

In an area of the imaging sensor we are interesting of many parameters and only part of them has real impact to consequential image and quality of this image. Interesting parameters for simulation purposes are fill factor, sampling distances, dimensions of pixels and area sensitivity of pixels. We can consider a few possible arrangement of sampling aperture: rectangular pixels, L-shaped pixels and symmetrical octagonal pixels.

In the case of our experiments in objective image quality measurement, we try to measure Modulation Transfer Function of selected image compression methods. As an example we have selected some of the compressions methods based on Discrete cosine transform, Hadamard transformation, Karhunen - Loève transform (we have used universal KLT basis determined from the class of astronomical images of DEEP sky kind - it is important that KLT basis did not created from 2D sine image because of its high value of correlation), vector quantization (VQ) and fractals.

For the purposes of simulation, we have used unified input image (sine pattern with flexible frequency), which was been coded by selected compressions methods (size of image *1536x1024x16* bits). Methods have had comparable. For obtaining of transfer characteristics of compression methods was been used method similar to simulation of transfer characteristics of imaging system. Input image was been compressed with compression method (KLT and VQ war realized in Matlab), parsed to particular frequency beams and for all beams was been calculated Modulation Transfer Function.

The modeling of the imaging systems in Matlab environment is a full featured, flexible and low cost allowance of traditional measurement methods. Results presented in this paper were been used for the objective (compression methods) and the subjective (model of imaging sensor was been used for obtain of degraded images) image quality measurement.

The Matlab package *CCDSIM*, which was been used for obtaining of results, have been used for the educational purposes at Department of Radioelectronics of CTU FEE.

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Signal Processing in CNS Systems

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GNSS Signal processing for indoor navigation

The GNSS signal processing is based on correlation principle. The cross correlation $R(\tau,\omega)$ of the received signal s_r and replica $C(t)e^{-j\omega t}$ is given as follows:

$$R(\tau,\omega_d)=\int_T s_r(t+\tau)C(t)e^{-j\left((\omega_c+\omega_d)t\right)}dt \tag{1}$$

Correlation method enables to process weak signal. The signal acquisition is performed in two-dimension space of delay τ and Doppler ω_d. This space is divided on Doppler and frequency bins. The size of the delay bin depends on the rate of ranging code $C(t)$. The size of the Doppler bin is inversely proportional to the integration time T.

The processing gain depends on integration time. In the case of indoor navigation, the received signal is strongly attenuated, so that the processing gain should be high. The classical GNSS receivers calculate cross correlation function sequentially, one point of the autocorrelation is calculated for given delay and Doppler per T. This acquisition method is not sufficient for AGPS due to its high time consumption. Thus massive parallel algorithm should be implemented. AGPS receivers compute cross correlation function for all delay bins during one T [1]. Our *super parallel* algorithm can calculate cross correlation function for all delay bins and for N Doppler bins. For Doppler bin $\Delta\omega_d = 2\pi/T$ the cross correlation function can be assessed as follows:

$$R\left(\tau, n\frac{2\pi}{T}\right) = DFT_N\left(\vec{r}(\tau)\right), \tag{2}$$

where $\vec{r}(\tau)=\left[r(k,\tau)\right]_{k=0}^{N-1}$, $r(\tau,k)=\int_{\frac{T}{N}k}^{\frac{T}{N}(k+1)} \bar{s}_r(t+\tau)C(t)dt$ is partial correlation,

$\bar{s}_r$ complex envelope of the signal s_r

Experimental GNSS Receiver

Our experimental GNSS receiver enables experiments with GNSS signals. The main application of this receiver is in the GNSS signal processing algorithm investigation, development and evaluation. Our receiver is optimized for

- Research and study of the new GNSS system (Galileo, e.g.)
- Development and evaluation of the modern signal processing algorithm for GNSS, Assisted GNSS (AGNSS), AGPS
- Investigation of the multipath mitigation algorithm
- Development of special GNSS receivers

The architecture of our Experimental GNSS receiver is based on the SDR (Software define Radio). The receiver consists of three units: RF unit, DSP unit and PC Workstation.
The RF unit has two independent radio channels, while each channel covers a frequency band from 1 GHz to 2 GHz. The bandwidth of the channel is adjustable (3 dB bandwidth 2, 4, 8 and 16 MHz).
The DSP unit is based on FPGA Xilinx Virtex II with two 14-bit Analogue to Digital Converters. The sample frequency can be up to 65 MHz. The communication between DSP and PC Workstation is maintained with a PCI computer interface.
The high-level software development is performed with the Matlab Simulink using a Xiling System Generator for DSP. The Simulink model can be compiled to the VHDL and processed in ISE 5.1 FPGA synthesize tool.

Conclusion

This paper deals with a new algorithm for GNSS signal acquisition based on parallel correlation. Algorithm performance will be tested in real time with a real signal and the results will be compared with the concurrent algorithms. Experiments will be performed on our Experimental GNSS receiver, described above in this paper. The Experimental GNSS receiver is an appropriate tool for development and testing of signal processing algorithm for most of GNSS applications.

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Dynamic testing of AD converters with high resolution in higher frequency range

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The most common way of ADC dynamic testing is to use sine-wave input signal and to evaluate its purity from the sampled digital data. The quality of the evaluation of dynamic parameters of ADCs is much dependent on the quality of testing signal generator then. Several manufacturers produce low-distortion generators, which are applicable for this purpose as well. They are usually based on direct digital synthesis and dispose of variable parameters (amplitude, frequency) that enables the testing of various ADCs within a wide frequency range. Nevertheless the disadvantage is that the spectral purity is mostly not sufficient for high-resolution ADCs (14 – 16 bit) and frequency range of input signal from several tens of kHz to several MHz, for which no commercial generator with the required parameters is available.

One of the methods how to gain a spectral pure harmonic signal is applying a high-quality selective pass-band filter on a harmonic signal (e.g. produced by a common harmonic generator). The basic condition for this signal is a high stability and spectral purity (free of spurious components) near the fundamental harmonic (because of the pass-bandwidth). The other spectral components and noise are suppressed by the filter.

If the pass-band filter is not linear, higher harmonic components arise on the filter's output. The nonlinearity is caused e.g. due to ferromagnetic parts, which cause the increase, especially, of odd harmonic components. They can be even higher than those produced by the harmonic generator. Nevertheless, the main goal is that the filtered signal is free of spurious components. Then, to measure SNHR (Signal to Non-Harmonic Ratio) of the tested ADC is possible but not SINAD (SIgnal to Noise And Distortion) and THD (Total Harmonic Distortion). This is the case of most of the high selective pass-band filters in the frequency range up to several MHz.

To get rid of the higher spectral components requests a high quality linear pass-band filter, which often makes a problem (complexity, costs). One of the solutions can be the exact determination of these components and their subtraction from the ADC measured frequency spectrum. This operation must be made in the complex form (as vectors), because the phases of higher harmonic components are not defined and have to be computed as well as the amplitudes. So, in the ideal case the frequency spectrum of the ADC remains then.

Because of the high dynamic range of the filtered harmonic signal, a stop-band (notch) filter has to be applied for the measurement of the higher spectral components. Then it is easy to determine all components using any digitizer with the condition of a stable frequency characteristic and the dynamic range considerably better then the signal on the stop-band output. These components have to be recounted to the ADC input because of the influence of the stop-band filter. If the filter is not used, high errors could appear due to the nonlinearity of the digitizer, which is much more difficult to determine so exactly.

An amplifier on the filter output serves for the setting of the signal amplitude – most of the quality filters are passive and cause signal attenuation. They must be linear and mainly with

low noise. If the amplification behind the stop-band filter is high enough, the measured ADC can be used instead of measuring digitizer. The error caused by the ADC nonlinearity could be neglected if the stop-band filter suppresses the fundamental harmonic component enough (the dynamic range of the ADC is essentially higher).

The frequency characteristics of all parts (amplifier, filters) could be measured as the vector difference of the frequency spectrum of the output signal and of a known input signal. One of the suitable signals is e.g. saw function, because it contains all harmonic components (odd and even) with relatively high amplitude.

The basic question is the accuracy of the results. There are several sources of errors: time and temperature instability of the filters and amplifiers, suppression gain of undesired harmonic component(s) of the filters together with the dynamic range of the measuring digitizer, the uncertainty determination of the harmonic components' phase. Generally, the more is the correction of harmonic components needed (the less is the difference vector) the more accurately should the measurements be done.

Signal filtering and following digital correction of residual components minimizes a high demand for the spectral purity of the testing signal by the exact determination and elimination of the distortion. This method is not so simple as the direct measurement and evaluation; however, it could be applied for the testing within wide frequency range because it provides relatively very quality ADC testing with defined input signal parameters. The disadvantages of this method are a relatively high demand for the accuracy of amplitude and phase measurements of parasitic harmonic components and the fact that for each frequency extra filters are needed.

First measurements proved that the elimination of known parasitic harmonic components is possible. They showed how sensitive the corrections are. Since this method is new and it has not been tested enough so far, its verification and accuracy should be analyzed. One of the basic problems is the correct phase determination of parasitic harmonic components – specific steps in the frequency phase spectrum appear when noncoherent sampling. The solution of this problem needs a mathematical analyze in the field of signal processing.

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Non-Destructive Characterization of Deep Damage Layers in Silicon Introduced by Proton and Alpha-Particle Irradiation

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Control of excess carrier lifetime is an important tool for optimization of the trade-off between static and dynamic parameters of power semiconductor devices. Nowadays, the ion irradiation is widely used for this purpose [1]. It introduces a very narrow defect region, where the recombination of charge carriers is enhanced, only in that part of the device where it is necessary. This allows to decrease a switching time without substantial deterioration of static parameters. To be able to apply the ion irradiation effectively, an accurate knowledge of defect distribution is a must. Therefore, this project is focused on accurate and reliable control of axial defect distribution in the depth scale of hundreds of micrometers.

Radiation defect profiles introduced by proton and alpha-particle irradiation in the low-doped <100> FZ n-type silicon forming the n-base of the planar p^+nn^+ diodes were investigated. The diodes were irradiated with 1.8, 2.8, 3.6, 7.35 MeV protons ($^1H^+$) and 8, 12, 14.5 MeV alphas ($^4He^{2+}$) using the tandem accelerator in FZ Rossendorf. The irradiation was performed at fluences from $7x10^9$ to $5x10^{10}$ cm^{-2} ($^1H^+$) and $1.4x10^9$ to $1x10^{10}$ cm^{-2} ($^4He^{2+}$).

The resulting radiation defects were characterized by using four electrical methods: the capacitance deep level transient spectroscopy (C-DLTS), I-V profiling [2], the high voltage current transient spectroscopy (HV-CTS) [3], and C-V measurement. C-DLTS spectra of proton irradiated samples revealed six electron traps labeled as E1 to E6 and two holes traps H1 and H2. Only three electron trap levels E1-E3 and one hole trap H2 were resolved in the C-DLTS spectrum of samples irradiated with helium. The levels E1(E_C-0.127 eV), E2(E_C-0.167 eV), E3(E_C-0.252 eV), E5(E_C-0.436 eV) and H2(E_V+0.359) are associated with the vacancy-related radiation defects which are usually found in the silicon irradiated by electrons, protons and alphas. The most pronounced electron trap E2 is mainly given by an acceptor level of vacancy-oxygen pair $VO^{(-/0)}$ ("A"-center). E3 and E5 are given by a divacancy double- $V_2^{(=/-)}$ and single- $V_2^{(-/0)}$ acceptor level, respectively. The hole trap H2 is given by a donor level of the carbon interstitial-oxygen interstitial pair C_i-$O_i^{(0/+)}$ and levels E4, E6, and H1 are attributed to hydrogenated VO, V_2 and C_i-O_i, respectively.

The investigation was further focused on the divacancy, the defect which is responsible for carrier recombination at low injection levels and generation in depletion regime. Divacancy profiles introduced both by protons and alphas were measured by HV-DLTS and I-V profiling and compared with simulated distribution of primary defects (vacancies) obtained from calculations using the Monte Carlo code SRIM2000. Comparison showed that both the profiles follow in principle the simulated distribution of primary damage. However, the peak given by proton irradiation significantly broadens its left edge towards the irradiated surface while the peak given by irradiation with alphas stays symmetrical. Both the profiles show a considerable discrepancy between the simulation and experiment on the deeper side of the defect peak where the divacancy distribution is not terminated abruptly. This broadening was already observed by different methods on distributions of divacancies and VO pairs in diodes irradiated with protons and alphas [3]. The suggested explanation was an underestimation of channeling effect which is not accounted for in SRIM.

Table 1. Divacancy profile parameters and introduction rates at different depths.

Projectile	Energy [MeV]	Peak depth R_D/Straggle ΔR_D [μm]		Divacancy introduction rate $\times 10^2$	
		Measurement	Simulation	Peak	Tail
H^+	1.8	38.5/1.45	39.4/0.844	0.73	1.7
	2.8	83.8/2.65	81.7/2.14	0.76	1.6
	3.6	124/3.60	124/2.91	0.79	1.1
	7.35	373.3/10.8	375/7.4	0.99	0.89
He^{2+}	8.0	47.2/1.25	47.7/0.55	0.90	1.7
	12.0	92.4/2.15	91.9/0.98	1.1	1.6
	14.5	127.6/2.63	125.6/1.31	1.2	1.4

The divacancy introduction rates for different irradiation energies are shown in Table 1. Table shows that the divacancy introduction rate in the peak region is generally lower than in the region closer to the irradiated surface (tail) and increases with ion energy. Lowering of the production rate in the heavily damaged peak region can be explained by increased defect annealing and also by the formation of more extended clusters that consume a large part of primary defect. If the ion energy increases, the defect peak broadens and the concentration of primary damage decreases. As a result, the magnitudes for the tail and the peak are converging. This effect is more pronounced in the silicon irradiated with alpha-particles where the width of the peak is narrower and more divacancies are generated in direct collision.

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Radiative Recombination Mechanism of Subnanometric InAs/GaAs Laser Structures

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Experimental investigations of semiconductor structures with isovalent δ-layers have revealed an extremely high optical recombination efficiency [1] which persists even at elevated temperatures. Moreover, embedding of thin strained InAs layers or InAs quantum dots in the GaAs matrix as laser active region can extend the emission wavelength up to 1.3 μm. Recently [2], we have reported lasers with different InAs δ-layer structures in GaAs waveguide prepared by Low-Pressure MetalOrganic Vapour Phase Epitaxy (LP MOVPE). We showed that, depending on the configuration of InAs δ-layers, these lasers are lasing at room temperature with energies from 1.15 to 1.4 eV. They operate in the temperature range from 20 to 400 K with differential quantum efficiency between 12 and 18 % and exhibit a threshold current density of about 0.2 $kAcm^{-2}$ at room temperature which is decreasing to 0.04 $kAcm^{-2}$ below 100 K.

The main goal of this grant project is to identify and explain the strong interaction between δ-layers in the multiple structure, which is responsible for the energy shift and enhanced optical quantum efficiency, and support this investigation with adequate theoretical models which will be used for explanation of photoluminescence (PL), electroluminescence (EL), and photocurrent (PC) measurements on the InAs δ-layers in GaAs grown by MOVPE. The next aim is to further optimize the multi δ-layer structure and use it as an active layer for preparation of low-threshold semiconductor lasers operating in the wide spectral (850-1300 nm) and temperature (above 100 ^{o}C) range.

In the first year of the project, we focused on the MOVPE growth of single InAs δ-layers with different thickness W_L, double δ-layers separated by the GaAs spacer with a variable thickness S_L and different multiple δ-quantum well structures suitable for active layers of semiconductor lasers. While, in the first two cases, the calibration of the theoretical model and of the MOVPE growth was of the primary importance, the growth of multiple δ-quantum wells was focused on shift of emission wavelengths to lower energies. All δ-layer structures were grown in the AIXTRON 200 MOVPE horizontal low pressure reactor in the Institute of Physics ASCR.

Samples were structurally characterized by the Transmission Electron Microscopy (TEM), the Scanning Tunnelling Microscopy (STM) and the X-ray diffraction (XRD). Optical properties were measured by PL and PC spectroscopies at the Department of Microelectronics CTU Prague. For interpretation of experimental data, we used simulation of electronic states in δ-layers using a theoretical model based on the elasticity theory giving realistic values of the hydrostatic and shear strain energy components for strained InAs δ-layers in GaAs. The energies of electron and heavy/light hole states in the active layer were calculated by solving the 1D Schrödinger equation with zero-field potential [3]. Energies of corresponding radiative transitions from the lowest electron to heavy hole (e_1-hh_1) or light

hole (e_1-lh_1) states in the δ-layer structure were compared with those received from polarization dependent in-plane PC measurement.

Results of the structural characterization with atomic resolution show that MOVPE is capable to growth very thin δ-layers (up to one monolayer) without significant broadening given by indium diffusion. The distance and thickness of δ-layer can be accurately controlled by growth parameters. We also found a good qualitative and quantitative agreement between the theoretical model and measured PC and PL data for single and double δ-layers when we used W_L and S_L magnitudes from STM and XRD analysis.

On the basis of these results, we designed, fabricated and characterized a series of multiple δ-layer structures with different W_L, S_L and number of layers N. We succeeded to significantly and reproducibly shift the emission wavelength to lower energies (up to 1.13 eV), however, we experienced a limitation given by the "critical thickness" similarly to the case of ternary InGaAs single quantum well lasers. Further experiments will be done to investigate and solve this problem.

At the same time, we characterized and investigated effects in the lasers with InAs δ-layer structures which were grown previously [4]. We focused on the characterization of emission characteristics at elevated temperatures (up to 100°C) and analysis of the wavelength switching which appears at high temperatures and high current densities.

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The Novel Methods of Local Lifetime Control in Semiconductors

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To increase the power and switching speed performance without suffering damage a considerable progress has been made in the field of local lifetime control in high-power silicon devices. The most advanced means are the hydrogen and helium irradiation with optional excess carrier lifetime profile very often supplemented by electron irradiation [1]. In the devices with extreme overloading under turn-off, the radiation defect density must be locally very high and results in increased leakage current. At the same time, the annealing temperature of the defects is not far above 300°C. Consequently, both the mentioned features decrease device reliability at elevated temperatures. To overcome this problem, the defects with a weaker temperature dependence of the leakage current compared to the ones resulting from the above mentioned irradiations should be used. Such defects exist, but the standard methods for their introduction into the device volume are lacking in capability to provide arbitrary concentration profile that is necessary to obtain arbitrary lifetime profile. The aim of this project is to develop a new method that leads to introduction of defects with optimal electronic parameters and, at the same time, provides their arbitrary concentration profile [2].

For this purpose we have studied the low-temperature diffusion of platinum stimulated by the radiation (point) defects to locally control the lifetime with the same degree of freedom that provide the standard hydrogen and helium irradiations. The source of Pt was created by 300 nm thick platinum silicide layer on the top of the anode [3] or using Pt implantation through the anode with the dose ranging from 10^{11} to 10^{13} cm^{-2} [4]. The final localization of Pt in the device volume was performed using the high-energy helium irradiation (3 - 15 MeV) with subsequent annealing in the range of 675 to 750°C.

The device under the test was 2.5kV/100A high-power press-pack P-i-N diode from Polovodiče a.s., Prague, with junction termination using classical bevel with rubber and 1.7kV/100A high-power P-i-N chip diode for power modules from ABB Switzerland Ltd., Semiconductors, with junction termination formed by field rings. The devices were fully characterized by means of physical methods, namely Deep Level Transient Spectroscopy and Capacitance-Voltage methods. The electrical parameters were obtained from the measurement of reverse current up to the breakdown voltage, measurement of forward voltage drop up to the rating current, Open Circuit Voltage Decay from high injection conditions, and reverse recovery from low and high injection conditions. The parameters and characteristics obtained from the methods above enabled us

- to acknowledge the implementing of the novel technique into the standard process of high-power P-i-N diode with benefit of low leakage current and low forward voltage drop,
- to verify that the obtained defect profiles are of the same quality as that of the standard irradiation techniques,
- to verify that the method introduces the required deep level with optimal electronic parameters,
- to obtain electronic parameters of the resulting deep level,

- to determine the annealing temperature that gives the highest defect peak and lifetime reduction efficiency at the same time,
- to compare the efficiencies of lifetime reduction of the novel and standard techniques in real devices normally used in practice,
- to compare the efficiency of lifetime reduction between the "platinum silicide" and "platinum implantation" techniques.

The major outcome of the project consists in finding that the efficiency of carrier lifetime reduction using the diffusion from platinum silicide is much smaller than expected. For the case of single energy helium irradiation followed by annealing, the maximal reduction of the reverse recovery maximum current I_{RRM} and reverse recovery charge Q_{rr} were achieved only at 40 % of the unirradiated device while the standard irradiation process allows the reduction up to 10 % approximately. This can be explained by two facts. Firstly, the maximal defect concentration is limited by the solid solubility of platinum in the range of annealing temperatures, where the principle of controlled diffusion works (700 - 725 ^{o}C). Secondly, the electron capture cross-section of the single acceptor level of substitutional platinum $Pt_s^{(-/0)}$ is at least one order smaller than that of the dominant recombination level resulting from the proton or helium irradiation – acceptor level of the vacancy-oxygen pair $VO^{(-/0)}$. For the device under test, the latter was acknowledged using the device simulator ATLAS the results of which are in good agreement with the injection dependence of lifetime.

The future works in the project will be to disclose the optimal conditions for obtaining the maximal lifetime reduction and carry out technological provisions that will overcome the drawback mentioned above.

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The Study of Contact Materials for High-Power Devices

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Platinum Silicide (PtSi) is widely used for contacts in integrated circuits because of its stable features, low resistivity, low silicidation temperature and low silicon consumption. In the technology of high-power devices, the dominant contact material is still aluminum (Al) or Al-Ti-Ni-Ag stack. These contacts are known to possess stable properties and good reliability up to elevated temperatures. However, the use of these materials leads to a relatively high voltage drop under high forward currents.

The obtaining of low value of the contact resistance is available by means of the PtSi material, that is studied as a potential candidate for contact material in high-power devices. It has been demonstrated in recent paper [1], that the use of platinum silicide at the anode contact of a P-i-N diode can lead to a significant reduction of the device forward voltage drop. Moreover, the PtSi contact can be used in the subsequent technological processes that are directed to the spatially localized reduction of excess carrier lifetime to optimize the trade-off between the static and dynamic device parameters [2, 3]. In this case, the PtSi layer is used as the source of platinum for the low temperature diffusion stimulated by radiation defects after helium irradiation. Unfortunately these advantages are accompanied by the deterioration of reliability at elevated temperature, namely the absence of the crossing point between the forward I-V curves at 25 ^{o}C and 125 ^{o}C. Under these conditions, a parallel operating device (e. g. in power module) could be destroyed owing to so-called thermal runaway, that is caused by the reduction of diode voltage drop with increasing temperature.

The device under test is 2.5kV/100A high-power $P^{+}NN^{+}$ diode from Polovodiče Inc., Prague. The starting material is 130 Ω.cm n-type float zone silicon cut in the <111> plane. The device is 16 mm in diameter and is about 370 µm thick. PtSi, PtSi / Al, PtSi / TiW / AlCuSi, PtSi / AlCuSi , Ti / Ni / Ag, Al / Ti / Ni / Ag contact materials were tested at the place of the anode contact. The PtSi, TiW, AlCuSi contact layers were deposited in rf plasma deposition system from corresponding targets. The bottom PtSi layer was prepared by the subsequent sintering of Pt layer. The sintering time was ranging from 40 to 100 minutes. The aluminum layer was evaporated and sintered at 460 ^{o}C for 15 min in nitrogen ambient. The titanium, nickel and silver were evaporated and subsequently sintered at the constant temperature. Forward I-V curves were measured in four point arrangement at constant temperatures ranging from +30 to +125 ^{o}C under a constant contact loading of 300 ± 1 kg. Application of a pulse measurement principle (t_{ON} = 150 µs, f = 4 Hz) was used to minimize the self heating effect.

Forward voltage drop, differential resistance, serial resistance, crossing point current and their temperature dependencies were evaluated from the measured I-V curves of experimental diodes. The measurements and calculations have shown, that the diodes with platinum silicide contact exhibit the lowest magnitude of both the forward voltage drop and differential resistance. The sintering time was found to be non-critical parameter up to the thickness of 100 nm, so that the process itself is robust enough [4]. The temperature

coefficient of the forward voltage drop has a magnitude of a typical silicon p-n diode, namely -2 mV/K. The differential resistance of the diode with PtSi contact was calculated in the region of high currents (200 - 500A) where the device behaviour was found purely ohmic. The lowest resistance was obtained for the 50 nm thick Pt layers and 5 times lower compared to that of the standard Al contact.

Unfortunately, the above mentioned contacts show a poor stability at elevated temperatures owing to the absence of the crossing point current of forward I-V curves. In practice, this means a decreased reliability when reliable parallel operation of several identical components under overload conditions is desired. The overcoming of this drawback is expected through application of additional layers, such as Al or AlCuSi. The TiW layer is used for preventing the diffusion of aluminum into the body of diode. The novel device has PtSi / TiW / AlCuSi layers on the anode and TiW / AlCuSi – on the cathode side. These diodes exhibit a higher serial and differential resistances, but, at the same time, the forward I-V curves of diodes at 30 and 125 ^{o}C cross one another. Therefore, if the diode is being used at the forward currents, which are over the value of the crossing point current, the increasing diode temperature would cause the increase of the value of its resistance. It means that, the diode does not undergo the thermal runaway and may be used in the overloading conditions, where the higher temperatures are predicted.

The subsequent annealing of the above mentioned diodes with PtSi / TiW / AlCuSi anode contacts did not call the lowering of diode resistance, but it decreased the value of the crossing point current. That improves the stability and reliability of diodes at high temperature operation that is of big importance in high-power devices. The following investigations will be directed to improve the mechanical properties of the contacts that are not good enough likely due to the surface roughness of the PtSi layer resulting from sintering.

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The Development of Recommendations ITU-T for Cable Modem Series J.

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This article presents a short introduction to history and evolution of recommendations for cable modems. At time when had begun growing interest in Internet connection, there were searched for easy and cheap solutions, which allows data transmission through various other networks. And cable television distribution networks are such a possible "ground" on which can be build digital data transmission.

Recommendations for cable modems

Within ITU-T was established in 1994 group named "802.14 Cable TV Media Access Control and Physical Protocol Working Group", which should worked out a draft of appropriate standard till the end of 1995. It should have based on ATM technology with fixed length of packets and with granted quality of service (QoS). This standard should have suited for multimedia transmission. The admission date of standard was still deferred. In the end of 1998 ITU-T ratified recommendation ITU J.112, which practically only improved industrial standard DOCSIS.

1. MCSN DOCSIS

This industrial standard originates from an american cable television companies which wanted to provide internet connection through cable television distribution. In January 1996 cable television distribution providers made a Multimedia Cable Network System Partners (MCNS) to create a non official industrial standard. The aim of the standard was to find easy and cheap solution how to assure Internet connection by cable television distribution networks. The standard was named Data Over Cable Service Interface Specification (DOCSIS) version 1.0 and was published in April 1997. Because of such a fast designing, this standard has not implemented QoS functions. But this functions are necessary to enlarge offered services, e.g. video on demand, IP telephony, and so on. In new versions of recommendation was implemented new functions, e.g. already noticed QoS.

DOCSIS 1.0

Forward channel has 6 MHz bandwidth which is the same bandwidth as one television channel and provider can "paste" this channel anywhere inside frequency range of 91-857 MHz. Sometimes are presented different values, mainly high frequency limit of that band in which is placed this channel. In this case it depends on network parameters and devices which are used. It is obvious, that the available baud rate of forward channel depends on bandwidth and type of used modulation. The most used is 64-QAM with maximal baud rate 27.9 Mbit/s or 256-QAM with maximal baud rate 39.4 Mbit/s. Backward channel can be placed in a band of range 5 – 42 Mhz. Available bandwidth of backward channel is 200, 400, 800, 1600 or 3200 kHz. It uses Time Division Multiple Access (TDMA) to share this band. There is used modulation QPSK and 16-QAM, and therefore it has 10 combinations of baud rate in backward channel available. For QPSK modulation and 3.2 MHz channel bandwidth is baud rate 5.12 Mbit/s. It is possible to use 16-QAM modulation, but usually is used QPSK modulation, because it is more resistant against interference.

DOCSIS 1.1

Newer version of DOCSIS 1.0 standard which especially solves QoS implementation and improving of backward channel. Standard DOCSIS 1.1 is compatible with DOCSIS 1.0 standard, it has improved security of transmitted data and allows network management. DOCSIS 1.1 unlike DOCSIS 1.0 allows more QoS profiles for each modem and has begun implementation of multimedia services, e.g. VoIP (Voice over IP). Backward channel has similar properties as in previous standard (5 – 42 MHz bandwidth, TDMA sharing), but available bandwidth is up to 6400 kHz. There are already used QPSK and 16-QAM modulations. Maximal baud rate is 10.24 Mbit/s.

DOCSIS 2.0

This standard is fully compatible with previous versions and after certification in January 2003 was labeled as Q1 2002/Q4 2003. It has improved backward channel again, which uses A-TDMA (Advanced TDM) and S-CDMA (Synchronous CSMA) access methods and due these is suitable for multimedia applications. DOCSIS 2.0 with A-TDMA access method uses bands of 200, 400, 800, 1600, 3200, 6400 kHz width in a backward channel. Modulation is one of QPSK, 8-QAM, 16-QAM, 32-QAM, 64-QAM. There are 30 possible combinations of baud rate, and maximal baud rate in upstream channel is 30.72 Mbit/s. DOCSIS 2.0 with S-CDMA access method uses bands of 1600, 3200, 6400 kHz width in backward channel and uses modulations QPSK, 8-QAM TCM, 8-QAM, 16-QAM TCM, 16-QAM, 32-QAM TCM, 32-QAM, 64-QAM TCM, 64-QAM, 128-QAM TCM (TCM Trelis code modulation). Commensurate with bandwidth and type of modulation there are 30 possible combinations of baud rate and maximal baud rate in upstream channel is 30.72 Mbit/s.

2. EuroDOCSIS

European Cable Modem Consortium (EuroDOCSIS) was established by end of the year 1998. This consortium for European cable modems has chosen ITU recommendation J.112 as a initial document and named it EuroDOCSIS. EuroDOCSIS comes from ITU J.112, so it is very similar to american MCSN DOCSIS, thought it has rather better parameters (e.g. maximal baud rate). EuroDOCSIS has besides version 1.0 newer and improved version 1.1, which supports QoS.

EuroDOCSIS 1.0

Forward channel has bandwidth of 8 MHz unlike MCSN DOCSIS, and is placed in a frequency range of 96 – 864 MHz. It appears to be a better situation, because it allows higher baud rates. For example: with modulation 64-QAM is maximal baud rate 42 Mbit/s and with modulation 256-QAM is maximal baud rate 56 Mbit/s. Backward channel has spread frequency band according to this recommendation, which has 5 – 65 MHz width. Due to this it is able to place backward channel onto higher frequency. It is obvious, that EuroDOCSIS offers better parameters then MCSN DOCSIS.

EuroDOCSIS 1.1

This version has already implemented QoS. EuroDOCSIS 1.1 has also implemented multimedia applications and IP telephony (VoIP). Version 1.1 uses the same modulations as previous version, 16-QAM and QPSK with maximal baud rate of backward channel of 10.24 Mbit/s.

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Measurement of GNSS Signal Parametrs in Difficult Environment

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The Global Navigation Satellite Systems (GNSS) are designed for position determination and navigation. The GPS system is the most widespread Global Navigation Satellite System and can be perceived as a model for other following systems (GLONASS, GALILEO).

The GPS position determination is based on the satellite-to-user distance measurement. The specially designed signal is transmitted by GPS satellites. The signal propagation delay is measured to obtain the distance information. Availability and reliability of the GPS measurement is affected by intensity and quality parameters of the signal received by user equipment. The signal propagation conditions depend on the environment in the neighbourhood of the user equipment.

The GPS is designed for using in uncovered terrain. The signal attenuation by terrain barriers may cause impossibility or unreliability of the signal processing. The satellite-transmitted signal is relatively weak, the power level on the omni-directional linear polarized near-ground antenna is up to –160 dBW only. The additional 15 to 20 dB attenuation is critical for usability of GPS signal in case of common signal processing algorithm. Furthermore, the attendant multipath effect impairs the measurement precision significantly.

Availability and reliability of navigation services supported by GPS receiver with the common signal processing algorithms are insufficient for many applications in terrain depressions, in forest or in urbanized areas and especially for indoor applications. The improved algorithms have to be developed for these purposes. The two significant ways of improvement will be investigate: the more effective signal processing and external assistance by a localization server connected with a communication channel (GPRS). The first mentioned way is referred in this paper.

The effective signal processing algorithm design has to be based on the signal propagation modeling in the complex environment. The mathematical model of the signal propagation has to be prepared in the concordance with the real environment need to be verified by physical measurement. Impulse response is considered as sufficient characteristic for description of the physical environment influence on the GPS signal propagation. This characteristic describes attenuation, disperse and the signal propagation delay profile.

Physical measurement of the environmental impulse response is difficult due to very low level of the GPS signal in tested environments (indoor). The extremely long intervals of signal integration have to be applied. Consequently, high precision and stability of the reference frequency base have to be ensured. The full bandwidth of the GPS signal (20 MHz) induces requirement of the high sample frequency. On the other hand, the wide spectrum of the GPS signal enables to reach high resolving power of the signal propagation delay profile.

A special receiver for measurement purposes was designed and constructed on the Department of Radioelectronics of the CTU FEE. This receiver allows advanced signal

processing of arbitrary GNSS signals in the frequency band 1 to 2 GHz. The radio-frequency part of this receiver contains two independent tracts, which are controlled by a common precise frequency base. The wide-band signal from each tract is digitized by high dynamics A/D converter. The digital signal processing is provided by FPGA Xilinx Virtex II device. A PC computer with high numerical power provides the final signal processing, result interpretation and real-time receiver control.

The measured signal was processed by the advanced GPS correlation technique (strobe correlator). The cross-correlation processing between measured signal and reference signal was provided. The second time difference of the discrete time replica of the transmitted GPS signal was used as the reference signal. The precise frequency and time synchronization was obtained by the auxiliary high-quality outdoor GPS signal processed by the second tract of the receiver.

As the first set of measurements, the residual GPS signal from indoor area of the CTU FEE building was processed. Occurrence of the residual GPS signal was proved. Attenuation of indoor GPS signal was estimated and the signal propagation delay profile was evaluated.

The range of provided experiments was limited due to numerical demands of the signal processing tasks. We plane to perform next indoor and outdoor measurements in future. The results from these measurements will be used for construction of the mathematical model of the signal propagation. We assume to use this model for design of new GPS/GNSS signal processing algorithms for the indoor and difficult outdoor environments.

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Augmentation of GNSS via GPRS Data Channel

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The Global Navigation Satellite Systems (GNSS) are designed for position determination and navigation. The GPS system is the most widespread Global Navigation Satellite System. The other systems (GLONASS, GALILEO) are not finished yet, but they are expected for completion in several next years.

The GPS is usable for localization and navigation anywhere on the Earth. But, the availability and reliability of this system is afected by impact of signal attenuation and multipath caused by properties of the users environment. Importance of this affects depend on type of GPS application and mainly on characteristic of the GPS signal propagation in the user environment. The signal attenuation by terrain barriers may cause impossibility or unreliability of the signal processing. The satellite-transmitted signal is relatively weak, the power level on the omnidirectional linear polarized near-ground antenna comes up to -160 dBW only. Additional 15-20 dB attenuation causes unusability of GPS. Availability and reliability of the classic GPS signal procesing algorithms are insufficient for many applications in terrain depressions, in forest or in urbanized areas and especially for indoor applications.

Time variability of attenuation and multipath effect interfere the signal continuity and impair the coherence of data demodulation from the GPS signal. The information (satellite ephemeris) carried by the data is necessary for user position computation. The discontinuity of received signal causes an appreciable extension of delay before the first position can be computed (TTFF, time to first fix).

The Assisted GPS/GNSS (AGPS/AGNSS) is a common name for a set of measures or techniques, which uses GPRS or other data channel for improvement of GPS/GNSS parameters in case of weak or disturbed received signal, in particular the availability, continuity and reliability. The simplest AGPS technique is based on the ephemeris transmission.

Noticeable reducing of delay before the first position fix can be achieved, with data transmission of ephemeris via other data channel, which is independent on the quality of GPS signal. The GPRS service of the GSM data network is suitable channel for this purpose. The ephemeris are received and decoded by the DGPS reference station or other specialized GPS receiver, which is located in position with good quality GPS signal. The ephemeris data volume can be reduced by appropriate compression to approximately 1 kB (for 12 satellites). The equivalent transport time through GPRS channel is about one second. It is significant reduction in comparison with time for classic ephemeris data transport method, which is 20-50 second for clean GPS signal or several minutes typically for disturbed GPS signal.

A more complicated, but more efficient AGPS technique is based on the localization server. The user GPS equipment is simplified significantly and it sends samples of received GPS signal via GPRS channel to localization server. The localization server is connected to receiver in DGPS reference station; it obtains high quality data and GPS signal parameters from this reference station. The user position is computed from the signal samples delivered

via the GPRS channel. This position information is subsequently sent to user via backward GPRS channel. This technique may be combined with differential GPS without additional cost or advance of system complexity.

Described AGPS technique was implemented (in experimental form) and tested on the reference station in the Department of Radioelectronics CTU FEE. The receiver Garmin GPS-35 was used as external user equipment, which was connected to localization server through GSM or GSM/GPRS data channel. The localization server was realized as a separate process running in the master computer of the reference station. The user equipment sends compressed raw measurement GPS data to localization server. The position information computed from these data was logged in the filesystem of the master computer. Copy of this information was sent through the backward GSM or GSM/GPRS channel to user equipment. The completed experiment proves functionality of used technique. Limited configurability of the used receiver GPS-35 made impossible measurement of TTFF, because the raw data output is suppressed until the ephemerides are received.

A special GPS/GNSS receiver for measurement purposes is designed and constructed on the Department of Radioelectronics. This equipment is powerful enough and fully programmable. We plane continue AGPS development and experiments on the receiver in future. The main aim of this work is development and verification of AGPS/AGNSS algorithms and techniques together with the other extended techniques, such as the multicarrier or multisystem GNSS signal processing.

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Verification of Waves on the Conductor - Backed Slotline

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This paper describes experimental verification and theoretical analysis of the wave propagation on the conductor-backed slotline (CBSL) and its modifications. The special attention is paid to leaky waves. The leaky waves cause an undesired crosstalk in MIC but on the other hand they can be utilized for an antenna design. Leaky wave antennas have a low profile as the patch antennas, but operate in a wider frequency band. This advantage is appreciated by designers of wideband communication systems. The paper presents the two methods of the experimental verification - measurement of the field distribution of waves on planar transmission lines. The second part of the work deals with the method used to calculate the propagation constants and the field distribution of modes propagation on the planar transmission lines. The paper summarizes new findings concerning the surface and the space leaky waves on the modifications of the CBSL.

Verification of the dominant bound wave, the surface and the space leaky waves on the CBSL, the inverted conductor-backed slotline (ICBSL) and the modified inverted conductor-backed slotline (MICBSL) was published in [1-2]. The modifications of the CBSL on an easily available plexiglass or glass substrates with relative permitivity 2.6 respectively 7, substrate thickness 6 mm or 12 mm (for glass) and the variable width of the slot were designed. The active radiometry was used to measure the field distribution. A simple dipole, movable over the substrate fed by a noise diode, emits radiation. A radiometer receives the signal. Simultaneously modified way of the field measurement was used. The field is detected by a sliding monopole while a narrowband tunable generator feeds the line. The monopole is movable over the substrate. The field magnitude in the relative units, not the phase, is measured in both techniques.

The propagation constant is calculated by the method of moments modified as in the Galerkin testing procedure in the spectral domain. Unlimited line size in the longitudinal and transversal directions and infinite metalization conductivity are assumed. The method of moments, based on the Fourier transform (Fourier integral), is applied in the spectral domain where the propagation constant is determined from the condition of the solvability of the system of the linear equations. The electric field distribution is calculated by applying from the backward Fourier transform. The integration paths occurring in formulae specifying either propagation constant or field distribution must be chosen properly with respect to the investigated wave. For the analysis of the transmission lines limited in the transversal plane – shielded lines I applied the modified technique at which the Fourier integral is substituted by Fourier sum.

I wrote the new software in program language C++ Borland under operation systems Windows 98 or higher (optimal operation systems is Windows 2000) calculating the propagation constant and the electric field distribution on the 16 types of the planar transmission lines. All types of planar transmission lines are modification of the basic shape CBSL. The programs have graphical interface for the better co-operating of the user wiht the

computer. New tools for viewing the electric field distributions in 2D and 3D were produced too. The 3D electric field distribution is created by graphical tool OpenGL which is used for 3D computer games. This tool enables to animate the wave propagating along line so the user can better distinguish the different types of modes. The knowledge, I have gained during last three years of working in this field, enabled me to write the program for simple analysis of planar transmission lines [3]. The program can be freely downloaded from www pages

http://www.elmag.org/k317/projekty/frvs_nm/index.htm.

The paper presents the behavior of the waves propagating on the modifications of the conductor-backed slotline. The dominant bound wave, the surface and the space leaky wave were found on 16 types of lines. The field distributions of some of these waves were measured by the active radiometry and by the monochromatic signal. The measured data fit the calculated field distribution. Radiation from the CBSL into the half space becomes an advantage for special antenna applications. The paper would stimulate discussion of the field behavior of the dominant and of the higher modes on these printed-circuits lines.

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Education in Antennas - Phased Antenna Arrays

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The paper describes the new tasks related to the subjects taught at the Department of the electromagnetic field. These tasks combine the following topics of phased-array antenna education, firstly the simulation as preparation for the lab lesson and secondly the practical measurement in the antenna laboratory. This combination enables students to keep better in minds the topic. One of these tasks demonstrates the difference between the radiation patterns of the radiating elements, the array radiation pattern and the phased antenna array radiation pattern. At the beginning, a phased-array antenna software simulator would help students to prepare tasks before the lab classes are held. Then, during their work in laboratory (in anechoic chamber), they are supposed to measure required antenna patterns of each task below. Students are supposed to work out the measurement protocol. The software simulator enables entering many parameters of each radiator element of the phased antenna arrays: placement, supply current amplitudes, supply current phases and radiation patterns. This simulator solves radiation patterns of the phased antenna arrays and enables displaying the 3D radiation patterns and 2D cross-section in three planes (x-y, x-z and y-z). For further information, see the following literature [1], [2], [3].

Task 1 – Influence of the amplitude current distribution

The task allows students to observe the influence of the amplitude current distribution at the array radiation pattern. The current amplitude distributions follow: binominal, optimal, uniform, marginal and others. Each of them enables to change the following parameters: beam-width, side-lobes levels, gain and directivity. Students are supposed to measure radiation patterns of some distributions and compare it with the home-prepared characteristics. For this task, the linear array of the monopoles above the ground plane can be used. In the same plane, the radiation patterns will be measured by students. The microwave signal from the generator is divided into each radiating element through the attenuators, which provide the demanded current distribution of the radiating elements. The coupling of the radiating elements is neglected.

Task 2 – Influence of the phase current distribution

The task allows students to observe the influence of the phase current distribution at the array radiation pattern. It deflects the radiation pattern into the demanded direction. Students are supposed to measure radiation patterns with some phase shiftings and compare it with the home-prepared characteristics. In order to solve this task, linear array of the monopoles above the ground plane can be used. In the same plane, the radiation patterns will be measured by students. The microwave signal from the generator is divided into each radiating element through the phase shifters, which provide the demanded deflection of the radiation pattern. The coupling of the radiating elements is neglected.

Task 3 – Influence of the antenna element placement

The task enables students to observe the influence of the antenna element placement at the global array radiation pattern. It permits to change the following parameters: beam-width, side-lobe levels, gain and directivity. Students are supposed to measure radiation patterns of some placements and compare it with the home-prepared characteristics. For this task, any configuration of the radiating elements can be used. The coupling of the radiating elements is neglected.

Task 4 – Influence of the antenna elements

The task enables students to observe the influence of the antenna elements at the global array radiation pattern. Each radiating element has a different radiating function and consequently different parameters, for example, the monopole radiates around its axes, the helix and the patch radiate in its axis. It enables to change the following parameters of the phased-array antenna: beam-width, side-lobe levels, gain and directivity. Students are supposed to measure radiation patterns of the antenna arrays (which are composed of the helixes, patches or the monopoles) and to compare it with the home-prepared characteristics. For this task, the linear array of the monopoles, patches or the helixes above the ground plane can be used, because the monopoles and the helixes have substantially different radiation patterns. The coupling of the radiating elements is neglected.

Conclusion

The paper describes the tasks created for teaching phased antenna arrays. They are included in antenna theory subjects. The first two tasks are aimed at the current distribution influence (amplitudes and phases of the currents), while the following two tasks are aimed at the used radiating elements influence (element placement and element parameters – radiation patterns). This paper also discusses the following principles of the education: current distribution determines all antenna parameters, difference between the antenna and the antenna array, connection of the simulation and the practical experiment.

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Methods of Partial Discharges Measurement

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It has been demonstrated in papers [1-4] that the cavities or voids included in electrical insulation are filled with gases, which have lower breakdown strength than the surrounding insulation. Under the normal working conditions of the insulation system, the voltage across the cavity may exceed the breakdown value of the filling gas and cause a breakdown in the cavity. This phenomenon is called Partial Discharge (PD). This research is focused on methods using basically detection and quantification of PD charge per the voltage pulses in charge sensitive amplifier. Two different principles of processing PD events are used - analog and digital technique. This method is useful for non-destructive and non-invasive on-line diagnostic systems.

Partial Discharges originated by dielectrically defective parts of the high voltage insulation system result in its degradation, which may ultimately lead to a failure of high voltage apparatus. Partial discharges can be detected and localized by various electric or non-electric techniques. For example PD detection by radio frequency or acoustic emission during discharge and by the after-discharge chemical reactions product such as ozone in gas filled isolation systems. This work is focused on methods using basically detection of the voltage pulses.

Preprocessing steps would be applied because of PD pulses signal extremely wide frequency spectrum. Partial discharge voltage pulses in solid dielectric systems are short with approximately rise time 10 nanoseconds and exponential falling edge up to 10 nanosecond time constant. These pulses are about 10 times longer in liquid dielectric fluids (transformer oil).

The total charge is computed and converted to DC voltage in charge sensitive amplifier (integrator). The result is DC voltage increased by the each PD event. For proper functionality the charge sensitive amplifier would be zeroed by the master circuit (microprocessor) or by the discharge constant much longer than input charging pulses.

In the realized PD meter sample, shaping amplifier and charge sensitive amplifier are replaced by passive coupling network on logarithmic amplifier input. This technique have major advantage of superior dynamic range (92dB with Analog Devices AD8307 log. amp.) and lower number of analog components. The passive coupling network realizes band pass filter 30-300kHz, but these cutoff frequencies are not finally evaluated. The filter output signal is logarithmized in logarithmic amplifier and maximal value is held in peak detector.

Alternatively this work is focused on direct digitalization of the integrated PD pulses with high speed ADC and fast digital processing by Field Programmable Gate Array (FPGA). In FPGA there are included shaping circuits, peak detector and storage memory for PD time distribution figures.

For this type processing the shaping techniques as described above are not suitable, because of heavy computing amount is needed for them – a lot of multipliers-dividers and summators. Shaping circuits are realized as digital delay lines and substractors that produce sharp digital pulses. The pulses are accumulated for increasing signal to noise ratio. The digitally shaped pulses are sharp and short. In case of 40 MHz ADC clock and the pulses eight or four ADC clocks long and output pulses are 200 or 100 nanosecond long (for our example). By the digital method increasing of time resolution is reached, because "dead time" of the aparature is as short as time resolution. This digital technique also has possibilities of good pile-up pulse rejection.

The digital shaping technique looks be perspective, because it's next important advantages: small count of analog circuits and high EMI immunity. In other hand analog technique uses relative simple components. Used coupling technique is non-invasive and is suitable for new or installed machines on-line predictive diagnostic. If the measurement equipment is synchronized with proper AC line sources of PD can be localized in tested power machines.

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Software Solution of GNSS Receiver

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The modern designs of GNSS signal processing require a powerful and variable design platform for their validation. The obvious way for making design more variable is to use software solution for signal processing as more as possible. Such solution is especially suitable for receiving and processing new European navigation satellite systems such as EGNOS or GALILEO because their specification isn't completely done yet. Furthermore, the design and validation of system intended for poor signal strength environment or multipath damage signal environment can highly use this approach too.

There are some software approaches based on GEC Plessey circuits (e.g. *OpenSource GPS*). This solution can't be an appropriate design platform because of low variability of this system (fixed correlation structure given by Plessey circuits). Our solution is based on powerful PCI cards with FPGA chip, which cooperate with personal computer. This enables a more flexible and efficient design of receiver for general navigation systems.

Our software uses an *Experimental GNNS Receiver* as a hardware platform, which was developed in our department. The hardware consists of *RF unit*, *DSP unit* – Nallatech's BenONE PCI card with Xilinx Virtex II FPGA and *PC workstation*. The details concerning the Experimental GNNS Receiver were discussed in [1 – 4].

According to hardware units the software can be divided into software for DSP and software for PC workstation. DSP software realizes a correlators structure on FPGA. High level DSP system modeling uses Matlab Simulink tools. The tested Simulink system together with auxiliary VHDL block can be convert into VHDL program. The VHDL code is then processing with Xilinx ISE and can be load into Virtex II FPGA. PC software not only controls correlators structure into FPGA but also provides position computing and realizes user interface.

The challenge, which should be solved with software, can be divided into three separate tasks: control and GUI, channels processing and position computing. This division is used as a basis for splitting into particular processes or threads. Despite the problems with sharing data between these processes, the splitting enables more efficient utilization of computer hardware sources in OS with preemptive multitasking. Thus it is useful to influence the scheduler treatment of the time slice with adjusting process priority. E.g. the correct function of DLL/PLL loops requires periodic controlling (500ns to 1μs) of correlator values and adjusting frequency of appropriate NCO. Wrong scheduler treatment can cause a lost of tracking signal in some situations. Other situation is the position computing task, which period can be relative long (100ms) and hasn't no strict time demands. Thus this task can use a low priority.

Obviously we need multitasking/multithreading OS for PC workstation. Because of strict time demands (the DLL/PLL tasks), the Real Time OS should be convenient for PC. But it proved to be sufficient to use ordinary OS, when critical processes have higher priority and PC workstation has an appropriate high performance. Important factor for OS choice is availability of development, debugging and visualization tools (IDE).

In our situation was choice of OS an IDE given by BenONE card programming interface library (API) for particular OS and language. On the base this restrictions we use a Win2000 OS and Borland C++ Builder IDE.

In writing code level the individual process or thread consists of several programming modules. Appropriate splitting code into modules can bring big advantage in portability. Some modules, e.g. containing code for loop tracking or position computing, don't depend on specific hardware or don't use OS API function, can be easily portage on arbitrary platform.
Our solution consists of a few separate processes: `GNSSrec`, `rcv_pk`, `prn_nmea`. They use shared memory for interprocess communication. The `GNSSrec` process is further divided into two separate threads: *GUI thread* and *loop thread*. Because threads share their common address space, we can simply use global variables for interthreading communication. In booth case (interprocessing and interthreading communication) we must ensure synchronization of shared address space access.
The `GNSSrec` is core of software receiver. Its loop thread is the most critical part of whole receiver. The receiver performance strongly depends on good loop thread design. The loop thread manages DLL/PLL loops, i.e. manage correlator registers in individual channel states. The other significant loop thread task is maintaining the shared memory with loop measuring results (a base for pseudorange estimation and navigation data decoding). The GUI thread is responsible for correct card initialization, provide a user interface, show channel status on display and makes log files.
The task of `rcv_pk` process reads data from shared memory (maintained with loop thread) and computing a position. The position is written into another shared memory. This memory is then read with `prn_nmea` process and displayed on terminal.

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Multimedia Support of Linear Circuit Education Using Internet

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The aim of this project was to support education of subjects of Linear Circuits and Electric Filters. Mainly it is software support by system for electric filter design. The system is based on SYNTFIL library of functions programmed using MAPLE macro-language. The main goal was creation an interface for using this design system in the Internet environment. It allows to use the system through internet on computers without any special software installation.

MAPLE is a versatile mathematical program that facilitates both symbolic and numerical computations. All main computations are made in this program by means of SYNTFIL library. The library contains functions for solving particular tasks in the complete design procedure of electric filters. These functions allow computation of filter magnitude approximation, consecutive synthesis of filter electrical circuit and analysis of designed filter structure. The library has two main parts:

- Set of functions for solving approximation tasks, mainly frequency transformations, computation of filter order for a chosen type of approximation computation (Butterworth, Chebyshev, Cauer (A, B, C) and Inverse Chebyshev (A, B) approximation).

  All partial results are available, for example secondary parameters of the filter, zeros and poles of gain and of characteristic function, gain and characteristic function, partial gain functions appropriate for cascade realization.

- Set of functions for filter realization, mainly computation of chain matrix from gain and characteristic function for a chosen load, realization of polynomial and elliptic LC ladder filters, cascade realization of ARC filters (SFB of 1st and 2nd order).

  Analysis of resultant structures is possible by another functions. Real properties of the resulting filter structures can be also analysed entering particular atributes of elements (Q of inductors, A_0 and omega_t of operational amplifiers) or rounding resistor values to values of E24, 48, 96 end E192 series.

In the period of widespread global information technologies it is very advantageous to create also an interface for using this design system in the Internet environment. User interface is based on WWW (client-server conception). The computation and interface program runs on the server and a user uses an arbitrary graphic client i.e. standard WWW browser (Netscape Navigator, Internet Explorer, Mozilla, Opera etc.) for results displaying only. The server runs under operation system Linux. The design of filters is solved using the above-mentioned SYNTFIL library in the mathematical program MAPLE. GnuPlot program is used for drawing graphs. There is one difference: result from GnuPlot isn't a text, but it is a picture in PNG file format. Both programs are run using batch-processing witch must be supported.

Procedure of calling GnuPlot is analogous to a procedure of calling Maple. The interface between those programs and WWW is built up on scripts in PHP and Bourne again shell

(BASH). According to client requests the results are presented by dynamically created WWW pages. These pages are provided to the client by means of HTTP server Apache.

The described application of filter design was realized according this model. Input requests are inserted in forms in WWW browser. The program in JavaScript tests the validity of these requests before sending them to the server where it is tested, too. Input files for MAPLE computing program are generated from input requests by PHP and BASH scripts. The results are saved in separated files. The PHP scripts process these files and create the structure of dynamic WWW pages, which are sent to the client. It is needed to solve many other problems, for example, to distinguishing simultaneously connected users, deleting temporary files and directories. Cookies, session variables (PHP), etc. solve these problems.

Dynamic Internet pages were created for synthesis of analog and digital filters as a support of education. These pages help very fast to solve routine tasks and simply enable to compare attribute filters with different options. Student can focus to physical and electrical center of problem. The whole system is well structured, modular and open. It is possible to use it for many various applications. The application for electrical filter design was created in this case.

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The project was focused to innovate equipment in department's laboratory that is used for education students in precision mechanics and optics specialization and common education for students in lower years. The actual application of grand results comes next semester, when every student of the third study year check up quality of realized work in the subject „Technical Measurement". The laboratory are used for interfaculty education too, since we participate in education of students from 2nd Faculty of Medicine, Charles University in Prague in bachelor degree study program „Optics and Optometry". The innovation program linked-up to changes in study plans as integration of small departments and relocation Division of Precision Mechanics and Optics.

In the project was built and rebuild a wide range of tasks and laboratory experiments for demonstration and practice of measuring techniques, principles and measuring devices for detection and recognition of technical element parameters. This knowledge is important for regular using in consecutive technical praxis. The aim of this project was provide higher quality if education and improve and enlarge experimentation's opportunities on department.

The first group of tasks is focused to contastless measurement of physical quantities as a length (or more generally size of parts) or temperature. These tasks are based on measurement with digital image and image processing methods. It can be compare with classical length measurement. Two systems for image acquisition are applied - the digital photography camera with high resolution and common CCD camera with TV output. It can demonstrate different measurement quality in dependence of image acquisition system. The first acquisition system is based on Olympus Camedia C-50 Zoom with 5 megapixels resolution, 2560x1900 pixels, which is higher resolution but with lower data transfer speed. The frame rate of this system is determined by the shortest delay between two shoots on camera and speed of data transport to computer (USB 2.0 bus). The second system is faster (standard video bus with National Instruments PC grabber card [1], e.g. about 25 frames per second) but with worse resolution quality only 420 image rows. Both systems are to be used for demonstration influence of illumination quality onto data processing too. Images are processed with PC equipped with image software. The results are compare with common mechanical measurement methods or with results from optical reading microscope. Other usage of digital image is interference field measurements. The classical interferometer device was innovated. The illumination set-up was rebuilt for use of different light sources as a laser or discharge lamp. It allows to perform interferogrammetry of 2D-temperature field or flatness measurement along 1,1 m distance. The image of interference field is scanned by CCD camera which enable much easier evaluation of interferometric stripes distance and shape then common evaluation based on classical photography and microphotometric methods.

The second group of tasks is focused on measuring of optical devices parameters. The two devices for measuring of light sources characteristics as bulbs or Light emission diode was rebuild. It can measure both directions emitting characteristic and spectral

characteristic at once now. Rebuild device can measure direction dependence light emitting with automatic stepping and scanning of detector signal. Rebuild apparatus offer to measure not only light sources characteristics, but due to its removable parts also spectral characteristics and direction characteristics of filters, diffusers or generally optical parts even with irradiance direction dependence. For spectral measurement a linear diode array digital spectrograph is used and data are processed on PC. A part of this group is special task for measuring optical and physical parameters of fluids and its concentration. This task is based on interferometric measurement of refractivity of fluids, especially carbon oxygen and nitrogen. The task was equipped with a new digital pressure and temperature gauge, which allow to acquire measured data directly to PC to provide temporal refractive index changes measurement. This task shows students thermal and pressure affects on the refractivity of gases or its mixtures and similar affect to refractivity of fluid mixture composition change in adiabatic process.

The third group of tasks is focused for mechanics. An experimental device for testing and measuring parameters of driving mechanisms with stepping motors was build. The stand enable place different types and sizes of stepping motors from (NEMA standard)[2]. The goal of this experimental system is to present the influence of different loads with combination of moment of inertia and torsional moment to dynamic parameters of simulated driving system.

Majority of mechanical parts of build and rebuild tasks is designed with support of modular system machinery construction based on aluminum profiles.

The impression of results of this grand to education quality is emphasize cooperation for investment CTU grant that equipped department laboratory with new lab furniture, antivibration table with holographic set and diode laser.

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Test System for Symmetrical Interfaces

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To take complex precise measurements and be able to analyse its outcomes, appropriate software and hardware tools are required. As most of already existing applications are either not accessible or designed for concrete hardware devices, solutions and aims, new tools have been made for testing symmetrical interfaces at the Department of Telecommunication Engineering. As a main hardware unit, spectrum-network analyser HP 3589A was used. The HP 3589A allows measuring signal in the range from 10 Hz to 150 MHz. The analyser is equipped with a non-symmetrical input and output. Hence, to take measurements of symmetrical interface, there is a need to use either symmetrical transformers or differential probes.

Drawbacks of available measuring transformers are high purchasing costs, restricted bandwidth and one value of its an input/output impedance. For these reasons there have been developed differential probes to be used for measuring of a frequency from 10 Hz up to 150 MHz when measuring devices got an option of automatic calibration. The probe's output transfer functions are fairly flat with deviations within ± 0,1 dB when used analyser HP3589A with an automatic calibration option. Without the automatic calibration the available bandwidth with deviation ± 0,1 dB is within 10 Hz to 6,5 MHz where the cut-off frequency 3 dB attenuation is at 35 MHz, 6 dB attenuation at 60 MHz and 34 dB at 150 MHz.

Next requirement for the probes was universality as for input/output impedance on the symmetrical side. Currently there are possibilities of taking measurements with interface impedance 100 Ω, 120 Ω, 135 Ω, 66 kΩ. Nevertheless, modular concept of the probes allows other interface impedance realisation.

The probes design was optimised so that it would not have an impact on the signal processing properties of HP3589A. The manufactured set of differential probes consists of N/S Active Probe (differential probe with a non symmetrical 50 Ω input and a symmetrical output with adjustable output impedance), S/N Active Probe (differential probe with a symmetrical input with adjustable input impedance and a non symmetrical 50 Ω output), interchangeable interface device allowing input/output adjustment, interconnecting cables, power supply and power leads. Similar set of differential probes has already been used for extensive period of time for cables measurement by company Prakab Prazska kabelovna, a.s.

The injection and monitoring differential probes have been developed to carry out noise instrumentation within range 10 Hz to 12 MHz and other line parameters on ADSL. The set of probes consists of N/S Injection Probe (injection differential probe with a non symmetrical 50 Ω input and adjustable output impedance 2000 Ω or 2700 Ω) capable of supplying 1,2 Vp-p voltage to 100 Ω or 135 Ω load, S/N Monitoring Probe (differential probe with a symmetrical input and high input impedance 66 kΩ and a non symmetrical output 50 Ω), interconnecting cables, power supply and power leads.

The further development of differential probes is aimed to improve their bandwith up to 600 MHz. Also bandwith of Injection Probes is to be improved along with the value of maximum output voltage. To sort out the maximum output voltage issue, there is a promising way in increasing the maximum output resistance through an active termination device which

consequently allows for high output voltage when 20 times smaller resistor on the amplifier output is applied. Such approach significantly improves signal dynamic range.

Following paragraphs describes developed software for an automatic measurement through HP3589A.

With newly created software can be the frequency range specified in two basic ways; Start and Stop frequency must be specified or Centre Frequency and Span must be specified. Another important parameter for these measurements is Frequency Resolution, which corresponds with a tuneable filter bandwidth used for the spectrum analysis. When measuring signal spectrum, two different modes could be used by the HP 3589A: Swept Spectrum or Narrowband Zoom. The main advantage of Swept Spectrum measurement is the possibility to measure wide range of frequencies (up to 150 MHz). On the other hand, the Narrowband zoom HP 3589A's capability uses digital signal processing to provide extremely narrow resolution bandwidths for spans of 40 kHz and less–down to 1,22 Hz, which result in 360 Hz to 0,011 Hz frequency resolution. These values allow very precise measurements but, on the other hand, they require a lot of time to be taken (from 0,01 s for 40 kHz up to 330 s in case of 1,22 Hz frequency span). In addition with averaging, which is used almost every time, the overall time is given by multiplying the actual needed time and the desired number of averaging. Here you can clearly see the time demands. In case of manual measurement, it would be almost unthinkable but while using automated software solution, it turns to a standard procedure.

The newly created software consists of three programs. First one, HP Lab Linear is designed to take linear distortion measurement through cooperation with spectrum and network analyzer HP 3589A. This program has a user-friendly GUI (Graphical User Interface), which allows swift and comfortable measurements taking. Measurement conditions are very flexible and user controlled.

Secondly, HP Lab THD is a program used to measure Total Harmonic Distortion of various equipments, e.g. generators, amplifiers, two-ports etc. It uses HP 3589A in Narrowband Zoom mode, which gives user the power to take very precise measurements in those frequency regions, where harmonic components are expected.

And finally, HP Lab IMD is sisterly product to HP Lab THD. Both programs were developed in parallel. They have very similar GUI and operating procedures. In case of InterModulation Distortion measurements, common (sine) generators cannot be used, but two-tone generators must be use. If no such generator is used, the program may use Agilent 33250 – Arbitrary Waveform Generator with built in memory for arbitrary waveforms, which may be loaded from this software and then used for intermodulation distortion measurement.

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Using E1 ISA-bus Kit for Line Coding Demonstration

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Since the main purpose of university education is to pass knowledge from teachers to students, there are two basic ways how this is being achieved on the university grounds. New information is presented to students during theoretical lectures and secondly, if possible, students may verify gained information during practical lesson under lecturer supervision. During practical lessons the students may use the latest technology in real application, special measurement tools or devices, PCs with specialized software etc.

We decided to show students line codes used for E1 interface in real, because it is necessary for them to understand the basic principles of line codes used in telecommunications and its differences. With AMI line code (Alternate Mark Inversion) there is not really much more to discover than is said during lectures. But it is not the case of HDB3 line code (High Density Bipolar). It is generally known that HDB3 is based on AMI line code with the solution of the problem of maintaining synchronization of both ends during long sequences of zeros. It is provided by replacement of a sequence of four zeros by adding a pulse of the same polarity as the previous pulse after sequence of three zeros. That fulfils one condition of line code only. Line codes must suppress dc components of the signal and carry on synchronisation. AMI successfully suppresses the dc component but doesn't do anything with long sequence of zeros. On the other hand, HDB3 breaks long sequences of zeros by inputting a pulse after three zeros (as it was already mentioned above). That looks very well indeed at first sight but it doesn't work as good in reality. In case of processing long sequence of zeros (e.g. 30), output signal would consist of sub sequences (each containing three zeros) separated by pulses of the same polarity. It apparently breaks long sequences of zeros but generates large number of pulses of the same polarity, which leads in creation of dc component. This is probably the biggest benefit to students, when they found out, that it is not that simple as they usually thought. What really happens in the line coder is, that the pulses of each polarity are counted and when there is a need of polarity disrupt these counters are taken into account. Coded bits are divided into group of four and according to the counters the group of four zeros is replaced by a combination 0001 or 1001, where the fact, that the group of four zeros has been changed, is indicated by pulse polarity violation of the last bit in a group.

This demonstration is provided in a workspace consist of personal computer with development board E1 ISA and digital oscilloscope where the signal may be frozen or saved into memory and then analysed offline. As it was mentioned in [1] and [2], we have developed ISA plug in card for personal computer equipped with integrated E1 controller and line interface unit. For purposes of education we also have developed the program, which allows for students configuration of E1 interface in two levels. The first level of configuration of E1 interface is called high level configuration. This mode of configuration allows for students to configure E1 interface via predefined functions such as type of line code selection etc. In the second mode of configuration of E1 interface, students have full documentation for E1 controller and line interface unit and can directly modify registers of the integrated circuit via interface provided by the same program as it was in the high level configuration mode. In this mode students could set a constant data into each channel of PCM30/32 signal transmitted onto E1 interface and observe the line code changes.

When the workspace was built up we decided to use it also for demonstration of impact of the size of termination impedance on the signal amplitude and shape. It is very useful for students to see the signal of E1 interface when the line is terminated with correct impedance of 120 Ω (we use symmetrical version of E1 interface) and the signal when the line is left unterminated and verified than their knowledge of wave theory on physical lines. Although the demonstration doesn't meet all requirements for wave theory validation (insufficient length of line etc.) students are very grateful for that demonstration.

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VHDL Based Programming of Digital Switching Arrays in Education

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Last year we have introduced huge changes into the practice lessons of Construction of Telecommunication Devices course. Today the course is aimed at design of the digital switching arrays. The design of the digital switching arrays is based on a hardware description language – VHDL. Verification of programmed source code is performed in two levels. The first level of verification is VHDL based simulation and the second level of verification is the real implementation into a field programmable gate array FPGA. FPGA has been chosen as a trade off between full ASIC development and construction using general purpose parts (controllers, processors or even parts with lower scale integration). We have built five identical workplaces each with two personal computers PCs. The first PC, more powerful, is used to program VHDL source code and verified it via VHDL simulator, and the second PC contains development board with FPGA Spartan II made by Xilinx.

As was mentioned above the first PC performs functions as programming and configuration of field programmable gate array, and verification of function of the designed circuit. The program itself is developed in ISE WebPack integrated environment version 5.1 made by Xilinx. This software has been chosen according to our good previous practical experiences and also due to the fact that it is offered for free by the producer. The development environment provides tools to accomplish all design stages beginning from the source code editor with VHDL syntax check, compilation, input/output pin mapping, and programming the field programmable gate array. Programming FPGA can be achieved in two ways. The first way of programming is direct programming of the FPGA when the configuration is preserved as long as the power supply works. The second way of programming of FPGA is the programming FPGA's supplementary configuration serial EEPROM. In that case, which we prefer, the configuration is loaded automatically to the FPGA after power up. Although this method requires an additional memory, it allows semi-permanent storage of the configuration. The second reason why we used additional memory to configure FPGA is the fact that the FPGA has implemented PCI interface, which requires configuration via PCI BIOS that is started after power up or reset of the second PC. Programming of configuration memory is performed via JTAG interface connected to the standard parallel port of the first PC. Integrated development environment also provides functions to examine and eventually modify final logical element interconnections. As these issues strongly depend on the compilation process, there are many options affecting the compilation available. It is always trade off between speed and size of the design implementation. In addition to all functions, which are necessary for successful development of FPGA, WebPack software brings the opportunity to use VHDL simulation program ModelSim. It is first useful feedback for students, which allows them to carry out validation of the design including simple tests of a propagation delay influence. Although the simulation might be considered as sufficient design stage for purposes of these lectures, simulated circuits are further compiled and programmed into the field programmable gate array, so that students are forced to solve all the practical problems of implementation starting up from structural design and leading to the final real signal measurement.

To verify correct function of the development board with FPGA the controlling PC contains logical analyzer ETC M121 with control software. Some inputs are currently connected to the pins of the programmable array on the testing board so it is possible to view state of outputs of the FPGA directly on the controlling PC. This form of signal inspection has been chosen among others (e.g. standalone oscilloscope usage) to reuse hardware already bought for another purpose and to save workspace.

As it has been already denoted, the testing PC contains development board with FPGA internally called PCI FPGA development kit. This board is connected to control PC via JTAG interface and also through TTL probes of the logical analyzer. Development board is implemented in the form of PCI card. Together with it, there is software dedicated to changing values in data and control memory included in FPGA. These memories, PCI interface, synchronization, and signal generator are also defined in VHDL. These parts of code are prepared to be used by students directly in order to allow them to concentrate just on the switching network design.

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Photon Counting Laser Altimeter for Planetary Exploration

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Solid state photon counting is a fast emerging experimental technique, which is opening new possibilities in deep space exploration. The recent achievements in the solid state photon counting technology enable us to construct detectors capable to response to both single and multiple photons signals with extremely high timing resolution in the wavelength range spanning from X-ray up to a near infrared. Our University had developed and tested the solid state photon counter based on silicon avalanche photodiode (SPAD), this detector has been selected for space applications for its unique properties: low operating voltage, low power consumption and high radiation damage threshold. The concept of the detector enables to avoid any analog signal processing – amplification and discrimination, which are usually both temperature dependent and power consuming. All the signal processing is based on logic circuits, only. To keep the appropriate biasing of the detection diode in the extreme temperature range of –80 to +50 degree Celsius, the detector biasing circuit has been designed and manufactured. No temperature stabilization is required within the entire temperature range. The detector is capable to operate in both gated and non-gated operational modes.

Planetary altimetry is the first candidates for solid state photon counting application. Our experience acquired in the deep space mission Mars'92 (USSR) [1] together with the numerical models show, that the altimetry can be performed from the orbit heights exceeding 1000 km using the moderate size, radiation and heat resistant optical telescope. The photon counting Lidar is a powerful tool for the planetary atmosphere studies. Our experience acquired in the mission NASA Mars Polar Lander '98 [2] shows, that the compact photon counting Lidar can analyze the planetary atmosphere, dust and aerosol distribution. The planetary laser transponder has been proposed to provide range measurements on the inter-planetary scale with decimeter accuracy. It will enable high accuracy deep space navigation. To detect the optical pulses at the remote side of the transponder link, the photon counting detector with nanosecond timing resolution is required. The solid state photon counting detector based on SPAD has been optimized for the transponder application. The Time Transfer using Laser Link (T2L2) experiment is based on detection of optical pulses with energies in the range of single to thousands of photons [3]. The picosecond time scales synchronization will permit to carry out the precise navigation on an inter-planetary scale. The collaboration with the Astrodynamical Space Test of Relativity using Optical Devices [4] (ASTROD) program is under consideration. The SPAD detectors have been found as the best candidate for the space segment.

The European Space Agency has nominated the photon counting altimeter as one of the principal devices for planetary research for the next decade. The first mission in view is Mercury with scheduled launch in 2010. The requirements on the device are rather strict: total mass below 5 kilograms, power consumption below 10 Watts. Additionally, the harsh radiation environment near Mercury requires, among others, small optical aperture of the device. Recently, the technology demonstrator of the altimeter and atmospheric Lidar is under development at our group. The altimeter technology demonstrator is based on the diode pumped frequency doubled Nd:YAG microlaser delivering 1 microJoule at 532 nm in 1 nanosecond long pulses with the repetition rate of 10 kHz. The electronics is based on a modular kit consisting of the programmable gate arrays and a control processor and software. The optical part of the altimeter is scaled down to simulate the real background count rate scenario and to reduce the energy budget link by a factor of 104 at the same time. The demonstrator should be capable to range objects at distances 0 – 5 kilometers in both night and day time. It will be used to develop data processing and filtering algorithms and to verify energy budget under various conditions.

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Photon Counting on Single Quantum Dots Photoluminescence at 1300 nm

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The quantum cryptography is an attractive application of single photon generation, propagation, detection and data processing. It permits to distribute the secret key for data encrypting and decrypting. Due to the single photon approach, any attempt to receive the key by the third party may be identified, this way; the extreme communication security can be achieved [1]. Both free space and fiber optics communication channels can be employed. We have been working on the single photon sources and detectors within the last year.

Quantum dots are very efficient light sources with sizes of a few nanometers. By tailoring their composition, size and shape it is possible to tune their emission wavelength. Devices based on single quantum dots enable new functionalities such as single photon emission [2]. We are studying the photoluminescence of single quantum dots grown by molecular beam epitaxy on GaAs substrates, which are emitting at a wavelength of 1300 nanometres. A micro-photoluminescence system optimized for optical studies of single quantum dots emitting in the infrared has been built at Ecole Polytechnique Federale de Lausanne. The features are a spatial resolution $< 1\,\mu m$ and a spectral resolution <0.05 nm. Ultrahigh sensitivity in the infrared (800-1600 nm) is provided by a liquid-nitrogen cooled linear array of InGaAs detectors. This system will is coupled to a fiber-based photon-correlation set-up for the measurement of the second-order correlation function of the radiation emitted by single quantum dots. The set up enables spectroscopic studies of single quantum dots emission in the near infrared spectral region. Our current research effort focuses on the realization of a Hanburry-Brown and Twiss (HBT) interferometer to observe the anti-bunched nature of the emission from single quantum dots. This will result in a single photon source emitting at a key wavelength for optical fiber applications, such as quantum key distribution. The standard scheme of the interferometer is based on two photon counting detectors and the time correlated photon counting process.

The requirements on the single photon detectors in a HBT setup are very stringent in terms of noise level and quantum efficiency. The correlation times of interest are within the range of picoseconds to nanoseconds. Recently, the single photon detector based on InGaAs avalanche photodiode developed at the Czech Technical University [3] has been implemented to the set up. The detector consists of the separate absorption and multiplication layer avalanche photodiode fabricated on the basis of InGaAs semiconductor. To enable the photon counting capability, the diode structure is operated in a so called Geiger mode, it is pulse biased above its breakdown voltage. The novel design active quenching and gating circuit is controlling the diode biasing. The entire detector package is cooled down to – 60 °C in a custom built cooling set up. The dark count rate of the detector is below 30 thousands counts

per second, the timing resolution is 4 nanoseconds full width at a half maximum. The detection quantum efficiency exceeds 10 %.

Collaboration between our two groups will enable a full optimization of our interferometer.

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SiGe Avalanche Photodiode for Geiger Mode Operation

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The Single Photon Avalanche Diodes (SPADs) have been developed in the early eighties [1]. Photon counting detectors based on Silicon SPAD operated in Geiger mode have been developed in labs on the Czech Technical University [2]. The unique properties of the solid state photon counter are: high timing resolution and stability, low operating voltage, simplicity and ruggedness. This detector has been applied in millimeter precision satellite laser ranging, in space research, in atmospheric LIDAR for aerosol detection and meteorology, in time resolved spectroscopy, fiber optics and sensor technology and others. SPAD detectors on Silicon may be employed in the wavelength region 220 – 1100 nm. For the wavelength above 1100 nm, Silicon is not suitable. Although the photons in the wavelength range 1100 – 1600 nm can be detected using the Si based photon counters, the quantum efficiency is too low for practical applications. However, the wavelength region 1100 to 1600 nm is quite attractive for numerous applications: time resolved fluorescent spectroscopy, biophysics, remote sensing, LIDAR, communications, and quantum informatics. The near infrared photon counters based on Germanium have acceptable quantum efficiency ranging from visible up to 1550 nanometres and picosecond timing resolution. However, they have to be operated in cryogenic environment.

One of the semiconductor material candidates for SPAD for the near infrared is SiGe. The theoretical models predict both the enhanced quantum efficiency in the near infrared and the increased timing resolution in comparison to Silicon based detectors [3]. To reach this performance the SiGe layer has to be at least several micrometers thick and the fraction of Germanium in Silicon has to be within the range of 20 - 70%. The world first published attempts to manufacture SiGe based photon counters with photodiode operated in Geiger mode have been made by our group in the early nineties [4]. The SiGe material has been prepared by Germanium implantation into the Silicon. The structures have been operational as photon counting devices at a room temperature; the timing resolution has been equal to a Silicon one. However, the SiGe preparation technology resulted in a low (< 1%) concentration of Germanium within a nm thick layer, not sufficient to increase the structure sensitivity in the near infrared and the timing resolution.

The recent achievements in SiGe mono-crystal growth permit to produce high conductivity silicon wafers with the SiGe epitaxial layer on their top with the Germanium concentration > 30% and with the quality acceptable for avalanche structure construction. The 4 inch diameter Silicon wafers with epitaxial layer have been acquired on a commercial basis, QINETIQ Ltd., Malvern Technology Centre, UK.

To achieve the forbidden gap of 0.9 eV and a working temperature range –40 ºC to +30 ºC we have designed the avalanche structure in the SiGe epitaxial layer on Silicon substrate. The epitaxial layer is composed of 40 % of Germanium and 60 % of Silicon. The p-n shallow junction will be created by ion implantation and following diffusion, the guard ring

will be created by a deep diffusion from a solid source. The SPAD structures will be of circular shape with active area diameters of 60, 100, and 200 micrometers and the break voltage of the structure will be 12 – 20 Volts.

The first structures have been prepared by Phosphorus diffusion from an implanted layer and by MESA technology. The MESA structure (etched under epitaxial layer) provides conditions similar to the structure with a guard ring; however it is more practical for experimental steps. The samples gave us the technological parameters for annealing and diffusion of the implanted layer. The vertical concentration profile of the SPAD structure has been measured by method of spreading resistance.

The V-A characteristics of the diode samples have been scanned on the curve tracer Tektronix 576. The p-n junction exhibits an avalanche break down characteristics; the break voltage is 12 V. The differential resistance of the structure above the breakdown voltage is 200 Ohms. The samples can be biased above its breakdown voltage and are to stay in this unstable state for more then 100 ns. In other words, samples can be operated in Geiger mode. Due to technology reason the metallic contact cover active detection area completely; the photo-detection properties cannot be studied for these samples properly.

The next series of avalanche diode structures dedicated for Geiger mode operated SPAD on the basis of the $Si_{0.6}Ge_{0.4}$ epitaxial layer on Silicon will be prepared by a planar technology with the standard guard ring. This will enable to test the detection properties in a photon counting mode.

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Linux Operating System in Measurement Technology

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This paper presents results of the project focused on the use of Linux operating system in measurement technology. The main benefit of project is the implementation of the measuring server integrated into computer network of the Faculty of Electrical Engineering CTU Prague. This server offers wide services as:
- demonstration of the utilization of Linux OS in measurement;
- examples of programs;
- development of measurement applications;
- means for distance education, etc.

Concrete results

I. An automated measurement and information system based on PC with Linux OS (the Red Hat 9.0 distribution). The system primarily serves as an IEEE 488 (GPIB) controller. The application of plug-in PCI data acquisition boards is possible. The system enables remote access via Internet using TCP/IP protocol.

II. An information WEB server (http://pck338-48.feld.cvut.cz) provides materials for education as synopses of courses, teaching texts, programming manuals, etc.

III. A system for development of Linux applications focused on problems of local and distributed measurement systems based on GPIB, VXI, PCI and Ethernet.

Development tools

Linux OS supports many programming languages (C, C++, Java, Perl, Lisp, Python, PHP, etc.). In our case the C and C++ languages are preferred. The compilers of these languages are
part of the GNU Compiler Collection (GCC). Source codes editing can be performed using either common editors (e.g. Emacs, vi or Midnight Commander editor) or Integrated Development Environments (IDE), such as Anjuta, Kdevelop, Kylix. IDEs simplifies development of complex applications (editing, compiling, linking, debugging, project management). In present time the Anjuta IDE seems to be the best vote (well-developed IDE with low system resource requirements).

Programming of GPIB systems is effectively performed using the VISA library defined by VXIplug&play Systems Alliance. In this case a choice of GPIB interface boards is restricted to the National Instruments AT-GPIB/TNT and PCI-GPIB boards. The other types of interface boards cannot be programmed using the VISA library and a device driver from the LINUX LAB Project (http://www.llp.fu-berlin.de) has to be used instead.

Application example

The simple application for data acquisition and data transfer is multi-threaded server with TCP/IP protocol implementation based on client-server model. The communication via Internet is performed using BSD sockets. For multi-threaded application there are POSIX threads implemented in Linux. The client part of the application is platform independent and can be created in any programming language supporting BSD sockets.

Conclusions

Described measuring server was successfully implemented and applied for partially distance education and training. For possible applicants it is available on the Internet address http://pck338-48.feld.cvut.cz.

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Short-Time Frequency Stability Testing

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In a number of cases it is helpful to characterize the testing signals by their short-term frequency (phase) stability (the effect of amplitude noise and harmonic distortion is neglected). In time and frequency metrology this kind of measurement is well elaborated and that can be advantageously used also for characterization of the ADC testing signals. Thus, for instance, it is a matter of standard procedures to calibrate, both in the time and frequency domains, the reference frequency sources (commonly high-quality quartz oscillators) used in function generators. The difficulties may only arise if the testing signal is of high purity and at a non-standard frequency (no matched reference available in the frequency domain or no enhancement sensitivity method available at this non standard frequency) at the same time. In the time domain direct frequency counter measurements can be employed at any frequency if the counter instability is smaller than the instability of the testing signal.

Generally, the shor-term frequency stability is represented as random variations in either the phase difference, $\varphi(t)$, or in related magnitudes as the phase-time difference $x(t) = \varphi(t)/2\pi\nu_0$, where ν_0 is the frequency of reference source, or relative frequency difference $y(t) = dx/dt$. The variations in these quantities can be characterized either in the time domain (in terms of variances) or in the frequency domain (in terms of spectral densities).

In the time domain we measure the average of relative (fractional) frequency difference

$$\bar{y}(\tau) = \frac{1}{\tau}\int_{t_0}^{t_0+\tau} y(t)dt = \frac{x(t_0+\tau) - x(t_0)}{\tau} \qquad (1)$$

where τ is the averaging interval. The recommended statistical measure of frequency stability in the time domain is the Allan deviation

$$ADEV(\tau) = \sqrt{\frac{1}{2}\left\langle (\bar{y}_{i+1} - \bar{y}_i)^2 \right\rangle}, \qquad (2)$$

where the symbol <> denotes the average over all samples. Thus *ADEV* is calculated from the adjacent samples $\bar{y}_i(\tau)$, $\bar{y}_{i+1}(\tau)$ that are measured with a time-interval counter (with no dead time between the measurements). *ADEV* can also be calculated from the time-difference samples, $x(t)$, using (1). *ADEV* has an advantage over the standard deviation in that it is convergent for all kinds of noises that occur in frequency sources. For the white frequency noise it is equal to standard deviation.

The Device Under Test (DUT) is connected to the counter input for this kind of measurement. Each time we measured m samples of $\bar{y}_i(\tau)$, at τ = 0.1, 0.2, 0.5....s, out of which $ADEV(\tau)$ has been estimated. The impact of the dead-time has been neglected, given the measurement response of the counter of about 10 ms. A high-resolution reciprocal Stanford Research SR620 counter was used with a Milliren MTI260-0504A quartz oscillator as external reference. The counter was set to the "Frequency" mode.

DIRECT TIME-INTERVAL MEASUREMENT

In case of this measurement DUT was connected to the STOP counter input. The counter was operating in the "Time" mode. The reference frequency, ν_0 = 5 MHz, was firstly divided to 10 Hz in a low-noise divider to define the basic sampling interval, τ_0 = 100 ms, and then applied to the START input. This allowed to measure the samples of the time differences $x(t)$.

Compared with the previous method, the counter noise contribution is by $\sqrt{2}$ larger because of the trigger-noise from two uncorrelated inputs. On the other hand, the knowledge of $x(t)$ gives advantageously more information about the noise process than merely the knowledge of its derivative, $y(t)$. Also, because of the continuous measurement there is no dead time involved.

CONCLUSIONS

Two function generators for ADC testing, HP33120A and Agilent 33250A, were tested in the laboratory designed for short-time frequency testing at Czech Technical University in Prague. The results of direct time-interval and direct frequency measurements were practically the same. Moreover, one more testing method in the frequency domain using precise Femtosecond Systems FSS1000E Phase Detector was proved at the Standard Time and Frequency Laboratory of the Institute of Radio Engineering and Electronics (IREE), Prague. The conversion between the stability measures in the frequency and time domains can be performed for the noises which are common in usual frequency sources [1]. This third method confirmed the results obtained from the time domain measurements.

The newly established workplace for the short-term frequency stability testing uses frequency references Milliren MTI260-0504A which were borrowed from IREE. The purchase of own frequency references is planed for the first quarter of this year.

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Practical Realizations in Microwave Technique

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Filters play an important role in many RF microwave applications. Emerging applications such as wireless communications continue to challenge RF microwave filters with ever more stringent requirements of higher performance, smaller size and lower cost. Because of these requirements, we have decided to integrate into our new educational program a subject called *Practical Realizations in Microwave Technique*. This program is recommended for students interested in planar microwave circuits, microwave measuring techniques and microwave simulation software tools, and at present improves the amount of hands-on exercises at the Laboratory of microwave, optical and antennas techniques.

The main purpose of this project is to familiarize students with design procedures and realizations of the most common planar microwave structures, as well as with their measuring. The project is innovative in a technical and in a pedagogical sense: a teaching, learning and evaluating methodology has been successfully conceived.

The first step in the conception of this project was the selection of the appropriate microstrip planar structures, i.e. ones showing adequate complexity and connectivity with the available technology. Another important criterion was the possibility of simulation in special microwave software (LinMic, WinMide, IE3D and Microwave Office); therefore, due to these requirements, microstrip planar filters were the best choice. So, a set of 15 typical examples of microstrip filters were chosen, together with the adequate study literature. The typical steps undertaken by a student in the design from scratch of a filter are summarized in the following paragraphs.

At the beginning of the design, the *Maple* program is used, as a very powerful tool for solving mathematical functions that define the frequency dependent characteristics. This program allows the student to select the optimal difficulty level, as well as the suitable frequency range for each filter. An important contribution for students is the visualization of many complex mathematical rules, which are necessary for filter design and his optimalization. This software also contain many tools specialized for filters design. The final outputs from this program are then the basic specifications (geometric dimensions) for each filter.

The second step in the design is the utilization of sophisticated software tools for electromagnetic simulations (Linmic, MicrowaveOffice, and IE3D) to check the design. Thanks to these software tools, students are able to optimize the final filter dimensions and also express some special properties, depending on parasitic capacitance and inductance in planar microstrip structure. These programs help to choose the optimal microwave substrate for a particular planar filter, and can also describe the effects of discontinuities at the boundary between coaxial connectors and planar microstrip lines, which may change the final scattering parameters. Therefore, the simulation at this level may be more precise and could even be necessary for the next step in the realization but it uses some software which requires high-performance hardware. Thus, access to a very powerful computer was granted to the students for some special simulations, which means that they can simulate and optimize their microstrip structure helped by professional microwave software tools.

The output of this simulation is the geometric structure with final dimensions, which are then exported into a typical technology format (Gerber file) and then transferred on the microwave substrate by a photo plotter, using the adequate technique. For practical realizations, it was necessary to purchase some materials, consisting of typical microwave substrates. Because the frequency range was between one and twenty gigahertz, substrates with different permittivities had to be chosen. Because of their excellent quality, we opted for substrates manufactured by the Rogers Corporation (Duroid).

The third step consists in the manufacture and completion of the actual filter structures by fixing the coaxial connectors to the planar structure. Then, a layer of surface anticorrosive material is applied, and finally the whole is placed into the box. For this task, a special work place equipped with many tools, construction materials and chemical products has been designed. This workplace is the main contribution for our educational program related to practical realizations. It is used by students finishing their diploma thesis, by students attending other, courses, as well as for PhD. students. It significantly contributes to the improvement of the quality of the students' realization, and allows them to deal with more sophisticated problems during their realization.

The final step is the measuring and comparison of the characteristics of the realized filter and its simulated model. For measuring students have at their disposal a set of typical microwave measuring equipment, e.g. a scalar network analyzer or a vector network analyzer. It is possible to determine each frequency-dependent scattering parameter, thereby fully describing the performance of the filter. Each result and experimental data from the student's project is presented as a protocol and in a short presentation. The realized filters are then used as educational samples in lectures from other subjects. Some filters are used for internal requirement at our department in some measuring systems.

The new subject *Practical Realization in Microwave Technique* has been introduced by the Department of Electromagnetic Field. Students attending this subject are able to improve their skills in microstrip filters design, and they can then solve and develop some novel planar filter structures. They can work and become familiar with typical microwave materials like microwave substrates and microwave connectors. They have the opportunity to use some specialized software tools for microwave design, as well as microwave measuring instruments. Thanks to this subject, students obtain a better preparation for their practically-oriented diploma theses.

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Tunable Low Pass Coaxial Filter

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Microwave system designs have traditionally depended on passive circuit filter implementations, involving tradeoffs between filter performance and size. There are many types of filter constructions and also many design possibilities. Because of this situation, it has been decided at the department to incorporate into our new educational program at Laboratory of microwave optical and antennas techniques a new project called *Tunable Low-Pass Coaxial Filter*. The main purpose of this project is to familiarize students with the design procedures and realizations of the most typical coaxial microwave low pass filters, as well as with their measurement. This project is innovative in a technical and in a pedagogical sense: a teaching, learning and evaluating methodology.

The first step in this project is to select an appropriate low pass prototype. The choice of the type of response, including pass-band ripple and the number of reactive elements, will depend on the required specifications. In our case, a Chebyshev low-pass filter with a cutoff frequency of 800 MHz, a pass-band ripple of 0.1 dB and a source load impedance Z_0=50Ω has been selected. Students may use the Microwave Office software for the LC prototype specification, as well as for the optimalization of the characteristics. As a first step, they have to optimize a LC ladder-type low pass filter, which is derived from pure mathematical computation. Because the actual realization of this coaxial filter is derived from the microwave design of a high performance low-pass filter that can be adapted for cutoff frequencies from 500 MHz to a few GHz, a mathematical model from Microwave Office has to be used.

The shunt capacitors are realized as low impedance coaxial lines, having their coaxial cylinder filled on the side of the inner conductor, and the inductors are realized as high impedance coaxial lines. The characteristic impedance of the line Z_0=50Ω replaces a lumped element. When the impedance is low for capacitive lines and the impedance is high for inductive lines, the electrical length of the line is short and the best performances are then obtained. It is then possible to easily design a model of such a coaxial structure because in Microwave Office has a library including many coaxial lines. Limiting factors are a lower diameter of the inner conductor, which creates a serial inductance and a higher diameter of the outer conductor which create a shunt capacitance. A critical limiting dimension is the aerial availability so diameters of 0.8 mm for the inner and 20 mm for the outer were chosen as a limit for both conductors. For the shunt capacitance, we choose a diameter of 16 mm, which gives a better pass band ripple and shorter capacitance sections.

In the next step, the Linmic sophisticated software tool for electromagnetic simulation was used for verification. Thanks to this software, students are able to optimize the final filter dimensions, as well as to express some special characteristics, depending on the parasitic capacitance and inductance of the coaxial structure. They may also simulate the effects of the connection between coaxial lines and SMA coaxial connectors which were chosen as output ports for this type of filter structures. Numerical simulation at this level may be more precise and even necessary for the next step in the realization, but this uses some software which requires high-performance hardware. Thus, access to a very powerful computer was granted to the students for some special simulations, which means that they can

simulate and optimize their microstrip structure helped by professional microwave software tools. Numerical simulation may also involve some geometrical asymmetry in coaxial step discontinuity, guaranteeing a more precise result. The output of this simulation is the geometrical structure with final coaxial filter dimensions.

A prototype of a telescopic coaxial filter with a tunable length has been created. Students have the possibility to alter some of its geometrical characteristics: the length of the serial inductor sections, the length of the shunt capacitors and the overall filter length. This means that basic filter parameters can be modified and their frequency-dependent characteristics may therefore be changed. Students may use the simulation results from the Linmic software to set up the final filter dimensions.

The final step is the measuring and comparison of the characteristics of the realized filter and its simulated model. For measuring students have at their disposal a set of typical microwave measuring equipment, e.g. a scalar network analyzer or a vector network analyzer. It is possible to determine each frequency-dependent scattering parameter, thereby fully describing the performance of the filter. Each result and experimental data from the student's project is presented as a protocol and in a short presentation. The realized filters are then used as educational samples in lectures from other subjects.

The new project *Tunable Low Pass Coaxial Filter* has been introduced as a new interesting project at the Laboratory of microwave optical and antennas techniques of the Department of Electromagnetic Field. Students attending subjects at the Laboratory of microwave optical and antennas technique are familiarized the design of coaxial filters and they can solve some new and advanced coaxial filter problems. They can work with typical microwave materials like microwave connectors. They have the opportunity to use some specialized software tools for microwave design, as well as microwave measuring instruments. Thanks to this subject, students obtain a better preparation for their practically-oriented diploma theses.

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Time-Domain Modelling of Microwave Structures

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Introduction

Modern radioelectronic and microwave circuit design and need for short development cycles require in fast and accurate electromagnetic field simulation tools. In recent years Time-Domain (TD) methods are becoming more and more popular. This is especially true for Finite-Difference Time-Domain methods. The method uses a discretization grid to convert continuous electromagnetic field satisfying Maxwell equations into a set of difference equations for discretized field values at grid points. Introduced by Yee [1], this method has been soon recognized as a modern and versatile tool. A number of papers has been devoted to it, pushing the state-of-the art computational electrodynamics beyond its former frontiers. Taflove [2] presents FDTD as a consolided, compact method capable of solving numerous problems.

Availability of new computers with gigabyte memories as well as gigahertz clock frequencies enables for solution of more and more complex problems. Yet even more complex problems arise, needing in more computer speed and memory. Fine-tuning of the method is still a matter of interest. As proposed by Yee [1], FDTD algorithm uses the leapfrog method to solve a set of difference equations. Such a method is potentially unstable, depending on the size of the time step. Also, a major factor that has a considerable influence on the precision is the time increment (Δt) of the FDTD algorithm.

An optimal value of Δt exists, resulting in fastest and most precise computation. The other reason for setting this constant properly is that even a small excess over its optimal value would result in instability of the algorithm. There is a condition for Δt called Courant [2], valid only for rectangular coordinates and an infinitely large mesh. So far, the optimum value for other coordinate systems such as cylindrical and spherical has not been known. In order to improve the aacuracy as well as speed of the process, the optimal value in other coordinate systems has been studied.

Method

New approaches have been used to find the best time step in geometries not restricted to rectangular coordinates.

First method [3] we used to determine the time step was based on modified variable separation method, applied to the set of difference equations. Each component of the field vectors has been assumed to be a product of 4 functions, each one depending on one

coordinate (or time) only. After variable separation, a number of solutions in can be found, each of these solutions representing one mesh mode. A stability condition can be found, requiring that the solution remains limited.

It is worth noting that a linear combination of the mesh modes can make up arbitrary initial state of the mesh. In other words, using variable separation method does not leave out any solution that could be expressed in the mesh.

The second method [4] used Railegh equation to determine wave numbers for highest modes. As the discretiyation mesh is limited in space, it corresponds to a certain cavity and possesses resonant frequencies. The wave numbers of these frequencies can be again used to find the critical time step.

Results

Using the abovementioned methods, one can obtain critical time steps for arbitrary orthogonal meshes. However, the number of mathematical operations may become prohibitive. That was why approximation formulae, accurate to four digits of precision, have been found for the critical time step of the Yee algorithm in cylindrical coordinate system.

Aplying the new approaches to classic rectangular grid yields the well – known Courrant condition, which is consistent with [2]. This is true for large grids only, and is in accordance with the fact that the derivation in [2] is made for an unlimited grid.

The obtained critical time increment Δt_c was verified experimentally by means of the FDTD algorithm itself. In order to verify that "our" critical time increment holds, we made two experiments with Δt slightly over and then slightly under our predicted Δt_c (using relative changes of about 1ppm). In all cases, exceeding predicted Δt_c values caused instability while lower values proved to be stable. To be on a safe side, we recomputed the field for many iterations to be sure that no instability appears.

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Novel Broadband Vector Microwave Measurement Methods

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Introduction

Classic vector network analyzers (VNAs) exploiting frequency conversion play a key role in the design, fabrication and verification of various circuits and systems. They provide full broadband characterization of the device under test (DUT) in the linear region. In addition, they enable to remove the effects of any discontinuities located between the DUT and the instrument itself.

However, their complexity and corresponding high cost caused that a group of novel instruments arose, among them six-port reflectometers being the most successful. Their common principle is the absence of frequency conversion. The corresponding loss of information about the phase is solved using a suitably designed reflectometer with scalar detectors and numerical algorithms. The algorithms serve two purposes:

a) during calibration, to solve a set of nonlinear equations,

b) during measurement, to evaluate reflection coefficient of the DUT.

In the following, two examples of such instruments developed at the Department of Electromagnetic Field will be described.

System with perturbation two-port

Common scalar network analyzer (SNA) along with a unique perturbation two-port (PTP) forms a system capable of vector measurement [1]. SNA is substantially cheaper than VNA but it provides magnitude of the measured quantity only. The PTP system provides not only full vector information from scalar data but it also removes systematic errors of the SNA that couldn't be originally removed.

The PTP that is placed between the DUT and the SNA servers as a variable impedance transformer. Then, a circle in the complex plane of the DUT's terminal containing measured reflection coefficient is transformed to a set of intersecting circles in the plane of the SNA's terminal. Each setting of the PTP produces a circle in the SNA's terminal plane. Intersection of the circles then corresponds to the reflection coefficient of the DUT.

The PTP system proved its viability in an experiment over a band of 7 – 14 GHz. HP 8757E SNA was used along with a PTP built in a structure of coplanar waveguide with cold FETs as voltage-controlled elements. The system was calibrated with seven impedance standards in the structure of the air 7 mm coaxial line. The difference between measured and nominal phase of reflection coefficient is in the order of several degrees and can be attributed to drift of system parameters during measurement.

System with resistive bridge

The second system developed at our department extends the idea of the PTP system in that it optimizes overall parameters of the PTP+SNA combination [2]. The original FETs acting along with parasitic reactances of leads as impedance transformer were replaced by differential Schiffmann's phase shifter in microstrip structure. Also, resistive reflection bridge of the SNA was redesigned and a second detector added. Thus, a completely new standalone instrument arose. It has an integrated swept synthesized generator, resistive bridge, diode detectors, A-D converters and other circuits. The instrument is controlled by personal computer by means of data acquisition card.
Experiments performed in the frequency band of 1000 – 2100 MHz demonstrated promising results. The maximum difference between measured and nominal reflection coefficient did not exceed 0,05 in magnitude. The system was calibrated by means of load and five shifted shorts characterized by means of the Agilent E8364A VNA.

Conclusion

Vector network analyzers with the absence of frequency conversion receive permanent attention at the Department of EM Field. Two designs were successfully tested along with numerical algorithms for calibration and measurement. Further modifications that should improve their accuracy, measurement speed, and even open the possibility to measure two-port devices are suggested.

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Innovation of the Course Microprocessor Technology of Telecommunications Systems

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The education of the microprocessor technology in the telecommunications engineering at the Czech Technical University in Prague was traditionally based on the general purpose microprocessors and microcontrollers Intel 86x, 8051 and Motorola 680x0, 68HC11. Due to the advance and specialization of microprocessors for the typical tasks found in telecommunication engineering, the syllabus of the subject was substantionally updated. The aim of the education is to demonstrate the common features and special functional blocks found in the microprocessors dedicated to the communications tasks. For the educational purposes the communications processor Ubicom IP2022 [1] was chosen.

The lectures make students familiar with principles, architecture, programming and applications of microprocessors in telecommunications applications. Both general and particular features of modern microprocessors are shown on the communications and internet processor Ubicom IP2022.

The seminars are based on the programming of the microprocessor IP2022 with special emphasis on the particular functional blocks. The students deal with individual semester-long projects. The semester project can be chosen from the sample offer or proposed by the student itself. The functional solution of the problem is required. For the practical training, there are 10 working places equipped with the Ubicom IP2022 Networking development kit available. On each Networking development kit work no more than two students at the same time. The Networking development kits are completed by the additional useful hardware in order to increase the variety of the practical tasks. Each setup is additionally equipped with the Bluetooth modules and different sensors that can be accessed remotely over internet or wirelessly. Each setup is equipped with LCD display found in mobile devices. Two setups are equipped with additional VGA displays. They are useful for the training of the programming of the tight loops exercised by the software VGA signal generation. Five setups are equipped with the simple servo mechanisms for steering of the position of the web camera. They are useful for the training of the programming of the internal timers/counters e.g. for the generation of the PWM signals. Two setups are equipped with CMOS image sensors for software implementation of the web camera including image compression algorithms. Because the factory made starter kits are relatively expensive our own modified starter kits are under development. To keep them simple and inexpensive, some features were modified. The starter kits can be used as a development platform, target platform for stand alone applications and for student's semester hardware projects.

Syllabus of the Lectures

Microprocessors in telecommunications, basic terms, families, overview
IP2022, architecture, functional blocks, signals, system integration
IP2022, instruction set
I/O ports, timers, RTC, watchdog, brown-out, ADC

Communication blocks for 10Base-T, UART, SPI, I2C, GPSI, USB
LFSR blocks for CRC, data scrambling, data en/decryption, whitening, hashing
Power management, system expansions
Support for the SW and HW development, ISD, ISP, remote managing
iPModule software concept, stacks for TCP/IP, UDP, HTTP, POP3, Bluetooth, powerline
IP3023, concept of multithreaded architecture for software I/O (MASI), instruction set
IP3023, true random generator, SerDes units, additional features

Syllabus of the Seminars

IP2022, features, architecture
Integrated development environment
Programming in C, introduction, libraries, preconfigured stacks
Programming in C, ports, timers, RTC
Programming in C, SerDes units
Programming in assembler, introduction
Programming in assembler, tight loops, SW generation of VGA signal
Programming in assembler and C, ADC, DTMF decoding
Programming in C, LFSR blocks, data en/decryption
Programming in assembler and C, LCD display control
Programming in assembler and C, Bluetooth stack, data transmission over Bluetooth
Programming in assembler and C, TCP/IP stack, simple web server
Programming in assembler and C, web camera steering
Programming in assembler and C, sensors, monitoring and reporting over internet

Sample Topics of Semester Projects

IP2022, data transfer from sensors via Bluetooth
IP2022, programming of a game for mobile phone on the LCD display
IP2022, phone answering machine using Flash memory
IP2022, intrusion registration and reporting via internet
IP2022, web camera realization using CMOS array sensor
IP2022, communication via infrared
IP2022, DTMF decoding
IP2022, DTMF generation
IP2022, sensor interfacing via USB
IP2022, bridge internet/USB
IP2022, bridge Bluetooth/USB

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Analytical Design of Optimal Comb FIR Filters

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Novel analytical method for the design of digital optimal equiripple FIR comb filters is presented. The filters are optimal in Chebyshev sense. The number of notch bands, the width of the notch bands and the attenuation in the passbands can be specified. The degree formula is available. The design algorithm provides robust tool for the evaluation of linear phase highly selective FIR comb filters.

In many applications of the digital processing of communication signals the removal of harmonic interferences is desired while leaving the broad-band signal unchanged. A typical one is to cancel power line interference. These tasks can be accomplished by comb filters. Comb filters are notch filters with equally spaced deep notch bands. The comb filter can be generated from either an FIR or an IIR prototype filter. The standard design procedure of the comb filter consists in the replacement of each delay with multiple delays in the lowpass or highpass prototype filter. In the design of comb filters, the width of the notch bands is essential. The available FIR comb filters exhibit relatively broad bandwidth of each notch band resulting in the attenuation of the desired frequency components. One approach to addressing this problem is to pair a pole with every zero. The effect of the poles is to introduce a resonance in the vicinity of the nulls and thus to reduce the bandwidth of the notchbands. The closer the poles are to the unit circle the narrower the notches will be and the less attenuation the desired frequencies will experience. This approach leads to IIR comb filters. The IIR comb filters exhibit very narrow notchbands, but their phase response is nonlinear. They produce substantial distortions of the output signal which appear near its flat region due to the group delay variation. This behavior is especcially apparent, if pulses are present in the signal as demonstrated recently. In [1] we have demonstrated the superior time response of FIR multiple notch filters due to their constant group delay over their IIR counterparts. In numerous applications, especially in the processing of pulse-like signals, the linear phase of FIR filters is essential. So far a procedure for the design of linear phase FIR single-notch filters is available [4]. In [4] we made a study of maximally flat FIR notch filters and their abridging which led to the efficient length of a corresponding impulse response. In [2] we introduced the design of equiripple double-notch FIR filters. The analytical design procedure is based on the extra lobes of the odd part of a Zolotarev polynomial. In [3] we demonstrated the design of triple FIR notch filter. Our approach presented in this paper addresses the analytical design of general FIR comb filters with extremely narrow notchbands. The narrowest notch bands exhibit optimal (in Chebyshev sense) comb filters with equiripple behavior of the frequency response in the passbands. Unfortunately, no analytical design method is available due to the lack of the analytical design procedure of the equiripple lowpass/highpass prototype filter. In our approach we do not need any prototype filter as we design the comb filter directly.

We assume the impulse response h(m) of odd length N=2M+1 with even symmetry. For convenience in notation we refer to a(m) as the impulse response coefficients understanding that true causal impulse response coefficients are obtained through a time shift. The analytical design of equiripple comb filter is based on the Chebyshev polynomial of the first kind $T_m(w)$, which represents optimal equiripple approximation of a constant on the interval [-1,1]. The generating polynomial F(w) of the multiple narrow band filter is based on the compounded Chebyshev polynomials T_R [L $T_r(w)$]. The compounded polynomial T_R [L $T_r(w)$] exhibits Rr+1 alternating extremes with the values 1 and -1 including the interval edges w=1, w=-1. Thus the normalized generating polynomial represents the optimal equiripple approximation of the zero value on r equally spaced disjoint intervals of the same width with respect to the equally spaced extremes of the same value between the intervals. The real parameter L affects the ripples in the passbands of the FIR comb filter. For increasing L the ripples of the filter decrease. The degree r of the inner Chebyshev polynomial defines r narrow bands. The even degree R of the outer Chebyshev polynomial defines R-1 local extremes between the narrow bands. The function Q(w) represents a polynomial in the variable $w= (z+z^{1})/2$ which on the unit circle reduces to a real valued zero phase transfer function of the corresponding FIR filter.

Filter design

The design procedure is as follows :

1. Specify the number of notch bands, the width of the notch bands and maximal attenuation in the passbands.
2. The degree r of the inner Chebychev polynomial is equal to the number of notch bands.
3. Evaluate the auxiliary parameter L.
4. Determine the degree R of the outer Chebyshev polynomial by the degree equation.
5. The real number R has to be up-rounded to the next even integer value.
6. Evaluate the polynomial Q(w) of the degree N=R r which represents the zero phase transfer function of the filter.
7. From the zero phase transfer function evaluate the 2 R r +1 coefficients a(m) of the FIR comb filter using conversion into the Chebyshev polynomial representation.
8. Calculate the actual attenuation in the passbands.

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Measurement of Concentration of gasses by Thermistor Using Zooming A to D Converter

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It is well known fact, that thermistor can be principally used for measurement of physical quantities which affect the thermal properties of properly chosen medium. The new generation of subminiature thermistors adds new possibilities of application or improves metrological properties of already known thermistor based sensors. The theoretical background outlined in this contribution together with experiments could be useful for the implementation of subminiature bead thermistors for sensors of physical quantities where thermal conductivity is of primary importance. As an example could serve sensors for chemical analysis based on thermal parameters of materials (measurement of concentration), chromatography detectors, vortices based flowmeter, flowmeters working on the principle of correlation, an array of thermistors for thermal field distribution measurement and similar applications.

The new generation of subminiature bead thermistors differs in many aspects from traditional well-known types and offers a variety of new applications especially for measurement of physical quantities. In this work equation of thermal conduction for bead thermistor is derived and the procedure for thermal conductivity measurement designed and experimentally verified.

One way how to measure concentration of gasses is a measurement of thermal conductivity of fluids by means of non-stationary hot - thermistor method. The principle of this method consists in finding the response of thermistor to the jump of temperature generated by the step change of heating current flowing through thermistor. The dependence of thermistor temperature on time during the heating process can be found by solution of the equation describing the exchange of heat between thermistor and surrounding medium.

The heat conduction equation is solved for point source of heat as this approximation adequately models the ball shaped subminiature bead thermistor. The equation of heat conduction is then expressed by partial differential equation. The approximation is valid only for large values of time.

The new generation of thermistors has metrological properties comparable to those of RTD based on Platinum. This fact justifies the replacement of well known exponential relation used for description of dependence of thermistor resistance on temperature by Stein – Hart equation.

In this implicit relation three constants are used allowing more accurate description of $R_T = f(T)$ dependance than it is in case of relation having only two constants and used for less accurate or obsolete types of thermistors.

As can be found from equations describing thermal conductivity, the amount of heat should remain constant during the process of measurement. During first experiments this

condition has not yet been fulfilled. The measuring circuitry most probably based on the feedback effect is now the object of further research.

There is yet another important requirement for precise measurement of thermal conductivity. The amount of heat delivered to thermistor during the transient heating process should be as small as possible in order to minimise the temperature difference between the thermistor and surrounding medium. The large temperature difference could lead to exchange of heat by free convection and consequently the conditions for the thermal transfer solely by conduction are not satisfied. From the similar reasons only certain part lying near to origin of the time record should be used for thermal conductivity calculation. On the end of transient process the temperature of the walls of measuring chamber affects the process of heat exchange leading to the systematic errors in thermal conductivity determination.

The work implement of integrated circuit XEMICS XE88LC05 with zooming analog to digital converter for measurement of thermal conductivity. The capability of the circuit to subtract the voltage offset corresponding to the zero resistance of thermistor is a valuable asset allowing to measure only changes of resistance after proper amplification (zooming) without cumbersome and complicated bridge arrangement of measuring circuit usually used in this kind of experiments. Zooming ADC forms one part of microcontroller which can be used for adaptive measurement and further processing of measured data.

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7th International Student Conference on Electrical Engineering POSTER 2003

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Student's research activity should be an inevitable part of the whole pedagogical process at all universities. Its main aim is to support an independent creative work of students and stimulate practical application of theoretical knowledge received during studies. We take for necessary and very useful to organize regularly student scientific conferences, namely because of comparison of contributions to solution of a certain research problem at different domestic and foreign institutions, establishing personal contact among young researchers, development of personal skills, and development of habits of research work and its presentation.

Students' scientific conferences POSTER organized by the Faculty of Electrical Engineering of the Czech Technical University in Prague began in 1995 as an internal meeting of students from all CTU faculties interested in the field of electrical engineering. In 1997, after two-year's experience, we decided to internationalize this event and invite both undergraduate and postgraduate students from neighbouring countries. Five following successful successors in 1998, 1999, 2000, 2001 and 2002 confirmed that this was a right choice.

The 7th international student conference on electrical engineering POSTER 2003 showed on further growing interest in this conference which was manifested by the 5 % increase of submitted contributions. The program committee selected for presentation 195 contributions of both undergraduate and postgraduate students from a record-breaking number of 245 submitted abstracts. Criteria of acceptance were namely based on the scientific quality and originality of student's contribution. Majority of contributions came from FEE CTU (142), 21 from other Czech universities and 32 from foreign countries (Germany, Poland, France, Hungary, the United Kingdom, Estonia, Belgium). The contributions were presented as posters in six specialized parallel sections :

Electronics and Instrumentation	42 posters
Communications	35 posters
Informatics and Cybernetics	35 posters
Power Engineering, Energetics and Material Science	33 posters
Management	15 posters
Natural Sciences	33 posters

Two page extended abstracts of individual contributions were published in the conference proceedings [1] that was passed to all participants at the desk of the conference.

POSTER 2003 was sponsored by the CTU Grant Agency, FEE CTU Prague, different companies (Czech Airlines, Siemens, Prague Energy Co. and T-Mobile) and scientific societies (the Czechoslovak section of IEEE and its Joint MTT/AP/ED Chapter) which

provided organizers with numerous prizes (flight tickets, mobile phones, books and journal subscriptions, etc.).

Members of evaluating committees chose winners and further rewarded contributions in individual sections. A total of 23 posters were awarded, 19 from FEE CTU Prague and 4 from abroad. Winners in sections advanced to the final selection where the program committee chose top posters awarded by special prizes :

EI 38 – Jiří Vajtr: Monofrequency generator 25 GHz,
C2 – Markus Beermann: Quantizer-adaption for hybrid video-coding
C16: Carsten Hoelper: Voiced/unvoiced/silence classification for offline speech coding
IC 17 – Mofreh Hogo: Educational data mining
IC20 - Pavel Kordík: Inductive modelling: Detection of system states validity
PE22 – Ladislav Musil: Mathematical model of liquid zinc feeder
NS1 – Pavel Čapek: Preparation of annealed proton exchanged channel waveguides in erbium doped lithium niobate
M11 – Miroslav Scholze: Model of assessment and controling company's strategy (balanced scorecard and its enhancement)

Six domestic student presentations, one in each section, received the IEEE Prize awarded by the committee of the Czechoslovakia section of IEEE.

To conclude we can state that the seventh international student conference POSTER 2003 was very successful. This fact is substantiated by yet another record-breaking number of participants and increased quality of presented posters. The program committee decided to continue in organizing this conference in the year 2004. The 8th POSTER 2004 is scheduled for May 20 2004

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New Generation of the Vibration Wire Devices

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The Klokner Institute of the Czech Technical University keeps the level of the vibration wire measuring technique on the world-top comparable level in the Czech Republic since fifties of the last century. Specific advantages of this measuring method in IN SITU applications spread the usage especially in building industry, so it is economically acceptable even for experimental research activities applied on the real constructions.

Due to the lack of miniaturisation possibilities of the vibration wire sensors, this method is not used in the industrial automation as well as in other areas suitable for mass production of the measuring devices.

To be price competitive at least in the specific area of the construction eg. mechanical function monitoring, optimization of the device family for reading and storing data was crucial. The basic task is to cover all application needs by a simple set of modular blocks, by a set of devices with optimal sharing of the functionality by hardware and software components.

The vibration wire method is mostly used for static readings. The set of devices for static measurement developed in the Klokner Institute with cooperation with the ASYS company consists of:

a) Basic one-channel reading unit with the accumulator cell, twin-wire connection of the wire sensors and the visual reading of the linearized digital output data.
   Recommended applications:
   - testing of complex systems
   - one-shot small scale experiments
   - backup of a larger scale experiment
   - experiments with the extreme long intervals between readings
b) Basic one-channel reading unit with a variable connectivity of the sensors and forced oscillation circuits
   Recommended applications:
   - same as a) plus
   - connecting sensors from a different producer
   - prolongs life-cycle of the sensors influenced by an aggressive environment
c) One-channel unit with an internal memory with the accumulator cell charged by an external adapter. It allows automatic one- channel reading or registration with help of an external channel switch with the possibility to check the proper value on the output display.
   Recommended applications:
   - same as a) and b)
   - especially suitable for co-operation with a measuring points switch equipped by a wireless connectivity or for points with a difficult access
   - check reading during walk-around
d) Mini switchboard with the internal memory and the switch (max. 32 / 64 points) charged by car-battery or backup accumulator charged by public power network adapter.

Recommended applications:
- middle range experiments with a computer based evaluation of results
- cooperation with a modem to transfer readings in a form of the SMS via GPRS (GSM) or Internet

e) Device for ON LINE evaluation of a histogram pair (frequency of readings cca. 10 Hz)
Recommended applications:
- checking of the static function changes during a service load of the construction
- using bridges for checking weights or pressures in traffic control.

In present there is optimized a set of devices for application of statistical dynamic methods. The goal is to predicate failures of the constructions on the base of the dynamical behaviour changes, on the base of the characteristic changes of the response to the service load. The aim is also the simultaneous determination of the influence of the load changes on the safety and life-cycle of the construction.

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Using of GSM/GPRS in Control System for Municipal Transport

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This paper is going to present an improvement in the control system for municipal transport by means of General Packet Radio Service (GSM/GPRS). This improvement eliminates human factor in control and information system and lowers operating costs.

Means of municipal transport in Prague is equipped with a board information system which mainly consist of board computer, announcer, Radio Communications Adapter (RCA), GPS receiver, receiver for visually impaired passengers and, in case of tram, also infrared control beacon. All these devices are interfaced by bus with protocol IPIS (enhanced version of Integriertes Bordinformations-system, IBIS) where the board computer is the master. The announcer holds voice equivalents of stops names and supplemental announcments. RCA allows wireless communication of vehicle with a dispatching and in the present day exists in several versions (analog radio, Tetra and GSM module). The board computer controls all the devices connected to IPIS, holds schedule and additional information useful for dispatcher and initiates stop announcement. The inforamtion system in trams is reliable and accurate enough mostly due to infrared control beacons.

The worst situation is in the busses on lines out of Prague, which are equipped with RCA with GSM module. These lines are usually out of range of private wireless networks and using of GSM network was only solution. RCA sends data for the dispatching in SMS. Apart from information about line, transferred data consists current position of the bus and time deviations from the schedule. The vehicles time deviation is evaluated as a time difference between the time record in schedule and the time of the announcement of the particular bus stop. To keep the number of SMS as low as possible, information is sent only if the bus is behind schedule or in special cases on demand from dispatching (two SMS - double price per information). The weak point in this solution is in the case that the bus driver does not announce the bus stop. It has several undesirable results:

- Acoustic information for the passanger is wrong or missing,
- delay information for dispatching is wrong and useless,
- growing operating costs due to unwanted SMS.

A new Radio Communications Adapter was developed as data from information system is going to be used also in newly builded visual and acoustic electronic system for informing passangers at the stops which shows the numbers of bus lines, the direction, the time in minutes until the next departure and read it for visually impaired who can activate the digital announcement system using the command transmitters. This RCA is based on the Sony Ericsson GSM module GR 47 with GPRS functionality. GSM/GPRS allows bidirectional data transfer with sufficient data rate and far lower cost per kB than SMS.

The GSM module GR 47 was selected because of good support of machine-to-machine (M2M) embedded applications. This module provides an internal IP stack so that there is no need to use extra processor to implement Internet protocol functionality. GR 47

also disposes of the sufficient processing power to ran a user embedded application. This aplication is written as a special script utilizing intrinsic functions. The application can be downloaded locally or remotely via GSM network to the module. The remote download considerably accelerates bugs removing in the working condition.

The module GR 47 can be configured either for UDP/IP or TCP/IP. Lot of trails under field conditions were performed to choose appropriate Internet protocol. TCP/IP is the reliable protocol with an acknowledgement system but compare to UDP/IP there are larger delay and cost per kB due to larger header, acknowledgement packets and possible retransmission. On the other hand, UDP/IP protocol shows in average lower delay, lower cost per kB of payload (absence of acknowledgement packets, shorter packet header) but some packet can be lost.

To investigate reliability of UDP/IP data transmission an experiment under real condition was established. A bus was equipped with a GSM module and 100 bytes packet was sent each minute to a destination server. Packets received during the period of two months were analysed. The experiment showed that more than 98% of packets was received correctly and in more than 95% of erroneous cases only one packet was lost.

Based on the results stated above and the fact that the value of old information (though reliable delivered) is low, UDP/IP was adopted. A dedicated higher layer protocol was designed and an additional acknowledgment system for data which require to be reliable delivered was implemented. The configuration of the system is following: a packet with a board computer idenitficiation, index of last announced bus stop and current bus possition is created in RCA. The packet is sent via GSM/GPRS network to the destination server where useful information is extracted and processed.

Development of the described system was motivated by need of human factor eliminating and operating costs decreasing. It was reached both requriments. The original solution based on GSM/SMS showed operational cost 2000 – 3000 CZK/month (mainly because of human factor). The solution based on GSM/GPRS was designed for operating costs cca 350 CZK/month and allows almost continuous possition monitoring. Collected vehicle data is processed, a potential time deviation from the schedule is evaluated and passed to the visual and acoustic electronic system for informing passangers at the stops. The delay information is not influenced by the driver. The system also provides a remote supervision over drivers and remote correction of some discrepancies like wrong bus stop announcement or wrong inserted date to the board computer. The solution is extensible for wireless transmission of other data like a collected fare, a new schedule or information from weighing machines.

The Radio Communications Adapter was manufactured in the company APEX Ltd and whole system is currently tested in the real traffic.

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Section 5

MATERIALS ENGINEERING

Coupled Transport of Water and Salts in Building Materials

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Water-soluble salts are considered (together with frost action) to belong to the most frequent causes of damage of both historical and contemporary building materials. The corrosion effects of salts in building materials are mostly related to their crystallization from the solution, recrystallization from the solid phase, sometimes also to chemical reactions with building materials themselves. Therefore, salt diffusion is a frequently studied topic in material research.

In the presented work, an experimental analysis of coupled water and chloride transport in cement mortars in the conditions of one-sided sodium chloride-in-water solution uptake into samples being initially at equilibrium moisture content corresponding to 45% relative humidity is carried out. On the basis of inverse analysis of single uptake experiments performed for several cement mortars, moisture diffusivity as a function of moisture content and chloride diffusion coefficient as a function of chloride concentration are determined.

There are two basic approaches for determination of salt diffusivity coefficients. The most frequently used methods based on direct determination of salt diffusivity use the experimental set-up designed for the so-called “Rapid Chloride Permeability Test” and “Conventional Diffusion Test” [1], [2], which were developed at the beginning of the 1980s in USA. Another possibility for determining the salt diffusion coefficient, employed in our work, is to use a mathematical analysis of measured salts profiles, what depends on the assumed model of salt transport in the material. We have assumed only diffusion model of salt transport, therefore for calculation of concentration-dependent diffusion coefficients from the measured salt profiles, the similar inverse methods as those for the determination of moisture-dependent moisture diffusivity or temperature-dependent thermal conductivity were used. On the basis of the previous experience with the solution of inverse problems of moisture diffusion and heat conduction, the Matano and the double integration method [3] were chosen for calculation of moisture and chloride diffusivity.

In the experimental work, the samples of cement mortar were used. The composition of the mixture of cement mortar for one charge was the following: Portland cement – 450 g (three types of cement were applied for different sample groups, namely CEM I 42.5 R Lafarge, CEM I 52.5 R Lafarge and CEM I 42.5 R Prachovice), natural quartz sand with continuous granulometry I, II, III (the total screen residue on 1.6 mm 2%, on 1.0 mm 35%, on 0.50 mm 66%, on 0.16 mm 85%, on 0.08 mm 99.3% - according to the Czech standard ČSN 72 1208) - 1350 g, water – 225 g. The mixture was put into 40 x 40 x 160 mm moulds and compacted by ten impacts of the compactor. After one day the samples were unmoulded and stored in a 100% relative humidity environment for 27 days. Then, the samples were dried, left for several weeks freely in the laboratory (relative humidity 45%, temperature between 20 and 22°C) so that they achieved equilibrium moisture content, and finally all their edges were water and vapor-proof insulated by an epoxy varnish. The organization of the experiments

was the same as in common water sorption experiments. The samples were exposed by their 40 x 40 mm face to the NaCl solution with the concentration of 18.195 g Cl- in one liter of the solution. Duration of the experiment was 1 hour, 24 hours and 7 days for three different groups of samples. After this time, the samples were cut and water content and chloride concentration were measured. Moisture content was determined by the gravimetric method using weighing the moist and dried specimens. In the determination of chloride concentration, the particular samples were after drying first ground by a vibration mill so that grains smaller than 0.063 mm were obtained. Then 10 g of the ground sample was leached 30 minutes in 180 ml of 80°C warm distilled water, a magnetic stirrer was used to speed up the leaching process. The content of chlorides in the leach was determined by a turbidity method.

The measured profiles give clear evidence that water penetrated into the specimen much faster than chlorides. However, the measured chloride concentrations close to the surface after already 24 hours of penetration were higher than the concentration in the penetrating solution. This reveals that a part of chloride ions was apparently bound on the pore walls of the matrix. The bonding of a part of chloride ions on the pore walls was probably one of the reasons why chlorides penetrated slower into the specimens than water. The other possible reason can be formation of hydration atmosphere around Na+ and Cl- ions in the solution. Chloride diffusion coefficients calculated by both double integration method and Matano method showed that the effect of used cements on the determined transport coefficients was relatively low in the range of low and middle moistures but in the range of higher moisture content the differences were higher. The comparison of results obtained by Matano and double integration method gives an evidence of the time dependence of both chloride diffusion coefficients and moisture diffusivities because the double integration method in the inverse analysis uses all profiles and therefore it performs some kind of averaging procedure. This effect was observed for all three used cements.

The performed analysis presented in this paper has clearly shown that description of chloride transport in cement-based materials should always be done in a combination with water transport. The experiments also confirmed that an application of ion binding isotherms in mathematical models of water and salt transport is an unavoidable condition for a realistic description of processes taking place in the porous medium. Neglecting the effects of water transport in the porous material and chloride ion absorption on the pore walls that is common in the simplest diffusion models using solely chloride diffusion coefficients can lead to ambiguous results in an inverse analysis of chloride concentration profiles, and consequently to a departure from the reality.

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The Application of Semi-Scale Experimental Analysis in the Development of Building Materials on the Basis of Gypsum

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Utilization of waste materials for further applications is becoming a very important problem at the present days. In the second half of the 20th century, there were developed technologies for desulfurzation of flue gases in power stations and heating plants. These methods are based on the reaction of sulfur(II) oxide formed during combustion of brown coal with high content of sulfur with limestone $CaCO_3$. Although it seemed that these methods are suitable from the point of view of the protection of environment, there is currently an opposition against these technologies. It is pointed out that the price of desulfurization equipment is too high, and that there is consumed a high amount of high quality limestone while a huge amount of flue gas desulfurization (FGD) gypsum being waste in these technologies is formed. The utilization of FGD gypsum is insufficient considering the amount of its production. Calcined gypsum is produced from FGD gypsum only in one power station in Czech Republic, the remaining production ends with gypsum that is used only partially as additive retarding the setting of cement. Calcined gypsum is mostly used for the production of gypsum plasterboards. That part of produced gypsum, which is not utilized, is deposited as waste. Therefore, it is very desirable to pay attention to utilization of calcined gypsum also in those applications where it was not yet used, i.e. in the exterior.

In our work, we are interested in the design and development of the new gypsum based material for exterior applications in building envelopes. For our purposes, calcined gypsum as a low-energy material produced in power station Počerady from the waste FGD gypsum by its dehydration at the temperatures of 110 to 150°C is employed. The solid structure of calcined gypsum is created by reverse hydration when gypsum $CaSO_4.2H_2O$ is again formed. This compound is relatively soluble in water, its solubility is 0.256 mg in 100 g of water at 20°C. Therefore, it cannot be utilized in the current form for exterior applications as the rain water could dissolve just the product that should safeguard the mechanical properties of the material.

For the utilization of gypsum elements in the exterior, it is necessary to modify it so that it would exhibit more suitable properties and longer service life. Modifications of gypsum are usually performed using polymer materials. Bijen and van der Plas [1] reinforced gypsum by E-glass fibers, and modified the binder by using acrylic dispersion in a mixture with melamine. The results show that this material had higher flexural strength and higher toughness than glass fiber reinforced concrete after 28 days. A disadvantage of polymers based on carbon chain is a decrease of fire resistance of calcined gypsum elements. Generally it can be stated that the resistance of hardened gypsum against water is not yet resolved in a satisfactory way. Therefore, some new modified gypsum based material has to be found for its applicability in envelope parts of building structures.

Our work will be done in three steps. In the first step of our work, β-gypsum produced from FGD gypsum with purity higher than 98% of $CaSO_4.2H_2O$ in power station Počerady

will be used. For this basic raw material, common gypsum without modifications, basic material properties will be determined. In the second step, the improvement of the properties of gypsum will be done by hydrophobic additives for decrease of water sorption both on the surface and inside, polymer substances based on carbon chain for the improvement of mechanical and fracture-mechanical properties, foam agents for improvement of thermal properties, fibers for the improvement of mechanical properties. For this set of modified materials will be performed comparative measurements of material properties and the final gypsum based material will be chosen for exterior applications in building envelopes.

Finally will be performed so called semi-scale critical experiment for the verification of possible problems in practical realization. The main aim of this experiment will be detection of possible further effects that cannot be expressed by computational models or can be expressed only with difficulties. A typical example is a resistance to water or heat transport at the interface between two layers which is very difficult to determine in a classical laboratory experiment. Therefore, the critical experiment has to be as close as possible to the real conditions which will the tested element be exposed to in practice.

The critical experiment, where the tested structure is exposed to the difference climate conditions, will be performed employing specially designed sophisticated technology called NONSTAT, designed in our laboratory for the investigation of the hygrothermal function of newly designed building materials and their multi-layered systems [2]. In the semi-scale experiment, the monitoring of moisture content, salt content, temperature, heat flux and capillary pressure is performed in the studied structure placed into the connecting tunnel fixed between two climatic chambers. As the real climate conditions, the typical climatic data for residential houses will be simulated on the interior side of the studied structure, and on the exterior side, the climatic data of temperature and relative humidity for the test reference year for Prague will be simulated.

In the case that the critical experiment will be successful, the probability of successful application of the developed materials on the modified gypsum basis in the practice will be very high, much higher than if only computational simulation or even mere analytical evaluation on the basis of knowledge of material parameters would be done.

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The Effect of Evaporation in Pulsed Laser Irradiation of CdZnTe

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In this paper, a computational model of melting, evaporation, and solidification of binary alloys due to the irradiation by pulsed lasers is applied to the numerical simulations of laser processing of CdZnTe. Only several attempts have been done until now in modeling laser induced phase change processes in II-VI semiconductors. Scepanovic and Jevtic [1] modeled the nonequilibrium segregation in HgCdTe induced by Nd:YAG laser irradiation and fitted the nonequilibrium segregation coefficient according to the measured data. However, the heat and mass transfer processes were treated separately in their analysis and, in addition, the thermal equilibrium model was employed in calculating the temperature fields. A more advanced model was formulated lately by Přikryl, Segeth and Černý [2]. This model takes coupled heat and mass transport into account, and due to the high velocities of the solid/liquid interface the nonequilibrium melting and solidification have been considered. The concept of the Wilson-Frenkel interface response function is adopted in the modeling process and nonequilibrium segregation coefficients are used.

The basis for the formulation of the mathematical model of pulsed laser-induced nonequilibrium melting, solidification and evaporation of pseudobinary alloys has been the previous work done by the authors in the field of melting and solidification of binary systems induced by pulsed lasers for one thing and in the field of vaporization of metals and semiconductors for another thing. In modeling nonequilibrium melting and solidification induced by pulsed lasers we have utilized the basic ideas from the work by Černý and Přikryl [3]. The model of evaporation has been designed in accordance with the findings of Černý and Bayazitoglu [4].

Concerning the applicability of the model, it should be noted that it remains on the pseudobinary concept similarly as the previous model [2], which did not take evaporation into account, and assumes no decomposition in the liquid phase in the higher temperature range that was observed for some II-VI materials experimentally. Therefore, the prediction capabilities of the model will certainly be better for temperatures close to the melting point than for a temperature say 1000^0C above the melting point. Nevertheless, also in this form the model can be quite useful for the experimentalist because, in addition to the classical output data, as the temperature and concentration fields and the position and velocity of the solid/liquid interface, it is able to provide the data for evaporation depths and evaporation velocities that can reveal the limits for the laser energy density of the incident laser from the point of view of the surface damage.

In the numerical simulations, the Nd:YAG laser (16 ns FWHM, 266, 355, 532 nm) and ruby laser (80 ns FWHM, 694 nm) induced melting, solidification and evaporation of CdZnTe was modeled. The initial content of zinc in the CdZnTe pseudo-binary was taken to be 4% in all calculations. The shape of the laser pulse employed in the computations was obtained by experimental measurements. The main outputs of calculations were temperature and concentration fields, positions and velocities of the phase interfaces and time-resolved incident laser reflectivities.

The computational analysis of melting, evaporation and solidification of CdZnTe induced by Nd:YAG and ruby lasers carried out in this paper clearly demonstrated the remarkable effect of evaporation in the laser irradiation process. The evaporation was found (contrary to the basic semiconductors such as silicon or germanium) - if combined with the relatively low thermal conductivity of CdZnTe in both the solid and the liquid phase - to dominate the process already in the range of laser energy densities that would not be considered for Si or Ge as very high.

Also, the influence of the incident laser wavelength was found to be very important. This feature itself is not surprising because the existence of an absorption edge is characteristic for most semiconductors but the quantitative effects are very different again from those observed with basic semiconductors. The substantial differences in the incident laser reflectivities and optical absorption coefficients due to the changes in laser wavelength can affect all the characteristic parameters of the process. The lowest reflectivity among all the studied lasers exhibits the ruby laser at 694 nm. Among the Nd:YAG lasers, the lowest reflectivity for both the solid and liquid is at 532 nm, while the highest at 266 nm. The optical absorption coefficients are lowest again for the ruby laser. Among the Nd:YAG lasers, these are lowest at 532 nm again, highest at 266 nm, and for 355 nm they are only slightly lower than those for 266 nm. However, the effects of both these factors on the laser irradiation process are counteracting because lower reflectivity means higher amount of energy absorbed in the material, and lower optical absorption coefficient leads to a less effective energy absorption by the material because the energy is absorbed deeper under the material surface. The competition of these two phenomena may cause different consequences for different characteristic parameters of the process so that the result for any particular laser wavelength is not easy to estimate. In any case, there is a good reason to believe that the shape of the temperature profiles was significantly affected by the place where the absorption of laser energy occurred. The lower optical absorption coefficients at 694 nm and 532 nm led to the laser energy absorption in deeper parts of the material than for 266 nm and 355 nm.

Finally, the effect of the laser pulse duration was found to be ambivalent from the point of view of practical experiments. The longer pulse seems to be an advantage from the point of view of the laser energy "window" applicable for the experiments but the effect of the longer time duration of the evaporation process may neutralize this advantage. Therefore, sound experimental evidence is required in this respect.

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The Measurement of Chloride Binding Isotherms in Building Materials

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The corrosion salt effects in building materials are mainly related to their crystallisation from solutions, recrystallisation of solid state, sometimes with chemical reaction. The ions can be found rarely in building materials at usual conditions, but for instance due to capillary action of ground water the capillary forces may cause the rising of salts concentration and the degradation of building material. If the salts in porous system of building material are in the form of solution, there is no danger. But in the moment of water evaporation the salts form hydrates and their crystallisation pressure is higher than the binding forces of material particles and it leads to destruction of material matrix. Hence it is important to study the transport and storage conditions of salts in building materials. On the top of it there is no database of salt transport and storage parameters in building materials, which is necessary to the simulation of materials behaviour in the salt solutions. The obtaining of this piece of knowledge is significant to prevent the salt degradation influence on building materials. The main purpose of the presented work was to measure salt storage parameters in building materials by the help of method from literature, to identify the most suitable one and to obtain a wide database for simulation of storage mechanisms.

The salt transport in the porous system occurs only if salts are dissociated in water. Almost salts are highly soluble in water, which is lead to quick adsorption of particular ions on the pore walls. For the salt transport simulation, it means ion transport, it is important to differ two phases, the free and binding phase [1]. The ion binding isotherms qualify the equilibrium state between the free ions content in solution and amount of binding ions due to physical and chemical sortpion on the pore walls in the porous system. Freundlich [2] written the simply non-linear equilibrium of ion binding isotherm and Langmuir suggested other basic relation, while the fundamental model of ion transport proposed Bear and Bachmat [3]. The models of ion transport from the salt solutions goes out Fick´s diffusion equation. Their input parameters are tansport and acumulation parameter. To find out transport parameter it is used the basic experiment based on suction from salt solution. But there is an interpretation problem, we are not suppose to differ free and binding ions in material pores. On this account it is essential to know the ion binding isotherms, which are the crucial parameter for simulation the salt transport. In this time there is no database of salt transport and accumulation parameters and amount of measured data is insufficient, the only source is work of Tang and Nilsson.

Under usual conditions, there are only a little amount of ions in most of building materials. In masonry we can find sulfates, nitrates, chlorides, and hydrogencarbonates as anions and the main present cations are ammonium, sodium, potassium, calcium and magnesium ions. Salts can originate from several sources. One of them is underground soil with water-soluble salts. The salt solution can be then transported into materials of load bearing structure by capillary forces. Another source of salts in building materials are sodium and calcium chlorides used for winter maintenance of pavements and footways. They can diffuse into underground soil or directly into the masonry. In concrete, cement mortar and cement paste, the determination of ion bonding isotherm is chiefly concerned with chlorides.

On the ground of time consuming experiments it was chosen the NaCl solution as a transport medium and two basic materials with different behaviour, brick and cement paste, as measured materials. The samples were cut in the case of brick and the cement paste samples were die casting. After curing for about six weeks the samples were prepared for measuring.

In our work, Tang and Nilsson [4] method for determination of chloride adsorption isotherms based on adsorption from solution was utilzed. Samples were vacuum dried firstly about three days to remove most of water, then stored in desiccators at 11 % RH kept by saturated LiCl solution for about two weeks so that only monolayer of water was adsorbed on the surface. Samples were then put into a given weight cups, then the cups were vacuumed for two hours before filled with a given concentration of NaCl solution saturated with $Ca(OH)_2$. The cups were covered and stored at 21 °C for equilibrium. The inside solutions after two weeks were analyzed to give a bound chloride content. After adsorption test, the surplus solution in the cups were removed as much as possible, and about 50 ml deionized water saturated with $Ca(OH)_2$ was added to all cups. Then the cups were stored at 21 °C for equilibrium before the inside solutions were pippeted and analyzed. From the obtained data the bound chloride content were calculated.

The measured data acknowledge that the brick binds chlorides much lower than cement paste, which is able to bind chloride ions on alumino phase. The ralationship between the bound and free chlorides can be decsribed by chloride binding isotherm. Of the bound chlorides, some are irreversibly combind into hydrated products by chemical reaction, and others can unbind as the free chloride concentration decreases.

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Erbium Doped Gallium Nitride Thin Films

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Gallium Nitride has become one of the most promising wide band gap (3.4 eV) direct semiconductor materials for use in high power and high frequency transistors, solid state photo detectors and high brightness blue light emitting diodes (LEDs) or laser diodes (LDs).

Many lanthanide elements have played a very important role in various optoelectronics and photonics applications [1], ranging from emitting elements in solid state lasers and displays to optical amplifiers. These so called "rare earth" (RE) elements have a partially filled inner ($4f^n$) shell shielded from its surroundings by completely filled outer ($5s^2$ and $5p^6$) orbitals. Due to this shielding, the intra $4f^n$ shell transitions result in a very sharp optical emission at wavelengths from the ultraviolet to the infrared (IR). The wavelengths of these emission lines are determined by the energy of the transition between 4f states of the RE and are relatively independent of the host material. However, the host material does have a very strong effect on the radiative transition probability, in other words on the photoemission intensity. It was shown at [2] that the thermal quenching in Er-doped semiconductors decreases with increasing bandgap. Therefore, wide-bandgap semiconductors are attractive hosts for RE elements.

The most important RE ion is erbium. Erbium doped materials are of great interest in thin film integrated optoelectronic technology, due to their intra-4*f* emission at 1 540 nm, a standard telecommunication wavelength. Er-doped thin films can be used to fabricate planar optical amplifiers or lasers that can be integrated with other devices on the same chip.

Several different methods have been used for incorporating Er atoms into gallium nitride [3]. These methods include: epitaxial growth, ion implantation, diffusion and nowadays also magnetron sputtering.

Three types of epitaxial growth have been successful to fabricate the GaN semiconductors doped with erbium atoms: Liquid Phase Epitaxy (LPE), Metal Organic Chemical Vapor Deposition (MOCVD) and Molecular Beam Epitaxy (MBE). First two methods are used only for GaN fabrication, for erbium doping ion implantation is used. By using MBE, erbium is incorporated into GaN during GaN growing. Diffusion of Er atoms into the GaN layers has not been yet described.

We report about the fabrication of erbium doped GaN layers by magnetron sputtering. The GaN samples were deposited by using the *Balzers Pfeiffer PLS 160* system from gallium (99.999 %) target on silicon, silica on silicon or quartz glass substrates. Typical growth parameters were: deposition temperature 300 K, deposition time 60 min, nitrogen-argon ratio

3:7, total gas pressure 3.4 Pa, power 50 Watts. For more details of the fabrication process see [4]. For erbium doping into the gallium nitride films the pellets of metallic Er (99.9% purity) were put on the top of Ga target.

The composition of the deposited layers was determined by means of nuclear analytical methods. The Ga:N ratio and content of oxygen (O) was obtained by the Rutherford Back-Scattering (RBS) measurement using 2.4 MeV protons. The content of the incorporated erbium was determined by RBS using both the 2.4 MeV electron and 2.2 MeV alpha particles. The structure of the deposited layers was studied by the XRD (X-ray diffraction) phase analysis, which results were evaluated by the PDF-2 database (ICDD Card no. 50-792). Raman spectra of the samples were taken using the LaBRam HR system (Jobin Yvon) under excitation at 532 and 488 nm. The transmission spectra of the samples in the spectral region from 300 to 600 nm were taken at room temperature using tungsten lamp and monochromator MDR 23 as a light source and pyro-detector to detect the transmitted light.

The thickness of the deposited samples was typically 1-2 μm and the structure of the GaN layers corresponds well with the pattern of the pure gallium nitrate of the polycrystalline GaN (001) texture. The total amount of Er^{3+} in the samples reached up to 1.79 at. % and it corresponded well to the weight of the erbium pellets placed onto the gallium target.

Thus the possibility to fabricate Er^{3+} containing GaN films by magnetron sputtering was demonstrated.

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Carbon Planar Waveguides for Integrated Optics

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Integrated optics is the name given to a new generation of optoelectronic system in which the familiar wires and cables are replaced by optical waveguides and optical fibres, and convectional integrated circuits are replaced by optical integrated circuits [1]. Planar waveguide is a basic element in photonics integrated circuits. In the last decade many research groups studied optical materials doped by rare earth ions, especially Er, Yb and nowadays also Tm. Er doped optical materials can by used for fabrication optical amplifiers or solid state laser operating at the wavelength of 1 550 nm. This wavelength are used by most optical telecommunications system and it is due to the fact that 1 550 nm corresponds to a low loss window of silica based optical fibres [2].

In the previous work it was shown that is was possible to fabricate carbon layers that had optical quality [3]. The best samples have optical losses les than 1 dB/cm. This encouraged us to focus our research on how the fabricated carbon layers can be doped with laser active erbium ions. Stepwise we investigated six methods for introduction of erbium into carbon layers grown by PECVD (Plasma Enhanced Chemical Vapor Deposition) or magnetron sputtering:

1. growth of carbon thin films using carbon target and a separated piece of metallic erbium,
2. growth of carbon thin films using carbon target containing metallic erbium,
3. growth of carbon thin films containing erbium using magnetron sputtering,
4. growth of carbon thin films from a gas mixture (CH_4+Ar+“erbium isopropoxide”),
5. growth of carbon thin films using a gas mixture (CH_4+“erbium tris”),
6. doping carbon thin films using diffusion of erbium.

The content of erbium was determined by Rutherford Backscattering Spectroscopy (RBS) and Elastic Recoil Detection Analysis (ERDA).

Ad 1.Using carbon target appeared to be a bed choice as not carbon layer was deposited. The only deposited layer was that of metallic erbium. The sputtering rate of erbium was much higher comparing with that of carbon.

Ad 2. The deposition of the erbium layer was rather successful, though the layer contained only very low amount of erbium (0.02 at %).

Ad 3. Very small pieces of metallic erbium were placed onto carbon target. After the sputtering the fabricated thin carbon layer contained 0.2 to1.6 at % of erbium, depending on the weight of the metallic erbium used for the fabrication. Very important factor for successful doping was also the exact location of the erbium pieces, because of the non-homogenous erosion of the sputtering process.

Ad 4. This way of the doping was not successful, as the fabricated samples did not contain any erbium at all.

Ad 5. Two approaches were used: the "erbium tris" was evaporated inside or outside of the apparatus. The erbium was found in all the fabricated samples, however, its concentration substantially differed. While the former approach gave 8.7 at % of erbium in the deposited layer, the later approach resulted in very low content of 0.01 at % of Er^{3+}.

Ad 6. The diffusion of erbium occurred from erbium salt dissolved in aqueous solutions or in glycerol. The doping from the glycerol media proceeded by rather anomalous way, as it seemed to be a capillary process. For deeper erbium containing carbon layers we developed a sandwich-like structure made of three consequently PECVD deposited carbon layers, which were immediately doped with erbium from external source.

As the most suitable approaches from the above mentioned ones appeared up to now the approach 4, and they will be further improved.

The details fabrication processes were previously described in [4].

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Yield Strength of Microalloyed Steels after Heat Treatment

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This paper is devoted to study of the effect of both primary heat treatment and following heat treatment on mechanical properties of modified microalloyed cast steels with the content of carbon 0,15% and manganese 1,5%. These steels are prepared for thin-walled castings with the wall thickness of up to 25mm.The programm continues the previous development of low-alloyed manganese steels designated for thick-walled castings [1-4].

The yield strength (YS) is most important mechanical property and with respect to dimensioning of structure and work high level is requested.The strength of materials depends on microstructure and in case of ferrite-pearlite of low carbon manganese steels the value of yield strength after primary heat treatment can be controlled by following factors:

- grain size (Hall-Petch equation)
- morphology of ferrite and pearlite (interlamellar spacing, thickness of cementite plate)
- volume fraction of present phases
- microalloying (solid solution hardening, precipitation hardening)

In addition to pearlite other microconstitutiens that are pruducts of austenitic transformation (martensite, bainite, sorbite) may be used to improvement of mechanical properties.

The modified microalloyed cast steels offer due to added elements better mechanical and fracture properties.In our study the attention was focused on strengthening influence of microalloying elements vanadium,titanium,niobium,molybdenum respectively nickel and copper.

Low-carbon steel in our program, was modified by commonly used microalloying elements Ti,Nb,V because form interstitial phases (carbides,nitrides, carbonitrides) which control the grain size and precipitation strengthening. Microalloying by vanadium supports precipitation of unstechiometric carbide V_4C_3 or nitride VN below 850^oC and has a positive effect on ferrite refinement and on hardenability. Titanium is used as a killing agent causes expressive precipitation and enables to control grain size. Niobium closes up an austenitic region, forms fine grain but on other hand intergranular carbide NbC reduces ductility and fracture toughness. Eight experimental heats were prepared for investigation with various content of alloying elements.

The first two heats (S1 , S2) and two procedures of heat treatment (HT1, HT2) were studied:

S1 - steel 20Mn5 (0,19wt.%C -1,16wt.%Mn – V,Ti,Nb≤ 0,01wt.%)
S2 - steel 20Mn5VNb (0,20wt.%C -1,2wt%Mn -0,06wt%V -,03wt.% Nb)
HT1 -normalizing (900^oC /3hours /furnace cooling)
HT2 -solution annealing (1100^oC / 10 hours / air cooling)

The values of yield strength YS for combination of materials and heat treatment were determined by tensile test (conditions ČSN EN 10002-1 , INSTRON Floor Standing Model type 5582).

On the base of results tensile test the following effects of the influence of alloying elements and heat treatment on mechanical properties were detected:

Normalizing offers higher values of yield strength (378 MPa) than solution annealing (350MPa) for steel 20Mn5, because after long period at temperature 1100^{o}C course structure is present. On the contrary in steel 20MnVNb procedure HT2 increases yield strength
of 20MPa in comparison with HT1.

The expected effect of alloying elements was more significant after solution annealing. In this case YS reached values 467 MPa which represents increasing of 33% while in normalizing state microalloying improves yield strength of 18% in comparison with unalloyed steel (20Mn5) only.

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Temperature Dependance of Fatigue Behaviour of an Ordered Alloy Fe-28Al-3Cr-Ce (at%)

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Iron aluminides based on Fe_3Al are attractive for high temperature applications owing to their low density, low material cost, good wear resistance, ease of fabrication and superior corrosion resistance in oxidizing and sulfidizing atmospheres. They can replace steels and nickel based alloys in many special applications including heating elements, furnace fixtures, heat-exchanger piping, sintered porous gas-metal filters, automobile valve components and molten salt applications [1]. Mechanical properties of Fe_3Al based intermetallics are significantly influenced by the change of order - $D0_3 \leftrightarrow B2$ order–order transition - at the temperature about 540 °C. As in the B2 ordered region the tensile and creep strength of Fe_3Al rapidly decrease, the limiting temperature for its structural applications is around 600°C.

After the study of static mechanical properties and fracture of vacuum cast and hot extruded or hot rolled Fe-28Al-4Cr (at.%) alloys with cerium addition [2], an introductory study of fatigue properties of these materials was carried out [3]. This paper reports a follow-up study of fatigue behaviour of a similar alloy Fe-28Al-3Cr-Ce (at%). The purpose of this paper is to contribute to the database of room temperature (RT) fatigue properties of intermetallic alloys and to extend these data to fatigue behaviour at elevated temperatures.The chemical composition of the studied material is given in the following table:

	Al	Cr	Ce	C	Mn	Fe
(at.%)	28.99	3.19	0.008	0.157	0.026	Balance
(wt.%)	16.54	3.51	0.025	0.04	0.03	Balance

Fatigue crack growth experiments were performed on compact tension (CT) specimens 5 mm thick, 50 mm wide and 48 mm high. The notch was prepared by electro-discharge cutting using a wire 0.1 mm in diameter. The fatigue crack propagated in perpendicular to the rolling direction. The specimens were loaded in tension at 20, 300 and 500°C on a computer–controlled servohydraulic loading machine INOVA ZUZ 50 equipped with a resistance-heated furnace. The frequency of loading was 10 Hz, the stress ratio R was in the range from 0.05 to 0.1. The crack length during fatigue test was measured by (temperature independent) potential method at alternative current with the frequency of 4 Hz, using TECHLAB SRT-2K device, controlled by Fatigue Crack Growth Monitor software.

Temperature dependence of fatigue life (including crack initiation and propagation at a constant maximum load F_{max} = 3,6 kN) is very strong. The average number of cycles to failure rapidly decreases with temperature, as well as the scatter of measured values: at 20°C the average fatigue life is ~300 000 cycles, while at 300°C it is ~160 000 cycles and at 500°C only ~10 000 cycles.

Results of fatigue tests were plotted as a dependence between measured crack length a, and elapsed number of loading cycles N. Subsequently, the dependence fatigue crack growth rate v vs. crack length a was determined using secant method. Simultaneously, the stress intensity

factor ΔK was calculated as a function of crack length, $\Delta K = \Delta K(a)$. Finally, the results of fatigue test were plotted as the dependences $v = v(\Delta K)$. The fatigue crack propagation rate at RT and elevated temperatures is different – the slope of $v(\Delta K)$ curves (exponent m in the Paris equation $v = C(\Delta K)^m$) is much steeper at RT, while it remains nearly the same at 300 and 500°C. Curves for RT and 300°C cross at $\Delta K \approx 26$ MPa.m$^{1/2}$, when the fatigue crack gowth rate is about 10^{-7} m/cycle. If we compare $v(\Delta K)$ at elevated temperatures, the shape of the curve remains nearly the same, only the fatigue crack growth rate at 500°C is about two orders higher than at 300°C.

Fractographic analysis was carried out only at the samples tested at room temperature. Rugged fracture surfaces consist of facets different in the arrangement, size, and micromorphology. Practically negligible changes of overall morphology character were found with fatigue crack length increase, i.e., with increasing of the stress intensity factor. Owing to this, it is very difficult recognize the boundary between fatigue crack propagation and final static rupture (fracture morphology of final static failure is very similar to the morphology of fatigue fracture). Most of the facets are classical transgranular cleavage but also the other types of facets were found (transgranular quasicleavage, intergranular decohesion, and exceptionally transgranular facets with ductile dimples). Some of the cleavage facets are covered by fatigue striations. Striations of this type are brittle and corresponding mechanism is cyclic brittle cleavage [4], i.e., local plastic deformation is very small. Character of the micromorphology of these striations did not significantly change with increasing length of fatigue crack. Common ductile fatigue striations were found only exceptionally. These striations were produced by the classical Laird's mechanism. A detailed study of ductile striation micromorphology was carried out by the method of matching surfaces, i.e., the same area was found on the both faces of fracture. The relief of individual striations shows features corresponding to the local plastic deformation. This fracture micromorphology was probably formed due to the propagation of the fatigue crack through parallel dislocation networks, which were found in the material by means of TEM.

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Preparation of Ultra Fine Grain AA8006 Sheet by Accumulative Roll-Bonding

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The accumulative roll bonding (ARB) is a relatively new method of severe plastic deformation proposed by Saito *et al*. [1]. The basic goal of ARB is to impose an extremely high plastic strain on the material, which results in structural refinement and strength increase without changing specimen dimensions. The ARB process consists in repeating of cutting, stacking and rolling of sheets. It is known that ARB processing leads to the formation of a lamellar structure at high strains [2], and that the conversion of low-angle to high-angle boundaries dominates over grain refinement [3]. The ARB was successfully performed on commercial purity aluminium, some aluminium alloys and interstitial free (IF) steel [1,2,3]. Twin-roll cast (TRC) alloys, having a fine grain structure, have not yet been used for ARB.

The experimental material, a twin-roll cast strip of AA8006 alloy, was supplied by Al INVEST Břidličná, a.s., Czech Republic. Its chemical composition is in the following table (wt.%):

Mn	Mg	Fe	Si	Cu	Zn	Ti	Al
0.401	0.003	1.506	0.157	0.006	0.012	0.014	Balance

In order to obtain an O-temper material, the strip was annealed for 0.5 h at 400°C. Two pieces of the strip with dimensions of 250 mm × 50 mm × 2.5 mm were stacked to form a 5 mm thick specimen. Before stacking, the surfaces of the strips were degreased (in tetrachlorethylene) and wire-brushed (stainless steel brush with wire of 0.3 mm in diameter) to achieve good bonding. The pieces were joined together in the corners using Al wires and subsequently heated for 5 min to 200°C in an electrical furnace. After heating, the specimen was roll-bonded by rolling using a 50% reduction without lubricant. The roll diameter was 340 mm and the roll peripheral speed 0.7 $m \cdot min^{-1}$, respectively. The rolled specimen was cut into two halves, and the above-mentioned procedure was repeated four times more to achieve 5 cycles. In order to prevent the propagation of edge cracks, which appeared after several cycles, specimen edges were trimmed and smoothed down before each following cycle. There were problems with layers bonding during the first rolling experiments but well-bonded specimens were obtained by adjusting the rolling conditions.

The initial material and the deformed microstructures were examined using electron backscattered diffraction (EBSD) and transmission electron microscopy (TEM). Samples for EBSD were polished on standard emery papers up to the 4000 grade and subsequently electropolished using Struers Lectropol 5 unit filled with Struers A2 electrolyte. EBSD was carried out on a field-emission gun scanning electron microscope LEO Gemini equipped with a TSL EBSD analyzer. Standard TEM thin foils 3 mm in diameter were prepared by electrolytic twin-jet polishing (at -30°C, 30 V) in Struers Tenupol 2 filled with 6% solution of

perchloric acid in methanol. The observations were carried out at 200 kV with JEOL JEM 2000FX microscope. Vickers microhardness measurements performed on the cross-section of the rolled strips was used for evaluating the strength of ARB processed materials.

In the initial material a relatively large area of 500 μm × 500 μm was scanned with a coarse step of 3 μm. Equiaxed grains with mean size of 16 μm were observed on EBSD orientation map. In order to detect the grain refinement resulting from ARB processing, a much finer step (0.2 μm) was used for the analysis of the processed samples. In consequence, much smaller areas (80 μm × 80 μm) were scanned to achieve a reasonable time of analysis (~18 h). Aftehr the 1st ARB cycle, the smallest equiaxed grains had ~ 0.5 μm in diameter, the coarse ones were up to 50 μm long. The mean grain size in the transverse direction was 1.9 μm. The grain structure was much more homogeneous after the second ARB cycle. The mean grain size in the longitudinal direction was 1.5 μm, in the transverse direction only 0.9 μm. The grain boundaries were high-angle (≥ 15° disorientations). The attempts to perform an EBSD analysis after the third and subsequent cycles of ARB process were not successful in spite of the fact that the quality of the diffraction patterns was not worse than in the previous cases. Therefore, in very fine-grained materials, grain size and orientations could be characterized only by TEM. Recently, Funderberger *et al.* [4] reported about a computer-controlled method aimed at obtaining polycrystal orientation maps from TEM. The method possesses an orientation determination accuracy of 0.1° and spatial resolution of about 10 nm and would be appropriate in the characterization of ARB materials processed by more than two cycles.

TEM observations have shown that during 2nd and 3rd ARB cycle the low-angle subgrain boundaries converted to high-angle grain boundaries appearing in a typical fringe contrast. The size of the majority of these grains was from 0.4 to 0.8 μm, the largest grains had 1.2 μm in diameter. After the fifth cycle, the grain structure was only a little more refined, but the largest grains had still about 1.2 μm in diameter. The dislocation density inside subgrains or grains remained almost unchanged throughout all the cycles of ARB processing and is indicative for a recovered substructure.

The hardness of the alloy increased from 28 to 60 HV1 after the first two cycles, but during subsequent cycles it rose only very slightly.

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HREM, FIM and Tomographic Atom Probe Investigation of Guinier-Preston Zones in an Al-1.54 at% Cu Alloy

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An important metallurgical problem which still has not been solved completely is the question how phase separation is initiated and progresses during the early stages of solid solution decomposition when large parts of the sample are still in a supersaturated state. In many alloys, e.g. Al-Zn, Cu-Be, Fe-Mo, Al-Ag, Al-Cu or Al-Mg-Si, the decomposition (and hardening) process starts by forming small clusters of solute atoms - Guinier-Preston (GP1) zones. Their morphology (platelets, spheres, needles) depends on the interfacial energy and coherency strain energy. The decomposition of the supersaturated solid solution (SSS) in the Al-Cu system shows a variety of metastable states, following the sequence:

$$\text{SSS} \rightarrow \text{GP1 zones} \rightarrow \text{GP2 zones } (\theta'') \rightarrow \theta' \rightarrow \theta \ (CuAl_2).$$

GP1 and GP2 zones are pre-precipitates coherent with the matrix, the intermediate precipitate θ' is semi-coherent and the equilibrium precipitate θ is incoherent.

A single crystal of the Al-1.54 at% Cu (Al-3.41 wt% Cu) alloy, 80 mm long and 6 mm in diameter, prepared by the Bridgman method was homogenized at 530°C for one week, solution annealed at 540°C for 4 hours and, after quenching in ice water, aged for 30 hours at 100°C. It was then oriented by X-ray diffraction in order to cut, with a slow speed diamond saw, slices 0.30 mm in thickness, parallel to the {110} crystal planes. TEM specimens were prepared from discs 3 mm in diameter by electrolytic twin-jet polishing (TENUPOL 2) with the electrolyte composed of 30 ml of nitric acid dissolved in a solution of 300 g copper nitrate ($Cu(NO_3)_2 \cdot 3H_2O$) in 900 ml of methanol. High-resolution electron microscopy observation was carried out at 200 kV with the Philips CM20 instrument equipped with an UltraTwin objective lens (C_s = 0.5 mm), a LaB_6 gun and a LEP (Laboratoire d'Electronique de Philips) CCD camera. The atomic resolution micrographs were taken under symmetric (axial) illumination conditions. The HREM images were interpreted with the aid of the EMS software [1]. From the oriented slices, small rods 0.3 mm × 0.3 mm × 20 mm in dimensions oriented parallel to the <100> crystal direction, were cut by low-speed diamond sawing. Very sharp needle-shaped specimen for TAP-FIM were electropolished in a solution of $HN0_3$ (1/3) and methanol (2/3) cooled to -10°C, at 5 to 8 V dc. Field-ion microscopy (FIM) observations and chemical analyses were performed with the tomographic atom probe (TAP) designed at Rouen University. This instrument can be used either as a projection microscope, based on the field ionisation of a rare gas near the surface of the sample, or as a three dimensional atom probe, in which the material is field evaporated by high voltage pulses. In this analysis mode, the TAP is a ultra-high vacuum instrument equipped with a time of flight mass

spectrometer and a detector sensitive to the position of ion impacts [2]. The analysed volume of material is *a posteriori* reconstructed in three dimensions on a sub-nanometric scale. A few 100 000 ions are collected per analysis. The corresponding dimensions of the analysed volume are usually 10 nm × 10 nm × 50 nm.

HREM results showed that majority of GP1 zones were monolayers 1 to 9 nm in size. However, some GP2 zones and particles in an intermediate state of growth between GP1 and GP2 stage were also found.

The composition profile of a GP1 zone was obtained by the following method: a 0.2 nm thick sampling volume was moved step by step throughout the analysed and reconstructed volume of material, in a direction perpendicular to the GP1 zone. Each composition on the profile was calculated from the number of Al and Cu atoms present in the sampling volume at the corresponding level. Convolution with the aluminium matrix was avoided by choosing a sampling volume of smaller size than that of the GP1 zone. Reconstructed GP1 zones were thicker than one layer.

The composition profiles of twelve GP1 zones parallel to the tip axis were drawn. The thicknesses of these reconstructed GP1 zones range from 4 to 8 layers and their peak compositions from 10 to 40 at% Cu. In the hypothesis of a monolayer structure, three GP1 zones contain 100% Cu. The copper content of three other particles exceeds 100%, when brought to a single atomic layer. These particles could be either double layer GP1 zones as it was observed in another HREM study [3] or more probably they are particles in the intermediate state of growth between GP1 and GP2 (θ'') stage. Five other GP1 zones contain from 65 ± 5 to 85 ± 5 at% Cu and the composition of the last one is only 41 ± 7 %. It seems therefore that GP1 zones with various copper contents coexist in the alloy.

A large amount of copper remains in the solid solution outside of GP1 zones. Direct composition measurements were performed on 3D reconstructed material. Small volumes containing 5 000 to 20 000 atoms were extracted between identified GP1 zones. Their copper contents range from 0.3 ± 0.15 to 1.5 ± 0.2 at% Cu, most of them lying between 0.7 and 1 at% Cu. The fact that both significant as well as negligible depletions in copper are observed in different regions of the aluminium matrix reveals heterogeneity of the copper distribution (there is not an ideal solid solution). From Fig. 9 it is clearly seen that the Cu concentration in the vicinity of the GP1 zones falls down to zero on the distance ranging from 1 to 3 nm (approximately equivalent to 5 to 15 interplanar $(200)_{Al}$ spacings). The mean values of the solid solution concentration (0.7 to 1 at% Cu) are in agreement with the value of 0.75 at% obtained by Hono *et al.* [4].

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Influence of the Li Environment on the Characteristics of Zirconium Alloys Oxide Layers Determined by Means of X-ray Diffraction

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In this study the effect of Li environment is demonstrated on the characteristics of oxide layers determined by means of XRD such as stresses σ, crystallite size D and lattice strains ε in comparison with the oxidation in VVER water environment. Experiment was performed on the tubular specimens of three types of alloys: Zr1Nb, low tin Zircaloy-4 (Zry4 W) and ZIRLO which were exposed for various time in water with 70 ppm Li as LiOH and VVER water at 360 °C.

The „sum of the surface principal stresses“ technique with a reference substance was used with regard to the specific experimental conditions, especially to the marked texture of oxide layers and the shape of specimens. The evaluation of the crystallite size and lattice strains was performed by using „single-line“ method with the Pearson VII approximation of the profiles shape.

A θ/2θ-goniometer SIEMENS with CoKα radiation ($\lambda K_{\alpha 1}$ = 0.178892 nm) was used to measure lattice strains. X-ray measurements were performed on 15 mm long tubular specimens with a outer diameter ca 9-10 mm. Specimens were embedded in the special holder with a 2 mm wide slit to keep optimal conditions the same for all measurements performed. In oxide layers of investigated samples the measurements were performed on the {10-4} planes with $2\theta = 85.24°$ for the CoKα radiation ($T_e^{(10\text{-}4)}{}_{Co}$ = 3.68 μm). In metal substrates the measurements were performed on the {112} planes for which $2\theta = 81.66°$ for the CoKα radiation ($T_e^{(112)}{}_{Co}$ = 2.4 μm).

The high compressive stresses (from –1 GPa up to –1.5 GPa) were found in zirconia layers after oxidation, especially in the range of small oxide thickness. With further increase of the layer thickness stresses decrease. The smaller values and different courses of stresses were observed in the range the small oxide thickness for Zr1Nb as compared with both the other alloys and environments. For Zr1Nb the stresses are higher of about 170 MPa than the stresses founded over the same range of thickness for VVER environment. The stresses decrease after transition from high initial values to values less about 500 MPa. Tensile stresses from 100 MPa up to 270 MPa were measured in metal layers near the metal-oxide interface.

Comparing results obtained for two environments we can see that the crystallite size D in oxide layers of the Zry4 W and ZIRLO alloys significantly decrease in Li-environment. Almost the same values D were found for these alloys in early pretransition stages of oxidation in both the environments. Then the decrease of D values occurs in Li environment for the same oxide thickness (1.5 μm for Zry4 W and 1.84 μm for ZIRLO) at which the decrease of stresses as compared with VVER environment was observed. The mean values of D decrease from 23 ± 3 nm in VVER to 18 ± 3 nm in Li-environment for both the alloys. For Zr1Nb alloy the reduction of D values seems to be less significant and crystallite size D decreases from the mean value 15 ± 4 nm in VVER to 12 ± 2 nm in Li-environment.

The similar effect of Li-environment on lattice strains ε as on crystallite size in oxide layers of Zry4 W and ZIRLO alloys can be observed.

Based on the observations reported above we can conclude that

a) In all cases of oxidation in Li-environment the transition of kinetics is accompanied by decrease of stresses σ in oxide layers (especially sharp in the case of Zr1Nb) from high initial values to values less about cca 500 MPa.
b) No effect of Li-environment on the stresses σ in metal underlying was observed in these measurements.
c) For the Zry4 W and ZIRLO alloys the transition of kinetics can be associated with significant decrease the crystallite size D in oxide layers from cca 25 nm up to cca 10 nm. The decrease of lattice strains in this point is also observed in oxide layers for both the alloys.
d) Only small impact of Li-environment was observed on the microstructure characteristics in the pretransition stage of oxidation of Zr1Nb alloy. The values of crystallite size D slightly decrease and values of ε are almost the same in comparison with VVER conditions. Note that both the D and ε values are smaller than these for the former alloys in the VVER conditions.

Many investigators [1-4] reported that the oxide consists of the non-protective layer on the outside and the barrier oxide layer near the oxide/metal interface. This layer contains a tetragonal phase of zirconia being stabilized by high compressive stresses. Decrease the stresses in the vicinity of transition point and increase the oxidation rate could accompany the degradation of barrier layer (e.g. by its dissolution in enriched Li-environment). The main governing factor on the corrosion is the oxygen diffusion in barrier oxide layer. Thus the reduction of the barrier layer thickness and the increase of oxygen vacancies (resulted from the substitution of Li^{+} for Zr^{4+} in the oxide barrier layer) could significantly contribute to the acceleration of corrosion as the exposure time increases [1,2]. If we assume that a relation exists between the decrease of the crystallite size and incorporation of Li into inner barrier oxide layer respectively, thus the enhancement of the corrosion rate in Li-environment can be associated with effects described above.

The changes of all the characteristics obtained by means of XRD for oxide layers of Zry4 W and ZIRLO alloys correspond to changes of corrosion kinetics in Li-environment in accordance with the mechanism of a gradual degradation of the barrier layer. The behavior of Zr1Nb alloy was found to be different.

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Influence of Thickness Bilayer Period and Substrate Bias on Microhardness of Multilayer System TiN/TaN

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The experiment was aimed at microhardness of multilayer coatings on Ti_xN_{1-x}/Ta_xN_{1-x} basis applied on selected substrates of variable bias value, by means of reactive magnetron sputtering, in relation to the variation of thickness period Λ and substrate bias Us. Further on, fundamental mechanic, tribologic and growth characteristics of coatings were observed in dependence on the variation of thickness period Λ.

Thin singlelayered coatings normally fail when they are exposed to higher levels of chemical and mechanical load or to combinations of these. One of the methods to improve their resistance to this kind of loading is the application of coatings in a multilayer structure. Such coatings can be created by depositing two or more chemically diverse materials. The most usual manner of preparing multilayer coatings are PVD methods in which the most frequent is magnetron reactive sputtering and low-voltage arc deposition.

Systems of multilayer coatings display increased hardness and they tend to obstruct the shifting of dislocations and reduce their mobility over interfaces of phases of the individual layers. This is called consolidation effect.

Ti_xN_{1-x}/Ta_xN_{1-x} layers were prepared on a BALZERS LLS 801 apparatus and applied onto three types of substrate: steel samples (19 421), glass ceramic panels (sitall), glass samples. The thickness periods Λ were selected in view of the time revolution period and with regards to the expected layer increase per revolution, the initial bias in substrates was given as Us = 0V, Us = -100V.

The hardness measurement was based on indentation characteristics of the relation between the load of the indentor head L [mN] and the depth of the indentor penetration h [μm] into the layer. The values of universal hardness H_{un}, plastic hardness H_p and Youngs modulus were obtained using the maximal load L_{max} = 10mN. It is clear from the course of the acquired dependence that in the case of multilayer structures there is a point on curve L = f(h), which corresponds to the variation of the slope of indenting dependence dL/dh = f(h). The variation of the curve slope dL/dh = f(h) is delimited by the so-called critical point with co-ordinates (L_k, h_k). Generally speaking, the hardness of multilayer coatings intensifies as a result of the combination of elastic and plastic deformation. It was found that the variegating thickness period of multilayer coatings not only affects the position of the "critical point" but also the consequential speed of plastic deformation when the point is exceeded. The slowest course of plastic deformation, after the "critical point" was exceeded, was found in the sample with the lowest thickness period. A possible explanation to this phenomenon may be an intensive reduction of energy in shifting dislocations due to multiple penetrations through the individual layers and the stress fields on the interfacial borders and the mismatch between layers. Lower values of thickness periods are also the cause of higher tension τ, for the activation of Frank-Read dislocation source, as the result of the reduction of the characteristic dimension D in relation τ = Gb/D. Non-coated substrates manifest lack of critical point and the dL/dh = f(h) dependence is of linear character. With higher values of load force, single

layers tend to have lower resistance to growing plastic deformation and in comparison with multilayer coatings, the dL/dh = f(h) dependence exhibits a significant plateau. Substrate bias influences hardness values of multilayer system Ti_xN_{1-x}/Ta_xN_{1-x}. When bias is increased from 0V to –100V, the system chiefly exhibits higher resistance to dislocation movement over the separate interfacial borders, as well as higher initial hardness values $H_{0,}$ independent of the periodicity of components. With a change in the thickness periodicity, coatings applied on steel substrate showed a linear growth in hardness when bias to 0V and -100V, following the general Hall-Petch dependence. The ratio of elastic hardening in all samples increased with the falling thickness period and, as can be seen from the graphic dependence, due to bias, there was a shift of the entire dependence curve towards higher values of critical forces and of the depth of indentor penetration.

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Measurement of Modulation Transfer Functions of Non-destructive Testing Systems

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Aim of this thesis was to find, measure and evaluate such criterion which would optimize use of non nestructive testing systems. Idea is, that according measured parameter of this criterion, company will be able to decide whether to accept the order or not. It would help not only to describe system, but it would have also perceptible economic value.

After evaluation of many possibilites, I have decided to choose criterion of a Modulation transfer function. MTF is able to describe ability of a system to transfer information about evaluated object (defect) in details. By means of measured MTF of a system we are even able to determine minimal defect which may be recognized by given system. In this thesis I was dealing with two non destructive systems – Ultrasonic and X-Radiographyc system.

The measurement of the modulation transfer function of ultrasonic and radiographyc testing systems was carried out at the research department of a company ATG. For determination of the MTF of a each system was used method "Measurement of a knife-edge response".

Measured data were analyzed by means of a computer program by:

1) converting and displaying of measured data
2) smoothing the measured data by means of least square method using polynom of a fourth degree
3) differentiating the smoothed edge gradient to obtain line spread function
4) Fourier transforming of the line spread function to give the MTF.

In first case Imerse ultrasonic system was evaluated. Probe diameter was 16mm, ultrasonic beam was focused on diameter 2mm and frequency was 10MHz. As evaluated object was used stepped steel gauge. Transition between no mass and full mass of a gauge was measured then. Afterwards was calculated MTF of a given system by means of above stated steps. The MTF of a system was evaluated and after discussion was determined minimal defect which may be recognized by this system. For this system it was 0,51mm. Experimental verification confirmed that result is by means of this system achievable.

In second case X- Radiographyc system was evaluated. For this system we already had two radiograms which we had to digitize by means of high-resolution camera. Profile of transition was measured by means of software LUCIE. We have evaluated two transitions. First corresponded to gauge thick 0,8mm and second to 2mm. Data capture was realized by means of two methods – perpendiculary to transition and almost parallely (3-4deg) to transition. The measured MTFs of a given systems were compared and evaluated. MTFs revealed that for given setting is system more sensitive with gauge thick 2mm. MTFs given

by different data capture were evaluated to be satisfactory. Nevertheless it is recommended to continue with increasing of precision of stated methods.

Both measurements proved that criterion MTF is for comparation of a quality of a same systems (UT, RT, etc.) suitable and therefore may be used for optimalization of a use of non destructive testing systems.

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Prediction of Cleavage Failure Probability Using Three-Parameter Weibull Statistics

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The probability of cleavage fracture of a reactor pressure vessel A508.3 given by the Beremin model with the Weibull parameters identified at low temperature yields in the Ductile-to Brittle Transition Temperature (DBTT) range far too pessimistic prediction [1,2]. In this model based on the weakest link assumption, the number of microcracks in the reference volume, V_o, is assumed to be a power law function of the microcrack length. The defects allowing cleavage initiation are only distributed within the plastic zone and the spatial distribution of these defects is supposed to follow a Poisson point process. Using Griffith formula to relate the defect size to the critical stress for unstable extension, it can be shown that the probability of failure at time t is given by a two-parameter Weibull's distribution:

$$P_F(t) = 1 - exp\left[-\left(\frac{\sigma_w(t)}{\sigma_u} \right)^m \right] \qquad \textbf{(1)}$$

where m and σ_u (or $\sigma_u V_0^{\,m}$) are the parameters, and the so called Weibull stress σ_w, is defined as:

$$\sigma_w(t) = \sqrt[m]{\int_{Vpl} [\text{Max}_{0<\tau<t}\, \sigma_1(\tau)]^m \, \frac{dV}{V_o}} \qquad (2)$$

where σ_1 is the maximum value over time of the positive maximum principal stress over the plastic zone V_{pl}.

In Ref. [2], the fractographic analysis showed that different micro-mechanisms of cleavage fracture are present in the DBTT range: There is an evolution from cracked particle induced cleavage at low temperature to plasticity-induced cleavage at higher temperature. This last mechanism depends certainly on the mobility of screw dislocations and thus can be associated with some thermally activated process. Assuming that the fracture process remains weakest link controlled, this can result in an evolution of Weibull parameters with temperature due to an evolution of the defect density or the effective surface energy.

Hence in order to limit the number of parameters to be identified, the first attempt is to develop the σ_u parameter as an increasing function of temperature T, m being kept constant:

$$\sigma_u(T) = A\, exp\left(-\frac{B}{T} \right) \qquad (3)$$

where A>0 and B>0 are newly introduced parameters.

The generalised least mean square method was used for the identification of A, B and m parameters. The fracture probability estimator was the mean of the frequency value $i/(N+1)$,

where i is the rank for increasing fracture displacements order, and N is the number of tested specimens. A hybrid method composed of three classical methods (Gradient, Newton-Raphson and Levenberg-Marquardt) was used for the minimisation process.

Considering only this procedure, the increasing scatter of fracture toughness with increasing temperature cannot be predicted accurately. Hence, this results in a non-conservative prediction of low values of fracture toughness (numerically predicted $P_F = 0.1$ corresponds to about 0.3 observed experimentally). Some improvements in prediction of the low values of fracture toughness were received varying m parameter [2]. Nevertheless, the sharp upturn of fracture toughness observed in the DBTT range was not reached.

Another possibility to improve the coincidence of predicted and experimental values of fracture toughness is to introduce a threshold parameter σ_o into Weibull stress:

$$P_F = 1 - exp\left\{ -\int_{V_{pl}} \left[\frac{\sigma_1 - \sigma_o}{\sigma_u(T)} \right]^m \frac{dV}{V_o} \right\} \tag{4}$$

Increasing parameter σ_o leads to a decrease of parameter m and an increase of σ_u (e.g. Ref. [3]). For the m equal to 1/(1-ln2) (about 3.26), the modus of Weibull distribution is equal to its median: For m>3.26 the distribution is left-centred ("left-hand tail" for distribution), whereas for m<3.26 the distribution is right-centred.

Common value m~20 (e.g. Refs. [1,2]) leads to strongly left-centred distribution of Weibull stress. However, the distribution of experimental fracture displacement is right-centred at all studied temperatures. At low temperature the arise of plasticity leads to a non-linear evolution of the Weibull stress; thus the left-hand tail of Weibull distribution can be recompensed so that corresponding distribution of experimental fracture displacements is right-centred. On the other hand, at higher temperature when the fracture occurs in the quasi-linear part of the Weibull stress plot, the left-centred distribution of Weibull stress leads to the left-centred distribution of fracture displacements, unlike the experimental results. The using of the threshold parameter is therefore necessary to account for the actual skewness of the fracture probability distribution.

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EBSD Study of the Fatigue Crack Growth in the Fe3Al Based Intermetallic Alloy

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Fatigue fracture properties of the hot rolled Fe-28Al-3Cr-Ce (at.%) intermetallic alloy were studied. The alloy was prepared by vacuum induction melting and casting. The ingot was hot rolled at 1100°C to a plate 6 mm thick (reduction 75%) and quenched into oil. The thermal treatment consisted in annealing for 2 h at 700°C (above the temperature of the $D0_3$-B2 order-order transition) to relieve internal stresses and subsequent quenching to mineral oil to avoid environmental embrittlement [1].

Fatigue crack growth experiments were performed on a 5 mm thick standard compact tension (CT) specimens (33 mm wide and 32 mm high). The specimens were loaded at RT with the stress ratio parameter R=0.1 on a computer controlled INOVA ZUZ 50 servohydraulic testing machine. The fatigue crack propagated perpendicularly to the rolling direction. The crack length was measured during the fatigue test by the potential method as a function of elapsed number of loading cycles N. The fatigue crack growth rate $v=da/dN$, determined by the secant method, was plotted as a function of stress intensity factor range ΔK (calculated for the corresponding crack length a) in order to obtain v-ΔK curves [2].

After the threshold region (region I), v shows a roughly linear dependence on ΔK on a double log scale until the fracture; the alloy does not display the visible transition between the region II (Paris region) and region III as it is usual in common (disordered) alloys.

Fractographic analysis carried out on fracture surfaces of ruptured specimens revealed several failure mechanisms of crack propagation. The main failure mechanism is transgranular cleavage. The fatigue fracture surface shows a varied micromorphology. Besides transgranular cleavage, transgranular quasicleavage facets, ductile dimpled rupture, intergranular decohesion, ductile fatigue striations and brittle striations were found.

The influence of the microstructure (especially of the crystallographic orientation and the shape of grains) on the crack growth was characterized by means of Electron Backscattering Diffraction (EBSD). EBSD analysis revealed pancake-shape grains about 300 μm in size in the direction of rolling and 100 μm in the transverse direction. Inside the grains EBSD analysis revealed a typical recovered structure with low-angle subgrain boundaries formed by dislocation walls. EBSD analysis was also carried out in the vicinity of fatigue cracks on metallographic cuts of fractured CT specimens. The fracture surfaces of samples were firstly documented in SEM (entire area in the magnification 200 x, some details in the magnification up to 10,000 x), the fracture surface was then electrolytically nickel-plated to avoid edge effects. In the following step a cut in the rolling plane was carried out using slow speed diamond saw. The cut was then polished on standard emery papers up to the 4000 grade. The final operation was electropolishing (at 42 V, 10 °C) using Struers Lectropol 5 unit filled with Struers A2 electrolyte (solution of 5 % perchloric acid in methanol). The cuts prepared in this manner were examined by EBSD. The size of cleavage facets or distance between steps on fracture surface allowed us to assess the exact position of the cut plane on the micrographs of the fracture surface recorded before nickel platting and cutting.

EBSD analysis on the metallographical cut in perpendicular to the fracture surface (in the rolling plane) revealed that the local transitions from one type of fracture mechanism to another are very frequent even in the range of one grain, i.e. without the presence of an energetic barrier to the crack propagation such as high or low-angle boundary. The crack extension depends therefore on the crack growth resistance of the material but also on the local crack driving force. It is obvious that both depend on the microstructure (especially on the crystallographic orientation and the shape of grains, with very strong effect of neighbouring grains). Another notable feature was pointed out during the tilting of specimen to the position for the EBSD analysis: The facets containing the cleavage striations fields are rarely oriented in perpendicular to the loading direction, but the normal of these facets is frequently tilted to the loading direction.

The major mechanism of the crack growth in fatigue is the forming of cleavage facets (corresponding to the (100) crystallographic planes) in the main crack growth direction. After local crack jumps by transgranular cleavage these newly created facets must be connected for further crack propagation. Brittle or ductile striations are then often formed in the grains with unsatisfactory orientation (for cleavage) with respect to the loading direction. Obviously, this mechanism causes a significant variation of the crack growth rate both on the microscopic scale and on the macroscopic scale. The brittle striation spacing cannot therefore be used for the crack growth rate estimation (e.g. Ref. [3]) since the local crack growth rate given by the striation spacing is not representative for the total crack growth rate.

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Tribological Behaviour of Plasma Sprayed Al2O3 and Cr2O3 Coatings

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Plasma sprayed ceramic coatings are well known for their wear resistance. Plasma sprayed alumina and chromia oxide coatings are widely used to improve the resistance of metallic components against various types of wear and corrosion[1,2]. However, the particular structure of plasma-sprayed coatings (high porosity, cracks, nehomogenity etc.) affects their mechanical properties and consequently their tribological behaviour. The coatings were produced by water-stabilized plasma torch (WSP®). The feedstock was prepared by fusion and mechanical mixing of alumina and chromia. The feedstock was fused and mixed at the rate 92:8 and 66:33 (Al_2O_3 : Cr_2O_3). The substrate material was low alloy steel, which was grit blasted just before plasma spraying. The dimension of samples was 12 x 25 mm. No bond coat was used. Wet slurry abrasion test was used for determination of wear resistance. Behaviour ceramic coatings during slurry abrasion test, structure of cross section and fracture of plasma-sprayed coatings were also studied. Other characteristic was microhardness. Vickers hardness was measured using a weight of 0.3 kg. Slurry abrasion test was according to ASTM G75-95 and was performed on a specially designed device. The wear test was performed on four samples every coatings by four following two hour runs. Test duration of one run was 2304 m. After each run the samples was rinsed in water, cleaned in ultrasonic bath, dried and weighted. Abrasion resistance is determined by measuring mass loss. The cumulative weight loss is divided by coatings density. By this calculation we could obtain cumulative volume loss. Wear resistance of coatings is express by the wear rate, because the wear resistance is reciprocal value of this indicator. Wear rate is defined as the volume of loss material divided unit distance. The average wear rate was calculated as a coefficient of linear regression from the graph of cumulative volume loss vs. reached distance.

The goal of this measuring was obtained characteristics of plasma sprayed coatings Al_2O_3 – Cr_2O_3 by feedstock prepared fusion and mechanical mixing. The main requirement is determination of wear rate for every coating and appreciation of effect on this process.

Wear rate for each coating was result of wet slurry abrasion test. The wear rate of chromia coatings was $0{,}15x10^{-2}$ mm^3/m. The wear rate of alumina was $0{,}21x10^{-2}$ mm^3/m. It means, that the wear resistance of chromia coatings is approximately 1,4 times higher than alumina. The wear rate of mechanical mixing samples 92+8 and 67+33 were $0{,}19x10^{-2}$ and $0{,}18x10^{-2}$ mm^3/m. Increasing wear resistance with cumulative volume of Cr_2O_3 is in conformity with presumption. This presumption is out conformity in fused coatings, where wear rate for coating 92/8 is very low ($16x10^{-2}$ mm^3/m) and showed similar wear resistance as coatings Cr_2O_3. On the other side wear rate of coating 67/33 equals Al_2O_3, which could show

lower wear resistance than this coating. The different wear rates of coatings are believed to be due to different internal microstructure of the splats.

During the wet slurry abrasion test was seen considerable decrease surface asperity. The surface exhibited grooves parallel in the direction of the sample sliding movement after the first run of the wear test. In the case of comparison surface roughness value before test and after, we can see considerable decrease. Resulting surface roughness value relates with sand grading of wear test solution.

Microhardness of Al_2O_3 coating was HV02 1160 ± 97 a Cr_2O_3 was HV02 1257 ± 156. Microhardness of fused and mechanical mixed coatings increased with cumulative volume of Cr_2O_3.

The typical splat morphology was observed in alumina and chromia coatings. Two different types of microstructure inside of the splats were found. Columnar, predominant in Al_2O_3 and fine with randomly oriented grains predominant in Cr_2O_3. Formation of microcracks depends coatings microstructure. Columnar microstructure is more favorable for splat fracture along this shape. Fine and randomly oriented microstructure of chromia splats prevents formation and grow of microcracks. The fused and mixed coatings were transitional state between both coatings. At this coatings wasn't approve predominant columnar oriented structure. The reason is stabilization of α phase by adding Cr_2O_3.

Wet slurry abrasion test of coatings sprayed by WSP® prove that this spraying technique can successfully be applied for deposition of wear resistant coatings. The wear resistance of WSP® sprayed coatings is comparable with coatings sprayed by different techniques.

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High Temperature Tribological Parameters of Coatings

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Many different coatings applied in industry work at elevated temperatures. However, the friction and wear behaviour of these coatings at temperatures exceeding a room temperature have not been studied intensively yet. To help remedy this lack, three coatings widely spread in industry applications, TiN, TiCN and CrN, are comparatively studied with respect to their friction and wear properties.

The coatings were deposited on the substrates made from HSS either by unbalanced magnetron sputtering The measurements were provided by high temperature tribometer (pin-on-disc, CSM Instruments). The evolution of the friction coefficient with the cycles (sliding distance) was measured under different conditions, such as temperature or sliding speed, and the wear rate of the ball and coating were evaluated. As counter-parts were used the 100Cr6 balls and the Si_3N_4 ceramic balls. The wear tracks were examined by optical methods and by SEM. The surface oxidation at elevated temperatures and chemical composition the wear track was also measured by EDX analysis.

All measurements were done with a load of 5N and a linear speed of 4 $cm.s^{-1}$, relative humidity of air was (40 ± 5)%. The radius of a travelling circle varied in the range from 3 to 6 mm. As a consequence, we evaluated the dependency of the friction coefficient on the number of cycles, because use of the sliding distance did not allow comparison of friction curves measured with different diameters. The number of cycles was 5000.

TiN and CrN coatings were deposited using Hauzer's HTC-35 plant (2 cathodes) and arc deposition technology. Prior to deposition the chamber was exhausted to the ~10^{-3} Pa, deposition pressure was of the order 0.1 Pa. Substrate temperature was 450 ^{o}C in case of TiN deposition. During deposition of CrN the substrate temperature was 200 ^{o}C, bias voltage was 70 V, deposition time 10 hours.

The substrates coated by TiCN were taken from standard production of customer´s coating centre HVM Plasma (PVD Modřice - Hauzer´s HC 33 sputtering plant). The samples were prepared by unbalanced magnetron sputtering, the deposition temperature was 450 ^{o}C. Prior to deposition the chamber was evacuated to an order 10^{-5} Pa, deposition pressure was two orders higher. The deposition started with nitrogen and argon mixture (50:50), later acetylene gas was admixed step by step; the composition was graded towards the surface.

The friction and wear behaviour of the TiN and CrN coating prepared by low arc deposition method and TiCN prepared by magnetron sputtering was examined by changing the temperature and the counter-part materials. The tribological performance was evaluated with respect to wear rate of balls and coating, friction coefficient and influence of oxidation.

Conclusion can be drawn as follows:

a) Sliding against 100Cr6 ball

- The friction coefficient of TiN and TiCN slightly increases with temperature. The CrN average friction coefficient reaches highest level in the temperature range 100–300°C; the rise of temperature above 300 °C decreases friction to the minimum at 500 °C.
- The wear rate of TiN is measurable at temperature above 100 °C. Both TiN and TiCN wear rates increase with the temperature, the dominant wear mechanism is the mild wear due to plastic deformation. The coating wear loss in case of CrN is negligible. In contrary, the ball wear rate is very high with significant transfer of the ball material to coated surface.

b) Sliding against Si_3N_4 ball

- The friction coefficient of CrN coating decreases with temperature, TiN and TiCN show very complicated dependency on temperature.
- CrN coating wear rate increases with temperature up the 300 °C; CrN and TiCN coatings were partially peeled from the substrate at 500 °C. The main wear mechanism is mild wear due to plastic deformation. The wear resistance of CrN coatings is inferior to that of TiN and TiCN by a factor of 20-80 in temperature range of 100 – 400 °C
- Significant coatings surface oxidation occurs at temperature exceeding 300 °C for all tested coatings.

This study shows the in case of 100Cr6 ball the TiCN wear rate occurs at the room temperature, while that of TiN is measurable at a temperature above 100 °C. CrN coating does not suffer by sliding of the steel ball, however, the wear of steel counter-part was very high. It could limit the working conditions of this type of coating, particularly in combination with high friction coefficient. Despite the higher wear rate the TiCN coatings is suitable to perform as wear resistant coating at higher temperatures, particularly in conditions, where the sliding heat significantly increases temperature, because the friction coefficient is in comparison with TiN and CrN lower. Although friction coefficient of TiN coatings is higher than that of TiCN, wear rate is lower. The destruction of counter-part is 10 times lower compared to CrN. Thus, TiN coatings may cover a wide range of working conditions. Moreover, in tests with the Si_3N_4 ball only TiN coating was not peeled from the substrate.

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The Effect of Composition on Hygric and Thermal Properties of Fiber Reinforced Cement Composites

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Cement-based materials are characterized by very good properties in compression but their brittle failure behavior under tensile or impact loads was a limiting factor for their applicability from the very beginnings. Fiber reinforcement is a traditional and effective method how to improve the toughness and durability of cement-based products. In the current practice, steel, glass, carbon and various polymeric fibers are commonly used in cement-based materials. Although mechanical properties of these composites have been subjected to extensive research, transport and storage parameters such as moisture diffusivity, water vapor permeability and sorption isotherms as well as the thermal properties were not yet studied at all until very recently. The present contribution summarizes the results of experiments performed to study the effect of composition on hygric and thermal properties of glass fiber reinforced composites and carbon fiber reinforced cement composites, see [1], [2].

Glass-fiber reinforced cement composites are produced by incorporating a small amount of alkali-resistant glass fiber in cement mortar. The length and content of the glass fiber reinforcement can be chosen to meet the strength and toughness requirements of the product. Also, the type of aggregates can be varied in order to control thermal properties.

Carbon fiber reinforcement has found its application first in polymer matrix composites for automotive and aircraft industry. It partially replaced previously used glass fibers in such situations where superior strength properties, very low tensile strains and mass savings were necessary. Carbon fibers are produced by the controlled oxidation, carbonization and graphitization of carbon-rich organic precursors, which are already in fiber form.

A representative set consisting of several types of cement composites was formed to study the effect of composition on hygric and thermal behavior. The carbon fiber reinforced cement composite specimens (denoted as CC I and CC II) had the composition shown in Table 1 (calculated among the dry substances only). Portland cement CEM I 52.5 Mokrá was used for CC I, aluminous cement Alcoa CA-14M for CC II, carbon fiber was pitch based with 10 mm length. Water in the amount corresponding to the w/c ratio of 0.8 was added to the mixture for CC I, 0.73 for CC II.

Table 1 Composition of carbon fiber reinforced cement composites in %.

	Cement	Micro-dorsilite	Plasti-cizer	Carbon fiber	Wolla-stonite	Methyl-cellulose	Defoamer	Microsilica
CC I	39.71	16.50	0.98	0.98	39.6	0.11	0.16	1.96
CC II	40.00	28.40	0.80	1.00	29.50	0.10	0.20	-

The samples of glass fiber reinforced cement composites denoted as GC I, GC II, GC III were cut from a composite plate with Portland cement matrix (cement CEM I 52.5 Mokrá), which was reinforced by alkali-resistant glass fibers (CEM-FIL 2 250/5B Tex 2450 30 mm for GC I, CEM-FIL 70/30 6 mm for GC II and GC III), the materials GC II and III contained vermiculite and wollastonite. The basic components of GC I, II, III are shown in Table 2 (the

percentage is calculated among the dry substances only again, water corresponding to the water to cement ratio of 0.8 is to be added to the mixture).

Table 2 Composition of glass fiber reinforced cement composites in %.

	Cement	Sand	Plasticizer	Glass fiber	Wollastonite	Vermiculite	Microsilica
GC I	47.99	47.99	0.62	3.40	-	-	-
GC II	47.60	-	0.45	3.84	38.50	9.61	-
GC III	56.88	-	0.92	7.66	8.68	21.51	4.35

The hygric and thermal properties of glass fiber reinforced cement composites mentioned above for temperatures ranging from 25 to 1 000°C are presented in detail in [1], [2]. The results confirmed very strong dependence of overall thermal and hygric properties of these materials on different composition. In particular, application of wollastonite (fibrous character) and vermiculite (light aggregates in expanded form with porous character) in GC-II and GC-III instead of sand aggregates in GC-I led to a remarkable decrease of thermal conductivity. Moisture diffusivity of GFRC with wollastonite and vermiculite was at room temperature about one order of magnitude higher compared to GC-I with sand aggregates, which is again a clear consequence of density decrease to about one half and corresponding increase of porosity. On the other hand, the changes of hygric and thermal properties during and after subjecting to higher temperatures were not so unambiguous. The only measured parameter that was changed in quite a clear way was the linear thermal expansion coefficient. One of the reasons for more favorable high temperature behavior of linear thermal expansion coefficient of GC-II and GC-III compared to GC-I was better function of glass fibers in GC-II and GC-III. Another positive effect for the delayed heat transport to the glass fibers was the separation of fiber bundles during the preparation of the mixture caused by the additives of wollastonite, vermiculite and microsilica. Also, the presence of fibers of wollastonite could be a positive factor. Wollastonite is more stable at high temperatures than glass fibers, so that its fibers can maintain a relatively rigid structure of cement paste even after partial loss of its mass.

The effect of different composition of the particular carbon fiber reinforced cement composites was very pronounced, too. Besides from the already mentioned effect of wollastonite and microsilica, which was observed for the present material system as well, the positive effect of carbon fibers and microdorsilite was supported by experimental data. The sample CC-I showed behavior similar to GC-II, which can be primarily attributed to the high content of wollastonite, see Tables 1 and 2. The anticipated improvement in overall thermal properties and hygric properties of CC-II, however, has not been fully confirmed by the present study. This, quite suprising, behavior will be addressed in the future research.

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Application of TDR Method for Determining Moisture Content in Building Materials

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The Time Domain Reflectometry (TDR) is a method for estimating volume fraction of water in a material by measuring the time it takes an electromagnetic pulse to travel along a transmission line buried in the material [1]. The measured time is the time it takes pulse to travel from the beginning of the probe to the end of the probe, to reflect from the end and to travel to the beginning of the probe (the round trip time). The measuring time is directly related to the velocity of propagation of the electromagnetic pulse travelling along the probe, and the velocity of propagation is related to the average dielectric constant of the material in contact with the probe [2]. The dielectric constant of air is 1, of dry material 2-3, and of water approximately 80. Therefore, the presence of water in the material heavily influences the measured dielectric constant of that material.

The Time Domain Reflectometry was used as a new non-destructive technique for accurate determination of water content in soils first. The TDR technique with miniaturized probes [3] together with the miniaturized pressure transducer tensiometers [4] and relative humidity sensors can be used for a synchronous determination of capillary water potential and water content in the wet and dry moisture range. The basic idea for the development of this method was usage of the same specimen in the series of experiments to achieve different flow regimes by controlling the initial and boundary conditions.

The determination of the material water content from the measured dielectric constant by TDR requires to know their relationship. For that reason two main approaches were developed, namely dielectric mixing laws and empirical relationships. In the case of dielectric mixing laws, the measured material is considered to be a mixture of two or three phases, air, water and solid state. These phases differ in the value of dielectric constant how it was mentioned above. The usage of empirical relationships is very convenient, since no additional measurements or data are necessary. The multitude of experiments makes a choice of function, which most exactly fits the measured data. A construction of such function is done using the gravimetric measurements, so that the measured dielectric constants can be correlated and the (mostly polynomial) functions can be established. Because of a wide range of different materials, the accurate relationship between relative permittivity and water content that is valid for all materials does not exist. For that reason it is better to construct an individual calibration curve to respect the type of measured apparatus, probes and materials. A lot of calibration or conversion functions were developed; in our case so called Malicki normalized conversion function was used to calculate the material water content.

The experimental set up consists of measured equipment LOM/RS/6/mps (EASY TEST, Poland) and of miniaturized probes. The LOM/RS/6/mps is based on the TDR technology with $\sin^2$-like needle pulse having rise-time of about 200 ps. It periodically records the instantaneous profiles of moisture, water capillary pressure (water matrix potential), temperature, and water electrical conductivity in chosen time intervals. The required results are measured with help of different probes, LP/ms - probe for measuring

dielectric constant, moisture and bulk electrical conductivity, LP/p - probe for determining capillary pressure, LP/t - probe for measuring temperature. Minihygrometers together with minitensiometers allow to collect a set of corresponding water content and matrix potential (capillary pressure) gradient data from drying or wetting transition experiments, from which complete data set of unsaturated water flow characteristics of the material can be obtained, i.e., water retention (pF-curve), unsaturated water conductivity (k-function), differential water capacity and unsaturated water diffusivity.

The vertical suction experiment was carried out for aerated autoclaved concrete, AAC, in air-conditioned laboratory at 23±1°C, samples sizes were 70x50x330 mm by reason of probe installation. At first, samples were on four lateral sides water and water vapour insulated with epoxy resin to ensure the one-dimensional transport. Each sample was filled with sixteen LP/m probes into the holes bored before drying in the oven for a constant dry mass. The probes were placed into the prepared holes of the dry sample. There should be no air gaps around the probe as this can result in large, fluctuating errors. Therefore, the ECG (conducting) gel was used and finally, the probes were fixed and water and water vapour insulated with the technical plasticine and the samples were installed into the measuring place. The moisture transport was continuously monitored, and the experiment was stopped before the water suction has reached the end of the measured sample. Each measurement lasted ten days. Finally, the samples were cut to two centimeter thick slices and moisture content was determined with gravimetric method for comparison. The moisture profiles obtained from TDR measurement were used to calculate the moisture diffusivity as a function of moisture content. A comparison of this function with the apparent moisture diffusivity value obtained from the suction experiment has shown that the apparent moisture diffusivity crossed the function in the upper range of moisture.

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Basic Hygric and Thermal Properties of a High Performance Concrete

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Concrete is one of the most extensively used materials in construction industry. It can be damaged owing to corroding substances presented at environments. Therefore is necessary to develop and to produce a better, it means more durable, concrete. The measured data should be used as input data to computer simulation to predict the concrete service life and to discover the concrete behaviour. To improve concretes properties it is important to know the basic thermal and hygric properties of usually used types of concrete. To this end it was chosen the high performance concrete of two basic compositions C90/105 and C60/75, signed as I and II respectively. They are composed of cement CEM I 52,2R, silica fume suspense, aggregate of 0-16 gravel, accelerant Lentan VZ33, larry Woerment FM794, and water of given proportion. The difference between these two types of concrete is in content of silica fume suspense, the C60/75 do not contain this component. The measurement of basic properties was done step by step to find out the influence of particular concrete components on hygric and thermal properties of concrete. Therefore the cement pastes signed as PI and PI, concrete without the aggregate of 8-16 gravel signed as BBI and BBII, and concrete signed as BI and BII, were molded in the form of samples with required sizes. The experiments for measuring hygric and thermal parameters were carried out at 25 °C in usual laboratory conditions (relative humidity about 30-35%); another set of measurements was done with the various values of relative humidity. The sample sizes depended on the type of measurement. The initial state for all the measurements was dry material.

Hygrothermal behaviour of building materials is described by thermal and hygric properties. The one of the common material property is water vapour diffusion resistance factor μ *[-]*, basically measured according to standard ČSN 72 7031 [1]. The measurement is carried out in steady state under isothermal conditions. It is based on one-dimensional water vapour diffusion, measuring the diffusion water vapour flux through the specimen and on measuring partial water vapour pressure in the air under and above specific specimen surface. Water vapour transmission properties of a material are obtained by placing a specimen of the material on the top of a cup and sealing it. The cup should contain sorption material (desiccant, saturated salt solution or water). The sealed cup is placed in a controlled climate chamber and weighed periodically. The steady state values of mass gain or mass loss are utilized for the determination of the water vapour transfer properties.

There was also measured vacuum saturation moisture content w_{sat} *[kg m^{-3}]*, bulk density ρ *[kg m^{-3}],* and open porosity ψ_0 *[%]*. Each sample was dried in an oven to remove majority of the physically bound water. After that the samples were placed into the desiccator with deaired water. During three hours air was evacuated with vacuum pump from the desiccator, the specimen was kept under water not less than 24 hours. The so-called "Archimedes weight" was determined by weighing immersed water-saturated samples.

The simplest way, how to describe liquid water transport through a porous material, can be by way of water suction experiment. Set up for measuring the water absorption coefficient consists of tank filled with water, and the specimen, water and vapour-proof insulated on four edges, fixed on automatic balances and immersed 1-2 mm in the water. Using automatic balance allows recording the increase of mass. The known water flux into the specimen during the suction process can be employed to the determination of apparent moisture diffusivity [2]. The constant water level in tank can be achieved by so-called "Marriott's bottle". It is water filled bottle with two capillary tubes. One of them, inside diameter 2 mm, is ducked under the water level, the second one, inside diameter 5 mm, above water level. If the water level is turned down air bubble goes inside the tube and the second tube ejects water amount needed to alignment of water level in tank. The water absorption coefficient, A, is calculated from the linear part of the dependence of the increase of tested sample's mass [$kg\ m^{-2}$] on the square root of time [$s^{1/2}$]. Then moisture diffusivity $\kappa\ [m^2\ s]$ can be calculated from the vacuum saturation moisture content and water absorption coefficient according the simply equation [3].

Among the thermal properties, the most important are thermal conductivity $\lambda\ [W\ m^{-1} K^{-1}]$, thermal diffusivity $a\ [m^2\ s^{-1}]$, specific heat $c\ [J\ kg^{-1} K^{-1}]$, they were measured using the commercial devices ISOMET 2104 (Applied Precision, Ltd.), which is based on the application of impulse technique. This is equipped with various types of optional probes; needle probes are for porous, fibrous or soft materials, and surface probes are suitable for hard materials. The measurement is based on analysis of the temperature response of the analysed material to heat flow impulses. The heat flow is induced by electrical heating using resistor heater having a direct thermal contact with the surface of the sample. Calibration data in internal memory ensure interchange ability of probes without affecting the measurement accuracy. Gained data can be stored into the internal memory.

The measurements of thermal and hygric parameters of a high performance concrete were done with the primary aim to obtain the input data for computer simulation. Therefore, the different batch of concrete components were mixed and consequently the basic parameters of the prepared samples were tested. The results show the influence of silica fume suspense addition and a great effect of aggregate granulity.

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Structure of Turbine Blades of Jet Engine

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Progressive super-alloys (nickel-based alloys) work in service at temperatures till 1350 K, which is neither 200 K below their initial melting temperature. Melting temperature of pure nickel (1728 K) is absolute limit in development of these materials. Super alloys shall they improvement thermal properties thanks to two different strengthening mechanisms:

- hardening of solid solution by cobalt, chromium and high meltable metals like wolfram and molybdenum,
- precipitation hardening by intermetallic phase γ' $Ni_3(Ti,Al)$ or γ'' Ni_3Nb.

The most modern single crystal alloys contain as much as 70% vol. phase γ' with temperatures solution about 1500°K. Basic addition is chromium (10 till 30 %) which provides heat resistance of alloys. For higher temperatures have to be super-alloys protected against effects of high temperatures corrosion in combustion gas by covering coating. This could be created by diffusion saturation of surface by aluminum (alitizing) or producing by TBC type coating by method PVD or plasma spraying application.

Control of super alloys grain size is also critical factor in optimizing of their high up temperature mechanical behavior. Creep rate decreases with growing grain size respectively fatigue behavior is deteriorate. That is why it is necessary to establish optimal processing conditions so to have the best combination of quality for given part. For the turbine blades that are relatively little stressed at very high temperatures is creep a limitation factor for the service life of component, whereas for disks on which they are attached and which work at lower temperatures but with higher stress is fatigue behavior most important. That is why blades have generally big grain size and disks have fine grains [1].

In present-day engines are all blades and distributors in turbine cast and non-formed because of obtaining optimum creep and strength and termomechanic properties. Castings can have polycrystalline (equiaxial) or directionally solidified (DS) or monocrystalline (SX– singlet crystal) structure.

Blades working at high temperatures in aggressive atmosphere of combustion gas. First stage of tested motor turbine of works at maximum temperature 1250°C. That is why the blades have to be resistant to creep at high temperatures and oxisulfidic corrosion and high cycle fatigue but also e.g. erosive abrasion too. Used alloy is type ZS6K with comparable heat-resistance with Nimonic 118 alloy. The blades are produced by method of exact casting conventional way without directional solidification. On surface of blades is protective diffusion coating (alitizing), raising resistivity against the oxisulfidic corrosion at high temperatures.

Among structural factors that mostly affect behavior of material belongs to:

- precipitation hardening of phase γ' $Ni_3(Ti,Al)$, theirs shape, size and distribution, volume fraction of phase γ' in alloy
- condition of other minor phases - namely carbides, borides, or eutectic γ - γ', way of the precipitation, size and volume fraction
- presence of the undesirable intermetallic phase, which rise at operational exposure and deteriorate properties of blades (phase sigma and other)

- size of the primary grain phase γ´.

Study of the blades microstructure at classification their structure have had these points:

- analysis of the quite new blade – make basic analysis of the blade material by the optical microscopy and the scanning electron microscopy,
- analysis of the blades operates after defined service time about 1000 clock around,
- influence temperature load on structure – perform series test annealing at increased temperatures with new and operate blades and determine effects of annealing on the structural factors.

By the optical microscopy was studied casting structure of the particular blades with well evident dendrites. Size of the casting grains was at new blade almost to the value of 1 mm, by influence of thermal load it happen to the dissolution of the grains at size in range 0,2-0,5mm. The study of the alitizing layer demonstrated its changes too. Thickness of the alitizing layer of the new blade was about 0,03mm. At operate blades was evident rise of the third layer, which thickness is about 0,01mm, whereas thickness of the first two layers is moving in the range 0,02-0,04mm. Precipitation of the carbidic phase in the new blade is mainly in elongated drop-type shape in direction of the solidification gradient at castings. Their size is to the limit to 10μm. By effect of the longtime load happen sharply defined coagulation of these elements.

On electron microscopy scans it was possible to notice the distribution and a form of carbidic phases in interdendritic areas and on grain boundary, phase γ' as well as alitizing layer. Study of the grain boundary demonstrate the quantity of precipitates, carbides and particles of the phase γ' that are segregated on grain boundary in forms of fine chain. Quite clearly was shown difference in sizes and shapes of the phase γ' which was changing in the dependencies on the load. In the alitizing layer was evident rise of long acicular shapes intervening to the basic material.

Measurement of linear analyses was used too. Its results demonstrate that the volume fraction in dependencies on load relatively sharply changes. Maximum volume fraction of the hardening phase γ' was about 40% and during service load slip declines and at overloading of the material blades happen dissolving phase γ' and fall its volume fraction to 20%. Medium size of particles phase γ' was by effect load magnify and proceed in range 0,2-0,5μm. It was happen the coagulation and connection of element phase γ'[2].

Because all of described changes proceed at the same time, it is possible to qualify the material state of blades according to single criteria. One of them is classification of the condition alitizing layer, which predicate of stadium service life material blades. So it is using in practice with success, because damage of these layer results in an extreme load material blades and thereby also its degradation.

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Formulation of Contact Element for the Modeling of Nonlinear Response of Woven Composites on Meso Scale

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A successful prediction of the macroscopic behavior of complex layered composite structures requires detailed modeling on various size scales. Bridging individual length scales is usually accomplished by introducing multi-scale or hierarchical modeling. For example, see [2]. A suitable method of attack then depends on the complexity of the problem under consideration. While an accurate coupled analysis that satisfies all the continuity and equilibrium conditions between individual scales and at the same time accounts for all the local phenomena, e.g. stress and strain gradients, is of the general interest, the computational feasibility of the problem often calls for a simplified uncoupled solution strategy. Such an approach then assumes that the analysis at individual scales is performed independently in the sense that output from one is used as an input to the second.

The behaviour of woven composites on meso scale level, i.e. the level, where the individual constituents are in the form of bundles (tows) and epoxy matrix, is principally governed by the interface properties between individual bundles. In the reality, very thin layer of epoxy matrix can be found between bundles, but modeling of this layer with finite elements is not proper due to an enormous increasing of number of nodes, because these elements must be very small. The better way how to capture this problem is the introducing of contact element, which will behave very similarly as the real thin epoxy layer. As suggested by the title the general goal of this contribution is to develop such a contact element and material model which will appropriately model imperfect bonding between individual bundles.

For the simplicity, the material behavior of contact element is limited to an uncoupled response in shear and tension/compression. We will begin with the material model for shear. In contrast to purely elastic behavior commonly assumed for bundles, the matrix phase may undergo nonlinear viscoelastic deformation described by the generalized Leonov model. It is an experimentally confirmed fact that, to a good approximation, polymers show negligible volume deformation during plastic flow. Combining the Eyring flow model for the plastic component of the shear strain rate $\frac{\mathrm{d}\varepsilon_p}{\mathrm{d}t} = \frac{1}{A}\sinh\frac{\tau}{\tau_0}$, with the elastic shear strain rate $\mathrm{d}\varepsilon_e / \mathrm{d}t$ yields the one-dimensional Leonov constitutive model $\frac{\mathrm{d}\varepsilon}{\mathrm{d}t} = \frac{\mathrm{d}\varepsilon_e}{\mathrm{d}t} + \frac{\mathrm{d}\varepsilon_p}{\mathrm{d}t} = \frac{\mathrm{d}\varepsilon_e}{\mathrm{d}t} + \frac{\tau}{\eta(\mathrm{d}\varepsilon_\mathrm{p}/\mathrm{d}t)}$, where the shear dependent viscosity η is provided by

$\eta(\mathrm{d}\varepsilon_p/\mathrm{d}t) = \frac{\eta_0\tau}{\tau_0\sinh(\tau/\tau_0)} = \eta_0 a_\sigma(\tau)$ $\mathrm{d}\varepsilon_e/\mathrm{d}t$. A and τ_0 are material parameters; a_σ is the stress shift function with respect to the zero shear viscosity η_0 ~ (viscosity corresponding to an elastic response). More details can be found in [3].

As pointed out above the material behavior is limited to an uncoupled response in shear and tension/compression. An essentially brittle behavior is assumed in the normal direction. The local constitutive equation then becomes

$$\begin{Bmatrix}\Delta\tau_1\\ \Delta\tau_2\\ \Delta\sigma\end{Bmatrix}=\left(1-\frac{\sigma+|\sigma|}{\sigma}d\right)\begin{bmatrix}K_s & 0 & 0\\ 0 & K_s & 0\\ 0 & 0 & K_n\end{bmatrix}_{t_1}\begin{Bmatrix}\Delta\|u\|-\Delta\|u\|_{cr}\\ \Delta\|v\|-\Delta\|v\|_{cr}\\ \Delta\|w\|-\Delta\|w\|_{p}\end{Bmatrix}_{t_1}$$, where $K_s=\frac{\overline{G}}{w_c}$, K_n are the interface stiffnesses in the tangent and normal directions, respectively and w_c corresponds to the interface thickness. The viscoelastic response is represented by an instantaneous shear modulus $\overline{G}$ and increments of the inplane displacement jumps $\Delta\|u\|_{cr}$, $\Delta\|v\|_{cr}$ derived from the generalized Leonov model. The last two terms to introduce are the damage parameter d and an increment of the plastic strain in the normal (out-of-plane) direction $\Delta\|w\|_p$. They follow from the plastic-damage model described in [4].

Standard 6-noded triangular contact element with three translational degrees of freedom per node is implemented in the present study to ensure compatibility with a linear tetrahedron used to discretize the fiber-tow.

To show applicability of the present contact element the homogenization problem on the meso scale is chosen. The effective stiffness matrix $\mathbf{L}_{\text{meso}}$ is found from the solution of six successive elasticity problems. To that end, the periodic unit cell is loaded, in turn, by each of the six components of overall strain $\mathbf{E}_{\text{meso}}$, while the other five components vanish. The normalized volume stress averages then furnish individual columns of $\mathbf{L}_{\text{meso}}$ (see [2]). significant variation of $\mathbf{L}_{\text{meso}}$ as a function of interface stiffness can be observed. Recall that introducing large interface stiffnesses essentially provides a perfect bonding between fiber-tows. More results can be found in [1].

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Measuring Thermal and Mechanical Properties of Unburnt Clay Bricks

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Within the context of this research, thermal and mechanical properties of unburnt clay bricks (pressed by a mechanical press) have been studied. Unburnt clay is an ecological, fully recyclable material unexacting production energy. For its wider use, it is necessary to determine material characteristics as is it common for conventional materials.

The base material for the production of unburnt clay bricks was a clay obtained from a foundation excavation of a experimental single house in the village Únětice. After granulometric test it was found, that the clay is not fully suitable for pressing bricks. Therefore was necessary to add other components like sand, gravel and dry hydrate. These components affect cohesion and tensile properties. For testing compressive and tension strength, three mixtures marked A, B and C were made. Thermal parameters were further measured only on specimens from mixtures C. Taking into account that the clay was naturally wet, there was not necessary to add any technological water in the mixture. Bricks were pressed by a mechanical press PressBrick (made in France). After that bricks were dried by air (protected against insolation). The size of one brick was 295x140x85 mm. Mechanical properties were measured on specimens 140x140x85 mm, thermal parameters were measured on specimens 140x40x20 mm. For the comparison of thermal parameters, specimens of burnt bricks (producer Brick factory Kinsky) were measured at the same time.

The compressive and tension strength were tested in an accredited testing laboratory OL 123 of FCE CTU in Prague. Specimens were tested by a testing machine ED60 PMS04. The moisture by mass of tested specimens was 1.9%. The highest average compressive strength R_c=3.8 MPa was achieved on specimens made of mixture C. The highest average tension strength Rt=0.46 MPa was achieved on specimens made of mixture B. We can say, that the highest compressive strength was achieved with the mixture with the highest share of clay, or (if you like) the highest tension strength was achieved with the mixture with the highest share of sand.

Thermal parameters were tested in the laboratories of the Department of Physics of FCE CTU in Prague. Before measurement, specimens were placed into the drying kiln, where they were dried for 7 days at the temperature 110 °C. After that specimens were divided into two groups, they were weighted and placed into the desiccators with relative humidity 65% and 85%. After achieving fixed-ratio mass moisture, specimens were in the desiccators interchanged. The relative humidity was kept by solutions of $NaNO_2$ and KCl. In each step of measurement specimens were taken out from desiccators, weighted and measured. Specimens were weighted by digital balances Sartorius 1204 MP. Thermal parameters were measured using the commercial device Isomet 104 with surface probes. This device is equipped with various types of probes. Needle probes are determined for measuring porous, filamentous and soft materials, while surface probes are determined for measuring hard materials. The measurement is based on analyses of a thermal response of investigated specimens, which were exposed to pulsed heat flows. Heat flows are induced by a resistance heating element, which is placed on the surface of the measured specimen.

After 42 days from the beginning of the measurement, the fixed-ratio mass moisture was achieved. The value of the mass moisture w_m is 1.70% (for the relative humidity φ=65%), or 1.90% (for the relative humidity φ=85%). The value of the thermal conductivity λ is 0,385 $Wm^{-1}K^{-1}$, the specific heat capacity c is 570 $Jkg^{-1}K^{-1}$ and the density ρ is 1815 kgm^{-3} (all for the mass moiture w_m=2,0%). The results of the measurement shows, that the specimens made of unburnt clay (exposed to the same relative humidity) get damp and dry out faster than burnt brick specimens.

Unburnt clay is a perspective construction material, especially for environmentally friendly buildings. Obtained results shows, that this material is comparable with conventional materials like burnt bricks or autoclaved aerated concrete. For practical using it is necessary to determine another material characteristics like diffusion, absorption of moisture, frost resistance etc. Mechanical parameters can be improved adding natural fibres (e.g. fleece) to the mixture. Determination of these parameters will proceed in the next research.

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Material Properties of Carbon Fiber Reinforced Cement Composites

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The content of this research was to determine thermal properties (such as thermal conductivity λ, specific heat capacity c) and hygric properties (such as hygric strain) of newly designed carbon fiber reinforced cement composites. Carbon fibers have higher tenacity and thermal endurance than glass fibers. In the developed materials there are in addition to cement and carbon fibers also other components increasing thermal resistance. This material has ambition to replace earlier used materials on asbestos base. The measurement was conducted on two different materials marked UCII (on the base of Portland cement) and UCIII (on the base of aluminous cement).

The dimensions of specimens for the measurement were 60x250x10 mm. Specimens were divided according to the applied load (thermal, tensile a their combinations) in 11 groups. Loading temperatures were chosen according to the chemical processes changing the structure of the investigated material. The most important reactions for Portland cement are the decomposition of $Ca(OH)_2$ at 460-480 ^{0}C and the decomposition of $CaCO_3$ between 700 ^{0}C and 800 ^{0}C. Products of these reactions can cause local overpressure in the porous system and cracking. It leads among others to changes in the material structure and its local damage by microcracks. Therefore, for the measurement there were chosen temperatures 600°C, 800°C and 1000°C. The first temperature is in the interval between decomposions of $Ca(OH)_2$ and $CaCO_3$ and the second temperature is higher. The last temperature 1000°C was chosen to simulate a fire load.

Temperature loading was provided using the furnace BVD 100/KY. At first specimens were warmed with temperature increase rate of 10°C/min. After achieving the final temperature, the specimens were tempered for 120 minutes and then they became slowly cold. Tension loading was provided in Klokner's institut of CTU in Prague on a device MTS 500 kN. The LVDT sensors on the specimens registered longitudinal deformations in the whole range of loading until an apparent damage of the specimen. The rate of loading was chosen as 0.02 mm/s. After finishing the described loading the specimens were held in a laboratory at temperature 25±1°C and relative humidity 30-35 %. In these conditions, the measurement was performed. For measuring hygric strain the specimens were exposed to different moisture load. In each step of measurement, specimens were weighed and the change of their length was measured.

Thermal parameters were measured using the commercial device ISOMET 104. It is equipped with various types of optional probes. The measurement is based on analysis of the temperature response of the analyzed material to heat flow impulses. Longitudinal changes were measured using Zeiss's longitudinal comparator. Specimens were provided by a hole on the face for this measurement.

Results of the measurement show the decrease of the thermal conductivity after loading by 600°C for both investigated materials. For the composite UCIII is the decrease much higher then for composite UCII. This phenomenon can be explained by strong structural material change and micropore genesis, which proceed at this load. During loading by higher temperatures probably any other strong material changes do not proceed. However the dimension of pores is rising and it leads to heat transfer by radiation. Therefore the value of the thermal conductivity is increasing slightly. The tensioning has a very low effect on the thermal conductivity. For the composite UCII there was determined the thermal conductivity λ=0,318 $Wm^{-1}K^{-1}$ (for reference group), or λ=0,265 $Wm^{-1}K^{-1}$ (for loading by 600°C). For the composite UCIII there was determined the thermal conductivity λ=0,774 $Wm^{-1}K^{-1}$ (for reference group), or λ =0,379 $Wm^{-1}K^{-1}$ (for loading by 600°C).

After analyzing the results we can say, that the loading has low effect on the specific heat capacity. For the composite UCII there was determined the specific heat capacity c=800-950 $Jkg^{-1}K^{-1}$, for the composite UCIII c=950-1100 $Jkg^{-1}K^{-1}$.

For the composite UC II there was determined the maximum water absorptivity 26,1% (for reference group) and 30% (for the other groups). For the composite UC III there was found different behavior against UC II. Maximum absorptivity for reference group was 13,8 %, for loading by 600°C 23,5 % and for 800 and 1000 °C is 28 %. While for the composite UC II the length is rising faster in the hygroscopic range than in the overhygroscopic range (this is usual for porous materials), the composite UC III exhibits an opposite behavior. This difference can be caused by different chemical reaction at high temperatures for Portland and aluminous cements.

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Surface Characterization after Friction Test of 316L Stainless Steel

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This research was performed in laboratory CFH (Corrosion, Embrittlement, Hydrogen Laboratory) at École Centrale Paris [1]. The laboratory has a lot of experience in investigating friction of metals, particularly stainless steels. This research was focused on morphology of specimen surface after friction test. Especially the trace and vicinity of the trace was investigated using Scanning Electron Microscope (SEM) and 3D microtopograph.
Austenitic stainless steel 316L was chosen as a studied material, because it is very common and investigated material and it is not susceptible to deformation induced martensitic transformation [2]. Cylindrical specimens (25mm diameter, 15mm height) were cut from rolled bar. Samples were mechanically polished with the subsequent electrolytical etching (10% acid oxalic, 10V, 30s).
Friction tests were carried out on the pin-on-disc equipment, which allows choosing magnitude of normal force. Friction was carried out by rotative alumina hemisphere indentor with 5cm radius. Frequency of indentor rotation was 10rot/minute (corresponding to the velocity of 8,4mm/s). Experiments were performed with two different magnitudes of normal force (16N and 130N) and three different periods (5, 50, 150 rotations). According to the Hertz theory normal force 16N implies elastic deformation and 130N elastoplastic deformation. Different periods were chosen to distinguish different contributions of wear process during formation of friction trace.

After friction test the surfaces of all 6 specimens were inspected in the JEOL JSM-T220 SEM. On the specimen surfaces we have found out four interesting phenomenona caused by friction: Wear zone in the centre of friction trace, abrasion zones also in the trace next to the wear zone, borders of the friction trace and slip bands in the close vicinity of the trace.

The wear zone is characteristic by the occurrence of grain structure with a large amount of secondary cracks in the surface perpendicular to the indentor movement. The abrasion zone is composed of scratches, which are parallel to indentor's movement (parallel to the rounds of the trace). We have realized two important differences between specimens undergoing 150 rotations with the normal force 16N and 130N. Width of the trace was 200-300μm and 700-800μm respectively. It has to be noted that the wear zone is wider than the abrasion zone on the surface charged with 130N. This ratio is opposite in the case of 16N.

The borders of the trace slightly rise above the surface. The shape of the border is complicated and irregular. The shape is locally influenced by the force of the friction and probably also by the material structure. Occurrence of the slip bands is closely connected with the irregularity of the border. The slip bands are more concentrated near the trace. They were observed in the maximal distance of 100μm from the borders.

The same specimens were also investigated by 3D microtopograph Zeiss. The device was conducted by the software Surface map and the data were processed by the software MountainsMap. We used optical probe with followed parameters: scope in z-axis 80μm, accuracy in z-axis 30nm, resolution in x,y-plane 1μm. We have acquired four profiles across

the friction trace from each specimen. Each profile was measured with the step of measurement 0,5μm. We have measured specimens with different width of traces but the ratio trace/no rubbed surface was 50%/50% at each specimen.

Firstly we measured 2D parameters of roughness. The parameters R_a (average depth), R_q (average divergence) increase with the normal force magnitude. The parameters R_p (maximal height), R_v (maximal depth) and R_t (total height of the profile=R_p+R_v) indicate that plastic deformation takes place probably at the beginning of the friction process. After that the wear process is more important and cause the increase of the profiles depth and loss of the volume.

Consequently we measured other macroscopic parameters of the trace, which can be connected with plastic deformation and the wear process. The width of the trace changes with normal force magnitude. For normal force 130N, the measured value 800μm is in good agreement with the Hertz theory. For normal force 16N The value 250μm (force) is slightly smaller than 400μm proposed by the Hertz theory. As we have already mentioned, the borders of the friction trace are slightly elevated above no rubbed surface. Hence we have measured following parameters: width of the (elevated part of the) border, width of the exterior slope of the border. These parameters are also proportioned to normal force magnitude, but the dependency is not so strong as in the case of the width of the trace. The exterior slope is an important zone, because it is apparently influenced (deformed) by the friction process. The average width of the slope is 100μm and this value can be used as an estimation of the plastic zone size.

We measured also section area of profile line corresponding to elevated borders (interior and exterior) and section area of profile line corresponding to the hole (part of the trace under the level of no rubbed surface). These parameters strongly depend on normal force magnitude. The area of surface of border is stable during the friction process, but the area of surface of the hole increases importantly with evolution of the process. This fact confirms that the growth of the depth of the trace is caused by the wear process.

In this work we investigated mechanical response of austenitic stainless steel 316L on friction generated by alumina indentor on pin-on-disk device. Summarizing all listed results we can assume that increase of roughness and plastic deformation of the surface takes place at the beginning of the friction process, the other changes are caused mainly by abrasion and wear process.

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Mixture Development for Renewal Plasters of Historical Buildings and Determination of Basic Properties

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The lime plasters are damaged more easily than plasters with hydraulic or pozzolanic reactive admixtures. Therefore, it is reasonable to design renewal plasters for historical buildings based on lime putty and admixtures with pozzolanic properties. Pozzolana materials form first a solid structure of CSH compounds, later calcium carbonates (see [1]-[3] for details). In this paper, metakaolin, grinded enamel glass and grinded brick pottery were used as pozzolana materials in lime-pozzolana plaster mixtures.

The lime pozzolana plasters were formed by: 1-part hydrated lime (CL 90 Czech-Moravien Cement Mokrá) : 3-parts natural quartz sand with continuous granulometry 0 to 4 mm : 1,2-part water and 1-part pozzolana mixture. The reference lime plaster consisted of 1-part hydrated lime, 3-parts natural quartz sand and 1-part water.

The following type and number of specimens were used for measurements of basic mechanical, thermal and hygric properties: bending and compressive strength 9 specimens 40 x 40 x 160 mm, thermal conductivity and specific heat capacity – 3 specimens 71 x 71 x71 mm, linear thermal and hygric expansion coefficients – 5 specimens 40 x 40 x 160 mm, apparent moisture diffusivity – 3 specimens 50 x 50 x 20 mm, moisture diffusivity – 3 specimens 20 x 40 x 296 mm, water vapor diffusion coefficient – 3 cylinders with the diameter 105 mm and thickness 20 mm, sorption isotherms – 3 specimens 33 x 33 x 10 mm for every ambient relative humidity. The samples for determination of moisture diffusivity and water vapor diffusion coefficient were provided on all lateral sides by water- and vapor-proof insulation on the edges.

The measurements of basic parameters show remarkable differences in bending and compressive strength. That is clearly related to the formation of CSH gels first and later of calcium carbonates. The CSH gels have higher strength than calcium carbonate. This has led to an increase in compressive strength almost four times in comparison with reference plaster. The formation of calcium carbonates has in longer period an additional reinforcing function and the measurements show an increase in compressive strength in the period of 90 days almost seven times.

The measurements of capillary water saturation show the difference of plaster with metakaolin comparing to other plasters. Metakaolin is very porous material and may be used also as an aerated agent in concretes. In the plaster it causes bigger porosity and lower bulk density and leads to the increase of pore volume of the lime-pozzolana plaster. The porosity of the material could also be increased because of the porous character of the products of the pozzolanic reaction, mainly of the CSH gels.

Measurements of moisture diffusivity κ revealed that κ of the lime-pozzolana plaster with metakaolin was lower than of the lime-pozzolana plaster with grinded brick and of the reference lime plaster in almost whole range of moisture content despite the higher capillary water saturation value, the lime-pozzolana plaster with grinded enamel glass had higher κ in almost whole range of moisture content. For moistures close to water saturation values of all

materials the moisture diffusivities were comparable. We believe that the main reason for this fact is probably the effect of CSH gels that can bond by van der Waals forces more water molecules on the pore walls than calcium carbonate.

Sorption isotherms of both materials show higher values of adsorbed water in lime-pozzolana plaster with metakaolin compared to the reference plaster, which corresponds to the higher value of capillary water saturation value. It is a consequence of higher porosity of the lime-pozzolana plaster with metakaolin, which is caused by the presence of an aerated agent, and higher internal pore surface.

Thermal conductivity of lime-pozzolana plasters was lower compared to the reference plaster. Approximately two times lower was thermal conductivity of plaster with metakaolin, which corresponds with the differences in density and porosity, the plaster with grinded brick achieved 10% lower value and plaster with enamel glass 23% lower, which corresponds perhaps with formation CSH gels. Specific heat capacity of all materials was practically identical. Water vapor diffusion resistance factors μ of reference plaster and plaster with metakaolin were very similar, the value for metakaolin plaster was only about 20% higher which may be a consequence of CSH gels formation again. The other two materials had lower values of water vapor diffusion resistance factors μ, only 60% compared with reference plaster.

Linear thermal expansion coefficient of the lime-pozzolana plaster was measured in the range between 23 and 105^0C. It was almost two times lower for metakaolin plaster than for the reference plaster, which is a good feature. Plaster with grinded brick achieved 10 % lower value, and for lime plaster with enamel glass we have found the value 25 % higher than for the reference plaster. On the other hand, the linear hygric expansion coefficients were between the dry state and the capillary water saturated state two times and more higher than for the lime plaster. This is not very good result.

It can be concluded that the most important parameter of the lime-pozzolana plaster studied in this research compared to the lime plaster is a significant increase of both compressive strength and bending strength without using cement that was not used in buildings older than 100 years. The plaster with grinded brick pottery and the plaster with grinded enamel glass achieved better 28-days compressive strengths than the plaster with metakaolin. Therefore, all studied plasters can be successfully applied in historical buildings instead of the classical lime plaster.

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Deformation Measurement in the Vicinity of Friction Trace Using Micro-grid and EBSD technique

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This work concerns with deformation measurement in the vicinity of friction trace caused by friction on the pin-on-disc device at the laboratory CFH at ECP Paris [1]. Principal experiment of this work was deformation measurement using micro-grid technique and Electron BackScattering Diffraction (EBSD) [2]. The main goal of this work was to verify use of these techniques in the case of mechanical friction.

Austenitic stainless steel 316L was chosen as a studied material, because it is very common and investigated material and it is not susceptible to deformation induced martensitic transformation [3]. Cylindrical specimens (25mm diameter, 15mm height) were cut from rolled bar. Samples were mechanically polished with the subsequent electrolytical etching (10% acid oxalic, 10V, 30s).

Friction tests were carried out on the pin-on-disc equipment, which allows choosing magnitude of normal force. Friction was carried out by alumina hemisphere indentor with 5cm radius. Frequency of indentor rotation was 10rot/minute (corresponding to the velocity of 8,4mm/s). Experiments were performed with two different magnitudes of normal force (16N and 130N) and periods 150 rotations. According to the Hertz theory normal force 16N implies elastic deformation and 130N elastoplastic deformation in the specimen.

After friction strain hardening caused by friction in the vicinity of the friction trace was characterized by microhardness HV measurement. The increase of HVM reached 20% maximum comparing to mean value of microhardness before friction. This maximum increase of HVM has been achieved in very close surrounding of the trace, just next to the borders of the trace in the distance up to 100μm.

The deformation measurement using micro-grid technique was carried out in cooperation with laboratory LMS at the École Polytéchnique in Paris. This method allows to measure local deformation of the surface with resolution chosen by step of the grid [4]. This method consists in positioning very fine grid on the specimen's surface. The grid deforms at the same way as the surface therefore we can measure deformation by comparing the grid's position before and after experiment. According to applied positioning methods, whether we measure z coordination or not, and assumed deformation hypothesis (plane strain, plane stress etc.) we can calculate the Green-Lagrange deformation tensor or small deformation tensor as a function of x,y. Consequently it is possible to calculate different functions, e.g. Von Mises equivalent deformation - ε_{eq}. Current accuracy of the method is 1%.

In our case we measured only in-plane (x,y) grid position without any deformation hypothesis. The positions were calculated from images from SEM in 4000x4000 pixels Therefore we can obtain only ε_{11}, ε_{12}, ε_{21}, ε_{22} components of small deformation tensor. The grid is fixed on the surface before mechanical straining. We used square golden grid of 0,5 μm wide lines with step of 2μm. Images of the grid were taken before and after friction. These consequent images of the same area were then compared by image analysis software.

Finally we can obtain deformation cartography, which shows us magnitude of chosen tensor component of investigated area.
After friction the grid was destroyed in the trace and in some very deformed places in the close vicinity of the trace. The surface deformation is composed of tension component parallel to the trace and compressive component perpendicular to the trace, but the deformation is very localized and heterogeneous. The most deformed places are very close to the trace (<5μm surrounding) near shape extremities of border of the trace. There are usually slip bands at these places. Values of deformation rise up to 6% in the case of tension and 25% in the case of compression. The rest of the investigated area is much less deformed, the more far from the trace the less of deformation. The distance of no deformed surface from the trace varies strongly with the shape of the border. It varies between 5μm and 50μm.
Finally areas, where surface deformations were measured, were investigated by EBSD technique. Our aim was to characterize an influence of the material microstructure on deformation and to compare the grain structure state before and after the friction. EBSD technique provides knowledge of the crystallographic orientation of grains and the distribution of such orientations. EBSD technique has a spatial resolution of 50 nm and an angular precision typically of 1º. This method is very fast – it takes time inferior to 1 s to index one pattern using fully computer-controlled procedure. Relatively easy accessibility of this method offers wide applications for studying the microtextures, misorientations between two adjacent grains, coincident site lattice boundaries etc.
The specimens were examined in a Field Emission Gun SEM LEO Gemini 1530 equipped with TSL™ EBSD analyser. SEM observations were performed at 25 kV. For EBSD analysis the samples were inspected at a tilt angle of 70°. Acquired data were evaluated by OIM™ software.
In observed zones we have found only negligible changes in grain orientation in the vicinity of the trace caused by friction. The slip bands in the most deformed zones (according to micro grid measurement) are (111) crystallographic planes. We have verified feasibility of measurement of grain orientation by EBSD technique in the vicinity of the friction trace even on the surfaces with micro-grids. Quality of the measurement is strongly influenced by the existence of relief caused by elevation of borders of the trace above the level of no damaged surface.

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Neutron Diffraction Studies Of Si-Mn TRIP Steel In Situ Upon Tensile Load

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An excellent combination of high strength and formability can be obtained in a Si-Mn TRIP steels when processed by thermomechanical treatment consisting of high temperature deformation followed by isothermal holding in the bainite region and cooling to room temperature. Microstructure of these steels consists of ferrite, bainite and retained austenite. The combination of high strength and ductility is attributed to the transformation-induced plasticity (TRIP) effect resulting from the strain induced transformation of the retained austenite to martensite. These steels exhibit tensile strengths ranging from 800 to 1000 MPa and elongation up to 30 %. In the present paper, the influence of applied macroscopic stress on transformation characteristics of retained austenite in selected 0.2C1.9Si1.45Mn TRIP steel was investigated. Based on results of *in situ* high-temperature experiments [3], the set of specimens was prepared for neutron diffraction studies of transformation characteristics realized at room temperature *in situ* upon tensile tests. The reported neutron diffraction method has been found as an efficient tool for characterization of austenite transformation proceeding in TRIP steels during combined thermomechanical treatments.

The transformation induced plasticity (TRIP) effect is observed in high alloy metastable austenitic steels as well as in low alloy multiphase steels. The TRIP phenomenon was found first by Zackay et al. in steels with large amount of Ni and Cr [1]. They explained the enhancement of ductility in high-strength steel as a result of austenite transformation and named this effect as transformation induced plasticity. In the present paper, the *in situ* neutron diffraction (ND) experiment has been used to analyze the transformation kinetics and evaluate the lattice strains and stresses in ferrite and austenite as a function of applied load.

The specimens for tensile test were prepared following the different ways of thermomechanical processing in order to achieve a various volume fraction of retained austenite in the finely grained multiphase microstructure. Kinetics of retained austenite transformation has been studied to optimize industrial process of cold forming.

Neutron diffraction experiments were realized at the dedicated high-resolution stress/strain diffractometer TKSN-400 in NPI Řež (instrumental resolution of $\Delta d/d \cong 2x10^{-3}$). This facility is mainly used for *in situ* investigations of the deformation processes in different materials [8-10]. The instrument is equipped with a special deformation rig for tension/compression loading up to the force of 20 kN. The diffractometer is dedicated stress/strain instrument with a linear PSD providing diffraction spectrum in a relatively narrow 2θ band of about $2\theta=7^{o}$. The detector window was set to cover both ferrite (110) and austenitic (111) reflection.

Relevant information on transformation characteristics can be extracted from integral intensities and angular positions of the individual profiles. The austenite and ferrite integral intensities can be assumed as a measure of the phase volume fractions whereas the profile positions can be used for estimation of the elastic lattice strains evolving in ferrite and austenite during transformation, for details see Ref. [2,3].

Two specimens containing 13% and 21% of the retained austenite were tested. During tensile test, the specimens were loaded by a constant crosshead displacement in incremental continuous steps until failure; deformation step of 1.3% was uniform in all successive deformation steps. The strength and ductility depend on the amount of retained austenite in structure.

The diffraction data were collected after each deformations step during 1 hour stopovers at constant deformation. The position sensitive detector was set to record evolution of (110) ferrite and (111) austenite reflections. Evolution of austenite volume fraction was assessed from relative changes of integral intensities of austenite diffraction profiles; the absolute initial value was determined by X-ray phase analysis. The specimen containing larger amount of retained austenite exhibits very good transformation behavior; only of about 4 % of untransformed austenite has been detected in the final microstructure after failure, whereas specimen containing 13 % of retained austenite shows moderate TRIP effect and higher content of 10 % of untransformed austenite after failure. Difference in volume of retained austenite between both specimens is apparent also in strain-stress curves. The lattice strains evolving in both phases during the deformation process were evaluated as well; however, discussion about them exceeds extent of this paper (for details see Ref. [3]). The experimental values of lattice strains can be used for estimate of stress/strain partitioning in ferrite and austenite grains and could be also used for further micromechanical modeling. Relevant micromechanical model together with metallografic observations would contribute to interpretation of different transformation behavior.

The volume fraction of ferrite and austenite were determined from independent measurements, so that the sum of ($v_F + v_A$) was received less than 100% in most cases. This discrepancy can be explained either by the presence of the third phase (carbides) or a statistic error roughly estimated by ±5%.

The high-resolution ND method applied *in situ* upon combined thermomechanical loads has been used for characterization of the austenite transformation proceeding in TRIP steels during the tensile loading. This method describes evolution of phase volume fractions and transformation kinetics; although for explanation of observed facts the cooperation with other methods is necessary. Due to relatively low absorption of thermal neutrons in steel specimens, the neutron diffraction method yields relevant information from large sampled volume *in situ* during mechanical loading prior transformation. This is the main benefit of the applied method in comparison with other available experimental methods. The method provides also other useful parameters as a content of retained austenite and an estimation of the phase specific stresses during transformation. Implementation of these parameters (lattice strains namely) into micromechanical modeling would represent further progress in interpretation of processes proceeding in TRIP steels.

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Radiation Embrittlement Concrete

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The Nuclear Power Plant (NPP) concrete structures are composed of several constituents that perform multiple functions (i.e., load- carrying capacity, radiation shielding and leak tightness). Primarily these constituents can include concrete, conventional steel reinforcement, prestressing steel, and steel or non- metallic liner materials. The NPP concrete structures are exposed to a variety of damaging influences and degradation of concrete is realy imporatant one. In most cases, concrete damage will be the result of more than one degradation factor. However, the basic understanding of the various damage- mechanisms should be possible, in most cases, to determine the primary causes of damage of concrete structure. The physical and chemical causes of damage are moisture changes, freeze/ thaw cycling, thermal exposure, thermal cycling, irradiation, abrasion, fatigue, vibration, creep, alkali-aggregate reactions, sulfate attack, bases and acids and salt crystallization.

In design of reactor shields concrete is a widely used and versatile shielding material primarily because of its special attenuating properties for radiation and relatively low cost. It also has the required structural integrity and mechanical properties. Concrete is effective for gamma shielding because of its aggregates of low atomic number and hydrogen content which are desirable to accept the energy of photons within the shield. Photon transmission through concrete is very much dependent on its water content. However, over a period of time water content of the concrete can due to gamma radiation induce water radiolysis in the concrete and consequently chemical reactions leading to changes of concrete phase composition [2]. We can expect that changes in hydratation degree becomes evident by changes of the concrete strength.

Test samples were made according to the formulation in [3]. This formulation is exact that was used for construction of containment of NPP Temelin. Chemical composition of concrete is metioned in [3].

Concrete beams at dimensions 0,4x0,1x0,1 [m] were irradiated in the company Bioster Corp. in Veverská Bítýška. ^{60}Co is used as a source of gamma radiation. Each beam carried gamma radiation dosimeters. Classical Si diodes were applied as dosimeters. The beams were 83 days under gamma radiation.

At first, the flexural strength test (three – point supporting) was applied to concrete samples. Each sample was divided into fragments. The compressive strength test was used on the first fragment (in accordance with ČSN 73 13 18) and the tensile strength test on the second fragment (in accordance with ČSN 73 13 17).

The results show that irradiation at values of the order 10^5 Gy can lower strength of the studied concrete by approx. 10% resp. 5%. This finding rectifies the argument [1, 4] that concrete is faulted only at the integral doses of 10^8 Gy. An integral dose of 10^5 Gy

corresponds to the situation that concrete in the NPP Temelín is exposed to in the distance of 373,9 cm from the reactor axis for the operation period of approx. 30 years.

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Textural Fractography of Fatigue Failures under Variable Cycle Loading

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Up to now, the fractographic reconstitution of the fatigue crack growth process under variable cycle loading was generally impossible. Within crack growth experiments, marking of the fracture [4] was necessary: special short sequences of cycles were inserted into the loading, which made readable traces in the fracture surface. Fractures from the practical service usually could not be quantitatively analyzed.

Textural fractography of fatigue failures [1,2] is a new method, which has been developed since 1990 in the Dept. of Materials, FNSPE. SEM images of fracture surfaces are analyzed as image textures, and characterized by a set of textural parameters - a feature vector. The relation between the feature vector and the macroscopic crack growth rate is studied by means of multidimensional statistical methods. Up to now, this approach was applied and fully proved for cases of failures caused by a constant cycle loading. However, the cyclic loading in practice is usually variable, and generalization to this case is highly desirable.

Let us compare two extreme cases of cyclic loading:

1. constant cycle loading with stress cycle characteristics σ_{min}, $\sigma_{max,1}$;
2. loading by alternating a "great" and a "small" cycle, i.e. by the sequence of extremes σ_{min} - $\sigma_{max,1}$ - σ_{min} - $\sigma_{max,2}$ - ..., where $\sigma_{max,2} << \sigma_{max,1}$.

In the second case, due to the effect of retardation after an overload, only cycles with maximum $\sigma_{max,1}$ are active. That means, crack growth process is not affected by inserting small cycles (of course, with a proportional frequency). The morphology of the crack surface is almost the same as in case 1.

However, according to the traditional definition of crack growth rate, $v = \Delta a/\Delta N$ (where a is the crack length and N is the number of loading cycles), the non active loading cycles are also included. It follows, that crack growth rates assigned in both cases to the same crack morphology, are v and $v/2$, respectively. Generally, in the case of a variable cycle loading, crack growth morphology cannot be unambiguously related to the value of crack growth rate.

To overcome this problem, a hypothesis about counting time was proposed by Lauschmann: Let us express the crack increment in a cycle within variable cycle loading as $\Delta a = h\, v_{mon}$, where v_{mon} is crack increment (crack growth rate) in the same cycle within constant cycle loading, and h stands for retardation ratio. Then, for the time increment from this cycle should be taken h, instead of 1 in the traditional approach. It means, that the time should be expressed as sum(h_i), i = 1,2,..N, instead of N = sum(1).

In case 1 above, $h_i = 1$ for all cycles, and the time is equal to number of cycles N. In case 2, $h_i = 1$ for cycles with maximum $\sigma_{max,1}$, and $h_i = 0$ for cycles with maximum $\sigma_{max,2}$. That means, only "great" cycles are counted. It follows, that the same values of crack growth rate will be assigned to the same crack morphologies.

Of course, in a general case, the conditions are not so simple. There is a serious question, how far the above hypothesis can be applied for textural fractography of more complicated cases of variable cycle loading. Crack surface morphologies related to the same value of crack growth rate need not to be fully identical (in the random field sense). It is possible to apply the image textural analysis so that it automatically extracts similar features, also in cases of images which are visually different. A more challenging problem would be to relate mutually crack morphologies without similar features.

A large experiment was started to study the applicability of the hypothesis. A typical material used widely in the industry was selected - aluminium alloy AlCu4Mg1. Up to now, 25 CT specimens were loaded by different loading sequences: constant cycle, constant cycle with isolated overloading, Z+1 type (i.e., repeating Z constant cycles followed by one overloading, Z = 199, 1999, 9999), and random sequences of cycles. In all cases, crack growth was measured and recorded.

Crack surfaces were documented by SEM images in magnification 200 x (view field 0.45 x 0.6 mm). The two-dimensional Fourier transformation [3] was applied to extract a feature vector. It is composed of 45 mean amplitudes of spectral decomposition segments representing different directions and periods.

The statistical analysis of images brought the first results: SEM images of crack surfaces created under constant cycle loading with sporadic overloadings (verified for $Z \geq 199$) or without overloading ($Z \rightarrow \infty$) may be related to the (proposed above) crack growth rate by the same computational algorithm with the same set of parameters. It means that in all cases of this relatively wide range of variable cycle loading, images of fracture surfaces contain (in some segments of spectral decomposition) the same image textural information. This is a very important fact, because images are also evidently different in some aspects.

Results reached are extremely valuable for the practical application. The re-computing between the real time of the loading, and the transformed time proposed above, is not a problem - it can be done by using a selected crack growth model (for details, see Šiška et al. in this issue). The fractographic reconstitution of fatigue crack growth under variable cycle loading significantly improves possibilities of the quantitative fractography of fatigue failures.

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Modeling of Fatigue Crack Growth under Variable Cycle Loading

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Fatigue crack growth is a very important technical problem, which must be solved. Within textural fractography, the morphology of fracture surface is related to the fatigue crack growth rate by using image analysis. Methods of image textural analysis are used to obtain the set of textural parameters of fracture surface's image. The main goal is to find the relationship between values of textural parameters and the value of the macroscopic crack growth rate, in a set of images. Up to now, the research has been oriented only on fracture surfaces originated under constant cycle loading. There have been proved very close relationship between the macroscopic crack growth rate and the image texture in SEM images of the fracture surface.

In the following research, it is necessary to be engaged in fracture surfaces created under variable cycle loading. This case has a big importance in technical praxis, because most of real loading processes are variable. There's a problem to define the macroscopic crack growth rate in this case. When variable loading is applied, interactive effects are active. Due to them, the crack increment in each cycle is not the same as in the case when the cycle is a part of a constant cycle loading. To reach a wide compatibility of the assignment "crack morphology - crack rate", a hypothesis was proposed how to define the relevant macroscopic crack growth rate under variable loading. For the application of this hypothesis, increments of the crack length in single cycles must be known. This can be reached only with using some kind of theoretical crack growth model [1].

At first, an extensive experiment was designed and realized on a typical material for technical application - aluminium alloy AlCu4Mg1. About 30 CT specimens were loaded by several types of loading, representing the whole range from constant to random cycle: Constant cycle loading, constant cycle with isolated overloading, Z+1 block loading (Z constant cycles followed by one overloading, Z = 199, 1999, 9999), and random loading (a block of one thousand random amplitudes). Crack growth was monitored and stored as relations between the crack length and the number of applied cycles. Also all values of applied loading forces were stored.

Experimantal results were compared with theoretical calculation based on theoretical models. Three models of crack growth were chosen. Each model represents one group of existing models.

The Generalized Willenborg model belongs to the group of models, which are based on the principle of plastic zones' interaction. Calculation of the increment of crack is based on the comparison of the size of actual plastic zone and the size of plastic zone which was created by the last overloaded cycle. This comparison determines the value of the retardation of the crack growth rate. Some material constants take part in this model like the yield strength and the threshold value of stress intensity factor. Another constant specific for this model must be estimated experimentally [2, 3].

The Onera model represents the group of models which use the opening value of stress intensity factor. This value is calculated by comparison of plastic zone's sizes likewise in the Generalized Willenborg model. This model also takes account of the character of stress across the body section: the plane stress on the surface of the body and the plain strain in the central part of the body. Model works with the yield strength and with functions, which can be obtain empirically [4].

The Model with the Influence function is fenomelogical and has a regression character. Interactive effects are expressed by the Influence function. Shape of this function had been defined on the basis of several large sets of experiments. The Influence function includes three parameters, which must be estimated on the basis of experimental results.

Calculations were made and compared with experimental results. Results were demonstrated by plots and by calculated deviations between experimental data and theoretical calculation. The ability of crack growth prediction for each model and type of loading was evaluated. All models yield good predictions of crack growth, and differences between individual models are relatively small. In the case of Z+1 block loading, the best results were obtained with the model based on the Influence function. Optimal predictions of crack growth under random loading were reached with the Generalized Willenborg model [1].

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Application of Wavelet Transform in Analysis of Material Surface Morphology

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The application of wavelet transform [1] to images is becoming increasingly frequent due to the transform's advantageous properties: it allows to analyze the input data at several scales without sacrificing its local properties. This approach (also known as Multiscale analysis) is quite suitable for the characterization of textures as they (unlike fractals) exhibit self-similarity on a limited range of scales. In this paper we present the application of wavelets to texture classification.

The one-dimensional discrete wavelet transform transforms the input signal into two components: the approximation A_1 and the detail D_1. The former contains a representation of the signal at a coarser scale (i.e. a downsampled version) while the latter contains information lost during the downsampling. By downsampling the approximation A_1 a new detail D_2 is obtained. Using this recursive approach a set of signal representations { D_1, D_2, ... } is obtained, each of which contains information related to a specific scale. The precise nature of the downsampling is controlled by the wavelet function – a localized oscillation function (hence the name wavelet).

For two-dimensional signals, such as images, the transform is performed on each dimension separately (separable transform). The second dimension is also responsible for the creation of three types of details: horizontal, vertical and diagonal. Horizontal detail contains the detail part of the transform performed in the horizontal direction and the approximation part in the vertical direction. The situation is reversed for the vertical detail. The last type of detail represents the detail part in both dimensions. For example the detail D_{2H} contains the information lost in the horizontal direction when downsampling from scale 1 to scale 2.

The decomposition of the input texture along scales and directions allows for a very specific characterization, nevertheless it does not reduce the number of coefficients in an image (the transform is lossless). If N_0 is the number of pixels of the original image (which may be thought of as approximation at scale 0), the number of coefficients in any wavelet detail at scale 1 is $N_0/4$ is (i.e. quarter the number of coefficients of the approximation of the preceding scale). To compact the information and create siutable feature vector the simplest characteristics of a wavelet detail – its histogram – is investigated. Mallat [2] found the histograms of natural images may be modelled by two-parametric distributions and Van de Wouwer [3] showed these parameters may be derived from two simple characteristics of the histogram: 1) mean deviation $C_j = N_j^{-1} sum_{x,y}(|D_j(x,y)|)$ (an alternative to the first moment as the mean of wavelet coefficients is zero by definition) and 2) variance $D_j = N_j^{-1} sum_{x,y}(|D_j(x,y)|)$. It is to be noted that these characteristics are highly correlated.

The set $\{C_j, E_j\}$ forms the wavelet signature (feature vector) of the image over the analyzed scales. The number of features is the number of scales (j_{max}) times 6 (6 = 3 x 2 = number of types of details x number of characteristics for each detail).

The above-described method was verified for applications in fractography of fatigue failures. However, it has been used very successfully also to classify the dependence of

corrosion morphology on time of exposition in corrosion media. Image textures come from SEM images of internal surfaces of corrosion layers of the ***Zr1Nb*** alloy. This alloy is a perspective surface coating agent for the piping in VVER 1000 and VVER 440 nuclear reactors. For further details on how the images were obtained, see [4]. Altogether 16 images were used for the analysis, corresponding to 3 different expositions to the corrosive environment (84, 630 and 1006 days, 4+6+6 images).

For the purpose of this analysis, the images were analyzed at 6 scales. The wavelet signature therefore consisted of 36 features. The classification task was simple: find or construct a criterion that would sort the 18 images into 3 groups according to exposion time. The approach taken was as follows: Training images (o_{84}, o_{630} and o_{1006}) representing the 3 different classes were selected. For each image o its "distance" from the three different classes was calculated, e.g. d_{84} = abs($c(o)$-$c(o_{84})$), where c is one of the 36 features. The distances were calculated for all the features, which led to 36 different classifications. The class with the highest median count was than chosen as the correct class for each image. Finally, this task was repeated for all possible combinations of training images and the frequency of incorrect classification was observed.

In practice, this approach was modified to improve the classificator. 36 different features result primarily into 36 different classifications. The features were found to be generating rather similar classifications, most probably due to their high correlation. Consequently, the above procedure was modified in order to asses the classification potential of each feature and only the features with high probability of correct classification (e.g. 0.95) were selected. This criterion eliminated all but 5 different features, however the combined probability of correct classification increased to 97.8% .

The above-presented results show how to construct a wavelet signature of an image texture. The signature was found to be quite potent with respect to correct classification of textures according to different exposion to corrosive environment. The algorithm how to construct such a classifier was also shown.

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Mechanical, Thermal and Hygric Properties of Calcined Gypsum Produced from the Waste FGD Gypsum

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In the second half of the 20th century, there were developed technologies for desulfurzation of flue gases in power stations and heating plants. These methods are based on the reaction of sulfur(II) oxide formed during combustion of brown coal with high content of sulfur with limestone $CaCO_3$. Although it seemed that these methods are suitable from the point of view of the protection of environment, there is currently an opposition against these technologies. It is pointed out that the price of desulfurization equipment is too high, and that there is consumed a high amount of high quality limestone while a huge amount of flue gas desulfurization (FGD) gypsum being waste in these technologies is formed.

According to the information in Mining Yearbook 2000 the amount of sulfur in higher quality brown coal for households is from 0.9% to 1.78%. The coal for energy production contains to 2.5% of sulfur. Flue gas desulfurization of one power station block creates up to 20 t of FGD gypsum per hour.

The utilization of FGD gypsum is insufficient considering the amount of its production. Calcined gypsum is produced from FGD gyspum only in one power station in Czech Republic, the remaining production ends with gypsum that is used only partially as additive retarding the setting of cement.

Calcined gypsum is mostly used for the production of gypsum plasterboards. That part of produced gypsum, which is not utilized, is deposited as waste. Therefore, it is very desirable to pay attention to utilization of calcined gypsum also in those applications where it was not yet used, i.e. in the exterior. Utilization of binders with minimal energetic demand is in accordance with the current trend in their production when building materials including binders should be produced with a minimized impact on the environment, i.e. with a minimal if any production of CO_2 and a minimal demand on energy. Examples of such binders are belitic cements, binders based on silicate waste products and also calcined gypsum.

Calcined gypsum $CaSO4.1/2H_2O$ as a low-energy material can be produced with advantage from the waste flue gas desulfurization (FGD) gypsum $CaSO4.2H_2O$ by its dehydration at the temperatures of 110 to 150°C. Then, β-form of calcined gypsum is formed according to the equation

$$CaSO_4.2H_2O \ (110 \text{ to } 150°C) \rightarrow CaSO_4.1/2H_2O + 1\ 1/2H_2O. \quad (1)$$

The solid structure of calcined gypsum is created by reverse hydration when gypsum $CaSO_4.2H_2O$ is again formed. This compound is relatively soluble in water, its solubility is 0.256 mg in 100 g of water at 20°C. Therefore, it cannot be utilized in exterior applications as the rain water could dissolve just the product that should safeguard the mechanical properties of the material.

The resistance of hardened gypsum against water is generally a serious problem [1]. For the utilization of gypsum elements in the exterior, it is necessary to modify it so that it would exhibit more suitable properties and longer service life. Modifications of gypsum are usually performed using polymer materials. However, generally it can be stated that the resistance of hardened gypsum against water is not yet resolved in a satisfactory way.

Therefore, our primary aim is the adjustment of basic technologies for the production of modified gypsum, particularly from the point of view of hydrophobization and the improvement of mechanical and thermal properties. In this paper, we present reference measurements of thermal and hygric properties of common FGD gypsum that will be utilized for a comparison with various types of modified gypsum in the future.

The material, which was used for reference measurements, was β-form of calcined gypsum with purity higher than 98 % of FGD gypsum, produced at the electric power station Počerady, CZ. The water/gypsum ratio was 0.627. The samples were mixed according to the Czech standard CSN 72 2301 [2].

Experimental results can be summarized as follows. Among the basic properties, bulk density was 1019 ± 1.5% [kgm^{-3}], matrix density 2530 ± 2.0% [kgm^{-3}], and open porosity 60 ± 3.4% [% by volume]. Mechanical properties are shown in Table 1.

Table 1 Bending and compressive strength of FGD gypsum

Time [days]	0.08	1	3	7	14	28
Bending strength [MPa]	3.11	3.42	2.64	6.36	6.55	5.19
Compressive strength [MPa]	13.9	12.66	11.48	27.77	30.05	25.51

The basic thermal and hygric properties were determined as well. The thermal conductivity was 0.47 ± 10% [$Wm^{-1}K^{-1}$], the volumetric heat capacity (1.60 ± 10%)E+6 [$Jm^{-3}K^{-1}$], the thermal diffusivity (0.29 ± 10%)E-6 [m^2s^{-1}], the linear thermal expansion coefficient (7.22 ± 15%)E-6 [K^{-1}], and the water vapor diffusion coefficient determined by the dry cup method 17.3 ± 15% [-] and by the wet cup method 5.44 ± 15%.

Determination of a complete set of thermal and hygric properties of practically any type of modified gypsum is a very actual problem. Complete sets of these parameters are not available and without their knowledge it is impossible to perform any serious hygrothermal analysis of building elements based on these materials. During the development process of the various types of modified gypsum it is always necessary to assess the quality of their parameters in some way. Therefore, a set of reference measurements on common gypsum samples was carried out for the sake of future comparisons with the data obtained for modified gypsum.

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Tribological Properties of MoS2 and MoSe2 Coatings

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Transition metal dichalcogenides (sulfides, selenides or tellurides of tungsten, molybdenum and niobium) are well known for their lubricating property. Low friction coefficient is caused by the special layered crystal structure. These structures consist of stack of layers in which a layer of metal is surrounded with layers of chalcogen atoms. The attraction between molybdenum and chalcogen is strong covalent bonding while there is only weak van der Waals attraction between sandwich layers. Therefore a slip between lamellae takes place when friction occurs and it results in low coefficient of friction and other tribological phenomena, e.g. the transfer of coating material to opposing surface is possible.

MoS_2 is the most popular member of the above mentioned family and it is widely used as a solid lubricant in vacuum and inert gases. Modern method of application is a magnetron sputtering, which improved tribological properties and provided the modification of chemical composition and crystal structure. The main problem of MoS_2 used as a lubricant is the strong influence of humidity on the coating properties. Numbers of investigation have been done on that issue and a lot of different ways for solving the problem were shown .

There is lack of information on behavior of other dichalcogenides in humid air. This paper is a contribution to comparison of the friction properties of the molybdenum disulfide (MoS_2) and molybdenum diselenide ($MoSe_2$) measured in the air of different humidity and at elevated temperatures. The comparatively high resistance of $MoSe_2$ coatings to the ambient air relative humidity is presented.

The tribological tests were carried out with a high temperature ball-on-disc tribometer, CSM Instrument. This device allowed measurements of the friction coefficient continuously during sliding test at elevated temperatures from room temperature (RT) up to 800 °C in a controlled atmosphere. The counter-parts used in these measurements were 100Cr6 bearing steel balls with 6 mm diameter . All measurements were provided with a load of 5 N and a sliding speed of 4 $cm \cdot s^{-1}$ on radius in the range from 3 to 6 mm. Because of the variable diameter, the time dependence of the friction coefficient was evaluated on the number of cycles instead of the sliding distance. Measurements were performed in both dry nitrogen and humid air with relative humidity 35 and 50 %. The declared values of relative humidity were measured at room temperature.

The friction properties of $MoSe_2$ were unaffected by the temperature up to 200 °C. Typical friction trace of the $MoSe_2$ remained unchanged at higher temperatures.The value of MoS_2 friction coefficient at RT in humid air was 0.14, at 100 °C it decreased to values typical for dry air (0.05). The reason was decreasing of relative humidity of the atmosphere surrounding the heated sample (because the humidity was measured at RT). In contrast to MoS_2 the $MoSe_2$ coefficient of friction was stable up to 200 °C at a value of 0.06. At higher temperatures both friction coefficients increased in similar way. The reason of this increasing was the higher degree of oxidation that occurred at elevated temperature.

The effect of relative humidity on the coefficient of friction of the MoS_2 corresponds to the results published elsewhere. In dry air the coefficient of friction was very low and rapidly increased with increasing of the relative humidity presence of moisture. The values obtained for $MoSe_2$ were independent on humidity within the range of the measurement uncertainty. Therefore the coating showed very good resistance to humidity in accordance with our expectation.

The MoS_2 layers exhibited considerable decrease of friction coefficient in running-in period proportional to increasing temperature. At the temperatures above 150 °C the running-in effect was negligible (less than two revolutions. It was a consequence of the lower energy necessary to crystal re-orientation at higher temperature. Although the initial value of the friction coefficient at 150 °C was lower than values measured at lower temperature, steady state value was significantly higher as a result of the oxidation.

There was not found any clear connection between the coefficient of friction in first contact and temperature in case of $MoSe_2$. However, during the running-in period the friction coefficient decreased proportionally to temperature in the same way as in case of MoS_2. The running-in effects became negligible above 100 ^{o}C. Hence the running-in of $MoSe_2$ was driven by the same mechanisms mentioned above in studies of MoS_2. The difference values of the friction coefficient at the first contact could be caused by different influence of adsorbed water.

It is assumed that in case of MoS_2 water diffusion into inter-lamellae gap caused the increasing adhesion between the adjacent lamellae. Thus, the friction coefficient and wear rate increased significantly. We supposed that higher coefficient of friction in the case of $MoSe_2$ was caused by stronger forces between lamellae. As a consequence the water diffusion was inhibited. Because of the complexity of these processes more accurate study is necessary.

The results of MoS_2 test were in good agreement with generally accepted expectation. The friction coefficient in humid air increased rapidly to values three times higher than that in dry air. Increasing temperature showed the same effect caused by decreasing relative humidity at sample temperature.

It has been proved that $MoSe_2$ is very promising solid lubricant with satisfactory friction properties. The performed test did not show any influence of the moisture on film properties. Both the friction coefficient and the wear rate remained stable in atmosphere with different relative humidity. In dry air the friction properties were slightly worse compared to MoS_2, however in terrestrial atmosphere is pure MoS_2 useless.

Since the friction is driven by the same mechanism in both materials, interesting results could bring co-sputtering of $MoSe_2$ with any metal. Also the effect of sputtering parameters on film properties and adhesion should be studied in detail.

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Consortium for Research and Application of Nanostructural Coatings Improving Tribological Characteristics of Machine Elements

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The problems of coatings with special properties have been studied at the Department of Physics of the Faculty of Mechanical Engineering more than twenty years. Initially the research was aimed on thermal barrier coatings of turbine vans deposited by PVD methods, in subsequent years our activity was devoted especially to the deposition methods and tribological characteristics of hard and wear resistant coatings. The research was funded by many grants and research projects. In the years 2000-2002 was our Faculty the principle research laboratory in a project within the framework of the program CENTRA supported by the Ministry of Industry and Trade of Czech Republic. Since the beginning of the year 2003 the new project "Consortium for Research and Application of Nanostructural Coatings Improving Tribological Characteristics of Machine Elements" continues the successful results of the former project. Our Faculty is the laboratory in charge for this project, which is a part of the program KONSORCIA. The collaborating researchers are the company HVM Plasma and CKD Technical Laboratory. This project is funded by Ministry of Industry and Trade again.

The project is aimed to the research of two types of tribological coatings : hard and wear resistant coatings and self-lubricating coatings. It has been set out to optimize the deposition methods, to define the boundaries for successful utilization of these coatings clearly and to offer particular applications in industry. In this paper we present a short summary of the results achieved in this project in the year 2003. The activity of our Laboratory was aimed especially to the measurements of temperaturaly dependent tribological properties of both hard and self-lubricating coatings and to the deposition of MoS_2 and $MoSe_2$ based coatings.

TiN, TiCN and CrN are the hard coatings widely spread in industry applications. However, the friction and wear behaviour of these coatings at temperatures exceeding a room temperature have not been studied intensively yet. To help remedy this lack, these coatings were comparatively studied with respect to their friction and wear properties at temperatures in the range from RT to 800 °C [1,2]. The coatings were deposited on the substrates made from austenitic steel by unbalanced magnetron sputtering. The measurements were provided with the high temperature tribometer (pin-on-disc, CSM Instruments). The evolution of the friction coefficient with the cycles (sliding distance) were measured under different conditions, such as temperature or sliding speed, and the wear rate of the ball and coating were evaluated. As counter-parts were used the 100Cr6 balls and the Si_3N_4 ceramic balls. The wear tracks were examined by optical methods and by SEM. The surface oxidation at elevated temperatures and profile elements composition of the wear track was also measured. The coatings were evaluated from the point of view of their tribological properties and the wear modes were characterized.

The self-lubricated coatings could strongly decrease friction coefficient and working temperature of the surfaces of machine elements. Transition metal dichalcogenides are well known for their lubricating properties. MoS_2 is the most popular member of this family and it is widely used as a solid lubricant in vacuum and inert gases. However, the lubricating properties of MoS_2 are deteriorated in humid air. A general trend in this coating development in recent years was production of dense films with low porosity and proper orientation of crystal basal planes. Densification of coatings have been achieved by increasing of the ion bombardment of growing layer mainly with unbalanced magnetrons. Other way in development is co-sputtering of MoS_2 and a metal as Ti or Ni or forming a layered coating consisting of metal and MoS_2 layers [3]. Besides MoS_2 also other dichalcogenides ($MoSe_2$, WS_2) were investigated. Because of the larger ion diameter of these compounds, the decreasing of water molecules penetration is expected. It is known that molybdenum diselenide coatings have the same crystal structure and also exhibit suitable lubricating properties, but their dependence on air humidity and on temperature has not been studied yet in details. That was the reason why our study was aimed to the comparison of tribological properties of MoS_2 and $MoSe_2$ coatings measured in air of different humidity and at elevated temperatures. Both coatings were prepared by non-reactive DC magnetron sputtering and tested with ball-on-disc high temperature tribometer. We presented the results of measurements of friction coefficient and wear rate vs. tribometer revolutions and the resulting dependences of friction coefficient and wear rate on ambient air relative humiditity [4].
These results showed that the friction coefficient of $MoSe_2$ was not influenced by air humidity. Wear rate of $MoSe_2$ in dry air was substantially higher than that of MoS_2; in humid air the MoS_2 wear rate increased rapidly while wear rate of $MoSe_2$ remained unchanged. The operating temperature of both coatings was limited to 350 °C. It has been proved that $MoSe_2$ is very promising solid lubricant with satisfactory friction properties. The performed tests did show that both the friction coefficient and the wear rate remained stable in atmospheres with different relative humidity. In dry air the friction properties were slightly worse compared to MoS_2, however in terrestrial atmosphere is pure MoS_2 useless.

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Fracture Mechanical Parameters at the Curved Fatigue Crack Front

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The phenomenon of a fatigue crack propagation is known for many decades. During that time, it has been studied intensively and many sophisticated methods for such research have been developed. Some of them had to be abandoned, some had to be modified, and some of them are original, yet. These include for example a fractografic analysis of fracture surfaces, linear and nonlinear fracture mechanics, or elastic-plastic models based on finite element method (FEM).

Generally, two-dimensional approach has been preferred. Only past few years, mostly due to the progress in computers, we are able to study the three-dimensional nature of the fatigue crack growth process. Many methods of describing 3D models are based on previous 2D ones. In this paper, we examine the applicability of initially "global" fracture mechanical parameters to the "local" description of the fatigue crack front behavior in the 3D models. We will focus on crack closure, stress intensity factor, and out-of-plane deformation constraint.

The FEM simulations (through the use of software MSC Marc and Franc3D) were arranged to model two real experiments performed in VZLU Inc. [1]. The detailed description of the simulations can be found in [2]. The specimens P2 and P6 (the thickness B=6mm, the width $2W$=58mm, the length $2L$=180mm) were made of the aluminum alloy 2024-T42 which is produced for aircraft industry. The fatigue crack length corresponded exactly to the beginning of the shear lips formation: a=11.975mm for P2, and a=6.525mm for P6. The loading stress range was ΔS=31.3MPa for specimen P2 and ΔS=45MPa for specimen P6. The stress ratio was R=0.5 (specimen P2) or R=0 (specimen P6). A shape of the curved crack front was determined fractographically. Only one eighth of the specimen was modeled because of three planes of symmetry. The rest of the specimen was substituted by suitable boundary conditions. To induce a steady state around the crack front, 59 loading cycles were simulated. The length of the model crack path was 380μm. Only 29 "active" cycles involved a very small prescribed crack advance. This elementary crack "jump" was realized by the change of boundary conditions ahead the crack front. A rigid surface was inserted into the crack plane to simulate the contact of crack faces during the crack closure. The model assumed small deformations. The finite element mesh was intensively refined in the vicinity of the crack front, where the smallest eight-noded hexagonal elements (2x2x2μm) were situated.

It is generally accepted that the fatigue crack closing under plane stress conditions is more intensive than that at plane strain state. 3D FEM simulations are able to concretize this finding for the real curved crack front in a thick wall.

A crack is considered to be open at the moment when the last contact of fracture surfaces vanishes. According to this standard definition, the opening stress S_{op} is derived from the absence of the contact at any of the nodes on the crack face. Due to high stress ratio R=0.5, there is no crack closure at the long middle part of the crack front in the specimen P2. Only in a short marginal part, the normalized opening stress grows up to S_{op}/S_{max} = 0.57. The opening stress at the crack front in P6 (R=0) is also low; in the middle of the thickness S_{op}/S_{max} = 0.05. The influence of the free surface is apparent only in a surface layer with the

thickness of 250 μm. At the surface, the normalized opening stress is $S_{op}/S_{max} = 0.35$. These results correspond with known experimental facts.

The distribution of a stress intensity factor ΔK along the crack front is almost the same for both specimens. Towards the surface ΔK grows so that the maximum level at the surface is almost 200% of ΔK in the middle of the thickness. Analytical 2D value of ΔK for a given configuration approximates only about 2/3 of the crack front length with an error less than 10%. The high values of stress intensity in the marginal part of the front have to be of course lowered because of the crack closing which has been described above. In spite of this there is a high local maximum of ΔK_{eff} near the free surface. ΔK_{eff} is usually used for the crack rate prediction. However, such prediction does not correspond to the reality of the curved crack front in the 3D body. The disagreement between the FEM prediction and experimentally observed crack rate is acceptable only in the central part of the front. In the marginal part, the theoretical values are more than twice as high. The problem lies probably in the fact, that the routine methods for the fatigue crack rate prediction do not reflect the influence of a stress-strain state due to the constraint. The results are qualitatively the same for both simulated specimens.

The level of constraint can be characterized e.g. by a stress triaxiality H. The distribution of H in the crack plane is quite complicated and seems to be somehow connected with the crack length. Generally speaking, the high values of this quantity at the central part of the front decreases towards the free surface and also in the direction of the crack propagation. The optimal specification of some "stress triaxiality factor" as the second fracture mechanics parameter is quite complicated and demands further research.

As mentioned above, a description of the local curved crack front deformation mechanics by fracture mechanics parameters of usual type need not be very successful. Local values of stress intensity along the crack front do not give a correct local crack rate prediction. Neither crack front shape can be determined in this way. Nevertheless the results have confirmed that the description of an overall behavior of through-thickness cracks with the various lengths in a plates of the same thickness by means of 2D stress intensity factor is very good.

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Numerical Modelling of Stress Development in Nonlinear Plasma Sprayed Coatings

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The problem of thermally sprayed layers became indivisible part of engineering praxis. Together with new materials development and new finding about their behaviour there is a possibility to create more effective and superior surfaces especially on metal substrates. These thermally deposited coatings are used as mechanical shield (prevention against wear and abrasion), thermal barrier, prevention against chemicals or as a factor raising fatigue lives of specimens.

The fatigue properties of thermally sprayed bodies have been studied for a long time at the Department of materials FNSPE. The research projects deal with experimental measurements of influence of deposition of various materials on fatigue lives of specimens and numerical modelling of fatigue processes. These fatigue experiments are mainly of symmetrical bending character (cantilever beam with the deflection of free end of 4.2mm) and are carried out on specimens machined from low-carbon steel sheet. The specimens are dog-bone shaped with gauge width of 20mm, shoulder width of 40mm, length 200mm and thickness 4mm.

Different influence of different types of thermal deposition on fatigue lives of such specimens was experimentally proved [1]. Although most of coatings increase the length of fatigue lives (up to three times than that of non-sprayed body) there are several that decrease this important characteristic. Main goal of this work was to explain this difference by numerical stress calculations of specimens put through the bending fatigue experiments. All calculations were carried out in MSC.Marc software based on finite element method.

Former computations were based on linear behaviour of the coating material [2]. However, the coating material often shows non-linear dependence due to presence of microcracks. Therefore within the current modelling the material of coating was considered as a nonlinear behaving continuum. This nonlinearity was described analytically [3] by $\sigma_c = E_c(e\text{-}Ke^2)$ relationship, where σ_c stands for stress within the coating, e for its deformation ($-0.5\text{x}10^{-2} < e < 1/K$) and E_c and K are considered to be material characteristics which differ for various coating materials. Because of the porosity of deposited layer the value of E_c use to be even ten times smaller than the value for well-sintered material. The value of dimensionless material constant K was expected to vary from 200 to 600.

To determine the values of material parameters E_c and K simple 3PB test was performed for different types of sprayed materials. By using simplifying transfer of experimentally gained dependence applied force – deflection of centre of specimens (loaded with 3PB) to nonlinear stress - strain dependence were the values of E_c and K obtained [4] for corundum, white corundum and chromium coatings, as shown in table 1. These values were verified by 2D numerical finite element calculation.

Table 1: Material characteristics E_c and K for corundum and chromium coatings

Sprayed Material	E_c [MPa]	K [1]
Corundum	50000	300
White Corundum	40000	100
Chromium	60000	500

By determining of material parameters E_c and K for different types of sprayed materials it was now possible to model the fatigue experiment described above more accurately. Because of the complex structure of dog-bone shaped specimen, fully 3D finite element model was created. The influence of residual stresses and substrate material hardening was included in the calculations.

The residual stresses in plasma sprayed bodies are created by various processes. For the corundum (Al_2O_3) and chromium (Cr_2O_3) coatings on steel substrate, the most important factor for residual stresses development is the difference between thermal expansion coefficient of layer and substrate. When the sprayed specimens cool down to room temperature the layer and the body shrink differently which causes the creation of residual stresses.

The yield stress of substrate material was identified and the substrate material was considered as nonlinear elastic-plastic, with the isotropic hardening rule and given plasticity modulus.

As a result of numerical analysis of the stresses in the bend-fatigue loaded specimen the critical area of maximum bending stresses was located. The fatigue crack initiation should be expected at this area, which is in good agreement with experiment.

To determine the influence of thermal spraying on fatigue lives of specimens, the values of mean stress and stress amplitude had to be compared for sprayed and non-sprayed bodies. The values of mean stress and stress amplitude claim to be the main factor influencing the fatigue lives of such specimens. Achieved numerical results showed that corundum and chromium coating decreases both values, which causes (according to the experiment) raise of the length of fatigue lives.

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Structures of Lithium Titanium-based Li-ion Conductors by Powder Neutron Diffraction

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Structure properties of perovskites containing system Bi_2O_3 are now becoming increasingly important in the technology of new materials because of usefulness by the electronic industry. Recently, the phase diagram of the system $Li_2O/La_2O_3/TiO_2/Bi_2O_3$ has been studied. A region of perovskite-like solid solutions was obtained when the bismuth content in the general formula $Bi_yLa_{0.5+x-y}Li_{0.5-3x}TiO_3$ was less than y = 0.10. These compounds are ionic conductors [1].

In previous paper, chemical lithium intercalation was carried out on different compositions of similar systems [2]. In general, the amount of lithium inserted is consistent with the number of vacancies. The knowledge of crystal structure of gthese compounds is crucial to the understanding of the Li ionic mobility within the La(Bi)-Ti-O framework. In these perovskites, the tilt of the TiO_6 octahedra is a predominant feature that introduces structural distortions affecting Li mobility. The structure determination of these oxides by X-ray diffraction is difficult as the superlattice reflections associated with the tilting of the TiO_6 octahedra arise from the oxygen atoms, weak scattering if compared with La and Ti; hence neutron diffraction measurements [3] are more suitable for these investigations.

Lithium ions were electrochemically inserted into perovskite-type $La_{0.50}Li_{0.37}TiO_3$ [1]. The results indicated that lithium ions were inserted into A-site vacancies until they were occupied by lithium ions, then, the new lithium ions were inserted into the largest interstitial space, 3*c*-site, in the cubic perovskite structure.

In this paper, the structure of three members of the $Bi_{0.04}La_{0.53}Li_xTiO_3$ series (x = 0.29, 0.45 and 0.70) has been analysed by neutron diffraction. A Li-poor perovskite with composition $Bi_{0.04}La_{0.53}Li_{0.29}TiO_3$, Li-rich perovskite (occupied all the vacancies) with composition $Bi_{0.04}La_{0.53}Li_{0.45}TiO_3$ and a third composition with more lithium than A-site vacancies, with general formula $Bi_{0.04}La_{0.53}Li_{0.70}TiO_3$. The main point of this work is to know the Li position in this new perovskites obtained by chemical insertion.

$Bi_{0.04}La_{0.53}Li_{0.29}TiO_3$ was prepared in 10 g quantities from La_2O_3 (99.9% Fluka), TiO_2 (Aldrich 99+%), Li_2CO_3 (Aldrich>99%) and Bi_2O_3(99.9% Aldrich). La_2O_3 and TiO_2 were dried overnight at 900ºC prior to weighing. These chemicals weighed, mixed in an agate mortar with acetone, dried and heated to between 600 and 700ºC for 2 h to drive off CO_2. After grinding, the sample was pressed into pellets and covered with powder of the same composition to avoid loss of lithium and bismuth during the thermal treatment. The pellets were fired at 1100ºC for 12 h giving whitish product which was reground, re-pelleted, and fired at 1200ºC for a further 12 h. Finally, the sample was regrounded and re-pelleted, fired at 1250ºC for 4h and quenched to room temperature.

Phase purity was checked by X-ray powder diffraction on the Siemens D-500 diffractometer in reflection mode using Cu-K_α radiation.

Complete structural determination was carried out by powder neutron diffraction (NPD) on the diffractometer KSN-2 located at the LVR-15 research reactor near Prague. The diffraction patterns were taken at $\lambda = 0.1362$ nm over a range $2\theta = 10 - 92^{\circ}$ in steps 0.1°. The structural refinement was refined by a profile analysis using the GSAS package.

Tab. 1: Crystallographic data for $Bi_{0.04}La_{0.53}Li_{0.75(9)}TiO_3$ at 294 K

Atom	Site	x	y	z	Occupancy
La	4c	0.0123(19)	0.2500	0.9997(14)	0.537(11)
Bi	4c	0.0123(19)	0.2500	0.9997(14)	0.041(7)
Ti	4b	0.5000	0.0000	0.0000	1
O(1)	4c	0.4943(16)	0.2500	0.0202(17)	1
O(2)	8d	0.2345(12)	-0.0241(32)	0.2453(18)	1
LiA	4c	0.0000	0.2500	0.8350(24)	0.221(6)
LiB	4c	0.1291(29)	0.2500	0.1490(29)	0.040(10)
LiC	4c	0.0260(25)	0.3720(29)	0.9983(27)	0.149(10)
LiD	4c	-0.1470(26)	0.2500	0.0910(29)	0.122(11)
LiE	4c	-0.2390(25)	0.2500	0.7486(21)	0.158(11)
LiF	4a	0.0000	0.5000	0.0000	0.060(10)

Remarks: a= 5.4730(21) b= 7.7402(15) c= 5.4874(20), space group: Pnma

All structure parameters at the room temperature were easily determined in the frame of the Pnma space group and for the composition with x = 0.70 (as an example) are given in Tab. 1. Structure analysis by means of Fourier maps show the following alignemets of La and Li atoms: the La-LiC-LiF-LiC-La row and the La-LiA-LiE-La other one. But, when the lithium content is 0.74, LiA is desplaced from its position and becomes aligned between La and O1. The high content of lithium favours the occupation of the LiC, LiD and LiE sites (the coordination of lithium is four) which are far from the theoretical A-site. Our results indicate, that the insertion limit in these perovskites depends not only on the A-sites vacancies as well on the possibility of the creation of new lithium sites. So, it would be possible to obtain high capacities with this kind of compounds acting as cathodes in lithium batteries. In the future it is planed the low temperature measurement of these samples.

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Application of Microwave Impulse Method for Measuring Moisture Profiles in Building Materials

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Measuring the water content in building materials by microwave techniques is currently a well recognized treatment in building science. There is a several decades long tradition of these measurements. The first applications appeared in 60's, and a variety of different experimental techniques were designed in the subsequent decades (for a survey of the most of existing setups see [1]). Within the last 10-15 years, an increasing number of commercial companies also offered moisture meters based on microwave principles (see [2] for a list of major manufacturers). However, the basic setups are well known and the microwave components became very efficient, small and relatively cheap within the last years, probably due to the progress in commercial satellite transmission and TV. Therefore, the experimental laboratories of universities and research institutes mostly build their microwave moisture meters themselves from the commercially produced components, which makes it possible to adjust the particular setup for a specific purpose.

Recently, a microwave impulse method was designed for determination of free water content in early hydration stages of cement paste [3]. Measuring moisture profiles in building materials using this method can be utilized for its further verification and extension of its application. The measuring system based on microwave impulse technique is relatively compact and consists of three basic components, namely the impulse generator, the applicator and the sampling oscilloscope. The generator GPSI-1a (Radan, Ltd.) produces triangular impulses of a width of 250 ps and amplitude 2 V. It consists of the impulse generator itself, its feed circuits, controlling, auxiliary and protecting circuits. The energy output is realized by three SMA coaxial connectors. The applicator connected to the generator output consists of two pairs of transmitting and receiving antennas formed by coaxial/waveguide reducers and horns. The pairs of antennas are fixed parallel in separate holders ensuring a defined position, and therefore also stability and reproducibility of measurements. The specimens of the tested materials are put into the applicator between the measuring antennas. The sampling oscilloscope Tektronix 7603 analyses the impulse signals. He has a 7T11A sampling sweep unit and two 7S11 sampling units with a S-4 sampling head. The time resolution of the oscilloscope is about 10 ps and the sensitivity 2 mV. The frequency range is up to 14 GHz. The signal from the oscilloscope display is recorded by a digital camera and analyzed by a PC.

The moisture profiles were determined using a common capillary suction 1-D experiment in the horizontal position, lateral sides of specimens were water and vapor-proof insulated. Scanning by microwave impulse moisture meter along the specimen was done every 10 mm. The calibration curve was determined after the last scanning, when the moisture penetration front was at about one half of the length of the specimen, using this last scanning and the standard gravimetric method after cutting the specimen into 10 mm wide pieces. The calibration curve presents the moisture content in building material in dependence on permittivity of this measured material. The permittivity of measured material was calculated on the basis of measuring the time difference $\Delta t_{21} = \Delta t_2 - \Delta t_1$, where t_2 is the

travel time of the impulse to pass the thickness of measured specimen and t_1 the respective travel time in the air. The moisture profiles were then calculated from the calibration curve. The measurements were done at 25 °C ambient temperature.

The capacitance method [4] was used for verification of results obtained by microwave impulse method. This method was employed to the measurement of moisture content, the measuring frequency was 250 – 350 kHz. The parallel electrodes of the capacitance moisture meter had the dimensions 20 x 40 mm. The basic experimental setup for the measurements using the capacitance method is the same as in case of microwave impulse method. However, moisture meter reading along the specimen was done every 5 mm. The calibration curve was determined using the last reading and the standard gravimetric method after cutting the specimen into 10 mm wide pieces. Moisture diffusivity was determined by the Matano method.

Moisture profiles were measured in two building materials. Specimens from brick and AAC were used. The size of the samples was the same as the size of the samples for measuring moisture profiles using the capacitance method. The size was 300 x 40 x 20 mm. The basic measured data of permittivity and moisture content in dry and saturated building materials using the microwave impulse method are presented in Table 1.

Tab. 1 Measured data of permittivity and moisture content in dry and saturated building materials.

	permittivity dry material	moisture [% kg/kg] dry material	permittivity satur. material	moisture [% kg/kg] satur. material
Brick	2.9	1.5	14.3	16.0
AAC	2.0	1.0	14.7	75.0

The moisture profiles obtained by the microwave impulse technique were found to be in a good agreement with the data obtained using the capacitance method.

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Neutron Texture Analysis of Polymer Foils

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It is well known that anisotropy of a microstructural order is of the crucial importance for macroscopic properties of materials. The order level can vary from purely single-crystalline to completely amorphous state. Between these two extremes, polycrystalline materials exist featuring presence of crystalline domains with some level of translational order. The mutual orientation of the translation vectors belonging to the individual crystallites is called material "texture".

Characterization of texture is usually based on pole figures (PF) or inverted pole figures (IPF) obtained from diffraction experiments. The most frequent technique is X-ray diffraction, followed by use of neutron and electron radiation. A principal benefit of neutron diffraction with respect to texture analysis results from its high penetrating power and large cross-section of neutron beams. Thus, fully representative data about crystallite orientation can be obtained even for voluminous specimens, and the data did not suffer from presence of strong extinction effects. Such texture data can be easily correlated to sample properties.

Although most of the texture studies performed until recently concentrated on metallic materials, and, in a much lower extend, on minerals, a steadily growing attention is paid to texture investigation of semi-crystalline polymer materials finding an extensive industrial application. Extrusion, moulding, and drawing procedures used during a polymer processing result in developing characteristic textures having strong influence on functional properties of the final products.

The presented research deals with neutronographic texture analysis of plasticised PVC foils, moulded and subjected to subsequent drawing. Raw PVC resin with low level of polymer chain tacticity posses generally a low structural order. The structure of PVC crystalline domains formed by syndyo-tactic chains was proposed by Natta and Corradini [1]. It is orthorhombic, space group Pacm, with the lattice parameters a = 1.06 nm, b = 0.54 nm, c = 0.51 nm. Polymer backbones are packed parallel with the c-direction. Mechanical stretching accompanying a moulding process leads to an increasing orientation of polymer chains featuring usually a slight total crystallinity increase, some variation of the crystalline lattice parameters, texture formation, and mechanical strength growth in the orientation direction. The later is depending on the mutual ratio of the applied deformations. The results obtained in [2,3] on samples of monoaxially and biaxially drawn PVC foils by means of wide angle X-ray diffraction, density, and optical birefringence measurements, suggested co-existence of two distinct orientational distributions of crystalline domains. The first one (T1) is characterised by c-axis oriented preferentially in the foil plane and can be related to a mesomorphous phase arising during the drawing process. The second distribution (T2) features c-axis oriented along the foil normal, a-axis parallel with the foil plane, and is ascribed to re-orientation of lamellar platelets already existing in the undrawn foils.

Samples for neutronographic measurements were provided by M. Gilbert from University in Loughborough (UK). Composition and preparation of the samples was described elsewhere [2]. The neutron diffraction measurements were performed in Laboratory of Neutron Diffraction of our Department. Five pieces of foil biaxially drawn with the ratios

2.4 x 1.4 were stacked to give 1 mm thick specimen for measurement. Wide angle neutron diffraction patterns with the specimen in symmetrical reflection and symmetrical transmission position, respectively, were recorded at the constant monitor mode, with 2-theta scan step 0.1^{o}, on the neutron spectrometer KSN-2 located on one of the horizontal channels of the research reactor LVR-15 at Institute of Nuclear Research in Řež. Low crystallinity of the PVC material (~ 10%) and the high incoherent scattering background resulted in very weak diffraction maxima observed. A low-pass FFT filtering was applied to reduce the noise level. Texture of the samples was characterised by means of IPFs calculated by Harris method [4]. Integral intensities of a reference sample with random orientation distribution of crystalline domains were calculated using the structural data [1].

Analysis of the obtained IPFs and namely the mutual relationship of the pole intensities (010), (200), (110), (210), (111), and (310) led us to conclusion that the texture distribution component T1 is prevailing within volume of crystalline domains of the investigated foil, with the c-axis preferentially oriented in the direction of the major drawing, and a high dispersion of the a-axis orientation within a spatial angle of about 50^{o} around the foil normal.

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Integration of Quantitative Fractography into the Fatigue Evaluation of Aircraft Wing Spar

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According to [1], damage-tolerance evaluation of structure components must include a determination of the probable locations and modes of damage due to fatigue. Full-scale fatigue test must demonstrate that widespread fatigue damage will not occur within the design operational life. The efficiency of these time- and money-consuming experiments can be considerably increased by the application of quantitative fractography.

Experimental study carried out at the Institute of Aerospace Engineering, Brno University of Technology was focused on the fatigue crack propagation in the aircraft wing spar [2]. Geometry and dimensions of the tested model specimen correspond to the Ayres Loadmaster LM 200 wing spar (e.g., the spar length is 2 900 mm). During the high-cycle fatigue tests, the four point cyclic bending at stress ratio $R = 0$ and loading frequency $f = 2$ Hz was applied. In critical areas of the wing spar, the loading induced a stress, the maximum of which corresponds to the maximal value in loading spectrum applied usually in the fatigue life tests of similar small transport airplanes, i.e., σ_{max} = 100 MPa. Main structural components of the wing spar, i.e., the web and both flange plates were made of Al-alloy 2124. Fatigue cracks under study initiated in a critical area on sharp artificial notches in a hole of the rivet connected the web and the lower flange plate. Growth of the fatigue crack in the spar web was optically monitored during the test, except the first part, where the crack was covered by the flange plate and thus a direct macroscopic measuring was impossible. No other fatigue cracks in the studied critical area of the wing spar were optically observed - neither second crack in the web nor both cracks in the lower flange plate.

The limited macroscopic data set obtained was completed by results of the quantitative fractography carried out at our department. By means of scanning electron microscope, striation spacing as a function of crack length was measured on the fracture surfaces of the spar web and the lower flange plate. The fractographic reconstitution of fatigue crack history was based on several alternative hypotheses dealing with the relation between macroscopic crack growth rate $v = \mathrm{d}a/\mathrm{d}N$ and striation spacing s (this problem in detail - see [3]). Assumption of equality of the both quantities, i.e., $v = s$, results in a very inaccurate output data. Also an application of relations based on data published by other authors was not fully favorable. The best results of fractographic reconstitution were obtained when the empirical relation

$$v = 1{,}797 \cdot 10^{45} \cdot \frac{s^{1{,}1108}}{(79{,}55 - s)^{23{,}84}}, \text{ in the range } (0{,}059 \le s \le 4{,}74)\,\mu\text{m},$$

based on our previous laboratory experiments, was applied. Achievement of the hypothesis was verified on the second period of fatigue crack growth in web, where the direct optical monitoring was applied. Application of the above relation has led to the best agreement between the results of fractographic reconstitution and the macroscopic ones. The same hypothesis was applied also in fractographic reconstitution of growth history of all other

fatigue cracks where the direct optical monitoring during the full-scale test was impossible, including the first part of the crack in spar web.

Final information about fatigue degradation of the wing spar was based on the synthesis of macroscopic data with the fractographic ones [4]. Altogether four fatigue cracks (two in the web, two in the lower flange plate) were under study. The results obtained were summarized in the forms:

a) fatigue crack length as a function of the number of loading cycles,
b) crack growth rate as a function of the number of loading cycles,
c) crack growth rate as a function of the crack length.

These functions imply complex knowledge on the time sequence of individual fatigue cracks in the wing spar, their interaction and other valuable information on the real course of the fatigue process in the structure.

Detailed analysis of both macroscopic and fractographic data dealing with the crack in spar web has disclosed the fact that the fatigue crack growth process was partially influenced by the measuring process applied: In moments of direct optical measurements during the fatigue test, the cyclic loading was interrupted and the static load was holding on the level of the maximum in previous cycle. In some cases, this load dwell acted as an overload including the following effect on the fatigue crack growth rate. This supplementary conclusion of the research is very important because the mentioned artifact can negatively influence the objectivity of similar full-scale tests and usability of results obtained.

Quantitative microfractographic analysis represents an effective experimental method able to provide detailed information about the structure response on the time variable loading. In many cases, information of this type is unobtainable by any other means. Precision and exactness of fractographic reconstitution of fatigue crack growth history strongly depend on the volume and the quality of input information. Above all, a priori knowledge of the relation between macroscopic crack growth rate v and striation spacing s under the given testing (or service) conditions plays a key role. For these purposes, specially oriented laboratory experiments must be carried out.

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Controlled Expansion of Cementitious Materials with High Frost Resistance

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The described project was aimed on the solving of partial problem that is connected with the issue of concrete pavement slabs concurrence restoration. One of the possibilities for concurrence restoration is the reinforcing bars insertion into the milled slots. Created space is subsequently filled with special mortar. To provide the concurrence of the mortar and surrounding concrete and to provide long time durability of mortar the requirements on frost and scaling resistance and the ones on suitable expansion setting are of a crucial importance.

The setting and hardening of concrete is accompanied by undesirable changes in volume (shrinkage). The changes in volume of cement mortars and concrete occur right after mixing of the components. Chemical and autogenous shrinkage prevails in the early stages of setting and hardening, while shrinkage due to drying gains in significance later.

Chemical shrinkage is caused directly by the reactions of cement, namely those of its clinker minerals with water, where the volume of the hydration products produced is smaller than the volume of substances entering the hydration process. A part of chemical shrinkage manifests itself as a macroscopic change in the dimensions of the element made of cement mortar or concrete (autogenous shrinkage) and the rest results in the formation or possibly expansion of pores in the cement matrix. In contrast to this, the contraction due to drying depends above all on the environment to which the mortar or concrete mix is exposed. The relative humidity of the environment is the decisive factor of the phenomenon.

Recently the frost and scaling resistance is routinely provided by air entrainment of the mixture. However the interaction between air entraining admixtures and expansive ones is not clear so far.

The aim of the project was to study the possibilities of cementitious materials volume changes control and to gain high frost and scaling resistance simultaneously. The project was aimed on the observation of the interaction between expansive mixtures and air entraining admixtures and also on the possibility of the preparing of expanding and high scaling resistant mixture without air entraining agent. The results of this project are used for basic orientation in this problem and for the external grant agency application preparation. The subsequent research would aim at solving of filling mortar problem, which comes into being during concrete pavement slabs concurrence restoration.

In the experimental programme, the use was made of several test methods. Two methods were used for determining the changes in volume on selected mixes, the method of weighing under water and the dilatometric method. The former method is based on Archimedes' principle of bodies immersed in a fluid. The contraction or expansion is determined by calculation from the change in upthrust, which is established by weighing the body immersed under the surface of a fluid. In the case of dilatometric measurement, the sample is placed in a special stand and the change in its length is measured directly with a precision dial gauge. The scale resistance was observed by the test of the surface resistance against the impact of frost action and chemical thawing agents' action. This test is extremely demanding on machine equipment and then it was the crucial factor determining the experiment range. Furthermore the beginning and the end of setting were tested by means of Vicat apparatus.

I tested several types of volume changes controlling admixtures, which was combined with several commercially available air entraining agents.

One of the methods of reducing or eliminating the shrinkage is the use of special additives allowing no-shrink or expanding concrete to be manufactured The additives are essentially based on the idea that a controlled expansion of certain structural phases of cement will compensate for the contraction. The contraction is thus not eliminated in the true sense of the word, as the elimination concerns just the change in length caused by the contraction. The type M of expansive mixture was used. It is a mixture of Portland cement, high alumina cement and gypsum. Ettringite is the prevailing component ensuring the expansion of this type of cement.

Besides, the admixture based on both calcium oxide and magnesium oxide and the admixture providing the gaseous hydrogen evolution from hydrating mixture were used.

The tests showed that the admixture providing the gaseous hydrogen evolution from hydrating mixture alone is not able to set an expansion as a final volume change. On the other hand it leads to significant improvement of the scale resistance. This system isn't effective enough to gain the set goal. It would be possible to use it only as a supplement for the systems using inorganic expansion admixtures.

Both inorganic systems for volume changes control can set the final expansion in a wide range, but their scaling resistance is very low. The results show, that the combination of these systems with air entraining agents leads (provided that the mixing is intensive enough) to the improving of scale resistance. Even the interaction between expansive admixtures and air entraining ones is positive (in the view of final expansion).

The research carried out showed that two of three selected admixture systems are able to control volume changes and to set the final expansion. The scaling resistance of these mixtures can be regulated in a relatively wide range. The subsequent research in this field (with the aim of formulating the available in praxis material) should concentrate on the definition of the requirements for the cementitious fillers for concrete pavements and on the influence of these admixtures on the other material characteristics, such as ones important for fresh mortar workability.

The results of this project provided the knowledge necessary for the preparation of the application for the grant, which will be send to the external grant agency.

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The results of this project will be used for the preparation of the application for the grant,which will be send to the external grant agency.

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Mechanical Properties of Plasma Sprayed Mo Coatings

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Thermal spray coatings can be the solution when improved mechanical properties of construction materials together with weight savings are needed. At the same time, mechanical properties of coated bodies are gaining importance due to increasing number of aeronautical, medical and other applications. The elasto-plastical mechanical properties can be measured using conventional methods such as the tensile and bending tests. However with these methods only volume averaged information is provided. The nature of the coatings is inhomogeneous and anisotropic, therefore a method for extracting localized mechanical properties at a given orientation can is required. This requirement can often be satisfied using an instrumented indentation method. Instrumented indentation was used to obtain through thickness residual stress profiles in plasma sprayed Mo coatings deposited at various temperatures. The results were compared with in-situ curvature measurements performed during the deposition and subsequent cooling.

The instrumented indentation method is based on pressing a indentor of known geometry against the investigated sample while recording load and displacement during both loading and unloading phases of the experiment. The indentor has usually a conventional geometry of a standard hardness indentor. Use of spherical indentor reduces cracking compared to sharp indentors and therefore is often used for coating investigation. Most common method for Young's modulus estimation is the Oliver and Pharr method [1] based on evaluation of the elastic unloading curve.

The investigated coating was deposited using Sulzer-Metco 3MB (Sulzer-Metco Inc. Westbury, NY, USA) gas stabilized plasma gun operated under three different conditions determined by the torch current (400-500 A). The spray distance was 100 mm, torch voltage was approx. 60 V, feeding rate, carries gas flow, stabilizing gas flow and other spray parameters were not changed. Powder feedstock Osram SD 152 Mo (Osram Sylvania, Towanda, PA, USA) was deposited on one side of the substrate. Sample size was (2 x 25 x 200) mm, the substrate was grit-blasted prior to spraying. During the deposition an in-situ curvature measurement took place. From the curvature measurement data an average Young's modulus of the coating was computed (for details see [2]).

The instrumented indentation measurements were performed on Microtest computer controlled indentation device (Micromaterials Ltd. Wrexham, UK) using WC-Co spherical indentor of 1.6 mm diameter. The indentation data were evaluated using a Oliver-Pharr method.

Two geometries of indentation samples were used. Both sample types were prepared from rectangular sections of dimensions (25x3) mm. For through thickness Young's modulus measurement (Young's modulus in a direction perpendicular to the substrate-coating interface) a wedge shaped area of both coating and substrate side was ground away so that the coating and substrate surfaces remained parallel. Both substrate and coating side of the specimen were then metallographically polished. On the coating side, one line of indents was done along the length of the sample starting in the substrate and approaching the surface of the coating. The distance of each indent from the interface was established using a simple geometrical relationship. For an in-plane Young's modulus measurement (Young's modulus

in a direction parallel to the substrate-coating interface) both lateral sides of the rectangular section were metallographically polished. A line of indents was done at the polished side of the specimen at a small angle to the interface. The line started in the substrate and approached the surface of the coating. The position of each indent with respect to the interface was established. The Young's modulus value was constant on the polished coating surface parallel to the coating-substrate interface (no spray pattern influence).

The Young's modulus through the whole thickness of the coating was established from individual indentation data using the Oliver Pharr method. The value of the Young's modulus through the whole thickness averaged through the whole thickness of the coating lies in the range 70±5 GPa (in-situ measurement resulted in 70±10 GPa). The maximum value of the Young's modulus is near the interface and the modulus decreases linearly towards the coating surface. The rate of the decrease is lower for through thickness modulus (45±20 GPa/mm) than for in-plane modulus (68±10 GPa/mm). The Young's modulus of the substrate increases linearly towards the interface. The anisotropy and spray parameter dependence of Young's modulus lies below the resolution of the discussed experiment and therefore was not clearly identified.

The inhomogenity of Young's modulus in both coating and substrate can be a results of two factors, the influence of substrate-coating interface and the residual stresses. Near the interface the deformed volume below indentor intersects with both coating and substrate and therefore the measured value is influenced by the value of both materials. Results of residual stress measurement by neutron diffraction in Mo coating deposited under similar conditions as investigated deposits are presented in [3]. The gradual transition from tensile residual stress at the coating surface towards small compressive stresses at the coating-substrate interface measure in [3] corresponds to increasing Young's modulus in the same direction. The gradual transition from compressive residual stress in substrate near the substrate-coating interface towards tensile stress near the free substrate surface corresponds to decreasing Young's modulus in the same direction. Similar decrease of Young's modulus of plasma sprayed deposit together with gradually changing the stress from compressive to tensile was also observed during four point bending measurement of Al_2O_3 coatings in [4].

The future research should focus on the influence of stress (residual and applied) on the value of Young's modulus measured by indentation and also on the role of the interface.

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Tribological Behaviour of CrN Coating

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Substrates were positioned in deposition plant in such a way that we obtained a set of samples homogeneous in thickness and composition. Prepared coatings were relatively thick (10,0 μm) and exhibited good adhesion (L_c = 50N). Adhesion estimate from Rockwell C test of the as prepared samples was also excellent (grade I), after few hours more realistic estimate was grade III. The coating thickness was 10.26 μm.

The friction tests with the 100Cr6 balls showed that the friction coefficient was dependent on temperature. Running-in was represented by increase of the friction coefficient during the first 1000 of cycles for all measured temperatures. This increase was interrupted at temperatures up to 200 ^{o}C, where the local minimum occurred after 200 cycles. The minimum disappeared at the temperatures above 200 ^{o}C.
The level of friction coefficient, which was stable after the running-in, was determined as steady state wear. The average value of friction coefficient in the steady state wear increased from 0.62 at a temperature of 25 ^{o}C to 0.7-0.8 at the temperature range 100-300 ^{o}C, then it decreased to lowest friction 0.47 at the highest tested temperature of 500 ^{o}C.

The tests showed that wear of CrN coating sliding against the 100Cr6 ball was not measurable. In contrary, the transfer of ball material to the surface of coating was very strong and the coating surface was fully covered with a layer of ball metal, which was oxidised. Profilometer measurements showed that the thickness of transferred layer increased with the temperature reaching 7 μm at 500 ^{o}C. As a result, the ball wear rate was very high. Wear debris was analysed and it contained only ball material, particularly iron oxides. Thus, the CrN coating acts as an abrasive surface caused rapid wear damage of steel counter-parts.

It was stated that the friction coefficient is lower at room temperature due to formation of thin transfer layers of amorphous and hydrated SiO_2 and $Si(OH)_4$ on the sliding surfaces which lower friction. By increasing the temperature a reduction in coating hardness was expected, which with drying of the air results in increase of the friction coefficient. However, in our study the friction coefficient reached maximum level at 25 ^{o}C and then decreased with temperature, thus, mentioned factors did not play such important role as formation of chromium oxide layer decreasing the friction.

The wear rate of the ceramic ball was about two orders of magnitude lower than the wear of the 100Cr6 ball. In the temperature range up to 200 ^{o}C there were no transfer of coating material to the ball, in the higher temperatures the ball was fully covered by wear debris, particularly by chromium oxides.

The wear rate of CrN coating sliding against ceramic ball increased with temperature (Fig. 6). To find the dominant wear mechanisms at different test temperatures, SEM was used to analyse wear track. The coating wear rate was negligible at room temperature. The surface of wear trace at room temperature and at 100 ^{o}C was relatively smooth and flat, thus, polishing wear occurred. No ball material transfer to the wear track was detected. On contrary, the wear debris consisted of silicon and chromium oxides built into coating surface was apparent on both sides of the wear track. At a temperature of 200 ^{o}C shallow scratches parallel to relative movement appeared in the wear track. The oxidation of intact surface of CrN coating started at a temperature of 300 ^{o}C. The wear track was more oxidised than the surface without contact. The decrease of the coating wear rate at a temperature of 400 ^{o}C could be explained by the presence of chromium oxides, which helped to build additional protective film on the worn surfaces and decrease the friction coefficient. However, there were other factors playing important role, such as softening of coating and substrate, adhesion, chemical interactions of coating surface with the ball material, appearance of pores in coating, etc. Because of the complexity of wear process it is very difficult to separate contributions of these factors. The coating was partially peeled off from the substrate at the temperature of 500 ^{o}C.

This study shows the CrN coating is suitable to perform at higher temperatures as a wear resistant coating. However, the wear of steel counter-part was very high, which could limit the working conditions of this type of coating, particularly in combination with higher friction coefficient.

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Effect of Reprocessing on Properties of Recycled Engineering Thermoplastics

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New design possibilities, better performance and weight lightening lead to the choice of plastics for use as car components. This is the case of car head and rear lights, where engineering thermoplastics has been used as a substitute for conventional materials like glass or aluminum. Generally, there are two main reasons why plastics in the automotive industry need to be recycled. Firstly, there is pressure from car manufactures on their suppliers to cut production and material costs. Secondly, but of great importance, is the effort to decrease the impact of End of Life Vehicles (ELV) on the environment (e.g. Directive 2000/53/EC of the EU parliament). To add, recycling is a rather complex problem, where the following facts has to be taken into account: Thermoplastics undergo degradation through their service live, their properties are affected by reprocessing and also by contamination of other polymeric or non-polymeric materials, which may affect their overall performance, so that possibility to apply recyclates to new products would be reduced. From this follows that upgrading their properties and improving their mutual compatibility is a key to the successful recycling. An example of difficult application of recycling is a vehicle rear light. The rear light comprises of two main parts: The housing (PC, ABS, PC/ABS) and the transparent cover (PMMA). The cover is welded with the housing. This leads to the problem of separation of each component or dealing with their mixtures. The second case was considered in our work. The effect of reprocessing on polycarbonate PC was closely studied at our institute [1, 2, 3].

This work investigates the ductility of PC/ABS, PC/PMMA, ABS/PMMA and PC/ABS/PMMA blends and the effect of processing parameters on their toughness on the basis of the instrumented Charpy impact test.

The blends were produced from Polycarbonate PC - Lexan LS2 (GE Plastics), Acrylonitrile-Butadiene-Styrene ABS – Cycoloy X37 (GE Plastics) and Poly methyl methacrylate PMMA – Lucryl G88 (BASF). The blends were mixed and injection molded into Charpy specimens using Battenfeld 500 injection molding machine. The Charpy impact strength of notched specimens was tested on a CAEST instrumental hammer according to ISO 179. The instrumented Charpy impact test enabled us to determine not only the overall absorbed energy but also the energy absorbed during the initiation and propagation stage of the fracture process.

Samples of PC/ABS blend with the increasing composition of ABS (25, 50, 75 %) were produced at the temperature of 245°C. Adding 25 % of ABS into the blend increased ductility. A huge synergetic effect was observed at the composition PC/ABS 75/25. This effect is in accordance with literature and commercially produced PC/ABS blends. Increasing

the content of ABS further caused ductility to decrease to the value lying under the imaginary value of linear law of mixtures at the composition of PC/ABS 25/75. Inflection point was observed at the composition of PC/ABS 50/50. The behavior of the initiation energy followed the same pattern, whereas propagation energy remained constant over the whole range of the blend composition. Ductility of PC/ABS blends is strongly dependent on processing parameters. Increasing the processing temperature, back pressure or screw speed resulted in deterioration of the impact strength. For example, the processing temperature of 260°C caused the impact strength of PC/ABS 75/25 to fall to one third compared to the value at the processing temperature of 240°C.

The processing of PC/PMMA blend was carried out at the processing temperature of 245°C. The impact strength decreased with the addition of PMMA (25, 50, 75 %) in to the blend. The behavior followed a negative power rule. By adding PMMA the initiation energy decreased while the propagation energy seemed to be constant or less affected. The Charpy impact strength of the ABS/PMMA blend decreased with increasing content of PMMA (25, 50, 75 %) almost linearly, following a rule of mixtures. The processing temperature was set to 220°C. Higher processing temperatures affected stability of the blend. Finally, PC/ABS/PMMA blends were prepared at 245°C. The ratio PC/ABS (75/25) was kept constant while the content of PMMA was varied. The addition of PMMA (5, 10, 25, 50, 75 %) decreased ductility of the blend. The impact strength markedly drops at the PMMA content of 5 to 10 % then it levels off at the PMMA content of 25% and again slowly decreases to the value of impact strength of the pure PMMA. The sudden drop of the impact strength corresponds to the fall of the initiation energy. The propagation energy almost remained constant independently of the composition, however, a slight decrease could be observed at the PMMA content of 25 %.

In conclusion, the Charpy impact testing of PC/ABS, PC/PMMA, ABS/PMMA and PC/ABS/PMMA was carried out in order to determine ductility of the blends and the effect of processing parameters on their toughness. PMMA decreases toughness of the blends, in particular in the composition with PC. On the other hand, the synergetic effect was observed by PC/ABS 75/25. This blend showed strong dependence on processing parameters, especially on the temperature. PC/ABS 75/25 ratio was chosen as constant for the PC/ABS/PMMA blend. It was seen that the PMMA content over 5% significantly decreases the impact strength. Form the point of recycling of PC/ABS/PMMA as a mixture, PC/ABS 75/25 represents the best material ratio to achieve maximum toughness, but the content of PMMA should be kept under 5%.

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Influence of b-phase on Mechanical Behavior of PP

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Content of β-phase in PP effects positively its behavior. The goal of this work is to show advantages of maintenance nucleation of β-phase in PP. Not only on polymer by it self but even on its structure, fractography and mechanical properties. Discusses the problem of transformation during cold-drawing and the problem of crystallization.

The crystalline structure of isotactic polypropylene is one of the most complex among industrially developed polymeric materials, since it displays several allotropic modification and variety of spherulitic morphologies. There are three possible crystalline phases, namely monoclinic (α), hexagonal (β) and triclinic (γ) in isotactic polypropylene (iPP). The first two are the most common phases. Under normal melt condition, the β-phase of iPP occurs only sporadically among the predominant α-phase. The α-phase is characterized by the presence of transversal crystallites in addition to principal framework of radial lamellae. As for the β-phase display radial lamellae only. However, high content of β-phase crystals can be produced under special conditions, such as crystallization in a high temperature gradient field, shear-induced crystallization or by doping the PP resin with a nucleating agent. Regardless of whether nucleating agents are present or not, high content of β-phase can be obtained only within a limited range of crystallization temperature and the most suitable temperature for growth of hexagonal crystals is temperature close to 130°C [1-3]. There are lower and upper temperature limits beyond which the β growth will convert to α growth. The lower critical temperature was about 105°C while the upper critical temperature was 140°C.

β-nucleated isotactic polypropylene homopolymers (PP-H) have received considerable interest recently. This interest is mostly due to the peculiar thermal and mechanical performance of the β-crystalline PP-H. Toughness of the β-phase PP-H is markedly higher than that of the α-modification, both below and above the glass transition temperature (T_g). Under tensile loading, the α-spherulites exhibit brittle behavior while the β-phase deforms plastically up to high deformations. This has been demonstrated in several previous works by several authors adopting the methods of linear and elastoplastic fracture mechanics. Note that fracture mechanics is the right tool when a toughness comparison between various PP modification is targeted. Concepts of the fracture mechanics, in fact, may yield an inherent material parameter which is independent of the test configuration. Attention should be paid to the fact that break-thoroughing research and application of β-crystalline PPs occurred when highly selective β-nucleants became available.

There are several explanations for toughness improving effect of the the β–phase. It has been shown in many papers that increasing of molecular weight (MW) results in improved toughness for β-nucleated PPs. High β-crystallinity usually yield high toughness. β-lamellae are not organized in a cross-hatched but in bundle structure.

The bundle β lamellar structure exhibits inherently higher ductility than the cross-hatched one [4]. Nevertheless, lamellae bundles, held together by the tie molecules that can be easy separated from one another upon loading. This lamellae separation is accompanied by

massive voiding with the simultaneous onset of craze like micromorphus structure. This failure, i.e. break up and defolding of the lamellae, triggers the β - α polymorphic transition. This occurs via a recrystallization process as the handedness of the helices in the related elementary cells should change during this transition [3,4]. The dominate transformation occurs on the upper shoulder of the neck. The β - α transformation over the neck was extensively investigated with DSC [3]. We can conclude that the β-phase is stable up to the yield point but transform to α-phase after necking.

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Polymer Nanokompozit Materials

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Nano materials and nano technologies is modern approach that is discussed very often in many research works. It is very important to study this phenomenon and problems with preparing, processing and its advantages in use as well the influence on morphology, physical and mechanical properties.

The use of inorganic fillers has been a common practice in the plastics industry to improve the mechanical properties of thermoplastic such as heat distortion temperature, hardness, toughness, stiffness and mould shrinkage. The effects of filler on the mechanical and other properties of the composites, depend strongly on its shape, size, aggregate size, particle surface characteristics and degree of dispersion. In general, the mechanical properties of the composites filled with micro-size particles are inferior to those filled with nanoparticles of the same filler. In addition, the physical properties, such as surface smoothness and barrier properties can not be achieved by using conventional micro-sized particles. In the recent years, intensive research efforts have been devoted to the development of nanocomposites [1]. Nanocomposites are a new class of composites, where at least one dimension is in the nanometer range.

It is known that the mechanical properties of the composites are, in general, strongly related to the aspect ratio of the filler particles. Based on this reasoning, layered silicates, such as montmorillonite, which has a fairly large aspect ratio has been extensively studied in recent years. Nanocomposites prepared with montmorillonite show improved strength, modulus, heat distortion, temperature and barrier properties. In spite of many attractive improvements in physical and mechanical properties of the polymer/clay nanocomposites, their engineering applications are greatly limited.

The mechanical properties of the nanocomposites can be significantly changed if the crystallization characteristics of polymer have been changed. A recent study has shown that the addition of the untreated and polymer-grafted nanoparticles of SiO_2 does not have any significant effect on the crystallinity and the crystallization temperature. But the crystallization temperature may vary in functionality of particle size and particles activity [2].

Depending on the organization of the silicate layers in a polymer matrix, two types of morphology can be achieved in nanocomposites: intercalated or exfoliated. There is wide variety of both synthetic and natural crystalline fillers that are able, under specific conditions, to intercalate a polymer [2, 3, 4]. Intercalated structure in which a single (sometimes more then one) extended polymer chain is intercalated between the silicate layers resulting in a well ordered multilayer morphology built up with alternating polymeric and inorganic layers. When the silicate layers are completely and uniformly dispersed in a continuous polymer matrix, an exfoliated or delaminated structure is obtained. The intercalation of the polymer chains usually increase the interlayer spacing, in comparison with the spacing of the used organoclay, leading to a shift of the diffraction peak towards lower angle values. As far as exfoliated structure is concerned, no more diffraction peaks are visible in the XRD

diffractograms either because of a much too large spacing between the layers, usually 8 nm case exfoliated structure, or because the nanocomposite does not present ordering any more.

Generally there are four strategies used to prepare polymer nanocomposite, i.e. exfoliation-adsorption, in situ intercalative polymerization, melt intercalation and template synthesis. Exfoliation-adsorption has been widely used with water soluble monomer, pre-polymer and polymer to produce intercalated nanocomposites. It is well known that such layered silicates, owing to the week forces that stack the layers together can be easily solvent in an adequate solvent. In the second method, the layered silicate is swollen within the liquid monomer so that polymer formation can occure in between the intercalated sheets. This method is suitable for some polymers, such as nylon polycaprolactone and epoxy. Melt intercalation is to enable the layered silicate mixed with the polymer matrix in the molten state. This solvent free method requires the polymer to be compatible with the layer surfaces. In the last technique are the silicates formed in situ in an aqueous solution containing the polymer and silicate building blocks. It has been widely used for the synthesis of double layer hydroxide based nanocomposites but is far less developed for layered silicates.

The large array of improved thermo-mechanical properties attained at very filler content (5 wt.% or less) together with the ease of production through simple processes such as melt intercalation, directly applicable by extrusion or injection molding make layered silicate based nanocomposites a very promising new class of materials. They are already commercially available and applied in car and food packaging industries. The quite low filler level required to display sizeable properties enhancement makes them competitive with other materials. Their incineration produces ceramic chars in low yield and the very limited filler content makes them compatible with recycling process.

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Effect of Annealing on the Optical Properties of the Proton Exchanged Waveguides in Lithium Niobate

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We report about experiments on fabrication of Annealed Proton Exchanged (APE) [1,2] optical waveguides in lithium niobate ($LiNbO_3$) based on using non-toxic, environmentally friendly adipic acid. Proton exchange (PE) is based on a reaction of the lithium niobate wafer with a suitable acidic source which results in a large increase of the extraordinary refractive index. The PE waveguides have high loss and degraded electro-optic properties. However, they can be substantially improved by the annealing of the as-exchanged waveguides [3]. One of the main advantages of the APE waveguides is that they support only TM or TE polarization for Z-cut or for X-cut, respectively.

To avoid damage of lithium niobate substrate wafers, adipic acid was used with addition of lithium carbonate (0.5 mole %). Temperature of the proton exchange was 213 °C and duration of the reaction was half an hour to two hours. The as-exchanged waveguides were stabilized by annealing in air (A) at temperatures from 350 to 390 °C for times ranging from 30 minutes to 50 hours. The mask (150 nm of Al layer and 50 nm of Ti layer) was made by standard lithographic technique with various widths of the openings. The channel waveguides were then fabricated with the experience gained in fabrication of the planar waveguides.

We studied the basic parameters of the channel waveguides made in Z – cut $LiNbO_3$, i.e., number of guided modes and near field patterns. The study helped to optimize the experimental approach to fabricate low-loss single-mode channel waveguide at 1.5 μm suitable for coupling to optical fiber for application as passive or active integrated optics structures.

At the fabricated samples the number of propagating modes as a function of width of the channels and the time of annealing was studied. The widths of the single-mode channel waveguides at 1.5 μm as a dependence of techniques parameters are included in Tab. 1.

Tab.1: The width at μm of the single-mode channel waveguides at 1.5 μm as a dependence on techniques parameters of APE procedure.

PE (h.)	PE (°C)	A (°C)	A (h.)							
			0.5	**1**	**2**	**3**	**5**	**10**	**15**	**20**
0.5	213	350	> 7.4	> 7.8	-	-	-	-	-	-
1	213	350	> 3.0	> 4.5	> 5.0	NA	> 6.9	-	-	-
2	213	350	NA	NA	3.9 – 6.7	NA	4.5 – 7.1	5.8 – 8.5	6.7 – 9.3	> 9.3
2	213	375	3.6 – 5.4	4.0 – 8.8	> 6.1	> 7.2	-	-	-	-
2	213	390	> 3.5	> 5.5	> 6.3	-	-	-	-	-

It was demonstrated that the APE procedure consisting of the proton exchange in buffered adipic acid from 30 min to 2 hours at 213 °C, and subsequent annealing at 350 °C to 390 °C from 30 min to 30 hours is suitable for fabrication of the channel waveguides that were single-mode at 1.5 µm as depicted in Tab 1. The mode profile of the channel waveguides at 1.5 µm has different mode dimensions from 4.2 µm x 4.1 µm to 18.3 µm x 13.5 µm measured at FWHM for 2 hours to 20 hours, respectively. Further work is in progress to measure the number of modes and near field pattern at other different wavelength and to measure the optical losses as the dependence on fabrication parameters, mainly the time of the proton exchange and the annealing.

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Stress and Strain Cycle at the Curved Fatigue Crack Front

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A quantitative understanding of a cyclic stress-strain field around the crack plays an essential role in life assessments of engineering structures subjected to fatigue loading. Many researchers have performed numerical simulations of different through-thickness cracked configurations using two-dimensional approach (plane strain or plane stress) or using three-dimensional model with straight crack front [1, 2]. However, even the simplest geometries and loading conditions, e.g. a constant amplitude loading of center-cracked plate (CCP) specimens, lead to three-dimensional crack shapes (crack tunneling and shear lips formation). The 3D finite element simulation of the elastic-plastic field along the growing crack with such realistically curved front is summarized bellow [3].

Simulated problem corresponds to the following fatigue experiment: Crack growth was observed in the CCP specimen (180×58×6mm) from Al 2024 T-42 alloy. The loading was periodic with the stress range $\Delta S = 44.96$ MPa and the stress ratio $R = 0$. The shape of the curved crack front for the start of the transition from a flat to a slant type of fracture was determined fractographically.

3D nonlinear finite element model is created using software MSC.Marc. One eighth of the specimen is covered by a 3D finite element mesh. Symmetrical constraints are added to simulate the rest of the body. Element size varies within the whole mesh – the smallest elements of the size 2×2×2μm are situated at the crack front under the free surface, where high stress and strain gradients are expected. The element size increases towards the middle of the thickness and also with the distance from the crack front. Material is considered as elastic-plastic with kinematic hardening rule. Small strain formulation is used. Total of 59 model load cycles were applied. Model contact surface in the crack plane makes possible to simulate the crack closing and opening during the loading cycle. Relatively large front jumps across one element size are prescribed by releasing the nodes on the crack front in so-called active cycles. During 29 active cycles the crack covers a distance of 380 μm and the plasticity-induced crack closing is stabilized. An "idle" cycle without crack advance is inserted between each two active cycles. It is reasonable suppose that the crack front deformation mechanics in the idle cycle will be much closer to the crack behaviour in the real cycle with the very small crack advance.

The following discussion summarizes the key findings from this study:

Material in the middle of the thickness is loaded by intensive triaxial tension-compression with relatively small plastic strains in the loading direction. On the other hand, normal stresses near the surface are low while the local plastic strain range is very intensive. However, the thickness of such intensively deformed surface layer is only 100 - 200 μm.

The whole simulated crack propagates in tensile mode yet. Final elementary fracture of the material at the front is therefore supposed to be induced by local tensile stress in the loading direction, which appears also as the major principal stress σ_{max}. This flat type of the crack growth can take place under very various conditions. Not very damaged material in the middle of the front is teared by high stress σ_{max}, while relatively low σ_{max} is enough for the

tearing of much more damaged material in the surface layer. The latter conditions are probably suited for shear lips formation.

The occurrence of shear lips seems to be a complex free-surface effect and not a direct consequence of the local stress-strain conditions near the surface. In spite of this, the local maximum shear stress τ_{max} reaches the extreme value immediately below the surface. Usually, the τ_{max} plane bisects the right angle between the direction of the crack propagation and the direction of loading. But at the point of the extreme this plane is turned 62° around the loading direction. This roughly corresponds to experimentally observed orientation of the shear lip plane. Therefore the subsurface maximum shear stress seems to be connected with the transition from a flat to slant type of the crack growth in some ways.

Fatigue crack propagation could be treated as a continual low-cycle fatigue of the material at the crack front. The cyclic plastic strain induces a material damage, which could be measured for example by local plastic strain energy density λ. According to simulation, the considerable increase of λ towards the free surface can be observed.

According to the Sih's concept, a material element ahead of a certain crack front point A can be considered. Let Δr is the distance of the element from A, λ is the actual value of the plastic strain energy density in the element and $\Delta\lambda$ is the change of λ during the loading cycle. Then, the local perpendicular crack front rate at A can be estimated as $v = \Delta r \cdot \Delta\lambda/(\lambda_c - \lambda)$, where λ_c is the critical value of plastic strain energy density to local elementary crack advance. λ_c can be determined from this formula, if experimental crack growth rate v is known. Calculations of λ_c along the three fronts of different crack length were performed. From distributions of λ_c along all three crack fronts arise: (i) λ_c increases towards to free surface, which is connected with increasing plastic strain range, (ii) λ_c decreases with increasing crack length (verified also by the 2D plane strain simulation considering gradual strain energy cumulation [4]). Therefore the critical energy for elementary fatigue fracture can not be supposed to be a material constant and a realistic energetic method for the fatigue crack growth rate prediction can be quite complicated.

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Effect of Annealing on the Amplifier Characteristics in Proton Exchange Waveguides in Erbium doped Lithium Niobate

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Waveguides in $LiNbO_3$ are commonly fabricated by titanium in diffusion and by proton exchange technique (PE). The erbium doped waveguide amplifiers and laser based on Ti in diffusion have been made. Nevertheless, waveguide amplifiers based on proton exchange process have not yet been processed. The technique for the formation of the waveguides in lithium niobate using the proton exchange (PE) process has been extensively studied since its discovery in 1982 [1]. When used with post-exchange annealing (A) and buffered (i.e., Li^+ containing) melts, this process produces waveguides and devices with good electro-optic characteristics. The annealed-proton-exchange (APE) process offers several advantages over other waveguide fabrication technologies, as the waveguides tend to have very low propagation losses and support only the extraordinary polarization. The flexibility of the APE process also allows for convenient tailoring of the waveguide refractive index profile and other properties. Most importantly, APE waveguides are much less susceptible to photorefractive effects than titanium in-diffused waveguides. It has been also shown that the annealing process has a positive influence on electro-optical properties recovery [2] and non-linear optical activity [3]. However, there are some disadvantages in reduction of excited-state lifetime in Er^{3+} ions in $LiNbO_3$, which is caused by the fluorescence quenching. The origin lifetime is reduced from 2.7 ms to several μs. The fluorescence quenching occurs because of a high amount of the OH groups created by the protons incorporated by the fabrication process. Two OH-stretch phonons mediate a transition between the $^4I_{13/2}$ and $^4I_{15/2}$ states. The reduction of the excited-state lifetime of $^4I_{13/2}$ level results in higher threshold pump power P_{th} to obtain gain in waveguide amplifiers. It may be expected that the longer annealing time the smaller proton concentration resulting then in lower P_{th}.

Our previous ERDA (Elastic Recoil detection Analysis) study [4], as well as our recent research clearly showed that annealing of the as-exchanged planar waveguides leads to the substantial decrease of the OH concentration almost to its bulk $LiNbO_3$ value. The possibility to lower substantially the concentration of unwanted OH groups by suitable regime of the post-exchange annealing encouraged us to study the effect of annealing process on the waveguiding parameters in channel APE waveguides at 1.5 μm with special attention paid to a change of absorption at 1.5 μm in single mode APE waveguides in erbium doped lithium niobate. In this paper we shall explicitly address the following question: What is the influence of annealing time and annealing temperature on the change of the 1.5 μm absorption in the erbium doped X- and Z- cut APE channel waveguides?

The change of the absorption at 1.53 μm was measured by pumping the wavelength with a 980-nm laser diode. The signal source used was an EDFA amplified spontaneous

emission (ASE) with broadband from 1.52 μm to 1.58 μm. Both the signal and pump lights were coupled into the channel waveguides using a 980/1550-nm wavelength-division-multiplexing (WDM) fiber coupler. The output signal was detected using ANDO AQ-6315A optical spectrum analyzer (OSA).

For the more detailed study was fabricated a series of the samples at the most suitable conditions, i.e. proton exchange was performed two hours at 213 °C in buffered adipic acid and the as-exchanged samples were annealed at 350 °C for 5 hours times. After the measurement the additional annealing occurred at the same temperature with following measurement again. These sequences were several times repeated so that the overall annealing reached up to 20 hours for the X-cuts and 11 hours for the Z-cuts where the waveguides supported 1.5 μm. At these time the channel waveguides were not been changed and were single-mode (SM) at 1.5 μm. After next sequence of annealing the waveguides were not SM at 1.5 μm in both types of the cuts. The change of the absorption was calculated as a difference of the absorption without pump power α_0 and with pump power α_p. It has been found that the post-exchange annealing had a positive effect on the change of the absorption and also therefore on the laser level lifetimes $^4I_{13/2}$. It practically means that using the same pumping power the change of the absorption increased with longer annealing times improving thus the lifetimes recovery of the laser level of the systems. The described effect was found to be linear with the times of the annealing, so that one would expect that the very long annealing will lead to achieving the origin value of the untreated substrate. However, the limiting factor is that a long annealing time destroys the optical confinement due to the lowering the positive change of refractive index of the channel. We investigated the effect of the post-proton-exchange annealing on the properties of the APE channel waveguides at 1.5 μm fabricated in the bulk doped Er^{3+}:$LiNbO_3$ and we obtained the following results: (1) The process of the annealing improved the rate of the change of the absorption, which correlates well with lifetime recovery rate of laser level in Er^{3+} ion. Long annealing times (above 20 hrs and 11 hrs for the X and Z-cuts, respectively) caused degradation of the waveguiding at 1.5 μm as a result of substantial decrease of the refractive index increment necessary for the SM guiding, and (2) better conditions for the laser lifetime recovery rate were found to be in the X-cut $LiNbO_3$ channel waveguides due to a faster migration of the hydrogen particles during the post-exchange annealing deeper into the substrate. The X-cut offered also a possibility of longer annealing without destroying the optical confinement at 1.5 μm.

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Investigation of Self-aggregation Process of Polymer Systems Using Molecular Modeling

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The molecular dynamics simulation is a progressive and well developed method in the material science. It allows one to study a material directly on the level of atoms with no interface introduced by measurement instruments. On the other hand, we have to accept restrictions coming from both fundamental and technical reasons. Fundamental restriction are implied by the fact that we deal with a simplified model of matter in which a priori assumptions of its behavior were made. Molecular simulation technique is founded on the atomistic model of matter which is based on two suppositions:

- We consider a system of interacting atoms in which some of them are linked with defined chemical bonds and all pairs interact with non-bond interactions (electrostatic, van der Waals and in some cases hydrogen bonding). No electronic density and other sub-atomic structure properties of molecules are computed.
- The time evolution of the system is determined by the general physical laws of motion, which are the same as for macroscopical objects. In most cases the Newton equation of motion is a sufficient approximation

A key-point is the expression of the potential energy in terms of the inner degrees of freedom of the system. In complex system we avoid of *ab initio* computations and use phenomenological formulas instead. Those formulas are derived from a comprehensive database of ab-initio-based data for particular groups and atoms. This database and the rules of assigning certain atoms or groups with a pronounced interaction together is called the *forcefield*. The energy expression is a starting point for the structural refinement (using the energy minimizer algorithm and/or dynamic simulation). For the dynamic simulation we mean solving the equations of motion with the potential obtained with the forcefield. In my recent project, I curried on studies of the so-called self-aggregation of syndiotactic poly(methyl methacrylate) (s-PMMA). This effect (and related phenomenon of isotactic polymer and polymer mixture association) has been a subject of various studies in the last 30 years (see review in [1]). Experiments have revealed its basic properties, the structure of aggregates and the conditions of its formation. There are two characteristic features of the self-aggregation process: the dependency on the degree of stereoregularity of polymer chains and the specific effect of solvents in which the complexes are formed. The interaction between the molecules of solvent and the syndiotactic polymer chains still has not been understood to such an extend that we could explain why in some types of solutions (tetrachlor, o-dichlorbenzene, toluene, for example) the aggregation takes place while in other types (chloroform, benzene, etc) does not.

My intention was to employ the molecular dynamics technique for investigation of interactions potentially responsible for the aggregation. A key point is to properly define the models and to plan calculations that will be performed because there is a high variability of possible experiments. My suggestion was to restrict the investigation on equilibrium systems of a single macromolecule in solutions. The question such investigation can answer is *whether there are characteristic changes in structure (conformation) or mobility of polymers (or its groups) that are prior to their association and are caused by interaction of*

stereoregular sequences with the 'active' solvents. This idea is based on the opinion of Spěváček and Schneider [1] that such changes can be responsible (beside other effects) for the aggregation process. A series of such models were constructed for polymers of various tacticity which were dissolved in tetrachlor, chloroform, toluene and orto-dichlorbenzene. They were led into the state of thermodynamic equilibrium in which basic structural and dynamical quantities were 'measured.' I focused especially on the polymer carbonyl group (C=O) because from planty of experiments it follows that mutual interactions among those groups, which have a permanent dipole moment, plays an important role in forming of the aggregates.

From the results that I have obtained I would like to pick up the most significant. Rotational time (auto)correlational function is a quantity which describes how rapidly the orientation of a certain group changes in time. If $\mathbf{u}(t)$ is an orientational vector, in our case it is associated with the direction of the carbonyl bond, then the function is defined: $m(t) = \langle \mathbf{u}(t_0).\mathbf{u}(t+t_0) \rangle_{t0}$. Empirically, it has an exponential form $m(t) = \exp -(t/\tau)^{\beta,}$ where τ is a correlation time and β is in (0,1). I have calculated the correlation times for all completed models of polymer solutions. From the results it follows that for stereoregular PMMA in toluen and tetrachlor solution the correlation period is several magnitudes longer than in chloroform solutions. Furthermore, in tetrachlor and toluene (which are the solvents where the aggregation takes place) the correlation time decreases with tacticity. For chloroform the dependency has the opposite character as it is rising for polymers with a lower tacticity. This result could indicate that a hindered rotation of the carbonyl group is necessary for the aggregates to be formed.

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Application of Ion Beams in Modification of the Gages Surface Properties

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Hard nitride surface coatings of various metals and alloys have found extensive tribological applications in many industries [1]. They have been studying in more details during recent years and have excellent wear, hardness, fatigue and corrosion resistance characteristics compared with the substrate materials [2]. Such coatings can be prepared by several techniques such as ion implantation, magnetron sputtering, chemical vapour deposition and ion beam assisted methods.

Ion implantation is a high technology approach for modifying surface properties of materials. It is similar to a coating process, but it does not involve the addition of a layer on the surface. Originally developed or used in semiconductor applications – and in fact still used extensively in that capacity today – ion implantation utilize a highly energetic beams of ions (positively charged atoms) to modify the surface structure and chemistry of materials at low temperature [3]. The process does not affect adversely the component dimensions or bulk material properties. The surface properties can be considerably improved by the ion implantation and the process can be applied almost to any material, including most metals, ceramics and polymers.

Nitride coatings achieved by the ion beam assisted deposition (IBAD) process are reported to have considerably improved properties of stainless steel. This method has been widely used on cutting tools and mechanical components to prolong their service life and to prove the working efficiency. Nitride has also been added to material in order to improve the hardness end wear resistance [4]. IBAD consists of simultaneous deposition of the material by using a vacuum evaporation technique and bombardment of an energetic ion beam. Thin film to be produced is simultaneously irradiated during the deposition process in vacuum by a beam of energetic ions. Thus, an input of additional energy into the surface region of the film occurs. This leads to the excitation and amplification of diverse chemical and physical processes that take place on the microscopic scale. As the result, a direct manipulation of the chemical composition, as well as the crystallinity and the microstructure of the produced film becomes possible.

It has been recognized that the presence of energetic ions has a synergetic effect on the process of thin film growth. Several aspects of film growth that have been beneficially influenced by ion bombardment during the deposition, include: a) film nucleation growth; b) adhesion; c) internal stress; d) surface morphology; e) density; and f) composition.

The nitride coatings on steel substrates were produced by ion beam assisted deposition technique. As steel substrates were used roller and screw gages. Among the hard measuring

tools every possible tolerance gages were selected. The measurments with gage assistance is limited by their application, whether actual size lies in tolerance, i.e. between two limit sizes. The gage has two sides: “good” and “low-end”. Their sizes responds in substance to both limits according to the principle: low-end size of the component can not be changed into the good one by the further machining. Good size of the gauge must always fit easier and without force (with its own weight) go into the article (for example through the bore), low-end size can not go through. The roller gage wear was investigated specifically while measuring the article (diameter of bore). An advantage of the tolerance gage size control is that it almost excludes the influence of the workman or controller on the measuring. The measuring itself is fast and easy and does not require a special qualification or experience.

Because of necessity to take into consideration the wear of the good side of measuring tool, the actual size of a good side is displaced on wear allowance till tolerance field of the measuring tool. The size of a good side of the gage is necessary to control quite often, otherwise the limit size of the manufacture will be exceed during the wear process. The wear of the low-end side is much less, because it’s measuring surface comes into contact only with the defective article.

Ion implantation was applied to roller gage of normal diameter 7 mm. Verification of size stability of a good size was carried out under production conditions with hundred-per-cent manufacture control. The gage was systematically controlled and the dimensional stability of it’s good side was provided during the 5200 measurements that corresponds to manufacture rate. This gage can be actually used for the further measurements. Prohibitive wear of the good side of gage without ion implantation was detected after 200 measurements. The results show that the size stability and the wear resistant of the roller gage with applied ion implantation was increased much higher than the gage without ion implantation. The sufficient service life and working efficiency was achieved.

The next step of the work was to measure the wear of the screw gage of nominal size 7/16-20 UNJ. The screw gage with applied ion implantation retain its dimentional stability till 2100 measurements. After that the prohibitive wear of the gage was detected and the screw gage was necessary to put out of the operation. Because the measurements were not provided on the same screw gage without ion implantation, it was not possible in that case exactly to determine the service life of the gage. Both cases are the first comparison measurement steps, and the following researches will be continued.

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Measurement of Thermal Expansion of Carbon Fibre Composites for Strengthening of RC Structures

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Thermal expansion of carbon fibre sheets has been evaluated in special set-up constructed in Klokner Institute. Elongation of the sample has been measured by LVDT sensors and measurement system Hewlett- Packard 3852. Measurements have been performed on carbon-epoxy unidirectional composites with approximately 74% volume content of fibres in epoxy matrix. The sheets from carbon- epoxy composites with 50x 1.2 mm cross-section were made by pultrusion technique and delivered by Sika and Degussa Co.

Specimens of size 200 (50, 80, 90) x 15x 1,2 (1,4)mm have been conditioned 24 h before measurement in standard environment, clamped into set-up and lengths of specimens measured by measurement system and stored in PC. A set-up with the specimen has been then inserted into temperature chamber attempered at 60□2^{0}C and conditioned so long, till no elongation has been registered. Mean coefficient of thermal expansion has been calculated from relationship: $\alpha = \Delta L/L.1/(T_2-T_1)$, where L is initial length of specimen, ΔL increment of length due to change of temperature (T_2-T_1). An error of measurement due to elongation of set-up has been corrected by relation: $K=L(T_2-T_1).\alpha_{steel}$. Thermal expansion of carbon composites has been measured in two directions; longitudinal and transversal in x-y plane. Following tables show evaluated coefficients of thermal expansion for Sika S512 and Degussa MBT 150/2000 carbon epoxy sheets.

Table 1. Thermal expansion of Sika S512 in longitudinal direction

Length [mm]	Temp. $T_1[^0C]$	Initial meas [mm]	Temp. $T_2[^0C]$	Final meas. [mm]	Correction [mm]	Coefficient $[K^{-1}]$
201	23,72	0,868069	61,25	0,794489	0,090522	2,25E-06
201	24,19	0,865478	61,25	0,794489	0,089389	2,47E-06
201	22,55	0,875417	61,62	0,803385	0,094237	2,83E-06
201	21,36	0,880619	61,62	0,803385	0,097107	2,46E-06
201,5	21,55	1,099323	61,47	1,025048	0,096527	2,77E-06
201,5	22,28	1,098765	61,47	1,025048	0,094761	2,66E-06
						2,57E-06

Conclusions

Thermal expansion of carbon fibre sheets for strengthening of RC structures has been evaluated. It has been found that despite of negative thermal expansion of carbon fibres the thermal expansion of unidirectional carbon epoxy composites in longitudinal direction has a positive sign; the absolute value however is much less than of steel. In case of unidirectional carbon epoxy composite the thermal expansion in transversal direction has been found 10 times greater than in longitudinal direction.

Table 2: Thermal expansion of Sika S512 in transversal direction

Length [mm]	Temp. $T_1[^0C]$	Initial meas [mm]	Temp. $T_2[^0C]$	Final meas. [mm]	Correction [mm]	Coefficient $[K^{-1}]$
50	24,01	0,477402	61,1	0,545066	-0,02427	2,34E-05
50	24,22	0,474164	61,1	0,545066	-0,02413	2,54E-05
50	22,05	0,393383	60,91	0,470548	-0,02543	2,66E-05
50	22,34	0,396004	60,91	0,470548	-0,02524	2,56E-05
50	23,16	0,684033	61,35	0,757155	-0,02499	2,52E-05
50	23,06	0,680835	61,35	0,757155	-0,02505	2,68E-05
						2,55E-05

Table 3. Thermal expansion of Degussa MBT 150/2000 in longitudinal direction

Length [mm]	Temp. $T_1[^0C]$	Initial meas [mm]	Temp. $T_2[^0C]$	Final meas. [mm]	Correction [mm]	Coefficient $[K^{-1}]$
89,9	24,04	3,455074	61,71	3,441453	0,022236	2,54E-06
89,9	23,99	3,454102	61,71	3,441453	0,022265	2,84E-06
89,9	23,47	3,514369	61,96	3,502736	0,02272	3,2E-06
89,9	23,59	3,514724	61,96	3,502736	0,022649	3,09E-06
						2,92E-06

Table 4. Thermal expansion of Degussa MBT 150/2000 in transversal direction

Length [mm]	Temp. $T_1[^0C]$	Initial meas [mm]	Temp. $T_2[^0C]$	Final meas. [mm]	Correction [mm]	Coefficient $[K^{-1}]$
80	24,18	1,228436	61,59	1,30917	-0,0033	2,59E-05
80	23,38	1,226314	61,59	1,30917	-0,00337	2,6E-05
80	20,99	0,779755	62,38	0,86659	-0,00365	2,51E-05
80	21,47	0,781016	62,38	0,86659	-0,00361	2,5E-05
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Acoustic Emission Measurement of Carbon Fibre Composites for Strengthening of RC Structures

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Measurements have been performed on carbon-epoxy composites with unidirectional reinforcement by carbon fibres with approximately 74% volume content of fibres and epoxy matrix. The sheets from carbon- epoxy composites with 50x 1.2 mm cross-section were made by pultrusion technique and delivered by Sika and Degussa Co.

Nowadays, in the majority of efforts to use AE in the direction of material characterization, a 'conventional' AE analysis is employed. It usually comprises the investigation of the AE activity in diagrams of cumulative hits (or counts) versus load (or stress) and the correlation of some AE features, such as amplitude or duration, to some basic damage mechanisms. Our approach was to apply this method on carbon- epoxy composites for strengthening of reinforced concrete structures.

Set of specimens 15x 1.2x 200 mm have been cut in longitudinal direction of the sheet. The specimens have been subjected to tension in testing machine Instron 1273 (speed $1mm.min^{-1}$) up to final failure. Load, longitudinal and transverse strains have been measured and data collected by Hewlett-Packard system HP 3852. Transverse and longitudinal strains have been calculated from diplacements measured by extensometers.

At the same time AE measurements have been performed by acoustic emission system AEDSP 32/16 (2 channel plug-in card, 16 bit resolution, sampling frequency max. $10MSa.s^{-1}$, Physical Acoustics, USA) and software MISTRAS (Physical Acoustics). AE sensors of type WD (wide band) have been used, preamplifier 1220A, gain 60 dB (both Physical Acoustics). AE sensors were attached to each specimen using suitable coupling agent and placed symmetrically onto the specimen along its longitudinal axis at a distance of 80 mm.

Results

Each AE signal is described by a seven component vector. These components, known as AE features, are measured real-time by the data acquisition system AEDSP 32/16 and they namely are: duration (DUR), counts (CNT), amplitude (AMP), counts to peak (CNP), risetime (RT), decaytime (DT), energy (E). Additional AE features such as rise angle (RAN=AMP/RT), decay angle (DAN=AMP/DT), average frequency (AF=CNT/DUR), initiation frequency (INIF=CNP/RT) and others were calculated at a post processing level. Noise reduction of the main set of AE data is of major importance and high priority.

AE signals were detected and stored in memory of PC computer. Cumulative AE counts, events and energy then have been calculated by software MISTRAS and shown in the figures as a function of duration of the experiment.

It has been found that cumulative AE counts and events increase roughly linearly in time and the curve suddenly changes the slope in two points of whole loading range.

Approximately in the same area the stress - strain curve slightly bends. Correlation of both curves shows, that the initialisation of matrix cracking occurs approximately in 60% of

failure load- followed by fibre debonding about in 90% of failure load. Finaly the failure occurs. Corresponding values for the set of all specimens have been determined and related to the deformation and failure micromechanisms. Future research will be focused on the verification of results by the PR (clustering) method.

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Apparatus for On-line Transparency Measurement of Scintillation Detector Materials in Gamma and Electron Radiation Fields

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An intensive research and development program to study the radiation hardness of scintillating crystals and fibers in radiation fields was undertaken to study effects, which could influence the overall performance of the particle detectors. The radiation forms absorbing centers both in crystals and fibers and it decreases transmission (or light yield) of materials used in detectors. Therefore the on-line facilities for the study of plastic and crystal scintillators transmission in gamma radiation field were set-up at the Microtron Laboratory in Prague and Microtron Laboratory in Dubna.

The microtron accelerator [1] at Czech Technical University, Faculty of Nuclear Sciences and Physical Engineering (now at Nuclear Physics Institute AS CR, Rez), was used for study of radiation hardness of both crystals [2] and fibers [3]. The crystals were irradiated in the bremstrahlung gamma radiation field produced by the irradiation of 3 mm thick and 30 mm diameter tungsten target by the 21 MeV electron beam. A flattening iron absorber followed by a conical collimator of special shape was inserted to equalize the pronounced forward intensity peak and to obtain homogeneous intensity distribution in the irradiating crystal area. The dose rates used were ranging from 0.5 $mGy.s^{-1}$ to 6 $mGy.s^{-1}$ (with the accuracy better than ±10 %). The different set-up without collimator was used for fibers studies. The sample fibers were placed perpendicular to gamma beam in distance 111 mm from target. Since our gamma radiation field had a conical profile, the fibers were not irradiated homogenously and the intensity distribution on fiber length had full-width at half-maximum approximately 44 mm. The measurements were performed in broad range of dose rates from 2 $Gy.s^{-1}$ to 25 $Gy.s^{-1}$. Electron field for fiber radiation hardness investigation was produced from microtron without tungsten target using.

An intensity of transmitted light was measured in time t during irradiation as well as during the time when the microtron was switched-off (after usual irradiation time of 1800 seconds, when the saturation level was usually reached). The recovery processes were monitored up to 7000 s. Induced absorption coefficients $\mu(\lambda,t)$ were calculated from equation

$$\mu(\lambda,t) = 1/d \ln [I(\lambda,0) / I(\lambda,t)] \quad (1)$$

for all measured wavelengths λ. d is the effective crystal length, $I(\lambda,0)$ and $I(\lambda,t)$ are transmitted light intensities before irradiation and at time t after start of radiation.

The specially developed double beam spectrophotometer was used for the on-line measurement of induced absorption coefficient changes. It is based on the 256-diode array spectrometer with optical fiber input LASP 2. Every diode forms an independent channel covering a wavelength interval of 2 nm. The spectral range from 190 to 735 nm was analyzed simultaneously. Due to the attenuation of the UV light in the optical fiber the useful light spectral range was 360-735 nm. The acquisition time can vary from 0.003 to 10 s; period of data acquisition was 20 s. A 10 W halogen bulb and deuterium arc lamp were used as light sources. The special voltage stabilized power supply assures the light beam intensity stability better than 0.1 % per hour. The light from the lamp was concentrated to a narrow parallel beam and divided by mirror to sample and reference branches. The light beams, passing through the investigated sample and reference space, were focused by collimating lenses on the entrance surfaces of the radiation-protected light guide bifurcated fiber cable. This cable was connected to 50 m fiber guide and the light signal was transmitted into the spectrophotometer situated in a radiation-protected room.

The special electromechanical chopper was used to chop the light beam either going through sample or reference branches between measurements to minimize photobleaching. The samples were placed in Peltier temperature-stabilized polystyrene box (useful range from -20 ˚C to +30 ˚C). Computer (with specially adapted LASP spectrophotometer and Matlab software) automatically drives all transmission measurement.

This on-line apparatus is unique at present time, because all other experiments are performed after stop of irradiation. Scintillating crystals $PbWO_4$, YAP:Ce, CsI, BGO with different doping ions and more than 25 kinds of light guide fibers, wavelength shifting and scintillating fibers were investigated by this apparatus. We received sets of data for kinetics of radiation damage and recovery processes, spectra of induced absorption coefficient during gamma irradiation and after microtron switch-off for various dose rates and temperatures. These results are very important for deeper understanding of radiation damage mechanism, especially for checking of doping ions influence to scintillating materials radiation hardness.

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Electro-Osmotic flow in Building materials II

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An integral part of majority renovation of historical buildings in Czech Republic is a dewatering of walls. The solution of dewatering is individual for every case and depends on many factors (category of acting damp, allocation in field, place of building, wall quality). The claims of State Institute for the Preservation of Cultural Heritage play an important role too. The requirement of preservation of historical structures leads to choice of dewatering process with minimum of side effects. A suitable way is using of physical phenomenon called electroosmotic flow.

The current electroosmotic methods employ direct current between pairs of electrodes for creation of electrical field. The fact of long time process of dewatering implicates, that secondary electrolytic reactions could cause malfunction of electrodes.

Our experience with the electroosmotic dewatering and some information on using alternating current for increasing efficiency of electroosmotic transport lead us to detailed study of these phenomena. We want to compare direct current method of electroosmotic transport with method based on asymmetric current pulses more exactly then was done till this time.

The first part of the proposed project was to develop an electric source capable to supply a current of desired form into the electroosmotic apparatus. The designing and construction of the current supply was performed in cooperation with some external professional.

The developed supply generates a voltage up to ± 50V at a current of 0 - 1 mA. The length of one direct current pulse is 0,1 - 60 000 second. The attached computer is equipped with the special software for controlling and monitoring all parameters. All data are stored on disc. Export of data to the Microsoft Excel sheet is possible.

The preliminary results suggest a positive effect of both methods in materials of brick bases. These results confirmed a dependence of the volume of the transferred solution on the total electric charge passed through the system. Type and concentration of salts dissolved in water contained in the porous structures of the building material are important in both cases.

The results show the dewatering process takes place in the desirable direction in all tested samples. The slope of the humidity content versus linear coordinate in the material (in the current direction) after expiration operation time was taken as a main criterion. This criterion showed a higher efficiency of the direct current process. Next study of the both methods will continue.

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The aim of the seminar is to present and discuss the latest results obtained by researchers especially at the Czech Technical University in Prague and at collaborating institutions.

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– nuclear engineering
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– transportation, logistics, economy and management

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CONTENTS

6. MECHANICS AND THERMODYNAMICS

7. MECHANICAL ENGINEERING

8. PRODUCTION SYSTEMS, TECHNOLOGY AND TECHNOLOGICAL PROCESSES AUTOMATISATION

9. ENERGETICS AND POWER ENGINEERING

10. NUCLEAR ENGINEERING

11. CHEMISTRY

12. BIOMEDICAL ENGINEERING

13. CIVIL ENGINEERING

14. ARCHITECTURE, TOWN PLANNING, GEODESY AND CARTOGRAPHY

15. TRANSPORTATION, LOGISTICS, ECONOMY AND MANAGEMENT

Section 6

MECHANICS
&
THERMODYNAMICS

Optimal Connection of Long Panel Radiators

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With the panel radiators it was determined during the measurement under standard conditions that the nominal heat output by the radiators called „short" is constant both for single-side top and for diagonal top connections. This information is not valid for called „long ($L \geq 4.H$)" panel radiators. Some technical literature is inclined to explain it as of ejector effect first heating flue connected with top distribution box [1], an other literature [3] interprets this phenomenon as significant decrease in dynamic pressure in top connection box with respect to its length. This problem was easily solved with the assistance of CFD methods especially in program Fluent, namely by mapping temperature and velocity fields by two above mentioned types radiators. Our aim was to evaluate on the basis of obtained temperature and velocity fields the cause of the decrease of heat output of „long" radiators by single-side top connections furthermore optimisation of the method of connection of these radiators with respect to heat output change. We carried out mathematical simulation on two types of panel radiators. The first type was „short" model. This model corresponded to panel radiator KORADO Radik Klasik type 10 – 500x500 (the first number is the type of panels, the second number is the radiator of height, the third number is the radiator of length) with single-side top connection and diagonal top connection by nominal and double flow. The second type called „long" model corresponded to panel radiator KORADO Radik Klasik type 10 – 500x2000 with single-side top connection and diagonal top connection by nominal and double flow. All dimensions of models proceed from real drawing, which we obtained from the company KORADO a.s.

The first let us deal with „short" radiator with single-side top connection. Temperature fields is distinctly seen gradual run entrance (hot) water in individual heating flues. In the bottom right corner of the radiator the colder area is also evident. This area was created repercussion lose heat water in radiator and lower velocities. The vectorial fields show orientation run in individual heating flues and the connecting of flows in the bottom-collecting box. From double-nominal flow we watch the reduction of colder area in the bottom right corner. The temperature of returning water from the radiator is higher due to bigger flow. By diagonal top connection of „short" radiator run by nominal flow the cool area moves down in the middle of the radiator. Now the picture of velocity fields shows quite different flow water through top distribution and bottom collecting box and thus different pressure conditions in the radiator. The areas of relative overpressure and relative underpressure are defined quite different by than in the previous case and imaginary neutral curve obtained a different form. Predominant part of water flow is divided into the first three and the last four heating flues. It means that in the middle of the radiator the water does not run in individual heating flue not even approximately as at its beginning and end. The vectorial field only affirms initiate conclusions. By diagonal top connection with double-nominal flow the cool area is almost suppressed. Velocity field is however affected by prevailing flow in the first and the last heating flue.

Now let us concentrate on „long" radiator. First we will consider single-side top connection with nominal flow. On the picture of temperature fields it is seen that entrancing (hot) water does not sluice complete radiator, but only about 50 % of total capacity of the radiator. Due to the pressure loss of the radiator, which in the form of friction and local

resistance increases with length of the radiator, predominant part of flow is immediately returned to bottom collecting box and to the outflow from the radiator. In the second half of the radiator unordered (chaotic) flow occurs and velocity moves in the order of $1O^{-9}$ [m/s] here, which Fluent interpreted as 0 [m/s] for graphic output. Vectorial field demonstrated completely accidental line of the flow of water with very low velocity in the second half of the radiator. By out-of-balanced hydraulic pipe system, in our case by double nominal flow water in the radiator, the area, in which does not occur the sluice of hot entrance water, is smaller, but conclusions are the same as by nominal flow. If we connect „long“ radiator with proportion L≥4.H diagonal top, the picture of temperature and velocity field is more favourable. The separation of predominant part of flow between the first and the last heating flue of the radiator takes place, which is the same as by „short” radiator. The cooler area arises in the middle of the radiator in the bottom part, but the utilization of heat potential is by far better than single-side top connection (better sluice of the radiator entrance hot water). To the significant increase of mean surface temperature of the radiator, contrary to single-side top connection, occurs and thus heat of the output increases. The vectors of velocity field have more ordered character along the whole length of the radiator. By double nominal flow the cooler area is smaller and mean surface temperature of the radiator is higher.

From the analysis of the results of mathematic simulation with the use of program Fluent the constriction of flow water is evident in the places of run in water from top distribution box to vertical heating flues. In the place of constriction flow, at the inside behind the inflection flow, the breakoff flow occurs and generates whirlpools. Kinetic energy of these whirlpools is a part of energy mean flow, i.e. energy in these places dissipates. The flow pattern is behind every heating flue, respectively its connection, different and unordered. Due to unordered flow and pressure losses in top distribution box occur, by long radiator in the second half of its length, to creeping flow about $2 \cdot 10^{-9}$ [m/s]. Take place such small velocity conditions determinate convection heat transfer coefficient inside the water, but at the same time more marked cooling water by flow trough complete panel radiator. The mean surface temperature of the radiator decreases and its reduction is a secondary cause of the decrease of heat output. In projection practise we should not design single-side top connection by called „long“ radiator, but only diagonal top connection. On the basis of acquired results we can recommend even more and change the condition of distinguishing „long” and “short” radiator with respect to the connection. As „long” radiators for which the above-mentioned recommendation of the connection is valid we consider panel radiators, which fulfil the condition ($L \geq 3H$).

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Fast Simulation of Fluids

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Simulation and visualization of various physical and nature phenomena using fluid simulators and solvers based on the Navier-Stokes equations has major theoretical and practical importance in simulation and especially computer graphics field. These simulators and solvers are widely used for various research projects and practical applications such as animations of liquids and water, fire, gas and smoke. Although many of the current fluid simulators offer real-time simulation and visualization, they are always limited by solution conditions under they achieve interactive frame rates. In most cases it is determined by choosing low resolution or even 2D grid for computations. Interactive frame rate of the fluid simulators can depend on the type of simulated problem. Moreover, when using fluid simulators for real-time simulation and visualization in practice, optimizations of the fluid simulator code to maximize the performance of the fluid simulator should be done as well.

One of alternative possible solution for maintaining real-time presentation of the fluid simulator results is to render the visualization output of the fluid simulator to common movie files (e.g. AVI or MPG). However, in this case we get significant disadvantages such as total loose of interactivity and impossibility to visualize more than one parameter at the same time, losing the possibility of high quality zoom of interesting areas and many others. The second common way is to store data sets of the whole simulation to the disk. But the major drawback of this approach is large requirement on the storage capacity and data transfer speed. This is namely a problem when storing characteristics of large grids and simulated objects (such as thousands of particles for maintaining simulation and visualization of combustion processes).

We have decided to design, investigate and test a new architecture based on fluid simulators with partial support by pre-computed states of fluid simulator stored on external storage devices. We have extended our structured fluid simulator [1] with particle system engine for both simulation and visualization of combustion processes [3]. In this architecture we benefit from today's both high capacity and performance hard drives in today's commodity PCs. This allows storing the data for later replaying and processing of the results.

Each state of the fluid simulator corresponds to values computed in selected time step. In general the state consists of arrays of variables (e.g. containing velocities, masses, temperatures and oxygen concentrations). The values in these arrays represent overall characteristics of the cell. When computing values for the next step, the values from current state are being used. New values are computed from previous solved state using internal fluid simulator code. The simulation using our extension is based on only partial computation with synchronous utilization of pre-calculated fluid simulator states stored on disk device. We extend fluid simulator by dividing the simulation progress to storing and replaying phase [2].

In the storing phase we run simulation and store states of the fluid simulator. After storing the pre-computed fluid simulator states, we can replay results in replaying phase. Instead of computing next fluid simulator state, we restore the state from storage device. Values from pre-computed state are then passed to combustion and heat transfer engine, which maintains the rest of simulation, namely combustion and movement of coal particles.

This part is independent on the fluid simulator code. Thus, with support of pre-computed values, only partial and less computationally expensive computations are being performed. After that, user interaction can be handled to react on user input, set or modify various solved task input parameters, boundary conditions, parameters and values. We can also maintain visualization of computed cell values and particle characteristics. At last, time is increased by a selected time step and the computation repeats. We use the stored results in replaying phase. Here, on one hand the interactivity is limited to visualization part only. On the other hand, in certain cases it is fully sufficient e.g. when presenting the simulation results in education [3]. All interactive actions and features such as changing the visualization parameters and visualization of arbitrary characteristics are kept. We can choose simulated area, immediate switch to any visualized characteristics of particles and cells and many more.

Overall, our concept can drastically accelerate the simulation and subsequent visualization speed of wide computer graphics and other applications based on fluid simulators and solvers while keeping the preciseness of computation unchanged. Pre-calculating states of the fluid simulator rather than storing full data sets of simulation results in much less disk space requirements (in orders) that would be needed for storing whole frames either as movie files (with total loose of interactivity) or full data sets. Even simple and not performance optimized applications based on 2D or 3D cell grid fluid simulators (even non-real-time) can benefit from our concept. In other words, pre-calculated fluid simulator states extension can help overcome performance bottleneck of time-consuming fluid simulator codes, namely when using high-resolution computational grids or more precise, complex computation methods.

We are currently working on real-time simulation and visualization system of pulverized coal combustion processes based on stored pre-calculated fluid simulator states organized in tree structure [4]. It allows fast, progressive, interactive simulation and visualization of multiple pre-computed configurations of boiler. We plan testing our system on very large datasets. Implementing existing compression methods for storage of files containing fluid simulator states could decrease both the disk space and traffic requirements.

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Contribution to X-ray Diffraction Evaluation of Elastic Constants for Residual Stress Measurements

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Whereas in the case of mechanical experimental techniques for strain measurements polycrystalline material is assumed to be semi-isotropic, X-ray diffraction measurements of lattice spaces always relate only to specific crystallographic directions of suitably oriented diffracting crystallites. Relationship between the lattice strain and the macroscopic (loaded and residual) stresses is expressed by using X-ray elastic constants $½s_2$ and s_1. These quantities depend on single crystals elastic moduli s_{ik} (resp. on coefficients c_{ik}) of the individual phases, on the composition of the material, lattice plain (hkl), bound of the crystallites and phases[1].

1. PRINCIPLES OF THE X-RAY DIFFRACTION METHOD FOR ELASTIC CONSTANTS' DETERMINATION

Diffraction methods for determination of X-ray elastic constants are based on the measuring of relationship between lattice strain and the applied uniaxial stress. When bend is used for measurement of elastic constants, a beam of X-rays impinges on the convex side of the sample. The impact of the stress gradient on the cross-section of the girder (plate) can be ignored if its thickness is approx. 100 times greater than the effective depth of penetration of X-rays (usually units of μm). When a biaxial state of stress is present the classic X-ray diffraction "$\sin^2\psi$" method is expressed by

$$\varepsilon_{\varphi,\psi} = ½s_2\sigma_\varphi \sin^2\psi + s_1(\sigma_1 + \sigma_2), \qquad ½s_2 = \frac{\nu+1}{E}, \quad s_1 = -\frac{\nu}{E}, \tag{1}$$

where terms E and ν denote Young's modulus of elasticity and Poisson's ratio, respectively.

When the sample's dimensions or shape do not allow applying the classic "$\sin^2\psi$" method with an ω – or ψ – goniometer for determination of X-ray elastic constants, it is possible to use the single-exposure method without reference substance [1], which is a special case of the "$\sin^2\psi$" method.

2. CHARACTERISTICS OF THE SAMPLES AND THE EXPERIMENTAL ARRANGEMENT USED

Elastic constants were determined on two types of material prepared as strips with a rectangular cross-section. A steel sample (α-Fe) had thickness h = 2.49 mm and width b = 9.08 mm, an aluminium alloy sample had dimensions h = 2.04 mm and b = 26.94 mm. A loading device was designed and allowed to carry out the X-ray diffraction measurements.

The angle of incidence of beam of CrKα radiation on the surface of the samples was $\psi_0 = 45^\circ$. The beam was collimated by a cylindrical collimator 1.7 mm in diameter, the distance between the film and the sample was D = 46 mm. Diffraction line {222} with θ = 78.33 º was analysed in the case of Al sample, reflection {211} with θ = 78.04º on the steel sample.

It has to be remarked, that the measured stress component σ_φ is always a sum of the constant residual stress σ_r in the surface layer of the investigated sample and the stress σ_I loaded by bending ($\sigma_\varphi = \sigma_r + \sigma_I$).

3. RESULTS OF PERFORMED MEASUREMENTS

Tab.1 Elastic constants $\frac{1}{2}s_2^{exp} \cdot 10^6$ MPa^{-1} of the investigated materials evaluated from the diffraction measurements and Young's moduli E_{calc}^{exp} calculated from them using tabulated values of Poisson's ratio ν (Al) = 0.33, ν (steel) = 0.30

Sample	{hkl}	$\frac{1}{2}s_2^{exp}$	E_{calc}^{exp}, MPa
Fe	{211}	6,14 ± 0,52	211 726
Al	{222}	18,19 ± 1,44	73 667

Quoted accuracy of $\frac{1}{2}s_2^{exp}$ represents the standard deviation of least squares method estimation of parameters.

Comparison with published data

- Values of X-ray elastic constants $\frac{1}{2}s_2$ recommended [2] for X-ray diffraction stress analysis of Fe based materials and Al-alloys by using CrKα radiation, i.e. on the planes (211) and (222) respectively:

$\frac{1}{2}s_2$ (α-Fe based materials) = $5.76 \cdot 10^6$ MPa^{-1}, $\frac{1}{2}s_2$ (Al-alloys) = $18.56 \cdot 10^6$ MPa^{-1}.

- Values of $\frac{1}{2}s_2$ calculated using the procedure given by Reuss [1]:
  for α-Fe and (211) planes $\frac{1}{2}s_2 = 7.42 \cdot 10^6$ MPa^{-1},
  for Al and (222) planes $\frac{1}{2}s_2 = 17.74 \cdot 10^6$ MPa^{-1}.
- Values of $\frac{1}{2}s_2$ calculated using the procedure given by Voigt [1]:
  for α-Fe (independently of the crystallographic planes) $\frac{1}{2}s_2 = 5.77 \cdot 10^6$ MPa^{-1},
  for Al (independently of the crystallographic planes) $\frac{1}{2}s_2 = 19.20 \cdot 10^6$ MPa^{-1}.
- Values of $\frac{1}{2}s_2$ calculated using the procedure given by Eshelby and Kröner [1]:
  for α-Fe and (211) planes $\frac{1}{2}s_2 = 5.76 \cdot 10^6$ MPa^{-1}, for Al and (222) planes $\frac{1}{2}s_2 = 18.56 \cdot 10^6$ MPa^{-1}.
- Values of Young's modulus E and Poisson's ratio ν recommended for calculations in the case of isotropic polycrystalline materials [3]:
  α-Fe based steels: E = 210 000 MPa, ν = 0.3, Al-alloys: E = 70 000 MPa, ν = 0.33.

4. CONCLUSION

The values of Young's modulus determined by using X-ray diffraction technique and thus respecting elastic anisotropy of crystallites are in a good agreement with published data in the both cases of investigated materials. Nevertheless, results of experimental stress analysis obtained by different experimental methods have a character of relative measurements and only their qualitative comparison is possible.

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Simulations of Fuel-Spray Behavior in Combustion Chamber of Engines

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Environmental impacts of the usage of continuously increasing number of road vehicles have induced the introduction of considerably tightened emission standards. The compliance with the contradictory requirements of improving environmentally friendliness without any loose of efficiency and performance calls for further development of internal combustion engines. The direct in-cylinder fuel injection has become the dominant technology for compression-ignition engines. The fuel efficiency and pollutant formation of these engines are strongly influenced by the fuel-spray evolution and, therefore, there is a great interest in optimizing the fuel-injection process and employing advanced fuel-injection systems. Methods of computational fluid dynamics (CFD) are proven being a useful aid to achieve this aim. Multidimensional mathematical modeling makes it possible to treat adequately the real geometry of the in-cylinder flow with the consideration of spatial and temporal distributions of flow properties. That is why the CFD methods can provide valuable, detailed information on the evolution of injection process.

The fuel injection takes place toward the end of the compression stroke, when the liquid fuel is issued directly into the engine combustion chamber through the nozzle orifice. The fuel carries significant momentum. Thus, it penetrates across the combustion chamber, entrains and accelerates surrounding high-density air environment. Due to aerodynamic drag, the initially continuous liquid stream disintegrates, diverges and atomizes into small droplets. The fuel also experiences heating by surrounding compressed hot air.

As obvious from the foregoing discussion, an analysis that would be able to handle adequately such flows must include a description of two-phase flow (gas-droplets) coupled in the mass, momentum and energy equations. Generally, the mathematical codes used for the description of such flows may be divided into the two basic categories: (1) Eulerian/Lagrangian models describe the gas-field using Eulerian approach, whereas the droplet-phase equations are written in the Langragian form (following a given droplet). (2) Fully Eulerian codes solve the both phases in the same, Eulerian frame of reference, considering the carrier phase (gas) as well as the discrete phase (droplets) as continua.

The mathematical code used in this study uses fully Eulerian approach. Based on the development of Advanced Multizone Eulerian Model [1, 2] at our department, the proposed fuel-spray model follows the same basic methodology. Thus, governing equations for flows of the both phases are derived from the general balance of generic mass specific quantity ϕ. For a cell of a volume V, bounded by a surface δV, it may be written,

$$\frac{d}{dt}\int_V \phi\rho\, dV = -\oint_{\delta V} \phi\rho(\vec{w}_L - \vec{w}_B)\cdot\vec{n}\, d(\delta V) + \oint_{\delta V} \chi\rho\vec{\nabla}\phi\cdot\vec{n}\, d(\delta V) + S_\phi, \qquad (1)$$

where RHS includes the convection term, diffusion term and other sources termed by S_ϕ. To enable the mesh to move with the engine piston, movable cell boundaries are used. Thus, the convective fluxes (first term in RHS of Eq. (1)) are formulated using the relative velocity of

flows (droplets or gas), $\boldsymbol{w}_L$, to that of the cell movable boundary, $\boldsymbol{w}_B$. The main advantage of the approach chosen is the unified formulation of both gas- and droplet-phase models, resulting in modularity and transparency of the numerical code, with the possibility of application of the same numerical methods. The code is, therefore, easily extensible and fully prepared to include a more comprehensive description of the injection process.

The set of governing equations derived on the base of Eq. (1) is solved by means of finite-volume technique. The discretization of the convection term is carried out by using the numerical fluxes evaluated as an average of the cell-centered values on the two sides of the face of neighboring cells. This approximation reduces to central difference scheme on Cartesian grid; therefore, it is of second order of accuracy in space. The three- or four-stage scheme of Runge-Kutta type is used for time integration of the set of equations, see Ref. [3].

Concerning the inter-phase transfer processes in fuel-spray simulations, the advanced CFD methods cannot be employed directly, since is impossible to treat adequately all the details of inter-droplet flow-fields and thus these processes take place on sub-grid scale of multidimensional computations. Therefore, making the use of approximate models is necessary, assuming the spherical symmetry of the transfer processes along the droplets and using average flow properties. Convection effects are allowed for by introducing the correlation laws. Taking into account such assumption, the integral values over the droplet surface for the mass, momentum and energy transfer can be evaluated, see Ref. [4]. These values appear in the multidimensional model as source terms incorporated in governing equations.

Several computations have been performed for the case of fully-coupled two-phase flow in the combustion chamber with movable piston. The axisymetric flow-case is considered with a simple computational domain in the shape of the cylindrical sector. Accordingly, the fuel-spray has a shape of hollow-cone. This simplified geometry does not correspond to that of the real fuel injection using the common multihole injector nozzle. Nevertheless, this simplification has been adopted within the code development in order to retain the computational costs at a manageable level. Thus, the results achieved do not give a fully realistic image of fuel-injection process; nevertheless, they illustrate the qualitative features of non-evaporating hollow-cone sprays.

Although the present model is still in development stage and uses many temporary simplifications, the results presented in conjunction with the experience from code development encourage the authors to consider the approach chosen having the ability to provide a solid base for further research in the field of fuel-spray simulations.

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Ice - Water Slurry Testing on the Experimental Circuit

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An extensive knowledge of the rheological qualities of ice slurries is the prerequisite for the design and optimization of ice slurry plants. These qualities depend on the ice crystals concentration, on the flow velocity and the pipe diameter as well as the type and concentration of the additive to bring down the freezing point. There have been a few publications on the subject of pressure drop and flow characteristics of ice slurries, but there are no known publications on heat transfer to such slurries – the information so much important for designers. It was the primary objective to build up the bellow mentioned experimental circuit which makes it possible to study and validate behavior of ice slurry at defined composition (it means the ice crystals concentration in the mixture – water and additive) and in the specific piping system.

Acquired experimental results can assist to compare our measured data with others e. g. [1] and then develop models which describe properties and behavior of ice slurries flowing and heat transfer. Pressure drops accurate calculations and heat transfer in the heat exchanger enable to optimize ice slurry systems from the viewpoint of investments and operation.

The drive for reduction of CO_2 emissions to the environment in many industrial and commercial sectors has promoted research that focuses on finding alternative cooling technologies. One of these alternative technologies is production and use of ice slurry in conventional cooling processes. Ice slurry is a mixture of ice crystals, water and an additive such as glycol, salt or alcohol to bring down the freezing point. The size of these crystals can vary between 100 μm to the size of several mm in diameter [1, 2]. Ice slurries have very good thermophysical and transport properties. They behave almost like liquids and can be pumped through pipes or stored in tanks. The energy capacity of ice slurries per unit volume is greater than that for chilled water due to phase change of the ice particles. Because of their large energy capacity, for a given cooling load, ice slurries can reduce the required cooling flow rate significantly compared to chilled water flow [3]. Therefore, pipe dimensions, pumping energy, heat exchanger size and operating cost could be substantially reduced. Another advantage of ice slurry systems is that the fluid can be completely safe and harmless to the environment. These advantages make ice slurry system very attractive from both the technical and economic view points [2].

Experimental facility - consists mainly of two independent circuits. The ice slurry formation and ice flow circuit.

The ice formation circuit - is ice slurry generating system. The major component of this system is scraper type ice slurry generator, a development type of generator by company Ziegra Eismaschinen GmbH, Isernhagen, BRD, capacity 100 l/h of ice slurry. The principle of the generator is based on rotating scraper inside the tube heat exchanger and scrapping the ice from its inner surface. The ice formation circuit and the ice flow circuit are hydraulically separated by an open storage tank. Its capacity is 100 l. A stirrer in the storage tank guarantees a homogeneous suspension. The water with additive are lead from the stirred

storage tank into the feeding pump (CALPEDA CT 61) and transported to the ice slurry generator.

Ice flow circuit - was designed and constructed to enable pressure drop measurements of ice slurry in horizontal and vertical pipes and other parts of the ice flow circuit as well as heat transfer measurements of ice slurry in heat exchangers. The ice slurry is drawn from the storage tank to the ice flow circuit by multistage centrifugal pump – electronically controlled (GRUNDFOS CRE 1-11, Qmax = 2.4 m^3/h, Hmax = 66 m, 0,37 kW). The frequency converter is used for setting the flow quantity. The circuit - all piping components are ABS plastics manufactured by Georg Fischer (+GF+, 1“ PN 16) and can be subdivided into two following circuits:

The first circuit is intended for measuring pressure drops of ice slurry in the horizontal and vertical pipes as well as in the plate heat exchanger. The suspension flows through the test loop and comes back to the storage tank. The vertical pipes are transparent to allow visual observation of flow patterns at various flow velocities of the suspension.

The pressure drops in the horizontal and vertical pipes as well as in the plate heat exchanger are measured using five pre-calibrated pressure transducers. The temperatures are indicated using thermocouples placed in the pockets nearby the pressure transducers. All the temperature and pressure sensors are connected to a PC based data acquisition system.

The ice crystals concentration is determined from the density measured with a Coriolis mass flow meter - CORIMASS MFM 3081 F with converter MFC 081 F. Since the mass flow meter generates a relatively large pressure drop, the loop with the mass flow meter is only momentarily active before each measurement. And then there is a control volumetric flow meter.

The second circuit is a closed loop with these components: a circular pump (PEDROLLO CP 120, Qmax = 4.2 m^3/h, Hmax = 18 m, 0,30 kW) controlled with frequency converter, an electrical heater (PZP/ A, 2 x 6 kW) and an expansion reservoir.

Both **the first** and **the second circuit** are pieced together with a standard plate heat exchanger manufactured by Tenez Chotěboř, a.s., type ST 03 24 1/1 VNZ01K. The heat exchanger has 24 plates, 11 channels and d_h = 4mm. The cooling capacity and heat losses are measured using the hot water circulated through the plate heat exchanger which has to melt all ice in the suspension on the other side.

Conclusion

Experimental circuit has been designed and built up to acquirement and confirmation experimental data at flowing of the ice slurry in the piping system – it means characteristics of the ice slurry pressure drops with flow rate for concentrations from 0% to 30% ice and whether selected components (pumps, heat exchanger …) are suitable for the system with ice slurry. These experimental results enable thermodynamically and economically optimize the ice slurry piping system and it will be provided to designers including our operation experience.

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Diagnostics of Refrigerant Compressor Valves

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Reciprocating compressors are used now in a vast range of application fields and sizes. They are manufactured for refrigeration in huge batches, and even a slight improvement yields important power savings favourably affecting the overall primary energy demand. Reciprocating compressors still find use in many industries, though many other positive displacement compressor types exist. They work reliably at heavy duty operation background and represent a widely used and preferred type of positive displacement machines above all in refrigeration technology owing to their simple and highly advanced design allowing building these machines in a wide capacity range.

The valves are critical elements of reciprocating compressors, connecting and separating the cylinder working chamber from the suction and discharge lines. Owing to their simplicity, so-called automatic valves are mostly used, i.e. valves whose closing member stroke is actuated by gas pressure. Owing to the hydraulic drag in the valve a part of compressed gas energy gets lost. Such loss can attain up to 35 % of power input on the compressor shaft. It shows the importance of a correct design and selection of reciprocating compressor valves.

The present paper deals with the problems of measuring methods and analyzing the characteristics of refrigerant compressor discharge valves. Basing on experimentally obtained data, their analysis has been performed. The results suggest that a complicated relationship exists between the valve plate stroke and the pressure pulses in the compressor discharge space, i.e. in the head space and in the adjacent discharge pipeline.

With the aim of efficiently solving the indication of the discharge valve activity, an experimental so-called reduced circuit was built in our laboratory. It is a modification of a conventional single-stage refrigerating circuit used in refrigeration. A conventional circuit contains a compressor, a condenser, a throttle element and an evaporator. The demand of refrigeration being practically zero in compressor operation testing, the evaporator can be eliminated from the circuit, the condenser becoming a vapour cooler and thus a reduced circuit is obtained. Such test rig can however be used in the field of superheated vapour only (R134a refrigerant has been used in this case).

When designing the experimental circuit a possibility of a flexible variation of pressure and temperature in the compressor suction and discharge with a relatively quick stabilization of the selected operational rating at various compressor speeds was above all envisaged. Other aims also were a low power demand of the experimental circuit in laboratory conditions including a smallest possible exchanged or compensated off-heat and, last but not least, also a low consumption of used structural materials and of overall floor area.

Used in the experimental circuit was a twin-cylinder single-stage refrigerant open-type uniflow compressor ThermoKing, model X214, with *2250 r.p.m.*, driven by a dynamometer with a V-belt transmission. The dynamometer provided for a continuous compressor speed variation in the range of *700* through *2500 r.p.m.*

The compressor discharge valve characteristic is expressed by the valve plate stroke pattern function, i.e. graph $y=f(\alpha)$ (plate stroke – compressor shaft revolution angle) or graph $y=f(t)$ (plate stroke – time).

For the valve plate stroke monitoring a pickup of our own design has been used, connected to the Micro-Epsilon measuring module, based on eddy currents. The pickup proper has been designed for heavy-duty operation conditions prevailing in the running compressor, above all a high pressure (up to *10 bar(a)* and high temperatures (up to *120°c)*. The pickup indicates the stroke of the valve plate connected with an aluminium disc having a diameter of *10 mm*.

A synchronized measurement of the valve plate stroke and of the pressure pulses in the discharge space enables us to perform a complex analysis of the interaction between the discharge valve plate and the gas pressure pulses and/or sonic waves. For this purpose a four-channel semiconductor pressure gauge, incorporating in the present case only two pressure pickups modified from the TM610/01 semiconductor pressure pickup has been designed and built in a close cooperation with the Academy of Science of the Czech Republic. The pickups are installed in the compressor head approximately at the centre axes of both cylinders.

The signals of the valve plate stroke pickup and of the pressure pickups are analyzed by means of a measuring PC card type PCA-1248 and/or by means of a memory oscilloscope, while the measuring could be started from the upper dead centre of the tested compressor cylinder using an incremental counter rigidly connected with the compressor crankshaft.

The measurements performed in the compressor rotational speed range of *700 …2500 r.p.m.* proved a considerable fluttering of the discharge valve plate during the discharge stroke. The frequency of detected oscillations was found to be in the range of e.g. *100Hz* up to *1 kHz* for the compressor rotational speed of *1200 r.p.m*. Fluttering of a valve plate during compressor operation is undesirable, but it happens frequently just in the case of refrigerant compressors. Flutter of a valve plate results in an increased pressure loss in the valve and in a considerable reduction of its life. For the discharge valve also bouncing of a valve plate at the discharge stroke end should be mentioned. It also results in high frequency flutter. Such oscillations are transmitted on to the compressor discharge space and to the discharge line, in which such pulses should be eliminated mainly by installing a pulse absorber, resulting, however, in an additional space demand.

The compressor valve diagnostics can be utilized at present above all in the construction and computation of mathematical models of the valve plate movements. They yield important background for the design of basic parameters of a valve. This method finds its practical application above all in the field of refrigeration technology in connexion with the task of replacing existing refrigerants with environmentally harmless and safe fluids.

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Thermal energy storage

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The idea of thermal energy storage has obtained great importance in connection with rising of the pressure on the utilization of alternative sources of energy, responsive to global increased energy-ecological crisis (petroleum crisis in 1973 and 1979, increase of CO_2 emission, Kyoto Protocol). This fact is not express only in the technical base, when a storage tank is necessary for correct operation of the appliance, but to a great extend also in the economical bases, when it is determinative factor of economical operation.

Explicit demand of heat storage is by the solar systems, where it is needed equalize irregularity that is emergent drifting of the intensity of solar radiation during the day of longer range. The same problems are necessary to solve also by the utilization of waste heat, because there are not in balance their sources and demands in general. The next area making use of heat storage is represented by heat pumps, for which we can acquire an original art of regulation as well as reducing of the purchase costs. We can also mention cooling systems as another area where it is efficient to solve the problem of storage of thermal energy.

Above mentioned follows that earnest research on the field of thermal heat storage potential is today unchangeable part of the global energy policy. R&D are currently directed to the methods allowed achievement of high density of stored energy and thereby decrease of the tank volume and solutions allow long term accumulation without heat loss.

These conditions are fulfil by utilization of adsorption. The adsorption process is well suited for high-density heat storage applications (as many as 1400kJ/kg 800MJ/m^3, for equal water tanks 84kJ/kg, 84MJ/m^3). Heat storage with the adsorption process works as a thermally driven heat pumping cycle interrupted by the storage time.

The adsorption of vapor on the surface of highly porous solid is well known process widely used in chemical industry for gas separation and filtering. A recent experience with application of the adsorption process getting great importance can be found in the field of heat transformation cycles such as for refrigeration, heat pumping and heat storage. Heat transformation processes require different characteristics for involved adsorbents. There are important not only the thermodynamic properties of the involved materials but also the operating conditions of the application nowadays. These operating conditions include parameters such as the available maximum desorption temperature and the temperature level of the heat source during adsorption.

The adsorption process is a reversible physico-chemical reaction, which endo-exothermical disposition is possible to utilize for storage of thermal energy. By the regeneration of adsorption filling is needed to add thermal energy for releasing of water molecular bonding on the filling, for heating up (sensible heat) and for covering of heat lost from the shell to the system environment. Broad delay between the end of reaction and the beginning of reversible reaction can cause loss of the sensible heat. (Amount of this loss is in the range of 10% of the stored energy).

There are only 2 ways in which the heat of adsorption can be dissipated: by heating up the adsorbent (and the vessel containing it) or by heating up the fluid exiting from the vessel.

When the concentration of adsorbent in the feed is low, say only a few wt% or less, then a large fraction of the heat of adsorption passes out with the effluent stream, and the adsorbent remains close to the temperature of the incoming fluid. When the concentration of the adsorbent is high, say 10% wt or more, a large fraction of heat will be trapped in the bed and cause large temperature increase with time.
Example of such adsorbent are e.g. Molecular sieves - natural (klinoptilolit) or synthetical Zeolites (5A, X13, Baylith), activated carbon and silicagel.

The amount of adsorbed mass is given according to Dubinin's theory

$$a = \frac{W_o}{V_T} \exp\left[- B\left(\frac{T}{\beta}\right)^n \left(\log \frac{p_s}{p} \right)^n \right]$$

In mentioned equation is a adsorbed amount of mass [mmol.g-1adsorbentu], W_o max adsorbing space [$cm^3.g^{-1}$of adsorbent], V_T molar volume of adsorbed mass [$cm^3.mol^{-1}$] by temperature T [K]. B is a constant incident the adsorbent [K^{-n}], β is dimensionless affinity coefficient, p_s pressure of saturated vapor [Pa], p break-even pressure [Pa] and n is Dubinin dimensionless exponent.

The first phase of this process proceeds up to the point when the zeolite is saturated with water. The reverse process is initiated by heating the zeolite at high temperatures in the second phase. The adsorbed water molecules are forced to evaporate (desorption). Condensation takes place in the water tank (condenser). The sequence of adsorption/desorption processes is completely reversible and can be repeated indefinitely.

At the Division of Compressors, Refrigeration and Hydraulic Machines U207 at Faculty of Mechanical Engineering of CTU has been designed and built up an universal unit to acquire and to confirm experimental data. Thus that is useful comparison of theoretical models of various types of adsorbents and especially acquisition further conception of the process dynamics. These experimental results enable thermodynamically and economically optimize the storage systems based on adsorption of water vapor on porous materials.

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Problem of Stiffness Maximization of Laminate

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Let us consider a problem to maximize a stiffness measure of some construction by manipulating with material mechanics properties (i. e. choosing and changing a stiffness tensor). We search the stiffness tensor from a set of accessible stiffness tensors that maximize a stiffness measure.

There is a first question at this place. What is the stiffness measure? It is great philosophy issue, which is beyond the scope of this study, and therefore we select the following one: Let a stiffness measure is a inversion of potencial energy of external loads, i.e., the sum of product of mass forces and displacements and surface forces acting on boundary and displacements.

It is necessary to use principle of minimum potential energy that states: Among all the admissible displacements which satisfy the prescibed geometrical boundary conditions, the actual displacements minimize the total potential energy.

From the theory of variational methods it is known that in a equilibrium state the minimum of the total potential energy is equal to a negative half of potencial energy of external loads.

Thence, for stiffness tensor that both maximize stiffness measure and minimize compliance measure we may solve the problem of simultaneous maximization of the total potential energy over stiffness tensors from set of acceptable stiffness tensors and their minimization over displacements which satisfy the prescibed geometrical boundary conditions.

In the case of linear elastic material it is posible to write the last problem by using a complementary energy as their simultaneous minimization over stress tensors from the set of all statically admissible stresses and over compliance tensors from where the set of all admissible compliance tensors.

Constitutive law of thin laminate ply in a main material coordinate system of orthotropic ply is in two-dimensinal tensor notation given by relation that introduces a stress tensor as the dotproduct of a strain tensor in the main material coordinate system of orthotropic ply and a stiffness tensor in the same main material coordinate system.

By transforming these expression of stress and strain tensors from main material coordinate system of orthotropic ply into global coordinate system of laminate plate we state the stress tensor of the ply in the global coordinate system as function of strain tensor of the ply in the global coordinate system. Transformation matrix has the well-known form.

Using the equations the searched relation between stress tensor of the ply in the global coordinate system and strain tensor of the ply in the global coordinate system takes the form of constitutive law of thin laminate ply.

In the case of optimization of laminate tube winding angle it is appropriate to use several coordinate systems. There are Carthesian coordinate system of the tube, cylindrical coordinate system of the tube, global coordinate system of the unrolled tube, and main material coordinate system of the orthotropic ply.

It is requisited to put transformation of two-dimensional stress tensor and strain tensor from the main material coordinate system into global coordinate system of the unrolled tube.

For a thin tube (tube made from one orthotropic ply) it is necessary to accept several premises. There are the following:

1. Tube is made from one orthotropic ply.
2. Hooke's law of that ply in the main material coordinate system takes the form above described.
3. We do not consider buckling.
4. Ply thickness is negligible with respect to radius of tube: cylindrical coordinate system of the tube coincide with global coordinate system of the unrolled tube.

At the case of searching of winding angle that maximize stiffness of one-layer laminate tube under torsion the set of all admissible stress tensors is one-component. Thus the only possible stress tensor is known. Stationary point fulfils polynomial condition for square of cosine of searched winding angle. However, extreme might also appear on the boundery of considered domain and thus we have three candidates for minimum. Values of objective function at these points say that the minimum of investigated function is in the case 45 or -45 degrees.

In the searching of winding angles that maximize stiffness of multilayer laminate tube under torsion we consider laminate tube made from N plies with premises above introduced. Also here we solve the described problem with set of all statically admissible stresses that has more than one point. Adopting some arrangements our problem takes form suitable for using the Lagrange theorem. Alike the one-ply case, we come up with the solution 45 or -45 degrees for all plies.

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Study of the Cooling System with Fluoroinert Refrigerants

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The goal of our project was an elaborate study of a lubricant-free cooling circuit working with a fluoroinert refrigerant. The cooling power of the studied circuit was set to be around 5 kW and the temperature in the evaporator around -20°C. A capillary behavior study was included into the project as well.

The Department of Applied Physics has been participating in design of cooling systems and consecutive measurements on prototypes of Pixel and SCT detectors at the international nuclear research center CERN (Geneva) for several past years. Main interest of current work is the design of cooling system for the Inner Detector of the ATLAS experiment. The fluoroinert refrigerants, having the chemical structure CnF (2n+2), were considered according to specific needs of the cooling system. These refrigerants are non-conductive, have low viscosity and low impact on an environment.

Prior to design of the cooling circuit, it was necessary to collect basic thermo-physical data of refrigerants. Our study has concentrated on the C_3F_8 (octofluoro-propane) and C_4F_{10} (perfluoro-butane). Manufacturers, suppliers and scientific conference's web pages were essential sources of information about the refrigerants. Using the Benedict-Webb-Rubin equation (MBWR) that contains 34 constants the log p-h and log p-T diagrams were prepared. Respecting all analyses one can conclude that the final design of ATLAS cooling system will use the C_3F_8 the most likely.

Our study of the cooling circuit proposal assumes the use of non-lubricated compressor, sub-cooling of refrigerant in inter-heat exchanger and ideal phase changes were considered. The circuit consists of following main parts: non-lubricated (~ dry) compressor, condenser, sub-cooler, pressure reduction element (capillary) and evaporator, all of them connected with the appropriate pipelines. The refrigerant undergoes following phase changes: isentropic compression in the compressor, isobaric condensation in the condenser, isobaric sub-cooling in the recuperative heat exchanger, adiabatic throttling in the capillary, isobaric evaporation in the evaporator and isobaric super-heating in recuperative exchanger. The projected mass flow through the circuit should be around 65 g/s.

A computational algorithm was made for all main components of the cooling circuit by use of MS-Excel. The input data can be simply changed to obtain optimal condenser, evaporator and recuperative exchanger parameters.

We have been also involved in pilot type measurements on the test prototype of the cooling system installed at CERN. The main goal of our work was to design and test the various prototypes of the recuperative exchanger in which the refrigerant superheated vapor, leaving the evaporator, cools down the inlet liquid arriving from the condenser. Two main designs were studied. In the first case, the heat exchanger consisted of two capillaries (containing inlet liquid) coiled around the support tube (filled with outlet vapor). In the second case, there were three capillaries coiled inside of the support tube.

As a supplementary part of the project, an experimental set-up for the measurement of capillary characteristics has been installed in the Prague laboratory. Data obtained from experiments on this set-up should provide better understanding of pressure-drop through a capillary as a function of its length and inner diameter. This knowledge is essential for the optimal design of cooling circuit that uses the capillary as the only pressure reduction element.

The set-up consists of a DARI air compressor providing a maximum of 9 bars absolute, a pressure tank manufactured at the faculty workshop, capillary to be tested, scale for measurement of refrigerant mass flow, and connecting tubes with operating valves. Two temperature sensors Pt100 and one differential pressure sensor DMD 331 were installed to monitor changes of running parameters along the capillary. All sensors were connected to a mobile DAQ system MIC 2000 using Advantec cards and Eflab software.

The set-up can be operated at normal room conditions (temperature, pressure) and with convenient testing medium (C_8F_{18}…or even with water). A similar test stand will be also installed at CERN for checking the reference capillaries that will be later delivered to the Inner detector assembly sites.

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Wind Tunnel for Airfoils

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Airfoils create one of the major parts in airplane design, affect significantly performance and handling qualities of both wing and control surfaces. Experimental data from suitable low-turbulence wind tunnel are of vital importance.
Presented work follows two main objectives – laminar separation in 2D flows as an up-to-date problem of fluid dynamics and its importance in sailplane airfoils design as practical implementation.

Aerodynamics of sailplanes rules their performance – extremely high lift-to-drag ratios are expected. Development of appropriate airfoils passed through three important steps. Laminar airfoils of 6-series NACA were developed in 1940's. Loading is prescribed with suitable pressure gradient for laminar flow up to 30, 40, 50 and 60% chord respectively. An unusual extent of wind tunnel testing was performed in Two Dimensional Low Turbulence Pressure Wind Tunnel (TDT) in Langley. New impulses arose from successful computer application in 1960's; Wortmann and Eppler wing sections were developed and tested in Laminarwindkanal (LWK) in Stuttgart. Last revolution came in 1980's with boundary-layer control by means of pneumatic and zig-zag type turbulators – those devices reduce detrimental effect of laminar separation bubble which proceeds during laminar to turbulent transition.
Thanks to information search, our project benefits from these results.
Aileron effectiveness during take-off is in high charge due to its safety reasons. Several sailplanes (especially high-performance) suffer from poor control while ground roll. Since reliable data are not available, described application and flow conditions create one of our research aims in new wind tunnel. Separation of the boundary layer under the high aileron/flap deflection is under suspicion.
Detailed study of the topic extended to higher Re numbers, establishing the criterions together with numerical simulation and optimization lead to airfoil design. A few works has been carried out in Czech Republic, but all sailplanes in series production still use foreign wing sections.

The main wind tunnel of the department U207.1 with cross-section 750 x 550 mm is not suitable for intended aims mainly due to its closed-circuit flow generated turbulence, hence a new one was designed using corporate 32 kW fan for both of them.
New wind tunnel of 1200 x 400 mm cross-section is an open-circuit type, with closed test section, designed for 2D tests of models which span the shorter dimension. Chord used is 400 mm, test Reynolds number up to 300 000. Multiple segment concept expands its capabilities – measurement of blade cascades is enabled as well as development of atmospheric boundary layer for modeling of pollution and environmental studies.
Measurement procedure is adequate to TDT and LWK practice – lift can be evaluated from pressure distribution over model surface as well as from its projection to the tunnel wall. Drag is calculated by means of momentum balance in wake behind airfoil. Required velocities are measured by Particle Image Velocimetry, which is a laser supported optical method. Our team

proved higher accuracy than with the standard pressure rake. Use of large transparent panels facilitates usage of the method and required calibration.
Behavior of laminar separation bubble under various inlet condition of the flow is a topical problem – duct of the wind tunnel is prepared for the installation of turbulence generator grids to fulfill ERCOFTAC C3A+ test case.
Design features of the wind tunnel and research aims were presented [1]. Methodology of measurement with respect to the PIV method was developed [2]. Basis for airfoil design and optimization has been established [3]. Possibilities for further development are already prepared [4] which contain new inlet section and wall boundary layer suction for further improvement the quality of air stream.

The new wind tunnel opens further field of aerodynamic research in the laboratory of the department U207.1 aiming at sailplane aerodynamics, airfoil research with respect to laminar separation bubbles and also at blade cascades and environmental studies in atmospheric boundary layer.

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Analysis of the Hole Drilling Method Principle Used for the Residual Stress Identification

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During the validation and development of conventional procedures for the residual stress identification new identification method and its theoretical background has been derived. This method offers new approach to the interpretation of the measurements obtained by the hole drilling method. According to the mathematical background, the method has been denoted as "the signal differentiation method". The new method is based on confrontation of the measured signal from the strain gauges to the function derived from the numerical simulation of the hole drilling process. Such function is unique for given material and diameter of the hole and therefore could be tabulated.

Several scientific teams in Czech Republic work on validation and developing of other techniques for the residual stress estimation. In our team we have postulated an original method for the stress gauge data processing. This method was compared to numerical simulations and the result is a good agreement. However several aspects of the method should be improved in the future. Description of our method is written above:

We assume isotropic elastic material. Principal stress perpendicular to the surface is assumed to be equal to zero in small depth under the surface (free boundary condition).

In surrounding of the point of interest a strain is measured using standard strain gauge rosette typical for hole drilling method. For numerical modelling 3D cantiliver models with a special rosette model by link elements was used. Computations was done using program Abaqus (Abaqus Inc.). Combined numerical model is used for simulation of hole drilling process in successive steps.

Hypothesis: We assume that the local changes in strain due to introduction of the hole are one-valued function of the original stress state. Strain ε_i in the depth of x unequivocally contributes to the signal from strain gauge εp_i applied on the surface.

We assume the validity of the superposition principle for small displacements. Mathematical modelling is performed by the finite element method and we are interested in the relationship between the stress under the free surface and strain measured by strain gauges. Behaviour of two strain gauges $\boldsymbol{\varepsilon p_1}$ and $\boldsymbol{\varepsilon p_2}$ from the rosette applied on the loated beam in bending (maximal bending normal stress $\boldsymbol{\sigma_0}$ *=126MPa*). These data, which are simulation of the measurement, were fitted by the sixth order polynomial curves.

Strain gauges signal function depends on the depth of the hole $\boldsymbol{x}$ and on the stress tensor (two principle stresses and their angle) in the depth $\boldsymbol{x}$. They represent four independent variables, except material constants. Differentiation of the signal function $\boldsymbol{\varepsilon p_i}$ serves to filter the history of the strain gauges signal.

$$d\varepsilon p_i(x) = \frac{d(\varepsilon p_i(x))}{dx}.$$

According to the above mentioned hypothesis the function $\boldsymbol{d\varepsilon p_i}$ depends linearly on the strain $\boldsymbol{\varepsilon_i(x)}$. To exclude such influence unit derivative is introduced which is function of the depth of the hole x only (for given material constants).

$$jd\varepsilon p_i(x) = \frac{d\varepsilon p_i(x)}{\varepsilon_i(x)}$$

The unit derivative of the strain signal function $jd\varepsilon p_i(x)$ should be defined for given type of the hole and material by a function which is independent on the particular strain gauge. Three strains parallel to the surface are adequate for the determination of the stress state in the depth x (in the axis of the hole). Shapes of the unit derivatives obtained from numerical analysis confirm mentioned hypothesis. Deviations are small if the depth of the hole is below 1 mm. Therefore we could proceed with residual stress evaluation after this principle.

First step in the data processing comprise of measured data fitting by a regression function for each strain gauge εp_i. Then the regression function is differentiated with respect to the depth of drilling hole x. Because the unit derivative function $jd\varepsilon p_i(x)$ is identical for all holes of given depth and material could be tabulated. From this equation strain in depth x and in the direction of i-th strain gauge can be easily determined:

$$\varepsilon_i(x) = \frac{d\varepsilon p_i(x)}{jd\varepsilon p(x)}$$

If the three relative strains in the depth x are known, principal residual stresses can be obtained after simple formulas – on the Mohr's circle principle.

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Upgrade of Drilling Hole Method for Residual Stress Identification

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The tested beams were modelled using the finite element method. On these cantiliver models load by tension and bending was simulated. Than the hole-drilling method was simulated and the results of the measurements from strain gauges were modelled. The strain radially to the modelled hole was taken to be proportional to the strain gauge signal. The more accurate results would probably give numerical model of the strain gauges rossete mounted on the surface of the specimen. Since the work is intended to test the principle of the hole-drilling method, simple strain evaluation was taken to be satisfactory. The load of the specimen by uniaxial tension was chosen to verify the hole-drilling method. Uniaxial load simplifies equation (terms for the plane stress state σ_x ,σ_y could be derived from the original Kirsch's solution using the principle of the superposition for the linear elastic isotropic material, where α is the angle between the direction of the principle stress σ_x and considered direction of the radial strain $\varepsilon_{(\alpha)}$, diameters and material are described by the constants A,B).

$$\varepsilon_{(\alpha)} = A*(\sigma_x + \sigma_y) + B*(\sigma_x - \sigma_y)*\cos(2*\alpha). \qquad (1)$$

Since the second principal stress is equal to zero. Than the strain can be computed as follows:

$$\varepsilon_{(\alpha)} = A*\sigma_x + B*\sigma_x*\cos(2*\alpha) \qquad (2)$$

Constants A and B can easily be determined from two independent signals of strain gauges for a given depth of the hole since the principal stress σ_x a location of the strain gauges α is iven. For example, for the angle $\alpha=45°$ the constant A is $A= \varepsilon_{(45°)}/ \sigma_x$ and the constant B can be determined: $B= (\varepsilon_{(\alpha)}/ \sigma_x - A)/\cos(2*\alpha)$.. For other value of the angle α gives linear equation (2) similar solution for the constants A and B.

For different combinations constant B is different although according to the theory it should be the same. It suggests a imperfection of the theory in comparison to the numerical simulations of the hole-drilling process. Constants A and B in the Eq. (2) could not be adjusted properly for a given strain around the drilling hole. Therefore, we suggest to search for a new function which can describe stress distribution around the hole more properly. Discrepancies between numerical simulations of signals and the results given by the theory is notable. Such discrepancies can yield to malfunction in interpreting of measured signals. In conclusion could be stated that it follows from our calculations and measurements that the function given by the theory (Eq. 2) is not accurate enough to exactly describe shape of the signal function for a given depth of the hole.

It follows from the previous results that the current theories of the hole-drilling method are not accurate enough since the function describing stress distribution (Eq. 2) is too simple to describe complex stress state. Therefore we want to suggest new regression function for the signal functions obtained from measurements and numerical simulations. Signal functions of the strain gauges for partial tensile stress depends on the angle α periodically and are similar for different depth of the hole. For the basis of the regression function Fourier series function for computed function of the radial strain in the neighborghood of the hole

with a depth equal to 2.4 mm was taken. Optimal regression function probably not include all frequencies of the Fourier spectrum. Maybe a simple function with decreased number of constant can be suitable. The complexity of the function is not a problem during computer evaluation of the data.

Values of the strain $\varepsilon(\alpha)$ obtained from the numerical simulation of the hole drilling method were normalized by dividing them by load stress 126 MPa. These values were fitted using goniometrical polynomial function which consists of odd multiple of the angle α:

$$\varepsilon_b(\alpha) = K0+K2*\cos(2*\alpha)+K4*\cos(4*\alpha)+K6*\cos(6*\alpha)+K8*\cos(8*\alpha)+K10*\cos(10\alpha)$$

Values of the principal stresses σ_x, σ_y and its position with respect to the given strain gauge (angle α) is obtained after solving a system of three nonlinear equation. In these equation measured signals from strain gauges for a given depth of the hole ε_i, ε_j, ε_k are involved as a result of superposition of the principal stresses:

$$i \to \varepsilon_i = \sigma_x * \varepsilon_B(\alpha) + \sigma_y * \varepsilon_B(\alpha)$$
$$j \to \varepsilon_j = \sigma_x * \varepsilon_B(\alpha) + \sigma_y * \varepsilon_B(\alpha)$$
$$k \to \varepsilon_k = \sigma_x * \varepsilon_B(\alpha) + \sigma_y * \varepsilon_B(\alpha)$$

The model was tested by taking numerically obtained signals from the strain gauges for a depth of the hole *0.2 mm* and unit load $\sigma_x=1$ MPa and $\sigma_y=0$ *MPa*. Accuracy of the solution was better for angle $\alpha=0$ (error was lower than 1%) and the error in prinicpal stresses was about 6%.

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Application of Numerical Simulation for Solving of Stability Problems

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Buckling and post-buckling mean the serious problem in various mechanical engineering branches, i.e. aircraft design. Analytical computations based on verified simplifying assumptions correlated with experimentally determined limit loads is still the basic approach to thin-walled load-carrying parts of machines design. Shape complexity, statically indeterminateness and missing experimental data introduce heavy difficulties into previously mentioned approach. Finite element method (FEM) is powerful tool resolving both shape complexity and statically indeterminateness of structures. On the other hand, FE solution of buckling and post-buckling is not so simple as usually described in user manuals of FE programs. Effective usage of FE buckling and post-buckling (namely thin-walled bodies) analysis requires insight into theory of structural stability, as well as into large deformations and complex constitutive laws.

Basic inputs into estimating critical values of forces or critic stresses are material and geometric values. Geometric imperfections of the latter ones are sources of differences between results received by classic Euler´s approach as well as by numeric simulation in comparison the results of experiment done with physical models.

We have verified FE approach in comparison with experimental and analytical ones using axially compressed thin-walled cylindrical shell in form of beer cans. These cans were used as experimental specimens, unfortunately not drunk up by experimentators, but provided by known Czech beer producer-Staropramen. Can bottoms were cut off and the aluminum alloy cylindrical shell (length: $L = 85$ mm; diameter: $D = 65.6$ mm; average wall-thickness: $t = 0.11$ mm; cross-section: $A = 22.67$ mm^2) was fastened using special mounting devices into testing machine (Eckert FPZ - 100, 1 - 10 kN). Eight such specimens were loaded significantly over stability limit. Inelastic deformation after unloading in form of six short axial waves approximately in the middle of specimen length were the typical state after experiment. Axial force versus axial shell compression dependency (loading curve) was recorded and plotted. Shape of loading curves having first part with both force and compression increasing, in second one, compression still grows, while the force decreases, is typical, for stability loss. Extreme of this curve represents experimentally determined critical force F_{CR}^{EXP}, while experimentally determined critical stress is expressed as

$$\sigma_{CR}^{EXP} = \frac{F_{CR}^{EXP}}{A} \quad .$$

Analytical computation of critical stress is based on [1]

$$\sigma_{CR}^{A} = K_T E \frac{2t}{D},$$

Where E is elastic module and coefficient $K_T = 0.605$ accordingly to the theory of Euler's buckling. Value $K_T = 0.176$ is recommended accordingly to experiences.

Finite element quasi-static (assuming inertial loads being negligible) computations used shell model of specimen, mounting devices and testing machine were modeled as rigid. First so-called buckling (based on Euler's approach) analysis resulted into almost the same as analytical computations with theoretical coefficient K_T. It documents the fact that geometrical imperfections are of non-negligible importance in thin-walled parts buckling (including imperfections this phenomena is not stability loss, but process of gradual stiffness decrease due to the shape change, called load-carrying capacity loss). Geometrical imperfections of the specimen were estimated and introduced into the model [2]. Both force and displacement driven loading were tested. Force driven loading was found unusable due to the computational resources and time demands. Displacement driven loading combined with small amount of artificial damping is suitable tool to determine limit load-carrying capacity force using computed load curve. Comparison of experimentally, analytically and FE determined limit stresses is provided in following table.

Methodology	Experiment	Analytical $K_T = 0.605$	FE buckling	Analytical $K_T = 0.176$	FE displ. driven
Critical stress [Mpa]	$37 \pm 19\%$	169	168	49	58

For future period it is necessary to implement imperfections of diameter and thickness of the shell in form of statistically processed values.

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Passenger's Seat of Small Transport Airplane During Emergency Landing According to FAR 23

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Small transport airplane passenger's seat computational analysis during emergency landing, is a part of project searching new design methodology to meet conditions of the FAR 23 rule. The project is supported by grant of Ministry of Industry and Trade of Czech Republic, holder of which is Aeronautical Research and Test Institute, plc. (VZLÚ). FME CTU is responsible for numerical computations described in this paper.

Not only strength proof, but also the assurance of passenger's safety during unusual operational conditions is required by FAR 23. Passenger's seat complying with FAR 23 rule becomes energy absorber in case of emergency landing. Significant part of passenger's kinetic energy must be dissipated due to non-recoverable deformation of the seat rather than due to passenger's body damage. FAR 23 defines emergency-landing influence on to passenger and seat as deceleration pulse. Two cases – vertical and angle impact – are taken into account. Passenger's safety is assured by two conditions: Tension in rescue belts as well as compression in passenger's spine must not exceed prescribed (safe) values.

FAR 23 requires experimental proof of the prescribed conditions compliance using impact test of seat with crash test dummy. Classical design approaches based only on the strength or stiffness of construction are, in case of FAR 23, insufficient. Designer needs the feedback with passenger-seat assembly response onto emergency landing impact. However, usage of experimental tests in design process is too expensive. Computational model simulating emergency landing dynamically, evaluating forces prescribed in the rule with appropriate precision, and enabling flexible introduction of design changes, is suitable alternative with experiments. We have developed such model using finite element approach, based on conceptual design study of VZLÚ.

Seat consists of back-rest, the frame of which is riveted of steel and duralumin blanks; seat itself- right and left sides connected by tube beams and duralumin seat blank suspended in special sleeves; legs interconnected by fittings are mounted in beams traversing airplane fuselage. In case of horizontal deceleration the rescue belts absorb part of kinetic energy of passengers body. Damping of impact vertical component provides specialized attachment of seat blank. Locating grooves are milled on opposite sides of seat blank. Cylindrical pins coming through the holes in groves, are riveted with lower and upper sheet of the sleeve. During vertical impact the passenger's body causes tension in seat blank making for cylinder cutting through locating groves. This process dissipates impact energy.

Modeling and computations utilize software ABAQUS (Abaqus, Inc., earlier HKS). Concept of two-level modeling was used to include seat blank attachment dumping effect. Response of

seat blank attachment was evaluated itself, using seat blank strip with single locating grove specimens. These specimens were FE modeled as 3D bodies assembly. Experimental results were used to identify material parameters for FE calculations, including elasticity, plasticity, and failure criteria. Presented second-level submodel is prepared not only to identify material parameters, but for looking for appropriate dimensions (depth of groves, pins and rivets diameter) to assure required dumping properties, too.

First-level model including both seat and crash test dummy is designed as multibody system. Single parts are linked by appropriate coupling conditions. Legs are modeled as 1D beams; sides utilizing 3D elements, as well as interconnecting members, i.e. fittings and back-rest bearing are modeled as rigid bodies with mass. Rescue belts are modeled as 1D continuum (without bending stiffness). Remaining parts are modeled as shells using special coupling condition called "spot-weld" to model riveted joints. All shell parts utilize offsets and double sided contacts. Seat blank attachment is, in global model, simulated by translator type "connector" elements with "frictional like" constitutive law providing simplified description of pin cutting through locating groves. Constitutive parameters are calibrated to conserve dissipated energy. Force-relative cut dependence correspondence is only approximation of experimentally evaluated one.

As FAR 23 does not require detailed description of impact effect onto passenger's inner organs, concept outlined from HYBRID II dummy was chosen as appropriate compromise between precision and computational efficiency. Dummy is modeled as rigid bodies assembly, fully described by single bodies geometry and mass properties and kinematical couplings between them realized as connector elements. Stiffness, damping and motion limits are defined in any degree of freedom of these connections.

Both models was solved using explicit integration scheme appropriate to strongly dynamic cases. The results may be found namely in [3].

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Measurement of Two-Phase Flow using PIV Technique

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Motivation

The objective of this contribution is to introduce a reader a novel measurement technique for velocity, diameter and position of transparent spherical bubbles or droplets. This measurement technique is called Interferometric Particle Imaging, abbreviated "IPI". IPI is technique based on properties of scattered light. Compare results of measurements diphase flow using IPI method and using standard PIV technique with new software module added.

Two phase software in PIV algorithms

Using standard PIV measurements technique is impossible to measure two-phase flow, however if in the flow field are big differences in diameter of both phases, measurement velocity field of this phases is possible. Software FlowManager from Dantec Dynamics which we us for measurement by PIV and post-processing does not contain module for measurement two-phase flow therefore we pre-set new software module susceptible measurement two-phase flow. This software module is implemented in standard software FlowManager in category link to Matlab like "Separate Phase". In the captured double images both small and large particles are seen. The small particles representing the continuous flow phase (air or water). Required density of seeding particles is standard for PIV algorithm. The large seeding represented a disperse phase. Seeding density a disperse phase is low compared whit standard PIV seeding density. This phase can for example be glass balls, liquid droplet and air bubbles. Using software module "Separate Phase" is possible create new two double images from captured double images. At the first double images are only small seeding particle. Velocity flow field computed from these double images represented continuous flow phase. The second double images which represented a disperse phase are without continuous seeding phase. Velocity flow field computed from these double images represented continuous flow phase.

IPI Interferometric Particle Imaging

Investigation of gas-liquid two phase flow is necessary to understand the behavior of droplets or bubbles in flow field. Using IPI technique we are able to measure position, diameter and velocity of each transparent droplet or bubbles respectively. More recently the IPI technique was applied to estimate the fuel oil droplets diameter distribution in a cylinder of engine on direct injection before ignition. If the camera is not focused on the particle (bubbles), the two bright points merge into one single unified image whit interference fringes. Particle size is determined from the spatial fringe information. Fringe spacing is linearly related to the particle diameter. Relation between the number of fringes or fringe spacing, the diameter of bubble and optical setup for droplets for droplets where the relative refractive index $m > 1$:

$$\kappa = \frac{\arcsin(\frac{d_a}{2z})}{\lambda}\left(\cos(\frac{\phi}{2}) + \frac{m \cdot \sin(\frac{\phi}{2})}{m^2 + 1 - 2m \cdot \cos(\frac{\phi}{2})}\right)$$

Where:

d_p	particle diameter	κ	geometric factor
N_{fr}	number of fringes	z	distance from light sheet to camera lens
d_a	aperature diameter	m	relative index of refraction
Φ	observation angle		

Experiment and Results

The experiment set-up consists of a pulsed Nd-YAG laser with a maximum frequency repetition of 15 Hz. An airbrush was used as generator of droplets. To detect the position of the illuminated droplets, a CCD-cameras (CCD = Charge Coupled Device) with resolution 1024x1280 pixels (12-bit) was used. Pair of CCD cameras whit special camera mount was placed on a camera supports in order to change scattering angle. Fog generator Safex was used like a source seeding particles. These particles were added to the air to able to trace of movement the air. Diameter, position and velocity of droplets generated by airbrush were measured using IPI technique. In IPI technique is particle tracing velocimetry algorithm used to measure velocity. Both velocity of air was measure by standard PIV technique with software module "Separate Phase" and velocity of droplets. In the paper the velocity of air and droplets are compared. Finally are compared velocity flow field of droplets computed using PIV technique and IPI technique.

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Accuracy of Stereo - PIV Measurement

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Motivation

Finding out influence of error, which is purposely added on measurement by Stereo PIV method on accuracy and change of output data was our objective. Two settings of experiment were (executed, accomplished, achieved), i.e. (I) measurement in plane parallel to primary flow and (II) measurement in plane normal to primary flow.

Procedure

Stereo PIV method is 3D extension of classic 2D PIV method. Stereo PIV allows evaluation of 3D velocity field with a pair of CCD cameras. Airflow in open-jet wind tunnel (open test section) seeded with particles was measured. Parameters of flow field and calibration target, dimensions of test section, location of CCD cameras was the same for both measurements.

Standard calibration target including traverse supplied by DANTEC Dynamics was used in case (I). The calibration target was placed to plane of symmetry of tunnel flow.

In case (II) calibration target was located in plane normal to tunnel flow. For this purpose we made target (Adobe PhotoShop) with the same parameters as in case (I) and printed it on a slide. The slide was placed and fixed between a pair of glass plates and on the traverse.

Angles between cameras were 30 and 60 deg for case (I) and 90 deg for case (II). Calibration was made for coordinate z from –5 mm to + 5 mm with a step of 1 mm. Error was added to calculation with calibration target adjusted as follows: yaw angle between target plane and flow symmetry plane was ±4 deg and ±8 deg in case (I) while in case (II) the adjusted angle was between target plane and plane normal to flow symmetry plane.

Then only one measurement of flow field and five calibrations were performed for each case. SW FlowManager 3D-PIV was used to calculate five transformation matrices (TM), which were used to transform a pair of 2D velocity fields to one 3D velocity field. Thus five 3D velocity fields were acquired where the one with zero yaw angle was reference.

Analyse of measured data

SW FlowManager was used to analyse measured data. Parameters of analyse: method – Adaptive correlation; interrogation area size – 32 x 32 pix; overlapping of interrogation areas – 50 %; mean validation. Output from SW FM is a set of pairs of 2D velocity fields**.** These were transformed then from five TM to five sets of 3D velocity fields. Statistics were gained for each set of 3D velocity fields then. Statistic data were exported to SW Matlab R12. A set of functions was made there, which enabled comparation of influence of yawing calibration target.

At first the global system of coordinates was set. Orientation of the x axis equals with the direction of expected primary flow. It means in case (I) horizontal in plane of calibration target, in case (II) also horizontal but to the plain of calibration target normal. The y axis was the vertical rotation axis. Z axis was normal to both previous axes together forming orthogonal Cartesian coordinate system.

Results discussion

Our results show that error increase with constant gradient with relation to distance x in case (I) and to distance z in case (II). Regression function to gain parameters of plane, which fit optimally the data, was made too. Magnitude of error with relation to y coordinate was negligible. The regression plane had therefore only two parameters: deflection angle from x axis (z in case (II)) and displacement in y-direction.

Conclusions

The results of experiment are: graphical interpretations which shows changes in percentage error of velocities, standard deviations, correlation coefficients in all directions (x, y, z); parameters of regression planes for each velocity function. These pairs of parameters contain information about magnitude of error, which could be expected when measure with not exactly set up calibration. This would be useful especially in cases where test section is badly attainable.

The project is still in development. This year it should continue measuring errors for more yaw angles, moreover adding other errors, e. g. from roll and pitch angles, or yaw angles with no symmetrical rotation of calibration target, bad traversing etc.

Thanks to fact that the magnitude of error is the same for both positive and negative direction, measuring positive directions would be acceptable only.

Complete results of this project should be a set of values of accuracy for each error type, occasionally their combinations, with which would be possible to derivate errors of measurements rapidly and with acceptable accuracy and reliability.

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Section 7

MECHANICAL ENGINEERING

Study of Possibilities Passive Elements Usage to Pedestrian Protection

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In vehicle-pedestrian impact, the majority of pedestrian fatalities are caused by head injuries. Accident analysis showed that bonnet of car often had consequences with severe head injuries in accidents involving young pedestrians. Therefore, this work takes a closer look at child pedestrian head impact mechanics and protection, on impact with bonnet of compact passenger car.

The bonnet structure was subject of deep examination because important factor involving risk of head injury is the design of bonnet structure. The injury risks to the head by an impact were examined by simulation of child headform impact test on bonnet. The test methodology is described in prepared Pedestrian Protection Directive proposed by EEVC WG 17 (European Enhanced Vehicle-safety Committee Working Group 17). The resulting load of child head impactor and other impact responses were measured. HIC value, bonnet deformation and contact force obtained from simulation of child headform impact were the main criteria for assessing of bonnet pedestrian friendliness. Moreover, the slope of acceleration time history curve was observed because the rate of acceleration (derivation of acceleration time history curve) is important phenomenon influencing performance of head. Different bonnet modifications were suggested and analyzed with help of mathematical modeling of such a test and their benefit for child head injury risk reduction was assessed by means of mentioned criteria.

The mathematical model of child headform impactor and car body forward structure was created by using the PAM-Crash program to simulate headform impact test. The validation of mathematical model was achieved according to EEVC WG 17 ANNEX VII. All of parts were modeled by FE technique. The bonnet consisted of two parts: skin and under-skin structure. Both parts of bonnet were modified in this study. Two modifications of sub-skin frame and one of bonnet skin ware considered. Modifications of under-skin frame provided distribution of support elements more uniformly in comparison with original sub-skin frame. This layout was designed to provide better support of bonnet skin and to minimize risk of injury. Other parameters like thickness of sheet metal or gap between bonnet skin and bottom surface of sub-skin frame etc. were preserved for purpose of possible comparison of results. Holes, designed in one of modification provided reduction of stiffness of sub-skin frame. The influence of these holes to impact responses was observed by comparing result obtained by simulations these modifications. The original bonnet skin (sheet metal with thickness 1.2 mm) was replaced by sandwich bonnet skin. The sandwich skin was created by two sheet metals (0.6 mm thickness) with a distance of 4 mm. The distance was filled with energy absorbing foam. This modification contained all sub-skin frames. It means there were six models to compare their behaviour (five modifications and one original).

The discussion of design possibilities leading to a more pedestrian friendly bonnet structure design was the main purpose of this work. All modifications of sub-skin frame provided the stiffest increase in the bonnet structure and HIC values did not exceed their limit in the all tested points. The stiffness increase led to reduction of deformation and minimized risk of contact of bonnet with hard structures under. The contact would stop free deformation of bonnet and cause sharp increase of HIC and other impact responses. Sandwich modification provided reduction of deformation at all tested points. But the reduction was not as large as in case of sub-skin frame modification. It provided reduction of HIC values for testing points close to middle of bonnet as well, while increase in HIC was observed towards to edge. To conclude the mathematical simulations showed that all bonnet modifications led to a stiffer bonnet structure causing reduction in bonnet deformation and increase of HIC. However, in all cases the HIC values did not exceed maximum value prescribed in prepared directive. Due to the boundary conditions the influence of modifications decreased towards the bonnet edge. Modifications of sub-skin frame provided more stiffness rise of bonnet structure than sandwich construction of bonnet skin as was designed for this study. But right design and material choice influence significantly sandwich impact behaviour. Therefore, the next study should be focused on more detail at analysis of different sandwich structures because the sandwich structure has a high potential in the reduction of impact consequences.

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Evacuated Solar Collector with Integrated Heat Pipes

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A heat pipe is a self-contained device which transfers heat by the process of boiling in an evaporator, vapor flow, condensation in the condenser and condensate return. Some of the advantages of the heat-pipe and specifically its ability to transfer high heat rates in a latent form over considerable distances and the extremely small temperature drops between the heated and cooled region resulting in small qualitative degradation of energy, make the heat-pipe an attractive option in solar systems. In addition, freezing of the heat-pipe is not destructive, there are no moving parts or external pumping power and the unit acts as a thermal diode preventing the reverse circulation problem in domestic solar systems.

The system consists of a collector with evacuated glass tubes and a condenser placed above the collector. Heat transfer from the collector to the heat exchanger is performed by the process of boiling in the evaporator, vapour flow, condensation in the condenser and condensate return. The evaporator of the heat-pipe consists of the evacuated copper tubes, which are led inside the evacuated glass tubes. The condenser which, is placed above the collector, consists of a multi-tube heat exchanger. The basic characteristics of the system are summarised as follows:

- Collector: dimensions 1.465 x 0.5 m, heat tubes diameter 20 mm, evacuated glass tubes diameter 47mm
- Heat exchanger: multi-tube with diameters 32 and 20mm
- Heat-pipe: total volume 2.3 l, diameter of adiabatic section (collector–heat exchanger connections) 20 mm, working fluid 95% C_2H_5OH.

In the final manufacturing phase of the system, the existing air is emptied from the heat-pipe and then it is filled with commercial ethanol.

The thermal fluid phenomena occurring within a heat-pipe involve mainly the boiling and vapour flow in the evaporator, the condensation and liquid flow in the condenser and the interaction between the liquid and vapour flow. An accurate theoretical analysis of the heat transfer phenomena that take place in a heat-pipe requires that all of the regions in the pipe be solved as a conjugate problem. However, approximations are often introduced, due to the extremely complex nature of the problem, especially concerning the dynamics of vapour flow. Therefore, some flow patterns may be neglected or combined with others and regions can be decoupled from other regions with appropriate assumptions (Faghri, 1995). In our case, the following assumptions are made concerning the theoretical steady-state analysis of the system.

I. The connecting pipes between the collector–evaporator and the exchanger–condenser are assumed adiabatic.

II. The temperature gradient in the longitudinal direction of the collector can be neglected. This assumption is also confirmed by the experimental results.

III. The exchanger is sufficient for all the vapour to be condensed and all heat delivered by the evaporator is totally removed on the condenser side. There is no vapour return in the collector.

IV. The working fluid inside the heat-pipe can be assumed as a wholly saturated liquid and the pressure is that of saturation corresponding to the vapour temperature.

The previous work on gravity heat pipe solar collectors was directed towards studying their performance or comparing them with the conventional type of solar collectors. The aim of the present paper is to study the effect of various operational and design parameters on the transient thermal behavior of wickless heat pipe solar collectors. The physical properties of the working fluid inside the wickless heat pipes, cooling water inside the heat exchanger, air in the enclosed volume between the evaporation section of heat pipe and glass cover and the internal heat-transfer coefficients of wickless heat pipes are taken into consideration as functions of their corresponding temperatures. The gravity heat pipe absorbers in solar water heaters have several advantages. These advantages include a thermal diode benefit, when the collector temperature is less than the storage water temperature, a small heat capacity, a reasonable resistance against corrosion by selecting a suitable working fluid to be compatible with the pipe wall material, easy freeze protection and lower pumping requirements.

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Simulation of Geometry and Load of Spur Gearing with Helical Teeth

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Gearings form important parts of the whole range of machines and equipments. They are used for the change of speed of driving or driven engines and for the attainment necessary kinematics relationship among mechanism parts.

One of the most often used gearing is involute spur gearing with helical teeth. The requirements for the safe and reliable operation during the whole working life place great demands upon design and strength checking of gearing. The complicated shape of coiled teeth is simplified during the process of strength checking. Helical teeth are in the majority cases replaced by gearing with straight teeth. It is generally assumed that the load from concentrated circumferential force affects on frontal section in the middle of the tooth width on pitch circle. The influence of loads' factor irregularity of simultaneously mating pairs of teeth and load's factor irregularity of teeth along the width are entered into the calculation through the mediation of coefficients. Without using computer the numerical computation according to ČSN 01 4686 or ISO 6336 is very time-consuming.

Other way of designing and follow-up checking is to create a precise model of toothed wheel by using one of CAD programs and its analysis with help of Finite Element Method (FEM). The creation of involute shape of side of tooth is very difficult, especially easement curve between the side of tooth and the dedendum circle, because the involute and easement curve are common curves. They can be obtained from analytical computation but their peaks will not be uniformely distributed, which is a disadvantage for FEM analysis. CAD programs are more suitable in this regard. The exact shape of lateral curve of the tooth can be gained by simulating the production of gearing with rack cutter. This way is also the most precise in production of real toothed wheel. Preciseness of CAD programs is optional and can be higher than is really reached during production. In our case we have used a parametric modeller Mechanical Desktop 6 which is correct to eight decimal places.

While simulating the rack cutter rolles along the pitch circle and generates a surface of tooth trace which is formed by short linear segments. The step of angle rolling of rack cutter has impact on the accuracy of shape of tooth trace. If the steps are sufficiently small, the generated tooth trace is very accurate. On the other hand, the tooth trace is composite from a huge number of segments. It causes an extreme increase of size of input data file for detailed analysis by FEM. The suitable solution of this problem is to separate the tooth trace on elected number of segments. Following the separation we interlay a new curve through the peaks of this segments. This can be easily reached by using standard commands of CAD programs. The newly created tooth outline is considerably simplier but still adequately describes the real shape. The whole tooth is gained by extruding outline along helix which is rolled up on cylinder with pitch diameter. The complete gearing is obtained from copying the previously created tooth along the circumference of wheel. The creation of both wheels' models allows us to solve the interaction of their teeth for optional swiveling angle of wheel.

Following outputs can be gained: beginning and ending of engagement, length and way of contact lines at the sides of teeth. The model shows us whether the gear engagement is one-pair or two-pair.

Following factors can be entered into design of gearing:

- inaccuracy of production,
- gear tooth correction,
- modification of tooth form,
- pitch error of adjoining teeth,
- chamfering of frontal surface of wheel,
- errors of assembly of wheels, etc.

There are several ways possible how to proceed while analysing models by means of FEM. Gearing is solved as a whole, i.e. one wheel is fixed and the second one is loaded. Only active parts of wheels models are used. Therefore, the computing difficulty is lowered. Hardware demands can be further decreased by using only active part of one wheel which is loaded by supposed load in the place of teeth´s contact.

Gearing can be solved as a uniplanar or solid computing task. The solid computing task is more comprehensible but more hardware demanding.

Using FEM places great demands on operation of the system and evaluation of results too. The advantage of above-mentioned method is an acquisition of informations about stress intensity, stress distribution and deformations of teeth.

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Better Tribological Qualities of Building Machines Components

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The machine component life is influenced with wear. Wear takes part in loss of energy and of material meaningfully and it has noted influence on charges attachment with machine components upkeep and their repairs. Abrasive wear is most frequent cause of machine small life and their trouble by building machines because they are in contact with different soil.
Abrasive wear is characterized with separation of elements from functional surface. Typical surface damages are grooves.

Measure of wear owing to abrasion is influenced:

- quantity of abrasive elements
- form of abrasive elements
- size of abrasive elements
- strength of abrasive elements
- hardness of abrasive elements

Resistance of metal to abrasion depends on their hardness. It determinates resistance to penetration hardness elements into components surface and resistance to plastic deformation. Therefore designers and technologists want to amount to hardest skins by save of impact strength and sufficient strength.

It is possible to amount to:

- selection of first-rate material with good abrasion resistance
- use of overlay materials with special properties on functional surfaces
- first-rate and good choose surface finish

We inquire into possibilities of abrasive wear resistance elevation with help of functional surfaces. Good surface finish or good functional surface gives to materials qualitative new properties. They differ from base material properties.
Surface is every matter coated on base material surface by expansion at least of one machine part dimension. Surface is determined with type and composition, its properties and its thickness are crucial too.

Surfaces used for wear resistance elevation are made above all with metal carbide and metal nitride. Their characteristics are big hardness and small impact bending strength.
For deposit of material coat on machine parts are possible to use many methods. Physical coating PVD (Physical Vapor Deposition) has considerable enlargement for utilization by machine parts.

Presuppose service life determination of machine parts is very difficult:

- laboratory detection
- working measuring

Testing and measuring technique play an active part in material choice. They make a thing possible selection of optimum technology, simulation of real part stress, quality control by production and resulting proof of reliability and lifetime by users too.

Simulating testing equipment for abrasive wear divide:

- with bonded particles
- with free particles

- with interlayer of particles
- tribometers

Experiments evaluation we take with microweighing. We take material loss in specific time. We take base material with different coats measuring in laboratory in this time. These works are taken in cooperation with Dept. of physics, CTU, Faculty of Mechanical Engineering and with Dept. of Technology, CUA, Technical faculty.

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Influence of the Ejector Coanda Setting on its Efficiency

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Coanda ejector is one of the streaming engines, which are used for constringency, extrusion or exhaustion gases, pars and liquids (literature uses for them expect to title ejector Coanda nomenclature transvector). These machinery can work with fluent mixtures so with liquid mixtures or with combination these matters.

The most of articles and works dedicate property description these arrangements at applications in air. The arrangement is possible to dispose in the area air condition, aeronautics or in the area transport liquid with the help of compressed air. Universal disappointments these engines are their low efficiency rate than classical engines like vans, pumps, compressors etc. Meaningful benefits is however their simplicity, price availability or in definite case construction- primarily in space with occurrence dangerous explosive matters and in cases broken or partial running.

Only one relatively fundamental problem remains and it is the operation of energy transformation in these machines. That is the reason for ejector is supported by mixing chamber and diffusor in practice. On gauging ejector track is used straight conical diffusor that is most commen type. According to purpose of the arrangement is possible to dispose other type like annulus diffusor with line walls or unstraight diffusor with curved axe. Division of the diffusors can be executed according to surface cut on circular or elliptical standards. In the ejector is created intensive mixing field of driving compressed media with driven media. In this place it is uneven undeveloped high speed field with a fluctuation and it can cause after direct input into output pipeline uneven flow, tremor and noice. It is useful to reach settled and developed velicity profil without eddy as soon as it is possible. Effort of ejector design is given to minimum of losses, which are created by mixing, whirls etc. and on the other side by frictional losses. The mixing losses equal to difference of speeds square each matter which rise by unsuitable division driven and driving media. The losses of friction depend on size of walls, quality of surface and geometry. The frictional loss grows with longitude of the ejector arrangement. The target is find acceptable solution to gain high efficiency, low cost or small meassures. Other view of issuis can concern output velocities and can consider them for waste (urge for small speed or decrease). One in possible solutions is installation of the mixture chamber behind the ejector, where streams stir, in order that creates developed high speed profile. When man needs increase output pressure of ejector, arrangement is equipped by a diffusor at the end of the set. The diffusor serves for conversion kinetic energy to compressive energy and join fluently mixture chamber with pipeline distributor. It is not admitable to choose apex angle at will, but in the suitable range in order to flows do not tear off walls and do not create backflow. These problems are solved closely in the works writen by Liepe and Jahn. The literature offers many information from this branch inclucive of experimental graphs and main relations. These authors compiled results their experimental studies and proposal diagrams for design of diffusor with ideal input parameters, which it is possible characterize by square wave of speed, thin boundary layer

and low turbulency of flow. In graphs there are marked waveforms for optimal suggestion of diffusor either with existing longiture or with existing area enlargement.
The complet of ejector contains mixture chamber and especially diffusor. That is the reason why it gets expensive and this apparat can be use only one way for designed parameters without universal application everywhere in a pipeline. This unfavourable situation can be removed by using alone at direct insert without further adjustment on the ejector and the tubes. It is quite clear, that arrangement efficiency will drop down. Investigation of the efficiency was provided on the track with rate value 3 (inner diameter ejector to pipeline diameter). Exhausting is proceeded behind the ejector through the annulus between the conduit and the outer diameter of ejector. Measurement confirmed increasing of the efficiency about 25-30% but it gave possibility of the ejector combinations thanks size and variability without other costs, which accepted straight installations. At gradual shrinking of annulus charakteristic begins resemble to equipment with the mixture chamber and the diffusor. The complet of Coanda ejector set reached the value of reinforcement 15 (rate between driven air mass flow and driving air mass flow). This value was obtained on the gauging track about 9 meters of longiture equipped by the throttling element for elicitation of the corresponding pressure gradient.
In practice that is relatively familiarly to supply this ejector arrangement without other accessories, it means single. Many applications do not require installation of the mixture chambers because the alone ejectors are joined to further pipeline or hose, where this procedure proceeds and it is finished. These applications are determinated for limited or eventually running at low power. Substitution of classical engines and arrangements should weigh up all effects on effectiveness and payback of embedded origins.

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Integrated Development of Machines

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According to globalization and rising speed of modern life, also the life of machines, machines have to be quickly launched and they will probably become obsolete in a short time. Producers are forced by users, governments and public opinion, to minimize all undesirable products and to recycle all, what is possible, through its whole lifetime.

Lifetime of the product

The first step of the development of the new machine is its need or market opportunity. Conception of machine is made in the second step. Then the producer has to decide, if the machine is profitable. Then money is invested to development. Machine is developed according to all demands or to most of them. After it the machine must be tested if the development was successful and if the product is ready to launch. After launch of new machine it is necessary to monitor carefully experience of customers. Time to time breakdown appears and then the machine has to be repaired. When the machine becomes to the end of its lifetime, it is ready for renewal or for exchange for a new one. The liquidation of the machine is the last step of the machine lifetime. Only if the customer was satisfied with the machine, he will buy another one from the same company. Now it is necessary to plan lifetime of machine as a whole.

Attributes of machine created by integrated development

Functionality

Machine has to fulfill all functions it is used for! Integrated development of machine can reduce some of functions or solve some functions together. It can also find functions which can be fulfilled without any input.

Costs and its structure

Purchase costs are only part of costs which are paid for machine trough its lifetime. Integrated development can reduce total lifetime costs.

Reliability

Reliability can be improved by using better materials, but it mostly produces rise of cost. Other way to improve reliability of machine is a recognition of breakdown in its early stage or its forecasting. Mostly the best way is to combine these approaches. Integrated development can decide which problem is better solved by progressive material and which is better to be solved by forecasting, monitoring and repairing or changing.

Design

Someone can say, that visual aspect of the machine is not important, but mostly machines are chosen by managers, who are not qualified to compare all its function attributes and all of us are subconsciously choosing things with nice shape and color. But the look of machine is not only its shape and color, but also the ergonomic, repair accesses, etc.

Repair possibilities

Most of machine parts have to be easily repaired or replaced.

Upgrade possibilities

Integrated development ensures also possibility for future upgrading of the machine.

Technologies

It is necessary to respect during development technological possibilities of the producing company. New technology can be also bought or outsourced, but it costs money.

Logistics

Integrated development of machines includes also logistics. Forward logistics ensures transport of sources, products and spare parts. Reverse logistics ensures claims, return of used parts and machines for recycle. Waste logistics ensures liquidation of production wastes, used products, etc.

Conclusion

Integrated development of machines perceives the machine as an inseparable whole. All parts are forced to be functional and most simply as possible. Monitoring of machine through its whole lifetime contributes very important information for improving the machine and for future development.

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The Effect of Design Changes on the Parametres of an Aerator

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Alternative solution aerate system is surface aerator pneu – hydraulic type. Aerator uses axial impeller evocatory hydrodynamic effect stream of fluid. One box unit conception of aerator consists of these main parts: driving unit (electric motor), shell shafting, hollow shaft and impeller. Effectiveness of equipment is done by an intensification of atmosferic oxygen occlusion by mixed fluid with relatively low investment and operational costs. Simple aerator construction enables easy service and high mobility of the equipment.

The main part of aerator equipment is axial impeller (propeler). This impeller is placed at the end of hollow shafting, submersion under the surface and his rotational motion makes (induce) leech of outside air to the basin. The design of the impeller is a combination of ship propellers, impellers of pump and mixers. The alternatives of propellers is consequence of model tests from the years 2002 and 2003 staying the same years 2002 and 2003.

Main watched parameters of the aerate equipment is input power and volume leech onto air - depth submersion characteristics. Several constructional changes have been done on starting constructional fulfilment aerator of the years 2002 and 2003. Changes were first of all focussed on increasing flow - air volume Q at uniform input equipment P. Important comparative parameter is specific input P/Q.

Original structural design was provisional admission leech onto air through one circular inlet in shell stator. Subsequent distribution of leech onto air inside shafting was secured with four circular inlets. Flow area surface for leech onto air in shell corresponds to the flow area in the shaft.

Existing structural design ensures input leech onto air some through oval inlet in shell. Air input in inside through shafting two oval inlets and by two original circular inlets. Position shaft inlet is symmetrical. Section flow area for leech onto air in shell is 8x bigger compared to original solution and 6x bigger is section opening in shaft compared to original solution. Other changes were made on submersion shaft end, where at one variant of impeller was increased (flow area in hub) by one third. Equipment is used at 2950 revolutions per minute and makes it possible to selectable slope shafting (max. depth submersion 60 cm).

Mentioned design changes of shell and input shafting contributed to the increasing of flow air volume about 300 % till 400%. Specific input P/Q decreased in some cases to quarters of the original rate. Increasing flow area shaft end brings 15% increase of air rate Q. Tests were in transparent basin, where influence of single impeller on flow in basin was monitoring. From these tests is identified right type, which will be consequent articles for an others research.

Experimentally obtained data confirm the rightness of ingoing ways of research. Futher data were gained needed not only for choice of optimum variant design of impeller, but above all for complete structural design. Owing to mentioned constructional changes aerate equipment provide under characteristics P and Q (P/Q) comparable with other types of aerate equipment. Acquired results of experimentation have not been published yet.

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Façade Solar Collectors

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Large amount of flats is concentrated in housing estates (panel or brick blocks of flats) in Czech Republic. These housing estates were established between 50's and 70's and should pass through complex renovation. Energy-conscious retrofit takes into account the reduction of building heat losses (thermal insulation, windows), systems of control and measurement, devices for hot water consumption reduction or reconstruction of heating systems (distributed plants) and renewable energy sources exploitation. Solar energy utilization has a large potential for water heating (domestic hot water), but solar systems, which are not an integral part of buildings, are often rejected by architects or town planners. Solar collector integrated into building facade could help to solve these barriers and to bring another possibilities.

Facade solar collector can be considered as a standard flat-plate liquid-type collector (preferably selective absorber) integrated into a building envelope. Collector back and edge insulation is common to building insulation layer. Facade collectors are usually available in wooden frames as large scale installation panels. Collector panel is directly mounted on insulation envelope of building facade, there is no thermal separation between absorber and insulation envelope in the form of ventilation gap. Solar collector is thermally coupled to the building wall. The integration brings several essential advantages in comparison with solar collectors mounted separately from building envelope (in the front of the envelope or on the flat roof). Additionally to the basic function of solar collector, facade collector serves as a protection shield against atmospheric effects (weather protection) and could improve the heat insulation of the building with respect to passive solar gains. Furthermore, collector integration into building facade is aesthetically more attractive solution when compared to collector plants placed on the flat roofs, which create foreign-like pilar bodies on buildings.

Conventional solar systems are designed to maximise annual solar gains. The basic principle to achieve this is proper orientation and slope of collector field. In the central Europe conditions, maximum annual irradiation is received by surfaces with south orientation and slope between 35° and 45°. In the case of facade collectors with slope 90°, the reduction in annual irradiation sum is around 70 %. Comparisons of annual profiles of daily solar irradiation usually show a large difference between summer peak and cold season values for roof collector (45°) and relatively uniform profile for facade collector (90°) which corresponds closely to hot water demand profile (approx. constant). This allows the design of solar systems with a high solar fraction (above 50 %) without extremely increased periods of collector stagnation in summer as it appears in roof systems with the same solar fraction.

Facade solar collector concept was investigated through computer simulation of collector thermal behaviour and solar system-building interaction. A detailed mathematical model KOLEKTOR has been used for an investigation of solar collector thermal performance based on the knowledge of thermal processes in the individual parts of collector. Model consists of absorber outer energy balance (heat transfer through glazing, air gap, frame and absorber surface) and absorber inner energy balance (heat transfer within the absorber fins with solar radiation and piping). Modelling of particular thermal processes has shown the effect of the integration on solar collector thermal performance. Facade integrated collector, when compared with flat roof-located collector, shows considerable reduction of heat transfer

coefficients, especially for natural convection in the gap between the absorber and glazing (to 80 %), wind-related convection (to 60-80 %) and back and edge frame heat loss coefficient (to negligible minimum dependent on facade insulation applied).

Energetic behaviour of solar system based on facade integrated collector has been investigated through computer simulations, performed using Transient System Simulation Program (TRNSYS). TRNSYS model for integrated facade collector has been composed from a multizone model and the solar system model with thermal interconnection between them. Last layer of zone envelope was coupled to collector absorber, i.e. absorber temperature was identical with the layer surface temperature. Solar systems (facade, roof) have been modelled as conventional ones – collector connected to storage tank with partial stratification. Facade solar collector with slope 90° has been modelled as thermally coupled to building facade as described above. Roof solar collector has been modelled separately with slope 45°. Thermal characteristics of the collectors were obtained from detailed simulation through KOLEKTOR model. To allow a performance comparison between the facade and roof system, a condition that both systems should have an identical solar fraction (60 %) was used. This resulted in facade collector area 6.3 m^2 (identical with zone facade area) and roof collector area 4.5 m^2.

The simulation has shown that facade solar collector should have an area increased by 30 % to achieve the same solar fraction (60 %) as conventional roof solar collector with 45° slope. Roof solar collector system gives 430 kWh of useful energy per m^2 of collector area with overall efficiency 41 %, while facade solar collector system 310 kWh/m^2 with overall efficiency 42 %. These results are not surprising. Based on the basic configuration of solar system (storage tank 180 l, control strategy), parametric analysis of collector area has been performed. Further increase of collectors area leads to higher solar fraction. To achieve values above 70 %, required area of facade collector is comparable with roof collector. However, roof collector gets to much more higher levels of stagnation conditions in comparison with facade collector, which leads to possible operation problems and material degradation. Vertical position of the facade collector results in a well-balanced useful gains profile and very low level of non-utilisable energy gains in comparison with the roof collector case.

Interaction of facade solar system with building has been investigated for winter (from October to April) and summer (from June to August) season. Performance analysis through collector-zone coupled modelling was done for two usual building types, light-weight (panel) and heavy-weight (brick). Due to high heat insulation level of the base case facade, the heat gains caused by facade collector in winter are relatively low, around 9 kWh/m^2 of facade area. Facade collector, due to good level of heat insulation and absorber temperatures kept under 70 °C (low level of collector stagnation as resulted from system simulation), doesn't cause notable temperature increase inside the building. Application of facade collector thermally coupled to the wall slightly moves the temperature distribution, but not more than 1 K higher.

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Stand with Torque Motor

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The basic tests of new type of rotary drive have been done. They are described in the text below. Short description shows the basic characteristics of this drive.

Torque motor is a new type of drive. It is synchronous rotary motor with permanent magnets for low revolutions by high torque. The magnets are made of rare earth elements (samarinum-cobalt or new neodymium-iron-boron). Their remanence is 0.9-1.2T. These type of motors have tens up to the hundreds of pole-pairs. Diameter of motors is from 0.15 up to 5 meters. Its main advantages are:

- High angular acceleration
- High stiffness by servo control of position
- Low rotation speed without gear transmission
- Solid connection to driven axes
- Low mass and low moment of inertia
- Accurate positioning
- High power by the low overall space required
- Chance of extremely low revolutions (1 rev/1 week)

Motor is directly connected to the driven axes without any gears. External case could be cooled by water or air. This motor is used for driving very precise axes and at first was used in army and astronomy (rotation of the radars and satellites). Now it is applied in other branch of industry (elevators, printing machines, precision measuring tables, …). For the high precision of position by the high torque is torque motor used also in milling machines. In this area is the torque motor applied in rotary and tilting tables, two axes milling heads and rotary axes of machines.

We have not enough experience with this drive in Czech Republic yet. Therefore it has been built test stand for testing of torque motor in RCMT. Motor was made by Czech firm VUES a.s., Brno. Stand consists of torque motor, frame, large radial-axial bearing firm INA, rotary measuring devices and servo amplifier type BUM61 from firm Baumüller. Required value of the position or speed is set-up and evaluated from the PC by using multifunctional card MF614 firm Humusoft. It contains 4 D/A (digital/analog) and 8 A/D measuring converters with 12bit resolution. Motor's type is ROL530881D and its specifications: max. torque/current 1125Nm/28A, max. speed. 150rev/min., number of pole-pairs 44, diameter/height 530/100mm cooling by air, K_E=1321.8V/1000min^{-1}, K_T=21.86Nm/A. Position measuring system type MEKO is a part of bearing with 5184 increments/rev. Position is mathematical interpolated by 1000 times and derived to get speed. Input frequency of card MF614 is 2MHz, therefore this measuring devices can be used up to speed 0.386rev/sec. For higher speed is used measuring system type SRS 50 C firm Stegmann with 1024 inc./rev. Moment of inertia of the motor is 2.2kgm^2.

Motor is controlled by cascade control with current, speed and position closed loop control. Torque and speed control loops are closed in the servo-amplifier with sampling rate 62.5μs. Position control is closed in PC and by analog input is set required value of the speed into the amplifier with sampling rate 0.5ms. Also the analog input has an input filter of the

first order with time constant 1ms. Actual value is sampled from analog output with sampling rate 0.5ms too. Therefore the measured value do not correspond with actual value and tests results are deformed, especially the tests of bandwidth. And therefore it was first measured transfer function between required and obtained signal. This transfer function was subtracted from measuring data to get real results independent of measuring errors. After the tests were set constants of the loops: Kpi=6A/V, Tni=1ms, Kp=9A*s/rad, Tn=5ms, Kv=100s^{-1}. By the test of position ramp was measured following error Δ=2160arcsec=0.6rad by speed v=10rev/min=60rad/sec. It corresponds to relation [1] Kv=v/Δ =100. Measured bandwidth is for position loop 28Hz, speed loop 125Hz, and current loop 600Hz. By the test of disturbance step response is measured position deviation 170arcsec by torque 350Nm. Thence it follows the stiffness of control is 425kNm/rad. The tests get expected results and confirm good characteristics of the drive.

Simultaneously with the real tests were simulated tests on mathematical model in software Matlab/Simulink. Model describes properties of the motor, driven load and control loops. The tests results in mathematical model correspond with real measuring. In the year 2004 will continue tests with different types of measuring systems and tests in special working conditions.

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The Pipe Bends and Residual Stresses

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Proper level of residual stresses of construction surface is expected on EU market today. Foreign standards require some experimental methods for determination of residual stresses such as hole drilling method or X-ray diffraction method. Modřanská potrubní a.s. produces smooth pipe bends and this article describe problems of residual stresses in pipe bends. Rolled weld less pipes are used for making pipe bends. Material of these pipes is unalloyed steel of class 11 and 12 of ČSN standard. This pipes are formed by hot forming under temperature between 920--980°C (Standard ČSN 13 2604) and cooled from this temperature by means of air. The forming temperature is higher then bottom anneal temperature of pipe material. This technique is suitable for pipes with dimension where ratio of external diameter D and thickness t is sufficient for shape stability by bending and water dash is not required for increasing shape stability. Small geometrically irregularities of circular cross section are awaited only.

Heat treatment of bends is provided by standard ČSN 42 0284 very often. Treatment temperature is mentioned in interval 850--1000°C. Stress-relief annealing is required by ČSN standard 42 0284 in this case, because both ends of pipe are not warm. Standard ČSN 42 0284 is in force from 1962 year. This old standard dos not correspond today trends because it is not permitted omitting stress-relief annealing. This operation is very expensive and time of production cycle is growing, and cost of production is increased by machining of scaled surface of bends.

Standard ČSN 130021-6-1 comes in force in 1998. This new standard make possible omit bends stress-relief annealing, if mechanical and structural property of metal are conform and level of residual stresses in construction is low. Similar foreign standards and specifications for production of pipes and pressure vessels describe possibility omission of stress-relief annealing also. Some experiments ware taken in Modřanská potrubní a.s. in past. It was proved that material of bends cooled on open air have similar mechanical and structural properties as materials of annealed bend. Problem of residual stresses was not solved in Modřanská Potrubní a. s..

Determination of residual stresses on pipe bend was made by means of measurement set RESTAN. This measurement system uses the hole drilling method. Small hole is drilled on the surface of the construction and relaxed strains are measured by means of the special strain gauge rosette. Residual stresses are computed from measured strains. Standard ASTM 837 E was used for estimating residual stress distribution.

Specimen pipe bend was produced in Modřanská potrubní a. s. Bending radius was R = 1250 mm, diameter of pipe was D = 273 mm, thickness of pipe wall was t = 16 mm. Material of the bends was steel ČSN standard 12 022.1. Part B was bended by normal technique. Part Straight part A was cut and after them was normalize annealed. Normalize annealing was omitted on bended part B. It was determined 14 place on part B, where was

carried out measuring of residual stresses. Comparing measurement was carried out on part A in one place.

On comparing part A was determined tension residual stresses. The extreme value of compression residual stresses was determined in zone of end of inductive heating. The extreme value of tension residual stresses was determined in top of bend. This measurement is carried out as basic of future research. It was shown the place of interest – end of inductive heating zone and top of the bend. More places on the comparing part A must investigate also.

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DAQ Systems Using the Different Platforms for Mechanical Engineering Applications

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A successful mechanical engineering product requires an advanced design, a high quality, a low energy costs and an acceptable price. One has to use properly all accessible advanced techniques, including the modern measuring systems during the testing of the products to achieve those parameters. The results from measurements provide an effective feed back for eventual design changes and overall optimization of the product.

Various solutions of the DAQ systems to monitor the most frequent engineering parameters (temperatures, pressures and flow measurements) have been assembled at our department in the past years. There are three versatile DAQ systems available at the moment.

The first DAQ System comprises a National Instrument Card based application and uses LabView, BridgeView software. It consists of a TempScan box connected via the GPIB interface. The TempScan is a high-speed measurement system, which can gather data up to 992 sensors. No external signal conditioning, multiplexers, or customs cable are required. The TempScan/1100 is designed with the flexibility to meet the needs of the most demanding temperature measurement applications.

The second DAQ system is multiplexer based system using Advantech cards and monitoring is realized through the EFLAB program prepared under TestPoint software. The DAQ is capable of monitoring up to 80 channels with temperature sensors (Pt 100 in 4 wire, 3 wire and 2-wire readout) up to 16 channels for pressure sensors (or tensometers) and up to 4 channels for flow sensors (frequency based). Reading of the voltage signals in the range between 5V to 10 V is also possible via individually prepared PIGI cards.

The third DAQ system, newly assembled, is an advanced solution using the Embedded Local Monitor Board (ELMB). It is a plug-on board for use in the applications and it has an onboard CAN-interface, local intelligence and is In-System-Programmable, either via an onboard connector or via the CAN-bus (so it is really remotely in-system programmable). Optionally a 16-bit ADC and multiplexing for 64 analog inputs is provided onboard. On the backside of the motherboard there are spaces for 16 sockets for dual-in-line signal adapters, each servicing 4 input channels. There are presently adapters for 4-wire Pt100 sensors, 2-wire resistive sensors and differential voltage attenuators (1:100) available. The ADC voltage reference (+2.5V) and the analog ground are available on each adapter.

The PVSS II software, object-oriented process visualization and control system from ETM Company is used. It allows implementing solutions tailored to specific needs. The PVSS objects model devices. The object type defines the behavior, data structures,

appearance and operability of the object. The objects themselves are created as instances of the object type.

Regardless of the applied software systems, one has to solve problems concerning the quality, stability and accuracy of the input/output interfaces (cards) and connected sensors during the measurements to achieve good measurement results. Therefore two versatile calibration set-ups were assembled:

(a) Pressure calibration circuit (It comprises of pressure vessel, multiple manifolds equipped with Swagelok and Legris connectors and valves, connecting pipes and precise reference pressure sensor).

(b) And temperature calibration set-up (It is based on the modified ASL Metal Block Calibrator. The model B140 was additionally equipped with computer-controlled card for its operation and originally "dry calibrator" was also adopted for fluoroinert liquid bath calibrations.

Database of calibration protocols was created for the most frequently used temperature sensors (NTC´s, RTD´s) and pressure sensors (Druck, Honeywell, Sensortechnics). The humidity sensor calibration procedure is the next set up under our consideration.

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Comparison of Classical and Modern Methods of Limit Calculation for Aircraft Structures with Experimental Results

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In spite of great expansion of modern computational methods and sheer increase computer output during last ten years classical computational methods [1] are still used in analysis of aircraft structures where most parts are thin-walled. This approach is typical for smaller companies. Till now invasion of computers is used in algoritmization of engineering calculation**,** processing of data, graphs and tables. Engineering methods have some limits for practical application and modern numerical simulation FEM have been used for:

1. stress and deformation state determination in massive thick-walled parts as under-carriage and motor beds;
2. fracture mechanics problems, where only limited region of the structure is analysed but in a great detail as in front of crack tip;
3. composite structures.

Engineering methods have on one side the advantage of relative simplicity of calculating by relative good agreement to the reality if we omit:

1. holes, shape changes of cross-sections;
2. sometimes problematic places of force and moment applications;
3. some statically indeterminated structures.

Resulting from this simplified approach there are uncertainties in safety for last mentioned three cases. Sometimes structure has greater cross-sections that means higher safety, but also higher mass that unfavourably influences economy of the whole aircraft structure, sometimes experimental testing proves underdimensioning of the structure. Only more precious analysis taking in account real load application as well as real geometry included its imperfections that strongly influence limit state of thin-walled structures can bring better agreement between results from calculating and from tests on real parts and structures.

The differences of results received by simplified engineering calculation and by experiment are presented on the example of loss stability of the rod having U cross section and axially loaded. If we use Euler´s expression for buckling of the whole rod the critical force was 16,7 kN. From experiment we received only 11,6 kN. The difference was 44%. If we calculated cross-section by means of Eulerian expression the structure would be strongly underdimensioned. This difference comes from the form of the stability loss. Euler takes it in the whole, practical cases as well as our experiment as local loss of cross-sectional shape (local loss of stability).

If we took engineering diagram for local stability in relation to the slenderness of the examined rod [1] the critical stress was 176,6 MPa. The corresponding stress to the experimentally determined force 11,6 kN is 169,6 kN. In this case the difference of the limit state is only 4,1%.

The stability loss of the above mentioned rod with U cross-section occurred in buckling of flanges. This place was not accurately in the middle of the length of the axially loaded rod and the visible change of cross section occurred during decreasing of the load. From the video documentation we can say that the moment of the buckling is very hard to estimate by own eyes. For more accurate estimation of the load at the moment of the loss of cross-sectional stability it is necessary to use some means for visualizating deflections by means of Moiré shadow method.

If we take in account all side effects this example proves competence of using the simplified engineering approach as it is used in small companies and in pedagogics.

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Residual Stress Determination - Nonomitting Procedure in Quality Assessing of High Stressed Parts

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As it was said in [1] contemporary requirements for higher outputs and simultaneous demands for higher reliability of structures compel application not only of better materials and modern means of analysis on a higher level during design but more precise technologies. Any failure of highly stressed parts in operation has to bring catastrophic accidents as we know from aviation, high speed train traffic or big energetic machinery. Railway axles or turbine rotors belong to the group of extremely dynamically loaded parts. That is why high attention is given to these parts during all steps from design over producing to operation [2]. Stress state in the surface layer, given by the stresses due to the operational loading and residual stresses due to the technologies having been used during production, is dominant for fatigue and reliability quality of the part and consequently for the whole structure.

The aim of all activities was to assure the limits of residual stresses induced into the railway driven axle for high speed locomotives during its production (forging, heat treatment and turning) and to give some recommendation from the point of residual stresses.

Methodology for evaluating and determining of residual stresses in structures is given by the ASTM Standard E 837 [3]. This measuring procedure, when all requirements and conditions are satisfied, ensure repeatability $\pm 5\%$. Thus the residual stress determination became one of the inspectional procedures during producing turbine axles [1].

The client asked to examine the residual stress state on the maximum of the examined surface. Time and financial conditions badly keep down the total number of measured points. It was concluded to measure the stress state in five cross sections, where two points are located on the diameter. To cover the maximum of the surface the cross sections were turned each other by 120^{o}.

The axle was made of steel ČSN 16536 (R_m = 980 MPa, $R_{p\,0,2} = 670 \div 830$ MPa) and the so called safe limit of residual stresses was taken as $0{,}1.R_{p\,0,2}$. The measuring should reliably fix the quality of examined structure as to residual stresses. If the rotors had not satisfied the residual stress limits then the heat treatment should have been repeated under stiffened and more accurate conditions. In such a way the experimental method became a control one in the technology.

Material constants were determined by measuring the sample of the used material for the rotor. From the measured deformation during drilling the determined hole and with the use of constant respecting rosette geometry, diameter and the depth of the drilled hole were taken from TN 505-3 of Vishay Co. [4].

The results of the determined residual stresses along the depth of the drilled hole in three sections with two measured points situated opposite were done.. In all points residual stresses in the surface layer were in pressure, as it was required, and their protracted and unruffled course proves homogeneity of the residual stress state and maximal values do not

exceed the prescribed limits. Also the orientation of the main stresses proved good homogeneity of the stress state and consequently the good quality of heat treatment and at the end good quality of the product. After residual stress measurement fine turning took off the layer containing the holes.

Results of the drilling and measuring procedures have given the definite recommendation for technology so that we receive product of the required and guaranteed quality.

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Importance of Longlife Learning in Engineering and Technology

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Progress and achievements in all branches of human activities mean continuous growing amount of knowledge. Everybody who wants to keep up with this growing has to go on study. Life-long learning represents a fundamental demand which should be assured not only by a will of individuals but it should be offered by organizations dealing with education in the relevant branch. Here there is an open field for universities which have staff of skilled and trained people either in pedagogics or in technical branches.

In the former Czechoslovak Republic special so called postgraduate study in all branches were practiced. After 1989 there was seen a reduction of the number of similar courses and their focusing particularly to economy and management. In it there was awaited economic progress of the country.

Any contemporary and future prosperity of companies or the whole country is based on high quality of products, service and skilled people. This is valid for industry as well as for small and middle companies and also for scientific organizations. The level of the graduated people from our universities were and has been same as in other countries. But only few of them can receive further education which is focused to the special part of their activities.

Only in 2000 official proclamation about support of all branches in long-life learning was put out. One of the goals of the proposed strategy is to make lifelong learning a common, generally respected and accepted practice. Lifelong learning represents a fundamental change in the educational concept, as well as a change in the organisational principle under which all alternatives of education – traditional educational institutions within the educational system, as well as institutions outside it – are appreciated as one interconnected unit, allowing various and frequent transitions from education to employment and gaining the same qualification and competencies in many different ways and at any stage of life. Such an attitude toward education includes individual and social development of all kinds and in all form: formally at schools, universities, in adult education institutions and in specific company programmes, as well as informally at home, in a team, at the workplace or within the community. The stress is put on the development of skills and abilities during the whole period of employment and even after its termination, if the individual decides to do so. In opinion and according to information of mine and my colleagues many mechanical engineers feel the necessity of further learning.

In their effort to start postgraduate study and not only doctoral one there are existing some obstacles particularly economic ones. On the side of universities high fees for these special courses are asked and on the side of companies there is a low willingness to give free paid time for the long-life learning to their employees. There are existing two ways for solving this problem: a) to put the duty for passing this special courses ; b) to prepare electronic learning.

Some companies as Aeronatical Research and Test Institute in Prague have prepared their own programme of postgradual study for their employees.

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The Axially Compliant Suspension for Secondary Parts of Linear Motors

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The axially compliant suspension for secondary part of linear motors is method applicable for reduction of unfavorable effects of reaction forces in highly dynamic motion axes. It can be applied only for feed drives with linear motors. The system uses an axially movable secondary part of a linear motor connected to the steady part of the moving axis by a preloaded spring and damper. In conventional cases the secondary part is firmly fixed to the steady part. The primary, active part of the linear motor is in both cases fixed to the moving part of the feed axis. In this arrangement, the reaction forces, generated by the linear motor are not directly transferred from the secondary part to the steady frame like in conventional configurations. The transmission occurs through the tuned spring and damper system which **changes the shape of the accelerating force, making it softer in time without changing its total impulse $F_R.\tau$. In other words it cannot bring about elimination of reaction forces**. Accelerating force acting on the moving part and reaction force acting on the secondary part, equal in size, are generated by electromagnetic interaction between the primary and secondary parts of the linear motor, more or less independently from the relative velocity of parts. This independence is based on the fact, that the intensity of Lorentz–Maxwell electromagnetic forces is independent from the actual velocity of the conductor in the magnetic field.

The equipment has to have two independently measuring systems. The first one measures the relative movement between the primary and secondary part and serves only for commutation of the linear motor itself. The second measuring system measures the relative position between the primary part, moving with the work piece and the machine frame, firmly connected with the tool. It serves as feedback measuring device for numerical control both the position and velocity. The actual velocity signal is calculated from the position signal by derivation in time.

Secondary part of the motor represents a classic dynamic system with a mass, spring and damper which is excited by the reactive force of the motor. It makes a considerable change in generating of internally induced voltage in the motor, which depends on the relative velocity of primary and secondary parts. Changes have been introduced into the corresponding Root-locus diagram of the closed current loop, which now possesses another two new complex conjugated poles and zero points. Fortunately, additional poles are usually located very close to the zero points and their effect will be only negligible. This means **that the regulation of the current and subsequently of the velocity and position will keep its quality when compared to the conventional case**. Actually, for elimination of dangerous resonant vibrations of the secondary part, it is at most desirable to reach values of damping ratio higher than *0.2*. As optimum, values between *0.2* and *0.7* could be suitable for individual applications. Under these assumptions, a stable regulation of the linear motor with compliantly suspended secondary part should be possible.

The natural frequency of dynamic system with mass and spring has to be tuned sufficiently above or better under the frequency band of exciting process forces. This requirement can be fulfilled for specialized machine tools where the range of working cycles can be delimited in advance. This may be for instance the case of the transversal motion axis on a lathe for turning of non-rotary surfaces of pistons for internal combustion engines or the case of a grinding machine for high speed plane grinding. In cases of milling machines and processes, the problem of tuning is much more complicated. Working movements of these machines involve apart from other things harmonic movements for generation of circular trajectories with frequencies up to 20 Hz, linear movements with strong acceleration impulses and exciting periodic forces in broad range of frequencies. In general, it has been shown that acceptable way for tuning of the spring-mass dynamic system is close above the working range of harmonic movements. The pretension of the springs has to be higher than the peak force of the motor. The compliant connection of the machine frame to the foundations with low rigidity must be also taken into the consideration.

Gained results show that the axially compliant suspension for secondary part system can, if properly tuned, bring about **improvements in reduction of shocks attaching the acceleration or deceleration of moving mass and in decreasing of vibration amplitudes of machine frames**. Its contribution can be observed especially at simultaneous action of periodic cutting forces when, in certain cases, the vibrations of the bed can almost disappear. Application of the axially compliant suspension for secondary part of linear motors brings about complications with the necessity to use additional guide ways for the secondary part and additional measuring system for motor commutation. Nevertheless, it may in special cases for high values of jerk help to reduce considerably transfer of reaction forces from the linear motor into the machine foundations.

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Section 8

PRODUCTION SYSTEMS, TECHNOLOGY, TECHNOLOGICAL PROCESSES AUTOMATION

Analysis of Reliability of Electrical Equipment with Regards to EMC

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Developing legislative of electromagnetic compatibility is bringing new methods for analyses of electric devices and systems, during all stages of development and life. New implemented standards are ever defining higher claims on noise immunity of electric devices and systems. The requests are also put on safety of electric devices and systems if a fault on the device is raised. This means if the device has a fault, a operation of devices has to be safety. These requests aren't only for electric devices, but for electric systems too. These aspects are leading to performing an analysis of electric devices and electric systems, to eliminate possible cause of device faults and system faults or to prevention of these faults. The potential rise of the fault is possible theoretically evaluate by means of calculation of the probability theory.

It is necessary to consider EMC during a live cycle of the electric device or the electric system from stage of design to discard the device from the operation to achieve fail-safe of the device. It is also very important consider electromagnetic environment for device using to the analysis of hazards and risks. The analysis of a reliability is performing in order to the safety-hazards caused by magnetic disturbances were establish. Functional safety of devices or systems isn't allowed to be to influence by electromagnetic environment much too, where the device is using. It demand that a level of electromagnetic immunity of the device has to be sufficient to defects caused by electromagnetic disturbances existing in count, that in combination with another causes of faults are with an acceptable risk. Electromagnetic disturbances generated inside the system aren't allowed to influence the functional safety of another parts of system adversely. It is possible in conjunction with the functional safety that the device could fail; if it is exposed to an electromagnetic disturbance to dangerous was avoided. It is also called as reaction by a failure going to the safety. We have several methods for analyses of reliability of devices. They are based on two principles i.e. deductive and inductive methods. Deductive methods are advancing during analysis from top event down in contrast to inductive methods, which are going of bottom up.

The approach is of the highest level of an interest; this level is called the top event, to lower events. The aim is to establish levels related with undesirable work of the system. This means, that we are able to define for all top events responsible levels and components of the system.

The inductive methods represent identifying of fault state modes on the level of components. For all fault state modes are evolving effects for next a higher level of the system. Consecutive interactions lead to identification of fault state of effects in all functional levels. These methods from bottom to up allow to identification all modes of the fault state.

The deductive methods are preferable considering effects of EMC disturbances on the safety of the system. This means we are defining top events, and we are searching causes leading to their rise. It is a disadvantage of inductive methods that they are showing all modes of the fault state, they include fault states, which aren't cohering with EMC disturbances; therefore they shouldn't be included to the analysis.

The fault tree analysis is one of many deductive methods. It is approached in several steps during the fault tree analysis. Intended functions of the system have to be defined in the first step, electromagnetic environments where the device will be exposed, in next step. They are able to be specified undesirable events in point of safety in next step. These faults are considering as the top events.

We can continue in proper analysis of faulty conditions for all dangerous situations, if we have defined everything. It is necessary to appoint which of lower events is able to cause top event. Electromagnetic disturbances are basic events in this case.

The function tests don't usually look at all possible EM disturbances in generic standards or in product standards. It is not possible so that the fail EM disturbance with the high level had the effect on the safety. It is necessary to consider whether fail disturbances in standards are able to occur in relation to the safety. We have to look at the effect, if it happens. The Board of examiners or the producer have to specify levels of the test, which are based on the most highest levels in environment of using devices, in order to the safety.

The purpose of the analysis of the dangerous and the risk is detecting undesirable risks for the safety; in order to we are able to do acquisitions for abatement of effects. It is detecting of EM effects and places, which are cause of the risk respectively where are occurring.

Production of Long-period Optic Fibers Grattings by Expusure Radiation of CO2 Lasers Beam

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In recent years long-period fiber gratings (LPG) have developed into a new and rapidly expanding branch of fiber grating science and applications. LPGs are usually formed in singlemode optical fibers by introducing periodic modulation of the refractive index with a typical modulation depth on the order of 10–4. The periods of the gratings are on the order of 100 μm and the grating lengths range from one to a few cm. Several methods of LPG fabrication have been demonstrated. The most frequently method used is based on photoinduced permanent index changes in a GeO2-doped silica fiber core. UV light in a wavelength range around 250 nm; e.g. from an excimer KrF (248 nm), frequency-doubled argon-ion (244 nm) or quadrupled Nd:YAG (266 nm) lasers and exposure through an amplitude chrome-plated mask with a rectangular transmittance function or a point-by-point exposure technique are used for this purpose.

A vast majority of theoretical and experimental investigation of UV-laser-induced LPGs has been focused on gratings fabricated in commercial step-index single mode fibers with a GeO2-doped core and uniform pure silica cladding. Only few exceptions from this picture have been reported, e.g. an LPG fabricated in a fiber with an eccentric core in a silica cladding, in a polarisation-maintaining fiber or in a fiber in which an intermediate part of the silica cladding was replaced with a polymer ring or with a special air-filled microstructure. Such LPGs were designed to enhance or suppress some particular property of the LPG, e.g. to increase its bending sensitivity or to make the LPG insensitive to external index and temperature variations.

Recently, a new, simple, highly controllable method of fabricating LPGs in optical fibers has been developed. This method is based on releasing residual stress in a drawn fiber by direct exposure of the fiber to focused light of a powerful 10.6 μm CO2 laser which locally heats the fiber. Due to the photoelastic effect the stress releasing causes changes of the refractive index of the core or the cladding. The residual stress in the fibers is given by a combination of thermal and mechanical stresses and can be controlled through the composition of the fiber core and cladding as well as through the tension during the fiber drawing. By using pulsed and CW CO2 lasers, LPGs have been fabricated in standard dispersion-shifted fibers, fibers with a silica core and fluorine-doped cladding or in fibers doped in the core or in the cladding with boron and germanium oxides. These LPGs inscriptions were realized without masks, only by controlled movement of the focused laser light along or across the fiber. Although such LPGs can be prepared without loading the fiber with hydrogen it has been found that hydrogen loading enhances the LPG quality. In contrast to UV-photoinduced LPGs, the CO2-laser-induced LPGs exhibit strong dependence of the transmission resonances on axial rotational orientation of the bent fiber.

The basic function of the LPG is that at discrete wavelengths λp, at which the phase-matching condition is fulfilled, it can couple the fundamental core mode LP01co with the effective index n01co propagating along the core, to co-propagating cladding modes LPopcl of the same symmetry with the effective indexes nopcl. As the cladding modes mean a loss, e.g. due to scattering at the cladding interface, the transmission spectrum of the LPG then contains one or several narrow attenuation bands with a FWHM of 5-10 nm centered at the wavelengths λp. The number and positions of these bands depend on the grating period Λ and effective indexes of the core and cladding modes, respectively. The effective indexes are dependent on the materials of the core and cladding, fiber structure, and external refractive index at the cladding interface, and are generally wavelength-dependent. The dependence of the effective indexes n01(co) and nop(cl) on various physical quantities is utilized in LPG sensors of temperature, strain, bending and external refractive index. Through chemically or biochemically induced changes of the external refractive index of LPG they can also be employed for chemical or biochemical sensing.

Long-period gratings (LPG) formed as periodic variations of the refractive index in the core of single-mode fibers are attracting increasing interest for possible applications in optical sensors and telecommunications. The positions and depths of narrow dips in the LPG transmission spectra depend on a number of fiber parameters and physical quantities such as temperature, axial strain, external refractive index etc. LPG have been fabricated in various ways, however, the technique employing a focused beam of a CO_2 laser seems to be very promising.

In the contribution, results on LPG fabricated by a focused beam of a CO_2 laser in step-index fibers drawn at different conditions are reported. Transmission spectra of LPG fabricated in fiber samples taken in different places of fibers drawn at 1880°C and 1930°C at several laser power levels with the beam scanned across the fiber with different velocities are shown.

The results show strong dependence of the LPG spectra on the conditions of fiber drawing and LPG fabrication. First results on the preparation of a new type of a graded-index fiber for the fabrication of LPG, from which some new properties are expected, are reported too.

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Laser Micro-Milling Technology

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There is a constant tendency to find new and economical usage of laser at the material processing in the area of the laser technology. At present, laser is used in three basic ways in technology:

- as a cutting tool (marking, cutting, carving, boring and recently there is a tendency to use laser for turning and milling),
- as a source of energy for heat operations (preheating of the material before the cutting edge of the cutting tool, hardening, tempering, welding and coating),
- Rapid Prototyping – Fast and cheap production of the complicated 3D models according to CAD data are made possible. Gradual setting of thin polymer or metal layers (from 0,05 to 0,1 mm) is the basic principle of the model production.

Laser micro-milling technology is described in more detail in this paper. This technology is suitable especially for production of forms, punches, printing blocks, tools for the ultrasonic machining and EDM electrodes. Punches and forms can be produced according to the complication of their shape in two different ways: laser-beam micro-milling and the combination of the conventional way of machining with laser micro-milling technology.

The paper is focused especially on the production of the punches and forms by laser-beam micro-milling. As in technologies using the laser-beam as a cutting tool, the heat process is concerned and micro-milling is mostly used for materials of already heat treated on the desired hardness (which is one of the substantial priorities of laser micro-milling). It was necessary to find out, if there is not any decrease of hardness of material work piece (e.g. form, punch) at the place of the influence of laser-beam. Further it was necessity defined what are the residual stresses and if it does not go at the place of the influence of laser-beam to rise the micro-crack. It was the mean reason, which made us to performance of experiments, at which it was established the following characteristics:

- the optimum laser working characteristics,
- the number of laser-beams crossing, needed for micro-milling into the desired depth,
- the quality of the machined surface, the residual stresses,
- the changes of the micro-hardness of the material work piece at the place of the influence of the laser-beam,
- the size of heat affected zone.

Experiments were performed on the constructional chromium steel to heat treatment, tool carbon steel and high-speed cutting steel, brass and electrolytic copper. The speed of laser-beam movement was changed in these experiments.

The most important results of performed experiments necessary for the punches and forms production:

- It was established that between the depth and the numbers of laser-beams crossing there is linear dependence. The cavity depth grows with the growing number of laser-beams crossing.
- The residual stresses were measured by two methods, namely the method of the gradual eating away of the material and the method of the diffraction of the X-ray. By the method of the gradual eating away of the material it was established that the

residual stresses have the character of tensile stresses. In dependence on the numbers of laser-beams crossing the measured values were in the range from 9 to 80 MPa. By the method of diffraction of the X-ray the tension stresses were established at the high-speed cutting steel 19 852 at the depth of 3 μm from the work piece surface. Regarding the low values of the measured residual stresses and with regard to previously acquired pieces of knowledge from the running of machined forms it is possible to state that residual stresses have no influence on the working life of the form. On the contrary, secondary hardening and also the rising of the micro-hardness was achieved.

- From the distribution of the dependence of the micro-hardness on the distance from the work piece surface it follows that the depth of the influenced thickness depends especially on the numbers of laser-beams crossing. It tested materials it moved from 0,0018 mm (at steel 19 857) to 0,022 mm (at steel 19 312). With the increasing numbers of laser-beams crossing the depth of the influenced thickness grows too. On the machined surfaces no micro-cracks were established.

Another way of punches and complicated forms produce is the connection of the conventional way of machining with micro-milling technology. In this case the main volume of material is removed by milling. Laser is then sequentially used for residual removal of material (sharp corners, fine formative grooves), i.e. in places where it is not possible to remove the material by milling due to the final diameter of tool.

In the production of punches it is necessary to take into consideration that the marks on punch have to be produced inclined along 30°. If it is not done when punching it results very quickly in deformation of marks. This chamfer has to be taken into consideration programming.

Laser micro-milling technology has a lot of advantages, such as the big flexibility. It is enough to compile the program for computer. By micro-milling it is possible to machine even the heat-treated, hard and hard-machining materials. Is more accurate and quicker than technologies used till this time (e.g. engraving). It is possible to produce even the very small and complicated shapes of business LOGO in 2D and 3D. In case of integration of laser into machine-tool it is possible to produce form, punch or electrode on one clamping of the work piece.

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Mathematical Modelling of Machine Tools Spindles

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Abstract

The paper describes the modelling of machine tools spindles in solver Dynast. New user-defined elements were created for this modelling. Models for statics and dynamics computation are based on FEM. The elements include mass matrix ***M*** and stiffness matrix ***K*** for element with three DOF for modelling of bending deformation or bending vibration. The models with these elements were verified.

Used solver

The Dynast software was selected for modeling of spindles. There is very easy to create computational model from standard elements library or from user-defined elements. New elements were created for computation of spindle statics and dynamics. This solution is easy, cheap and flexible.

Mathematical models of spindles

Models principles

For working precision of spindle and for cutting process stability is the bending stiffness the most important. The new elements have three degree of freedom – axial and radial movement and rotation. This three DOF are sufficient for computation of bending vibration of short fat beam, because the model can respect additional bending deformation from shearing.

Model of spindle statics

The new library element for computation of statics includes elements of stiffness matrix ***K***. The element has three connectors, which representative three DOF. The geometrical continuity of model is realized by joining of these connectors. Standard Dynast-elements like springs or force sources can be joined to all nodes of the model.

Model of spindle dynamics

Element with three DOF are used for dynamic model again. The element includes stiffness matrix ***K*** and mass matrix ***M***. The spindle model consists these beam-elements for representation of geometry. External forces and bearing stiffness are modeled by the standard Dynast-elements: springs or force sources, which are joined to specific nodes of the model.
The real spindle geometry contains same parts, which don't increase stiffness of the spindle rotor. These parts are e.g. spacer rings, rotor magnets, clamping system springs etc. These parts are the mass only and decrease natural frequencies of spindle. Special mass element was created for modelling of these parts. Model of spindle has then parallel structure (parallel joining of beams and masses).
Integral elements were created for easier model generation. These integral elements include beam and mass elements. New models with these elements have serial structure only.

Verification and using of models

Model of statics

This model was used for computation of deformation of grinding machine's grip spindle. A table of movement and turning by different load cases was computed for the machine manufacturer. The results were verified by independent computation in program SPA and by analytical computation by two load configurations.
Then the Dynast model was used for simulation of influence of bearing stiffness to enlargement of spindle static stiffness. Many types of bearings (different contact angles, ball diameters, ball material) were tested. The tests show, the bearing don't have main influence to general static stiffness of spindle. There is necessary to change spindle geometry for radical enlargement of stiffness.

Model of dynamics

An experimental stand was produced for verification of dynamics model. This stand represents a real spindle. Stand consists of spindle rotor with joined motor rotor maquette and bearings, which is included in spindle tube. There is a maquette of motor stator in the tube. There are glued accelerometers on spindle rotor. We can measure response of these accelerometers by excitation on spindle nose. This is very important, because there isn't possibility to measure this response of inner points by real spindles.
The stand geometry was modeled by new elements in Dynast. Then were natural frequencies and transmission between excitation nodes and response node computed. These results were compared with measurement results.
The maximum deviation in computation of natural frequencies between results from computation model and results from measuring is 5%. FRF were very similar.

Conclusion

The new-created elements for program Dynast enable computation of static and dynamic properties of machine tools spindles. The creating of model is quick and easy. The model gives ground information about object and enables optimalization of geometry and bearing properties.
The model was verified by measuring and is useful.

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Properties and Utilization of Machine Tool with Air High - Speed Spindle

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HSC milling spindles with manual tool change and highest speed range are often used as an additional device in conventional numerically controlled milling machines for ultra precision machining or high-speed machining of light alloys such as finishing tasks or fine detailing. These new applications require spindles with greater accuracy, higher speed range and lower vibration. The additional high-speed spindles increase quality and productivity, because different technology can be applied in the same setup of work piece. These properties make them ideal for high-speed precision applications, for example for the production of the sculptured dies and moulds. There are two basic groups of spindles - electric and air powered.

In the paper, the experience of utilization of high-speed air driven spindle is described. Before the first introduction into the real production, this spindle must be running-up to distribute grease lubrication in the bearing. Many experimental tests were performed on CNC machine tool with this auxiliary spindle. The results of basic parameters measurement, such as temperature, rotation speed, sound pressure levels, vibration diagnostics, etc. were obtained.

The paper deals with additional high-speed spindle, which is inserted and clamped into the power spindle of CNC milling machining center as an auxiliary machine equipment. The attention is focused on spindle *Deuschle DPZ 45/70/1* with spindle speed of up to 70,000 rpm. Rated at 1,1 kW, the add-on spindle with ceramic bearings and grease lubrication system is powered by compressed air, which is adjusted by separate air filter unit. Then, the air enters the speed regulation unit, which supplies the spindle. Because of the air supply and control speed loop, the add-on spindle cannot be included into automatic tool change and has to be changed manually by an operator. The air driven spindle replaces the original belt-driven spindle, increasing the machine top speed from 7,000 rpm up to 70,000 rpm (optimal working speed range of 20,000 - 60,000 rpm). The collets of the high-speed spindle allow to clamp the cutting tools with diameter up to 6 mm. This add-on spindle has been purchased as a special accessory to *MCVL 1000 Laser* vertical CNC machining center.

In addition, this milling machine tool is equipped with continuously controlled CNC rotary and tilting table as well. It means that the machining center offers five degrees of freedom, represented by three machine linear movements (X-/Y-/Z-axis) and two table rotary movements (tilting B-axis and rotary C-axis). The CNC table is located across the main working table of machining center. Thanks to the table, this machine tool is able to produce complex parts, which are manufactured continuously in five controlled driven axes in one setup. This fact increases a range of applications, which can be performed on *MCVL*.

The CNC machine tool has been additionally equipped with a diode Nd:YAG laser unit as well, which is located next to the main milling spindle. This configuration of machine tool allows to apply milling operations with laser technologies (marking, carving, polishing, boring and micro-milling as well) on straight or shaped surfaces in one setup of the work piece. The connection of the conventional way of machining with micro-milling technology allows the main volume of material remove by milling strategy. The laser is sequentially used

for residual removal of material (sharp corners, fine formative grooves), i.e. in places where it is not possible to remove the material by milling due to the final diameter of cutting tool.
The first real application of manufacturing was made with air driven spindle - the precision machining of copper electrodes for the production of small complex aircraft moulds. During manufacturing, all additional devices of the CNC machine tool were used. The shape of these electrodes was obtained in the form of 3D geometrical model (CAD data) by submitter. Next, the CAD data were imported into the *Unigraphics NX* CAM software - this system was used to generate the cutting tool path for machining. The right choice of machining strategy with suitable cutting conditions is an important step before creating part programs for production. Then, programs for roughing, semi-finishing and finishing operations can be generated. The cutting tool - 1mm ball nose end mill and rotation speed 45,000 rpm with feed rate 400 mm/m were used for finishing operations of electrodes with additional high-speed spindle.

During the real production, the first electrode was clamped into the standard vice. Roughing operations were performed using the standard cutting tool, clamped into the main spindle of machine tool. Functional sculptured surfaces of the copper electrode were finished using air driven spindle with clamped small cutting tool. Sequentially, the work piece was still clamped in the vice and was positioned underneath the laser unit. The focal distance was set using the Z- axis linear movement of the machine tool. In this position, the laser technique was used. During manufacturing very small filigree cavities, located on the functional surfaces of produced copper electrode, the laser beam was tilted according to external part program.

Another electrode was clamped directly into two rotary joints - the first joint was created by the scroll chuck of CNC rotary table (B-axis was tilted at 90°), as a second joint was used a tip of the manual tailstock, which was located opposite the CNC table. This configuration allows to supply missing rotary A-axis and to machine cylindrical surfaces continuously. Then, the semi-finishing and finishing operations were done using air spindle. The C-axis rotary table allows the cutting tool axis to be always at a normal to the surface of machined electrode. Sequentially, only linear movement in Y-axis of machine tool and rotary movement in C-axis of CNC table were used for micro-milling operations using the laser beam, which was pointed (without tilting) at Z-axis during creating fine cladding of electrode.

Using high-speed spindles and other additional devices of machine tool can help to increase the accuracy of machined parts, improve surface quality and decrease cycle times, and provide better cutting speeds for smaller diameter tools. The main reason of utilization of high-speed spindles relates to the tendency of increasing cutting speeds during manufacturing. The power spindle of machine tool does not frequently cover demanded range of revolutions. The add-on air driven spindles can be used universally because of their wide spindle speed capacity spectrum. Moreover, they allow using HSC - milling technology on current conventional CNC machine tools as well as grinding with high torque or deburring use.

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Material Information Flow Optimalization and Modelling in Manufacturing Processes

Analyse Material Flow at Build-up Steel Structures

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This text deals with problems of material flow analyse in the process of building-up building units and focuses on steel construction assembling. The branch of production and assembling steel construction is border, from the point of view of building-technological projection, where both building production and engineering technology meet. From the point of view of mechanical engineering is the terminology and technological projection engineering construction somewhat different and that is why it is necessary these differences unite.

Building technological projection deals not only with pre-production and production preparation, but also solves in advance indefinable problems of operational preparation, so-called operative scheduling. Pursuant to verification of construction progress, the model of industrial process is updated and at the same time, the comparative progress chart is carried out. For simulation of construction production is not sufficient to use only time progress chart, but is necessary to use spatio-temporal graph, which enables to joint time and technological textures on space axes.

At the simulation level of construction production is necessary to take into consideration not only the basic documents such as space, technological and time textures and check and trial plans which are used in the following period industrial process:

Front-production disposition – before processing help menu planning cards and time development plan. At the level of offers processing and closing work agreements is used prescriptive basis (database of building development from last done construction operative files). Important is an agreement on terms used typically in building construction such as termination and determination of supplier and subsupplier work. Determination of managing processes and hierarchy and realist scheduling.

Production preparation and assesment of a long-term plan – already includes detailed description of significant partial building specifications, specification of management system, level of building performance, production check and trial plan, estimation of structural features in terms of production construction, pertinent changes, coordination of nearly related processes or partial building steps, achievement of the continuity of work – balance of workers performance in the technological analysis.

Operational preparation – deals with operative scheduling and exercises control over construction progress, it is also helpful by updating the model.

This study deals more closely with assembling of building steel constructions in building process, where is for external assembly disposition necessary take into consideration the reserves and possibilities of changes because of weather conditions already in pre-production phase, as well as absence of workers, overtime work, work of specialized work squads, performance of machines etc.. Prefabrication of steel construction in the bridge-

production plant would have follow the progress at the assembly site at full blast. However character and effectiveness of production quite mismatch requirements of assembling, complete individual constructional whole like self-contained. Therefore it is necessary to analyze material flow in the process of production and assembling, which directly influence the option of assembling method. Factors influencing the choice of the method can be relatively exactly defined, i.e.. it is possible to optimize the assembling procedure.

The effort to create a modern building satisfying all safety criteria and esthetical requirements and at the same time meeting the requirement of time and expenses minimisation led to wide spread application of a new type of steel. Utilization of high strength structural and stainless steel in building industries make the steel construction producers more flexible and adjustable to the particular type of order. That is why there are more and more used the principles Just in Time in building industries , method typical in machine and industrial logistics. The whole process of production and assembling of steel constructions proceed through extremely complicated progress, therefore there will always exist from time to time some discrepancy between the agreed dates of supply and the fact date of supply, these are not due only economic situation, but also factors of production. However these factors can be more or less influenced and the analysis material flow is a tool, which can be used for minimizing of manipulation with considerable size weight building part.

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Section 9

ENERGETICS
&
POWER ENGINEERING

System for Verification of Theoretical Conclusions for Design of Switching Source

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The main using of the system is designated for verifying the theoretical conclusion of the construction switching power source. In the time, it will be used for this verification computer simulations program. The main benefit of the method is speed and simple output result. But the main disadvantage with this method is to respect the circuit topology and EMC, because it is necessary to realise a physical model of the system. The system which we describe in this article is designated for help with drive and control of the switching power source.

It is an open system, which is based on a single-chip control computer. The core of the computer is PIC 18F452. This IC contains: two PWM modules, one RS232 line , a few 10bit A/D converter and interrupt inputs.

The system contains:

1. The PC system (through RS232) can download the program in to the CPU and (optional) supervise the system, e.g. set-up program constants, turn on-off the system and further non time-critical commands.
2. The keyboard and LCD interface. This interface is designed for communication between system and operator. The keyboard has six buttons and LCD display format is 16 char x 2 lines. All buttons can call the fast interrupt, because the buttons serve as time-critical operations e.g. emergency stop.
3. The data extended bus is a 8bit bi-directional data port with two chip select signals.
4. The A/D inputs. The inputs use a chip built-in 10bit A/D converter. Each channel is optically isolated by an isolation amplifier (HCPL-7840). The minimum granted sample rate is 8 kHz.
5. The data inputs. This inputs can call fast interrupt. The main using of these inputs is zero voltage, zero current, under and over voltage/current detection. Each input has an optical isolation. These inputs are designed for high-speed regulation loop. Maximal response time is 200 ns.
6. The PWM output. This system has two depending PWM module (common repeat frequency) Each module has adjustable duty-cycle (8bit resolutions). The maximal repeater frequency is 300 kHz. The outputs have also optical isolations and output level signals are TLL/CMOS compatible, suitable for integrated power drivers (IGBT or MOSFET).

Using this system for the research

The main power circuit can be designed as PCB (THT or SMD technology) or rats-net. The control circuit is replaced or supervised by this describe system. The main advantage of this arrangement is easy to control and upgrade control programs.

Using this system for education

1. Explaining the base power switches circuit topology.
2. Dependence between circuit topology and power losses, EMC, over-voltage.
3. Dependence between control program and power losses, EMC, over-voltage.

For education and simple research it is suitable to use the module structure of circuit. Each module has a basic PCB (format 7,5x4 cm) and WAGO spring clamp. The module contains e.g. power MOSFET with driver, diode bridge rectifier, capacitors, inductance or diode. Some modules which are sensitive for EMF, are protected e.g. isolation amplifier, zero detector. For education it also serves a basic program module for PIC18F452. The program module can control the LCD, the keyboard, A/D converters, interrupt logic and PWM outputs. Or the simple program which controls the PWM is depending on keyboard commands.

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Problems with the Diagnostics of Insulating Systems in On-line Mode

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It has been demonstrated in numerous papers [1-4] that the diagnostic methods are used for the determination of actual state of high voltage (HV) insulating systems, for the estimation of their residual lifetime, their behavior estimation and the risk assessment in the future operation. Diagnostics of HV insulating systems in off-line mode, i.e. during the putout period or overhauling of the machine, is worked up sufficiently and it is broadly executed. However, the tendency of all operators is to monitor the state of their equipment continuously, i.e. by using on-line methods.

The application of some 'classical' off-line methods for on-line operational mode is inappropriate, sometimes even impracticable (e.g. direct current methods, loss factor measurement, overvoltage tests). On the other hand, suitable methods for on-line diagnostics are methods for the observation of a discharge activity, which are usually based on the monitoring of secondary effects accompanying partial discharges (PD) in dielectric materials. One of these PD methods, applicable on HV grounded objects, is the galvanic method with parallel connection of the HV coupling capacitor and the measuring impedance with a lowpass filter. The advantage of this method is also in the possibility in using it directly during the machine operation by means of permanently installed probes.

In the transition process from off-line diagnostics to on-line one (monitoring) it is not possible to take over original methodologies of the evaluation of diagnostic parameters 'automatically'. Some of diagnostic parameters of off-line diagnostics are not able to be measured in on-line diagnostics, some lose their sense and, on the other hand, it is necessary to develop new on-line diagnostic methodologies regarding of new conditions. For example, in an off-line PD measurement, the evaluation methodology is based on the dependence of basic diagnostic parameters (apparent charge, PD current, PD frequency) on applied testing voltage. In on-line measurement, the value of voltage is constant, but new dependencies appear, e.g. changes of basic diagnostic parameters in operational time. That is why is necessary to develop new methodologies based on the monitoring of time shift of diagnostic parameters.

As regards the evaluation of a diagnostic measurement, the quality of the evaluation and the reproducibility of results are stigmatized by relatively complicated methodologies and complicated (frequently artificially made) diagnostic parameters, what leads to the necessity of the consultation of top human experts for the high-quality evaluation. However, the complexity of the decision-making mechanisms (frequently on the edge of the intuitive decision-making) leads very often to the ambiguous or opposite evaluation of the actual state of the tested machine and estimation of its behavior in further operation. This practice is not acceptable for on-line diagnostics and it is one of reasons why it is not so reliable and why the on-line diagnostics is not so wide spread in these days. In connection with the on-line methodology development it is necessary to reduce a number of diagnostic parameters to the essential minimum, even at the cost of wasting partial information about the machine actual state. However, this disadvantage is entirely compensated by the fact that the changes in

diagnostic parameters in an on-line measurement are indicated at once, and the damage evolution can be monitored permanently.

The on-line measurements need a high reliability of the measuring apparatus. Unsuitability and complicity of 'classical' measuring PD measurement apparatuses is one of problems which must be solved by the diagnostic staff. The disadvantages of 'classical' equipments result from the analog data processing and from the stable system conception of the data processing. Both of them have negative influence on data processing quality: time shifts of tolerances and measuring ranges, low frequency ranges of analog amplifiers, displacement of operating points, apparatus sensitivity to disturbances etc. One of the most effective possibilities to reduce the disadvantages mentioned above is the consequent digitization of the PD impulses immediately after their detection at the beginning of the evaluation process (the best, directly after the indication of the PD impulses in the weasuring impedance) and subsequent processing digitized data only. In addition, this data processing system enables to apply an 'arbitrary' data filtration, data processing by the classical computer programs, expert systems etc.

A new principle of PD device has been developed at the Czech Technical University in Prague in cooperation with top diagnostic wokrplaces. The stable-measuring equipment (a stand, a measuring workplace) for the PD measurement and evaluation under the operational conditions in on-line (non-interruptive) mode has been developed, too. Measuring unit for the measuring, digitizing and processing PD data including a calibration equipment has been developed within. Detected analog PD impulses are digitized in the measuring unit by a special analog-digital converter and they are saved in a special memory block. The connection (via standard serial line RS232) between the measuring unit and the computer enables to transfer digitized PD impulses into a computer for their further processing.

The developed evaluating system also uses two independent expert systems for proceeding measured PD data. The rule-based expert system performs the amplitude analysis of PD impulses to specify the extent of the damage of the insulating system. The neural expert system (a neural network) has better ability of the abstraction, and therefore it is used for the phase analysis of PD impulses (the recognition of PD patterns), which enable not only to specify the kind of PD activity, but even to localize PD resources. These expert systems work simultaneously and special software controls their coordination.

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Using of Wavelet Transform and Computing Algorithms for Partial Discharge Data Cleaning

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Many people use PC for measurement and evaluation of measured diagnostic data. The staff of the High Voltage Laboratory, Czech Technical University in Prague, Faculty of Electrical Engineering, is interested in the development of the digital partial discharge measuring equipment. Partial discharge signals are converted into digital (discrete) form and then suitable computing programs are used for the saving and processing of measured data. The measuring equipment also uses special software for the elimination of the interference. By using of this software we can recognize and eliminate disturbing signals from measured data sets.

Two algorithms for the elimination of main disturbing signals from digitized partial discharge data were developed and two math theorems were applied through the computing program on all measured samples. The program applies math theorems to all measured samples, i.e. for 2000 data from ten measured periods (sets), each with 200 elements. The data cleaning computing programs were developed in the Matlab environment. The partial discharge generator [2] was also used for the generation of partial discharge data and disturbance signals.

For the basic data cleaning, we must eliminate the background disturbance, random disturbing signals and the SCR disturbing signals (disturbing signals from thyristors). For the elimination of background disturbances, we delete these elements, which magnitudes are under 50 per cent of values of measured partial discharges.

In case of random disturbance we supposed that the random signal is only one pulse in each data set and its value is about double value of the other pulses. In case of SCR disturbing signals we suppose that the disturbing signal has three periodical pulses in each set. That is why we have two of conditions, one for the amplitude and the second for the pulse's location (SCR disturbing signals consist three maximal values of the data set lined up by position in data set).

The developed algorithms deleted the disturbing signals (background disturbance, random disturbance and SCR disturbance) and we have obtained the real signals of partial discharges only. The software for disturbing signal elimination saves the cleaned data into special file for further using.

Another way for the elimination of disturbing signals from measured data is in the using of mathematical Wavelet analysis, which makes possible the elimination of more types of disturbance. Problem in these cases is in the finding out the best mother wavelet for these purposes.

The authors [3] advise Daubechies wavelet (db2) as one of the most useful mother wavelet. They found it in order to coefficient γ calculation [4]. We have also applied the discrete wavelet transformation to the same data sets. We have used a wave menu in Matlab

for it. As mother wavelet we chose the wavelet db2 and we made the decomposition in four levels. In the end we extracted the PD pulse without disturbance, but the background disturbance did not be eliminated.

In both cases (by the developed computing algorithms and by the wavelet transform) we eliminated pulses of random disturbing signal and SCR disturbing signal. In the first way, using the algorithms, we have to know the character of the disturbing signal. It is why we could eliminate the disturbance by hundred-per-cent effectiveness. In the other case, using discrete wavelet transform, we eliminate the pulses of disturbance, which pulse values are higher then the other pulse values. But in case of we do not know the character of signal disturbance or combined disturbing signal is the discrete wavelet transform better to use. We need not worry about the background disturbance because it's low values.

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Neural Network for Partial Discharge Pattern Recognition

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Insulating systems of electrical machines are the main factor affecting general reliability of a complex high voltage installation (a power plant, a switching station, a factory etc.). It is possible to determine the reliability of this equipment by tests and diagnostic measurements. The partial discharge measurement and evaluating of discharge activity in the insulating systems of high voltage electrical machines and equipment is one of the modern diagnostic methods for the evaluation of the state of insulating systems. The partial discharge measurement is also especially convenient for detecting the loosening of stator bars in rotating electrical machines which leads to the vibration of the bars during the operation, to mechanical damage of resin insulation and to the breakdown of the insulation. From this point of view the partial discharge measurement is the most effective method for evaluating the state of modern insulating systems based on the resin insulation. In addition, this method enables to check the state of the machine during its operation without any interruption (on-line method).

The evaluation of the discharge activity and the estimation of the machine performance in further operation are complicated, and that is why it is necessary to consult experienced experts. Expert systems are also a convenient solution for the evaluation of partial discharge data and for the estimation of behavior of the insulation system in future operation, because they use knowledge base and experience of human-experts from the previous measurements. The results of the expert systems are not only in the form of processed data of diagnostic parameters, but, in addition, they give recommendations to servicemen for the future operation of the observed machine or equipment. The most advantage of these expert systems is the fact, that by means of an expert system, even an inexperienced worker is able to decide competently about the state of the insulating systems and about the equipment behavior in further operation. During an on-line measurement, the expert system indicates a defect of the insulating system immediately and, at the same time, offers a solution with respect to the safety and reliability of the machine or equipment in further operation.

Nowadays, the most modern processes for partial discharge data evaluation are the amplitude analysis of current partial discharge pulses (for determining the damage of the insulation system) and the phase analysis of current partial discharge pulses (to determine the kind of partial discharge activity and for the localization of sources of partial discharge activity, respectively).

The phase analysis of partial discharge patterns is the process, which needs the high level of an abstraction. That is why we must use an intelligence system with the largest abstraction – neural network. However, the training of a neural network is very complicated – we must create a credible training set.

The aim of this project is to develop and make a neuron network for the recognition of partial discharge patterns (a phase analysis of partial discharge impulses) to determine the kind of discharge activity and the location of the source of discharge activity. Neural network will work separately or in cooperation with other evaluating systems, e.g. with the rule-based expert system for the amplitude analysis of partial discharge pulses.

The final neural network for the recognition of partial discharge patterns will be modified stepwise (step-by-step) by following training sets:
1st step: A training set for the modification of the neural network will be developed on the basis of information from literature and experience of human experts. The special SW generator of partial discharge impulses will be developed and created for the training of neural networks.
2nd step: A training set will be created following a direct measurement of partial discharge activity on simple high voltage arrangements.
3rd step: A training set will be created on base a direct measurement of partial discharge activity on real high voltage apparatus with known defects.

The 1st step was successfully finished. A neural network for recognition of partial discharge patterns has been developed using the Neutral Network Toolbox of Matlab®6. Choosing a suitable network topology, a training set and an algorithm, the neural network was successfully trained. This neural network recognizes not only basic partial discharge patterns, but also eliminates the negative influence of ambient disturbances. The others steps will be accomplished in a near future.

The results of this project will expand the scientific field of electrodiagnostics and artificial intelligence. In operation, the results increase the safety and reliability of the operation of large electrical machines (alternators and transformers) and high voltage equipment working in the Czech National Network System.

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Influence of the Coil Winding on Propagation and Attenuation of Partial Discharge

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The detection and measurement of partial discharges in the transformers insulation is one of the most useful diagnostic tools for quality assurance testing during design, manufacturing and service life assessment.

In the Laboratory of High Voltage of the Czech Technical University in Prague a lot of measurements of the attenuation of partial discharge pulses on the model of winding were realized. Current pulses from a charge calibrator were injected into different parts of winding, while their deformations were been observed, and the distortion of the charge at the end terminals was evaluated. It was found that the apparent charge of a partial discharge is a diagnostic parameter which is not relatively very sensitive, comparing to other diagnostic parameters, e.g. to the size the partial discharge pulse, to changes in shape and size of a partial discharge current pulse caused by passing through the winding.

After passing through the winding the charge of the partial discharge was evaluated by integration of current pulse on terminals by means of three different methods. It was found that the attenuation of the partial discharge pulse is significant. It was also confirmed by all three evaluating methods with similar results. Furthermore, a measurement both of the attenuation of pulse and changes of partial discharge charge was realized on different types of winding. It resulted in finding that the attenuation of the partial discharge charge on different types of winding depends on the winding parameters.

The shape of the partial discharge pulse is significantly influenced by passing through the winding. It can be distorted and then its apparent charge is very difficult to evaluate (i.e. in the pulse oscillation). Our aim was to find out which parts of the distorted current pulse of the partial discharge are the most suitable for the evaluation, so that the apparent charge of the pulse would show the smallest change. Therefore we used following three methods for evaluating the distorted current pulse of the partial discharge.

We can see that the charge decreases while passing through the winding, when passing the 40 per cent of the winding it decreases to about 80 per cent of its original value, when passing 70 per cent of the winding to about 60 per cent of the value, when passing 90 per cent of the winding to about 25 per cent of its original value. This fact was confirmed with all the methods of evaluation. The differences among the methods of evaluation of the apparent charge of the distorted partial discharge were not significant. Differences in values obtained in method a), i.e. q_1 (this method is used by the majority of commercial measurers) and in method b) i.e. q_p are max. 7 per cent, between q_1 and q_s (method c) is max. 5 per cent, which is quite acceptable for the operation measurements of the partial discharge deviation.

To be able to find out the influence of the different type of winding and winding parameters on the attenuation of the apparent charge we made measurements of the pulse attenuation and changes of the charge of partial discharges on different windings. We also measured the independence of measured values of the apparent charge on the partial discharge pulse passing through three different windings.

The attenuation of the apparent charge of the partial discharge on different windings is similar and depends on winding parameters. This stands for all types of windings. In case of the plate winding (winding C) extra resonances and reflections occurred.

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Implementation of Signal Microcontrollers in Technical Resources of Regulation

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Over the last years, the advanced methods of AC and DC motor control are very often used to improve drive behavior. In most cases, these methods use a complex mathematical calculation. Therefore the high performance microprocessor based motor controller is needed. Many ICs manufacturers like Texas Instruments, Motorola, Analog Devices produce microprocessors designed especially for motor controllers. At our department we have a good experience with Texas Instruments digital signal processors (DSP) TMS320F240. So we chose its successor TMS320LF2407A for designing of digital signal processor based controller ProDrive III. In addition the field programmable gate array (FPGA) Altera Cyclone is connected with microprocessor to improve performance and facilities of controller.

The controller ProDrive III is based on two main components – DSP and FPGA. Implementation of high performance DSP (40 MIPS) together with the fast FPGA (up to 300 MHz internal clock) is very effective. The FPGA is connected both to input/output connectors and directly to address and data bus of DSP to fast data transfer should be possible. It is important, because through FPGA can be few ProDrive III controllers connected together to build a multiprocessor system for sophisticated applications. Most of known digital peripheral such as input/output ports, I2C, CAN bus, USB controller, PWM generators and so on can also be programmed to the FPGA to extend abilities of DSP.

The implemented DSP is high performance 16-bit, fixed point microprocessor especially designed for using in motor control applications. The microprocessor contains fast RISC kernel which offers sufficient performance for advanced control algorithms for techniques such as adaptive control, Kalman filtering and state control. Further many peripherals are included in microprocessor such as 32KW flash memory for program storing, 2KW static RAM for data storing, fast 10 bit 16 channel A/D converter, CAN bus and SPI controller and two event manager unit for PWM signal generating.

The controller ProDrive III is designed for developing as well as for using in end applications. All electronic components are placed on four layer board with size of small Eurocard (100 x 160mm) industrial standard. Together with main components (FPGA and DSP), another components are added to the board in order to extend usability of controller. These added components using in the most cases the I2C bus. Therefore the I2C controller is programmed in the FPGA to DSP should easy access to these components. To the I2C bus is connected serial EEPROM (64 KWords) for applications which need to preserve some data against power failure like parameters of device or postmort data. The RTC (real time clock) with backup battery is also connected to the I2C bus. This RTC can provide system timing or generate interrupts to microprocessor on predefined date and time. Next the digital thermometer for temperature monitoring and four channel 10 bit D/A converter are connected to the I2C bus. In addition, the I2C bus is accessible through the connector for connecting other I2C devices.

The ProDrive III can communicate with other systems through three buses – SCI (RS232 line), SPI and optically isolated CAN bus. SCI is also used for program loading. Program can be loaded to internal FLASH (32 KWords) of microprocessor or to the external RAM (32 KWords) that enables easy program developing. For an application data is available internal RAM (2KWords) or external RAM (32KWords).

The advantage is that power supply is placed on the board, so the ProDrive III needs only one not regulated DC supply voltage at range 8V to 24V. The switching and linear voltage regulators on the board generate required voltage (1.5V, 3.3V and 5V). The independent linear voltage regulator is used for supplying A/D converter and analog sections to increase noise immunity.

Most of components described above have their signals connected to the connectors. The connectors are placed at the sides of the board. The ProDrive III offers these types of signals: 36x general purpose input/output (3.3V logic), 16x PWM output with deadband ability for driving single transistors or transistors connected in bridge (3.3V logic), 2x QEP (quadrature encoder pulse circuit) input for connecting two incremental sensors (3.3V logic), 16x analog inputs to the high performance (375ns conversion time) A/D converter with overvoltage and undervoltage protection (0 to 3,3V), 4x analog output of D/A converter, SPI, SCI and optically isolated CAN bus.

The complex supporting software was programmed for PC within the project. This software allows ProDrive III board control and monitoring in real time. The communication between the board and PC is established through the RS232 line with help of sophisticated serial protocol with CRC16 protection. This protocol ensures reliable data transfer. During developing of the software was put the accent on comfortable software control. The software is based on graphical user interface with several control panels. Through this panels can be watched or changed content of any register (HEX, DEC, BIN and bargraph visualization), displayed in graph the register content changing in time, changed or watched up to 256 application parameters. The 16 buttons are placed on the main control panel for application program control. With the help of this software can be downloaded user program into the controller too.

The motor controller ProDrive III is general purpose board with the high performance microprocessor (40 MIPS) especially designed for motor control application. This board can drive up to two power converters (inverters for AC motors, choppers for DC motors, compatible rectifiers, controlled rectifier and so on) simultaneously. The ProDrive III is suitable for using in traction (main and slave drives) and other electric vehicles too. Universities can also use this board for educational purpose. The controller ProDrive III with the help of graphical supporting software for PC allows easy and comfortable developing and subsequent implementation advanced control systems based on usage of digital signal processors. In addition used FPGA offers easy adaptation to wide range of applications.

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Photovoltaic Systems

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After 30 years of development, the market for photovoltaic systems has started growing in recent years, and the market growth will be about 30% per year to achieve 3 GW_p of installed power in the European Union by 2010. An increased demand for specialists in this area is therefore anticipated in the relatively near future.

Photovoltaics is relatively broad and interdisciplinary field. On one side there are necessary deep knowledge on material physics and the interactions with incident light, cell structure optimising, anti-reflection coating to understand physical construction of different types of solar cells. There are many different technological processes used for fabrication solar cells and photovoltaic modules. On the side of applications, there are important knowledge about characteristics, relations between load and maximum power output and operating conditions of photovoltaic systems that depend on meteorological situation. To understand problems in this field needs more detailed course than a part of general course on renewable energy sources.

At the Faculty of Electrical Engineering of the CTU in Prague, in 1996 a course on photovoltaics was introduced as an optional course (2 + 2) in undergraduate study. Since then, about 30 students per year have chosen the course as a part of study programme. The programme of lectures established in the form

COURSE STRUCTURE - LECTURES

Week	content
1.	Solar energy and basic forms of its exploitation
2.	Ways of conversion of solar energy into electrical energy
3.	Solar thermal systems
4.	Photovoltaic effect
5.	Solar cells, basic structure and characteristics
6.	Single-crystalline, poly-crystalline and thin film solar cells
7.	Construction and technology of high-efficient solar cells
8.	Construction and technology of modules
9.	Photovoltaic systems – basic types
10.	Stand alone systems
11.	Grid-on systems, system operating conditions
12.	Energy storage for photovoltaic systems
13.	Photochemical cells and fuel cells.
14.	Economical and ecological aspects of photovoltaics

This way, students are given relatively detailed information about both devices (structure, physics and technology) and applications.

Practical exercises form a very important part of the course. At the beginning, they were oriented on physics and fabrication of solar cells. On demands the practicals became

more application-oriented in the year 2000, where tasks on photovoltaic modules were introduced.

COURSE STRUCTURE - Practicum (after 2000)

Week	content
1.	Organisation, introduction
2.	Laboratory measurements on solar cells – explanation
3.	Comparison of V-A characteristics of different types of solar cells
4.	Influence of series resistance on characteristics of solar cells
5.	Influence of parallel resistance of solar cells
6.	Temperature dependence of solar cell parameters, 1. check test
7.	Fabrication of silicon solar cells – explanation with samples
8.	Laboratory measurements on solar cells – explanation
9.	Measurements of solar module characteristics
10.	Measurements on a solar module – dc load system
11.	Measurements on a solar module – regulator – battery – dc load system
12.	Measurements on a solar module – dc/dc – dc/ac system
13.	Photovoltaic system design (simulation)
14.	Final test

Measurements on 26 W_p modules have been performed in exterior using direct sunshine. This brings some problems with respect to timetable: exercises must be performed in summer semester in he middle of the day and the result of practical measurements depends on weather. The main aim of this project was to develop measurements on photovoltaic modules in laboratory conditions.

Laboratory measurements on 26 W_p modules were developed using halogen bulb (1000 W) with Fresnel lenses collimator as a light source. This solution allows prepare collimated source of incident light of intensity about 500 W/m^2 of area 380x500 mm^2 which may be used for measurements on photovoltaic modules. For demonstrations, a 3kW_p on-grid connected photovoltaic system on a roof of the Faculty has been also included into the exercise curricula. The course has become more applications-oriented and more suitable for students from all branches of study in the field of electrical engineering, even they obtain during the course full set of information about physics, materials and fabrication processes.

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The Steam Cogeneration Unit

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One relatively very effective way to enhancement utilize of primary energy sources is electrical energy and heat cogeneration, which enables fuel utilization from 70 up 90%. About 6 % of electrical energy consumption in advanced countries is generated in cogeneration systems at present. This quantity could be several times increased by all possibilities utilization. Present estimations show that up to 30 % of electrical energy consumption can be generated this way disregarding equivalent ecological effect namely.

Project description in compliance with the internal grant having been solved in 2000, the project was dealing with fundamental problems connected with finalizing the development and operational tests on a small cogeneration unit. The project was primarily aimed at:

1) Carrying out inevitable verifying and operational tests on a designed small cogeneration unit prototype, using their results to develop and implement necessary constructional modifications of the prototype.
2) Verifying predetermined operational properties and output parameters of the unit.
3) Finalizing the development, checking the triggering and regulating mechanism of the cogeneration unit while verifying its function under operational conditions.
4) Optimizing the cogeneration unit based on operational tests.
5) Verifying output levels of the unit depending on steam parameters and distribution timing.

A cogeneration unit equipped with a non-lubricated working cylinder eliminating any oil content in steam supplied is being developed at present in cooperation with PolyComp Ltd. in order to substitute the pressure-reducing valve in terms of low output for rotating reduction designed also for customers who for technological reasons exclude even the lowest content of oil in steam delivered. As in case of the previous design, this prototype also utilizes fundamental components of the combustion engine produced in series. The original piston functions as a crosshead in this type of solution. The working cylinder itself, taken over from the combustion piston-type engine produced in series and designed with special non-lubricated piston rings, represents a superstructure of the equipment. The whole unit is designed as double acting. This solution has a positive impact on the even function of the unit. The projected investment costs of this design are comparable with the original concept of the cogeneration unit. A similar equipment developed abroad, utilizing a standard steam machine design in contrast with the above given concept, is incomparably more expensive and its use in our conditions is unreal in terms of capital costs.

The project solves problems connected with a possible substitution of pressure reducing valves in medium-pressure boiler rooms for ”rotating reduction“ using a steam machine. The solution makes it possible to utilize full-value of steam energy in order to produce electric power. The pressure energy comes to nothing when using a pressure-reducing valve. Putting the project into practice will make it possible to increase considerably the use of energy in fuel and besides an economical positive impact; it will result in a substantial ecological effect.

With regard to the fact that the pressure reducing valve successful substitution for the steam machine is conditioned mainly by low investment requirements, the gear lay-out was based on the original system of rotating inlet and exhaust cylinders (slide valves) without the possibility of the gear resetting during the steam machine operation. The gear design itself makes it possible to adjust the steam machine to new working conditions by a relatively simple replacement of slide valves sets, taking into consideration both admission and emission pressures, as well as admission changes. It permits to use the unit for a relatively wide range of admission and emission steam pressures simply by changing sets of rotating cylinders. The IG solvers were awarded a certificate in an industrial design registration for the combustion engine application and the steam machine gear system.

The physical principle of the pressure reducing valve substitution for rotating reduction results in the fact that regardless of the value of achieved effectiveness of the pressure energy transformation into useful work, the additional fuel costs given in kJ are always equal to the electric power produced in the cogeneration unit in kWh substituting the pressure-reducing valve. The cogeneration unit effectiveness level does not, therefore, influence its operational costs. Simple and cost-effective machines are thus considered the most suitable ones from the economical point of view, even in case of lower transformation effectiveness.

Present level of electronics allows especially for larger outputs per unit use configuration that consists of cogeneration unit - power generator - frequency converter.

Marketing research results and responses from exhibitions where cogeneration plant was exhibited proves great interest of heat energy sources operators. Decentralization effort of electric energy and heat generation also belongs among subsidiary and indispensable arguments. This could mean independence on supplies from outside electric distribution nets. Vice versa in the case of surplus electricity can be supplied to these nets.

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Testing of PLC System and Its Co-existence with Other Transmission Systems

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Powerline Communication (PLC) is a common term used for transmission of communication and data signals over the existing low-voltage electricity distribution grids 110 or 230 V. This is a new technology in the "last mile" of broadband access networks which could be used together with ADSL or Wi-Fi enables to connect end subscribers to broadband services like Internet, video-conference, digital broadcasting and other multimedia applications. Primary advantage of PLC is existence of transport medium throughout the world because the electricity grid covers approximately 95% of the world and it is the largest worldwide network.

There are now about tens of companies all over the world developing own PLC systems or its components. The most famous and most successful companies with own complex PLC systems are Ascom (Switzerland), Corinex (Canada) or DS2 (Spain). These companies produce PLC systems based on Orthogonal Frequency Division Multiplex (OFDM) or Gaussian Minimum Shift Keying (GMSK) of communication signal. These systems works mainly in frequency band from ones to tens of MHz and the choice of carrier frequencies is based on measurements and frequency planning with respect to individual national standards. Achieved data rates are typically between 4 and 14 Mbps on distances of few hundreds metres. System components are compact and small and could be easily installed by customer.

First trials with PLC technology were held in Manchester, United Kingdom, in 1997 and since this there were carried many other pilot trials in many countries all around the world. PLC technology was introduced in Czech Republic by Ascom in 2002 when were commenced first trials and one of these project was placed to the Department of Telecommunication Engineering where were installed single network consisted of only two devices.

Ascom PLC system works with GSMK modulation and it is based on Master-Slave architecture divided into two zones: procedures performed outside the building (Outdoor) and procedures inside the building (Indoor). The Outdoor Master device is typically placed in local transformer station and sends a data stream compound of voice and Internet signals via a distribution grid to the individual households. There are Access Points which forwarded incoming data to the Indoor network where intermediate adapters separate power and data. Other possibility of usage offers Indoor Master. This device is placed in a building and it is directly connected to the backbone network. Indoor Master together with a relevant number of Indoor Adapters makes a local network. This case of just Indoor PLC system was tested in this project where the Master position is fixed and Adapter could be moved anywhere to test inherence of PLC signal.

Ascom PLC Indoor System operates on three carriers in frequency band from 15 to 30 MHz and the maximum possible data rate is 4.5 Mbps on distance 80 – 100 metres. There is a graphical configuration, analysis and measurement tool PLCcam. This software provides

fundamental capabilities to configure and to control Ascom PLC units from any point, which provides network connectivity to the desired PLC unit.

Joining of PLC signal into low-voltage electricity distribution grid is always made by connecting between two of three phase conductors for example by 3-phase power socket. Choice of concrete pair of conductors is based on monitoring of the PLC signal quality. In most cases one pair of conductors has better Signal Noise Ratio the others. This selection can be done by user or is automatic depending on the type of Master device. Adapters are connected via standard power sockets so the PLC signal is connected between phase and neutral conductor.

In this contribution are present first results and practical experiences with Ascom PLC Indoor system. First sort of testing showed that Indoor Master is able to cover perfectly rooms all over the floor (about 60 metres). There was an idea to cover with this Master two more floors (above and underneath) but there was found a problem with individual distribution grids for each floor in our block. So there is a necessity to move Master to distribution point for coverage of more floors.

Next tests were held with Adapter in the biggest possible distance (53 metres) from the Master. These tests were aim to common office work like Internet browsing, sending e-mails etc. together with multimedia applications like listening of digital broadcast. PLC system provides access to all mentioned services without any problems and with the same access rate as in case of standard connection to local network. (During these trials maximum capacity of PLC system was used just by one user adapter.)

This phase was followed by measurements of Cell Error Ratio (CER) of PLC signal carried out by PLCcam software. There were made few series of measurements in two extreme points and all measurements were done for three possible combinations of joining PLC signals between pairs of phase conductors. Peak values of CER attained 8.9% in the biggest distance of 53 metres and 0.4% in the smallest distance (in the same room as Master). These values of CER are not high but in other pilot trials in Czech republic carried out in other larger locations were reached lower. The main cause could be in method of connection of Master to distribution grid. There was used 3-phase socket in our case while other projects used inductive method with ferrite barrel conjunctions which generally shows better conditions of joining PLC signal into distribution grid.

There was not made any special measurement for EMI of PLC system but after a year of running there is not known any case of interference of PLC signal with other telecommunication systems or computer equipment used on the same floor.

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Creating of Expert System Database for Evaluation of Combustion Engine Defects from Rounning Roghness Measurement

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The presumption for the effective usage of the non dismantling diagnosis method is, that this method is reliable and fast enough for the determination of the type and place where the defect originates. The further requirement is, that there is a collection of the typical defects obtainable, which arise most often during the operation. To distinguish and detect precisely and quickly the defect means, that the method has the sufficient differentiation capability.

The method, which establishes the defects of the combustion engines by means of the instant angular speed measurement of the crankshaft, complies with this requirement. Therefore the final task for the use in the practice is to create the collection of data knowledge in the sufficient quantity and to store them in the PC memory.

In the laboratory conditions there is a problem, that does not exist the sufficient quantity of the test engines for the forming of the faults collection and therefore the possibilities of the verification of the influence of the single defects are very limited. The way how to proceed is the faults simulation. The simulated fault must be sufficiently expressed but it must not be severe in such a way, that the engine may be damaged.. The range of the simulated defects is therefore rather restricted.

The developed diagnosis method is suitable for the engine with a number of cylinders in the lower level. For this reason the two cylinder engine was tested and analysed. (ČKD PRAHA 2S110 engine,15 kW, 1500 ot/min).

The defects simulation enclosed the reduction of the output due to the increased mechanical friction losses, due to the untightness of the piston or valve, due to incorrect adjusting of the engine etc. During the tests the courses of the angular acceleration were picked up. They show the changes in the characteristic of the measured course due to the simulated defects mentioned above. To obtain the broader bases of the data it is necessary to carry out the measurement on the other types of the engines with the respect to the number of the cylinders.

Another way how to simulate the defects is the mathematical modelling of the engine. It is then very easy to realize the changes of the input and output parameters. With respect to the complexity of the mathematical methods used and due to the difficulty in getting the required parameters, the work on the model is being carried out.

The problem in the final phase of the target is the independent verification of the correctness of the method in question. The standard way is the combustion pressure measurement. It was also followed, but the probes and the software are very expensive and the realisation will continue according to the further situation.

The important property for the method is the reproducibility. That was proved by means of the repeated measurements with the same conditions of the engine. The reproducibility can be used with advantage by the measurement of the good and faulty engine respectively after the repair, which was carried out in the service shop.

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Section 10

NUCLEAR ENGINEERING

Diffusion of Tritium and Cesium in Compacted Bentonite

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A high-level radioactive waste is planned to be released in deep geological repository (DGR) in steel canisters. After canisters failure the spent fuel will get into the contact with water and radionuclides will migrate through corrosion products and surrounding materials to geosphere. The basic parameters to determine release rates of radionuclides out of the repository to the geosphere and biosphere are: leaching rates of radionuclides from waste matrices, solubility of radionuclides, and sorption and diffusion coefficients of radionuclides in the near and far field of the repository. The work performed in co-operation of NRI Rez and CTU was focused on the implementation of methods for determination of diffusion coefficients in near field region of the repository.

The important role in the Czech concept of DGR plays compacted bentonite, which will protect, after possible canister failure, waste forms from the contact with groundwater and slows down migration of released radionuclides to the geosphere. The permeability of bentonite is so low that the main way of transport will be diffusion. Porosity, bulk density, distribution (K_D) and effective (D_e) and apparent (D_a) diffusion coefficients are parameters, which are necessary for calculations based on the solution of diffusion equation. The effective diffusion coefficient D_e describes the diffusion in pore water in the case of sorption equilibrium, the apparent diffusion coefficient D_a reflects the sorption quality of bentonite.

Analytical solution of transport equation including dependence of sorption on concentration or other factors such as pH, Eh or groundwater composition would be very complicated and probably not feasible. This obstacle could be possible to overcome by numerical modelling. In approximate numerical modelling it is possible to input easily distribution coefficients as a function of concentration or other factor in the model. Despite extensive research in this area in the past 20 years, the question of diffusion coefficients is still open. This confirms recent literature surveys of Yu and Neretnieks [2], in which values of diffusion coefficients for cesium differ by orders of magnitude (D_a = 1 x 10^{-10} to 8.5 x 10^{-13} m^2/s).

For radionuclides that can penetrate in reasonable time through the bentonite layer the through-diffusion method is suitable. In case of highly sorbed radionuclides, it is usually used the method of planar source (also “in-diffusion” method). The development of diffusion cells suitable to determination of both diffusion coefficients mentioned proceeded through several phases. The stainless steels diffusion cells with brass frites of diameters 30 mm for penetrating radionuclides (through diffusion method) were first build-up, as usual, by pumps and two vessels for mixing solutions with contaminants. The system of circulation of solutions around frites using tubes and pumps turned out to be, however, unreliable and therefore, the diffusion cells were replaced by cells with direct contact with solutions. A laboratory shaker ensures the mixing of solutions during diffusion experiments. Measuring of water comsumption during bentonite saturation proceding diffusion experiments checked out the full saturation of compacted bentonite samples with water.

For the first through-diffusion experiments, tritium, representing a group of non-sorbing radionuclides, was used. Tritium was measured using liquid scintillation spectroscopy in Central Analytical Laboratory of NRI. For further both through-diffusion and planar source experiments ^{137}Cs was used. For evaluation of planar source the bentonite samples after experiments were cut in the developed cutting equipment. NaI(Tl) scintillation detector was used for measurement of ^{137}Cs activity.

Via our through-diffusion experiment effective diffusion coefficient (D_e) was determined. The solution of diffusion equation and calculation of D_e is based on the assumption of constant concentration of contaminants on two sides of the diffusion cell and achieving the steady state in the diffusion. Using through-diffusion experiment it is also possible to evaluate so called apparent diffusion coefficients D_a.

Through diffusion experiments with tritium were performed for about 30 days with two types of Czech bentonites and with distilled or synthetic granitic water. The values obtained (D_a = 9.8 x 10^{-11} to 3.8 x 10^{-10} m^2/s, D_e = 1.3 x 10^{-10} to 2.6 x 10^{-10} m^2/s) are in the same range as the values obtained by Kato [3].

In the same through-diffusion arrangement, the experiments with cesium were performed. The experiments were finished after approx. 100 days without penetration of cesium through the bentonite layer. The decrease of activity in the vessel with cesium was recorded and the bentonite samples after experiments were cut into thin slices. D_a values obtained in through-diffusion arrangement were in the range 5.5 x 10^{-14} to 1.8 x 10^{-13} m^2/s. The result of cesium apparent diffusion coefficients obtained by planar source method was 7.7 x 10^{-14} m^2/s. The results for cesium from both through-diffusion and planar source methods corresponded to each other which showed a good experimental technique and a proper method of mathematical evaluation of results.

The experiments will be continued in the future period to confirm the results obtained and to start systematic measurements of migration parameters of radionuclides in bentonite and other repository materials.

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Experimental Study and Mathematical Modeling of Cs(I) and Sr(II) Sorption on Bentonite and Corrosion Products Using Three Types of SCM and Generalized Composite and Component Aditivity Approaches

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The controlling process of migration of radionuclides through bentonite barrier in deep geological repository is the diffusion, which is strongly influenced by sorption phenomena. In our deep geological repository the canisters made of stainless and carbon steel and compacted bentonite barrier are planed. The aim of this work was to experimentally investigate sorption processes in such system and to find out appropriate mathematical description.

Based on own experiences and literature data, we arranged batch experiments in PE vials. The experimental systems consisted of: (i) synthetic granitic ground water with a given ionic strength and concentrations of radionuclides studied; (ii) pretreated (with the aim to remove carbonates) bentonite suspension; (iii) solid magnetite as a representative of corrosion products of steel (two corrosion test were performed to identify main corrosion products).

The interaction of protons and hydroxyl ions with the bentonite, magnetite and their mixture was investigated by alkalimetric and acidimetric titrations under exclusion of CO_2 (N_2 atmosphere) for ionic strengths of background electrolyte 0.1 and 0.01 ($NaNO_3$) [1].

The percentage of sorption as a function of pH was determined under oxic conditions at room temperature. Preliminary experiments, with the aim to study sorption on vessel walls, phase separation conditions and time of equilibrium (28 days are required for equilibrium establishment), were performed. The suspension of bentonite or magnetite powder or their mixture were mixed with required amount of liquid phase (synthetic granitic water, 10^{-6} mol/l CsCl or $SrCl_2.6H_2O$ spiked with ^{137}Cs or ^{85}Sr) under given conditions. During 28 - day period the pH of the system was five times adjusted to the pH value required. Then phases were separated by centrifugation and the equilibrium Cs or Sr concentrations in solution were determined [2, 3].

The resulting data were modeled using: (i) surface complexation models for edge sites, namely, two electrostatic – Diffusion Double Layer Model (DLM) and Constant Capacitance Model (CCM) - and Chemical Model (CEM), without an electrostatic correction, (ii) ion exchange model (IExM) for layer sites. The corresponding program package was developed (STAMB-2003). For the modeling of sorption data, two different approaches were tested: (i) Generalized Composite Approach (GC), where the bentonite-magnetite mixture was considered as compact sorbent characterised by a single set of titration and sorption parameters, which were sought by direct fitting of experimental data, (ii) Component Additivity Approach (CA), composed of weighted combination of models describing sorption on bentonite and magnetite [4]. Sorption parameters were obtained by fitting appropriate experimental data. Data calculated by CA Approach for given mixture of bentonite and magnetite were compared with corresponding experimental data.

Formulation of sorption equations was based on speciation of Cs(I) and Sr(II) in granitic water. In case of cesium, Cs^+ dominates in the system in the whole pH range. For strontium, important forms (> 0.1%) are: Sr^{2+}, $SrCO_3^0$, $SrNO_3^+$ and $SrSO_4^0$; precipitation of $SrCO_3$ occurs approx. at pH > 10. All activity coefficients were calculated using Davis equation. The formation of sorption complexes on edge sites ($\equiv SO^-$, $\equiv SOH$, $\equiv SOH^{2+}$) and sorption by ion exchange on layer sites ($\equiv X$) were considered for the sorbents modeled.

In the first modeling step, the protonation constants, total concentration of edge sites, cation exchange constants, total concentration of layer sites for bentonite, magnetite and their mixture and Helmholz capacitance for CCM were obtained via fitting of titration data. The goodness of fit was evaluated by means of the WSOS/DF criterion, the values of which should be approximately lower then 20. On the basis of these criteria values and the meaningful values of the parameters, the CEM models, including the ion exchange model (IExM), were chosenand the corresponding values of above mentioned quantities were used for further calculation.

In the second modelling step, the experimental data of sorption of Cs(I) or Sr(II), separately on bentonite and separately on magnetite and on the mixture of bentonite and magnetite, were fitted by CEM+IExM. The corresponding averaged values of sorption constants, including the WSOS/DF, were obtained. From the results it is evident that the sorption of both metals on magnetite depends more on pH than their sorption on bentonite, but the values of WSOS/DF point to the better goodniss-of-fit of sorption on bentonite. In addition to this it has been found that the reactions taking place on layer sites play the most important role in the sorption proces.

The sorption of Cs(I) and Sr(II) on mixture of bentonite + magnetite (see above) was predicted via CA approach using CEM + IExM models and input data gained from modeling of sorption experimental data of Cs(I) or Sr(II) separately on bentonite and separately on magnetite.

In order to enable quantitative comparison, calculation of values of WSOS/DF was incorporated into CA Approach code, too. The following order of suitability of CEM + IExM models to the prediction of sorption of cesium and strontium on the mixture of bentonite and magnetite, was found (the averaged values of WSOS/DF are given in brackets):

GC Approach: Cs (6.49) > Sr (9.42)

CA Approach: Cs (3.92) > Sr (24.9)

It seems to be evident that both approaches are quite well comparable, especially in the case of sorption of cesium.

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Preparation and Realization of Experiment with Subcritical Assembly BLAŽKA and External Neutron Source NG2 at Cyclotron in Nuclear Physics Institute, Academy of Sciences of the Czech Republic

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Faculty of Nuclear Science and Physical Engineering, Department of Nuclear Reactors (FNSPE DNR), solves problems associated with a dynamics behaviour of subcritical reactor with external neutron source and provides wide information for study of transmutation technology. FNSPE DNR closely co-operates with Nuclear Physics Institute (NPI), Academy of Sciences of the Czech Republic in study of this issue. In a close collaboration of the NPI Řež and at the FSNPE DNR , the high-power external neutron source at the NPI Fast Neutron Facility (FNF) and the module of the fluoride-salt subcritical blanket Blažka at the FSNPE DNR were developed. Both, the basic characteristics of these facilities and the forthcoming research program are outlined. Experimental research program concerns the neutronics of AD (Accelerator Driven) system which employs a subcritical blanket Blažka and an external fast-neutron source NG2. Experimental measurement with blanket Blažka and external neutron source NG2 will be conducted in first quarter of this year at NPI.

Subcritical blanket Blažka was designed and fabricated at Department of Nuclear Reactors. Blanket consists of graphite, NaF, and fuel element EK-10 (core of fuel element is constructed by mixture of UO_2 and Mg , ^{235}U enrichment is 10%, ρ = 5.87 g.cm^{-3}, height – 500 mm and diameter - 3.5 mm, number of fuel elements EK-10 is 232). NaF was stored in polyethylene covers (covers isolate chemically aggressive NaF from fuel elements). Fuel elements EK-10, NaF and graphite were assembled in regular square lattice. These all materials were stacked up in aluminium cover (height - 731 mm, cross section - 355x355 mm). Value of blanket's multiplication factor is approximately 0,5. There is a graphite block in the centre of the blanket, which can be changed for another materials or some equipment (for example the inlet for the external neutron source NG2).

The NPI Fast Neutron Facility (FNF) employs the variable energy cyclotron U-120M, operating in two modes. In the positive-mode, protons, deuterons and $^{3,4}He^{++}$-ions of energy up to 22, 18 and 50 MeV, respectively are at disposal for the NG1 target station. Higher-power beam (current up to 20 μA) of protons and deuterons (energy of 35 and 18 MeV, respectively) could be delivered on the NG2 target station in the negative-ion extraction mode. Fast neutron sources based on protons and deuterons from low energy cyclotrons provide intensities that cannot be generated by other methods. The present FNF activities are based on results of the experimental investigation of light-nuclei break-up reaction at medium incident energies, performed at the NPI. In a series of experiments the deuteron break-up process in light nuclei reaction has been proven as the most powerful neutron source with respect to accelerated particles and beam energies available for the NPI cyclotron. Results have allowed to formulate various benchmarking experiments of the fast neutron production,

neutron transport and neutron activation calculations, being formulated at NPI under auspices of the EFDA (European Fusion Development Agreement) and in the collaboration with FZK Karlsruhe and ENEA Frascati. The source strength of developed NG2 neutron source seems to be suitable for the target/blanket neutronics benchmarking as well.

During the last three years an upgrade of optical system hardware of the NG1 beam-guide was performed to improve options for neutron spectrometric experiments presumed by the benchmark tests of the neutron production and the neutron transport calculations. A triplet of quadrupole magnets and beam diagnostics were located on beam-guide to reach a loss-free transport of accelerated beam to the target. New installation of NG1 target station permits to enlarge a neutron flightpath to perform data acquisition at acceptable count-rate with correctly handled dead-time effect (pile-up consideration). Large database, concerning the energy and angular distribution of neutron spectral yields from proton, deuteron and helium-3 induced reactions on various thick targets (D, He, D_2O, Li, Be, Al and Ta) is collected employing the NG1 target station.

Design and manufacture of NG2 target station which includes the high-power heavy water target and a beam line from the negative-ion extractor have been completed. Here, the location of nowadays, parameters (i.e. a beam emmittance, a beam spot) and trajectories (i.e. a point of beam line entrance, an output angle) of extracted beam are extensively studied and optimized. Variably designed targets of NG2 neutron source correspond to user requests. The outer dimensions of heavy-water target tube ending (500 mm long, 70 mm of outer diameter) correspond to the inner hole (the inlet for the external neutron source) of the blanket Blažka.

Subcritical system with external neutron source will be created in first year 2004 at NPI, Řež. This system will be composed of subcritical blanket Blažka and NG2 target station (in first measurements will be used Be target). Experimental measurements will be focused on neutron characteristics (especially measurement of the delayed neutrons) of the subcritical blanket with external neutron source.

Safety report is finished for this experiment at present. This report includes detailed description of the experiment, all calculations for experiment (calculations of neutron distributions, shielding and radiation situation during and after experiment) and plan of measurements. MCNP and MCNPX codes were used for calculating preparation of the experiment. Obtained experimental resuls will be used for validation and verification of both codes.

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Application of X-ray Fluorescence in Art

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Nuclear techniques represent invaluable tools in non-destructive diagnostics applied to archaeological findings and objects of arts, mainly for dating and determining the composition of materials used in the production of artefacts [1]. In this work we present the application of X-ray fluorescence analysis (XRFA). XRFA belongs to the category of radiation analytical methods based on excitation of characteristic radiation by suitable primary radiation. The methods PIXE (Particle Induced X-ray Emission) belongs to this group too; it uses a beam of heavy charged particles, for example protons, for the excitation of characteristic radiation. In electron microscopes, a beam of accelerated electrons is used for the excitation of characteristic radiation and for the depiction of the examined surface. The method is called electron microprobe and enables us to obtain data about the chemical composition of the surface depicted by the microscope. XRFA uses a low energy gamma radiation for the excitation of characteristic radiation. To obtain a signal from the detector, we must excite the characteristic radiation. For the excitation XRFA uses a radionuclide source, emitting the radiation of the appropriate energy level. For the detection of the excited characteristic radiation the spectrometric detectors are used enabling not only the detection of particle presence, but also the measurement of their energy.

The X-ray fluorescence apparatus built and operated in the Laboratory of Quantitative Methods in Research of Ancient Monuments, constituent part of the Department of Dosimetry and Application of Ionizing Radiation, FNSPE, was used for the purpose of old relics measurements. The X-ray sources (radionuclides) generate the characteristic X-ray photons from the sample. The detector is mounted on a copper bar that is submersed into a special Dewar container filled with liquid nitrogen. The Si(Li) detector measures numbers and energies of photons emitted from the specimen. The energy and number of photons detected can be converted into kind and amount of measured atoms. After processing the resulting signal, we obtain information about the chemical composition of the tested sample. These results give data for qualitative and quantitative analysis of samples. XRFA is relatively simple and non-destructive method. Capability of in-situ measurement is one of big advantages of this method. The radionuclide sources of exciting radiation (e.g. ^{55}Fe enables the excitation of elements with Z up to 23, ^{238}Pu is used in interval of Z from 20 to 39 etc.) were used. The Si(Li) semiconductor detector with the 5 l Dewar vessel and portable spectroscopy system enables the in situ measurement. Narrow collimation of the exciting beam makes it possible to select the measured area of e.g. fresco painting.

This configuration was used for example to find the fresco composition in the Karlštejn castle. The original frescoes come from 14th century and were restored in the 19th century. The applied method allowed us to determine, according to the painting composition, which part of the fresco was original and which had been restored. Using XRFA, it is possible to obtain the information about the paints the painters used in the Middle Ages. The usage of distinct paints was often typical for a certain period or the period of discovery. The analysis

of paints used on paintings can provide information about the historical period in which a painting was created, or eventually discover restored parts.

In April 2002, a newly restored reliquary of St. Mauro was exhibited in the castle at Bečov nad Teplou. It is a very rare relic from the first quarter of 13th century. Towards the end of the Second World War, the reliquary was hidden under the floor of the castle in Bečov and rediscovered again in 1988. During the years 1995 – 2001 it was expensively restored and today it can be admired in the castle chapel. The reliquary decoration includes fourteen statuettes made of gold-plated silver sheet and 12 gold-plated moldings with scenes from lives of St. Mauro and St. Apollinaire. The medieval goldsmith painted each silver object with amalgam and then annealed it. By measuring the gold layer by XRFA, we discovered that various pieces had been annealed by different methods. Spectrum of characteristic radiation obtained from different components of the reliquary decoration contains different amount of Hg and Au. Such measurements give the restorer the information, how to proceed with the repair of damaged parts and enables the comparison of processes used in the fabrication of fine art pieces by individual artists.

The measurement of objects from the collections of The Naprstek Museum in Prague was carried out in this year too. Two samurai swords from Japan, metal rings, amulets, knife and other object from South American collections, and also Egyptian metal statues of the god Usiris have been measured. The content of important elements in the samples as iron, nickel, zinc, arsenic, lead and manganese gives data about the level of metallurgy etc.

The measurements were carried out in the collaboration whit the Analytical laboratory of the State Institute for the Preservation of Historic Monuments. A suitable analysis of fresco paintings and metal objects makes it possible to detect kind of samples and evaluate changes in the surface and suggest useful and timely procedures for their conservation and restoration.

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In-situ Gamma Spectrometry as a Part of Environmental Monitoring of the NPP Temelin Neighbourhood

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Environmental monitoring of Nuclear Power Plant (NPP) Temelin neighbourhood is conducted by employees of the Department of Dosimetry and Application of Ionizing Radiation, FNSPE, CTU Prague from the year 2000. Measurements cover atmospheric radionuclide deposits monitoring in the environment using bioindicators (forest humus, surface of pine bark, Shreber moss, edible mushrooms and forest berries) as well as monitoring of the air kerma rate and in-situ gamma spectrometry measurements in reference height 1 meter above ground. The 29 sampled locations (15 points for spectrometry measurements) were selected along eight radial profiles intersecting the area of interest up to distance of 20 km from NPP Temelin. First series of measurements were carried out in the year 2000 before start of NPP operation and results were designated as reference values of the observed quantities.

Two methods of the gamma radiation field characteristics (dosimetric and spectral) measurement were selected for in-situ monitoring:

1) direct measurement of the integral value of air kerma rate using Tesla NB 3201 monitor (based on the energy compensated scintillation detector)
2) in-situ scintillation gamma spectrometry, using portable spectrometer with MCA μNOMAD EG&G Ortec and 3" x 3" NaI(Tl) scintillation detector

While first method gives only integral value of desired basic dosimetric quantity (air kerma rate), the second one provides full spectral information and enables to identify also individual sources (natural as well as man-made contaminants) contributing to the gamma radiation field in the point of measurement. The special method of spectrometry data analysis and processing was designed and developed for the evaluation and interpretation data from in-situ gamma spectrometry measurements [1, 2]. The method is based on the deconvolution of the experimental gamma spectra from scintillation spectrometer, calculation of the photon fluence rate energy distribution in the point of measurement and possibility to derive other dosimetric quantities (e.g. desired air kerma rate) from this quantity. Older version of this method was successfully used for gamma spectrometry data analysis and interpretation in the frame of radiological assessment of long-term effects at the Semipalatinsk nuclear weapons test side [3], for monitoring of uranium industry radiation impact, NPP Dukovany spent fuel temporary storage vicinity monitoring, etc.

To apply the deconvolution technique for the experimental spectra processing it is necessary to know the used detector response function/matrix [1, 2]. The response matrixes for the used detection system (3" x 3" NaI(Tl) detector), corresponding detector energy resolution and desired energy interval (typically up to 3 MeV for environmental measurements) were calculated by prepared code using Monte Carlo method [2].

All measured spectra were processed by the code for deconvolution (applying Scofield-Gold iterative technique) and air kerma rate energy distributions were calculated. Results for reference measurements (year 2000 before the start of NPP Temelin operation) show contributions from natural radionuclides (U and Th-series and ^{40}K) and small (but different in individual points) contribution from ^{137}Cs (fallout from nuclear weapon tests in the fifties of last century and from Chernobyl accident) [4]. These results represent very important reference values for comparison with results of monitoring in the process of NPP operation and verification of NPP operation environmental impact. No such effect was observed in results from year 2002 [5] when next series of measurements were done. Differences only in the range of measuring accuracy confirm no measurable environmental effect of NPP operation (the same conclusion can be done for results of biomonitoring measurements and measurements of the background).

Values of background air kerma rates calculated from spectrometry data were also compared with values measured directly by calibrated portable monitor (see used methods of measurement discussed above). Good agreement was achieved taking into account different sensitivity of compared methods to the background cosmic component.

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Study of Possibility to Use the DIRAC Setup Upstream Detection System for the Low Energy Protons Spectrometry

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The main objective of DIRAC experiment is the measurement of the lifetime τ of the exotic hadronic atom consisting of π^+ and π^- mesons. The lifetime of this atom is determined by the decay mode $\pi^+ \pi^- \rightarrow \pi^0 \pi^0$ due to the strong interaction. Through the precise relationship between the lifetime and the *S*-wave pion-pion scattering length difference $|a_0 - a_2|$ for isospin 0 and 2 (respectively), a measurement of τ with an accuracy of 10% will allow a determination of $|a_0 - a_2|$ at a 5% precision level. Pion-pion scattering lengths have been calculated in the framework of chiral perturbation theory with an accuracy below 5%. In this way DIRAC experiment will provide a crucial test of the chiral symmetry breaking scheme in QCD effective theories at low energies [1].

The DIRAC spectrometer has been commissioned at CERN with the aim of detecting $\pi^+\pi^-$ atoms produced by a 24 GeV/c high intensity proton beam in thin foil targets. A challenging apparatus is required to cope with the high interaction rates involved, the triggering of pion pairs with very low relative momentum and the measurement of the latter with resolution around 0.6 MeV/c. The general characteristics of the apparatus are explained and each part is described in some detail. The main features of the trigger system, data-acquisition, monitoring and set-up performances are also given [2].

The DIRAC spectrometer set-up consists of the proton beam line, target station, secondary particle vacuum channel, spectrometer magnet and detectors placed upstream and downstream the analyzing magnet. The upstream section of the secondary particle channel between the target station and the spectrometer magnet is instrumented with the following detectors: microstrip gas chambers (GEM/MSGC), scintillating fibre detector (SFD) and scintillation ionisation hodoscope (IH). GEM/MSGC is a proportional gas detector, complemented with a second amplification and read-out stage provided by Micro Strip Gas Chambers (MSGC) and measures particle coordinates in 4 planes (4 individual detectors). The SFD consists of three fibre planes to measure the *X*-, *Y*- and *U*-coordinates of incident particles. The IH detector is a scintillation hodoscope consisting of 4 planes. Each plane is assembled from 16 plastic scintillating slabs made of fast scintillator (BC-408).

Aim of presented work was to study the possibility to gain additional information from the experimental data evaluating upstream detector responses from point of view identification and spectrometry of incident low energy protons. Such information could improve and precise of the studied effects analysis.

The detailed composition (materials/layers) of the upstream detection systems (totally 11 individual planes) was described and the SRIM/TRIM computer code [3] was used for the simulation of the proton transport through the detection system. Dependence of the proton range on the proton energy was calculated in the first step to assess the interval of proton energies that can be measured. With simplest processing technique (identification of the

detection system plane where proton was stopped) was measurable energy interval determined as about 5 – 40 MeV.

As the next step, the average energy loss in the ionisation hodoscope (provide the ionisation loss measurement) was simulated to analyse possibility to identify the incident proton energy from the responses of the IH individual planes (4 planes). Energy scope of such measurement is from about 35 up to 50 MeV.

To improve interpretation of the previous calculations and verify effective resolution of the designed method, the fluctuations of the energy loss and range in the individual IH planes were calculated (for considered proton energy interval).

To analyse requirements for trigger, dependence of the time of flight on the particle momentum were calculated. Calculations were done also for the other particles (μ, K, π) whose identification and/or spectrometry is considered in the frame of Dirac experiment or eventual continued experiments.

Performed studies will continue with respect to running reconstruction of the upstream detection system and with idea to analyse backward acquired experimental data.

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Accelerator Driven Transmutor Calculation, Emphasis on Target Calculations, Proton (Neutron) High Energy Cross-Sections Based Problems

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Accelerator Driven Systems are new project which ideas are use these systems to incinerate long-lived fission products and minor actinides produced by conventional fission reactors. These systems should be also useful to burn out large amount of plutonium from nuclear weapons.

Concept of ADS is very complex, AD-systems are compound from many freestanding technological and physical ideas; we are talking about a coupled system (fission reactor and accelerator; target and blanket, protons and neutrons, high energy physics and conventional reactor physics). Their construction is joined with a lot of technological and also physical problems; major problems, coupled with their design and demonstration unit projecting are - lack of experimental data in some energy regions, data for some actinides and fission products isotopes; and incompleteness or inaccuracy of theoretical models and computer codes for high energy reactions simulations. That is why, it is very significant to benchmark existing codes, models and evaluated data libraries with experimental data. There are three major successive points of view to study:

1. High energy proton reactions with thin target and residual nuclei and neutrons production studies. Target materials should be especially heavy metals with large A number (to produce a big amount of spallation neutrons) like lead, bismuth, mercury, wolfram, tantalum, thallium or uranium and thorium; or materials chosen to transmutation, like plutonium, americium, neptunium, iodine, technetium; or any other materials, to measure new data, improve nuclear databases and validate intra-nuclear cascade codes for as many isotopes as possible.
2. The second step is research of neutron spectra, which is generated in thick targets from possible targets materials mentioned above; bare target and with various moderators surrouned target studying.
3. The third most practical step is investigation, how interact this neutron field in sub-critical blanket with fertile materials (uranium, thorium, plutonium) inside. Experimental study of this system and its calculations and benchmarking is the most significant research in the field of nuclear data and computation codes for ADS design now.

There are only small amount of this kind of experimental facilities around the world, so international collaboration is absolutely necessary for nuclear data and computer codes development. For theoretical benchmark calculation were chosen facilities constructed at Joint Institute for Nuclear Research in Dubna, Russia. DNR FNSPE is participated in collaboration with JINR and has at disposal experimental data to compare them with theoretical predictions. One of participation is in experimental study of reactions in thin natural uranium target irradiated by 660 MeV protons. Data has not been completely analyzed yet and theoretical calculation with modern intra-nuclear cascade codes, like LCS (Bertini, Isabel models), CEM2k+GEM2, LAQGSM+GEM2, CEM2k+GEM, LAQGSM+GEM2, INCL+ABLA, CEM2k+GEMINI, LAQGSM+GEMINI, TALYS etc. are not at DNR pursued. These computations and all this work are done with wide international team of collaborators (Margburg, Jullich, Los Alamos etc). There were also experiments with thick pure lead target

(bare and with paraffin or graphite moderator [3]) in facility called "GAMMA-2", where neutron spectrum was measured with set of threshold detectors and in these neutron field were some radioactive samples transmuted; and experiments with facility "ENERGY & TRANSMUTATION" inside Russian ISTC project [2]. This facility consists of thick lead target with more than 200 kg of natural uranium in cylinder fuel rods around. Neutron field parameters and transmutation of RA samples were measured too.

Theoretical study of GAMMA-2 and E&T facilities were performed; various conditions were taken into consideration, like protons energy, beam asymmetry, hypothetical conditions like various targets materials, incident particles, uranium enrichment. All calculation has been done with MCNPX-2.5.d Monte Carlo transport code [4] (DNR is MCNPX beta tester team member). Dependence on nuclear data libraries used for transport calculation was also tested. Data libraries [1] were processed from general purpose format ENDF-6 into MCNPX ACE format using code NJOY-99.81. Emphasis was put on most world-wide used libraries JEFF-3.3 (European), JENDL-3.3 (Japanese), ENDF/B-6.8 (American) and also BROND (Russian) and CENDL (Chinese). Calculations, which have been made, can be satisfactory used and complexly compared with experimental data from JINR, and MCNPX benchmark can be created. These comparisons will be presented on IYNC conference on May.

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The First Effective Dose Calculation from Radon Daughters and Aerosol Particles Measurements in Caves

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There are some places on the Earth where higher radon concentrations could be found either on houses or on workplaces. The most important from the point of view of human health are houses, as the time spent here exceeds the work-time. On the other hand, it is possible to identify some workplaces with exceptional higher radon concentration (caused by the subsoils composition and/or by the place disposition with low airflow and air exchange) where radon caused doses should be significant. The annual doses in that case frequently exceeds limits for public (in CR 3 mSv year^{-1}) and the employees must be considered as workers-with-radiation (which are under special medical supervision and must respect some limitations). The current radiation protection principles require to dose not to overrun value where the potential health damage should be momentous, but the limitations should not be much overestimated because of exacting and expensive remedies. So, the correct and accurate dose estimation is advisable to not to under- or overestimate real values for the radiation protection purposes (it should not be easy or possible to accomplish this goal at each case – e.g. caves).

One of the radon risk areas where radon concentration found should to be higher is cave. It is due to underground position of the cave (subsoils should surround corridors from the all sides) and due to usually lower air exchange rate inside the cave. On the other hand, not all caves are potentially radon-dangerous, because there are usually karsts caves with lower radionuclides (esp. ^{226}Ra) in subsoils concentration and only few of them are open to public. For the case of open to public caves the State Office for Nuclear Safety (SONS) supervise the dose limits compliance (esp. for staff) both by the short-time measurement (in case of low-risks areas) and by long-time continual measurements (higher-risks areas). Radon dose is crucial in the second case; SONS has prepared a methodology how to measure using solid state alpha track detectors and how to recalculate values obtained into effective dose to compare it with the limits. This methodology is based on radon and its daughters in cave measurements (i.e. equilibrium factor in caves presumption), on aerosol in houses studies (i.e. unattached fraction presumption), and on so called caves-factor which include differences between aerosols properties in houses and caves and other factor with impact to the radon concentration (caves-factor increase the value obtained by standard evaluation procedure for track detectors by approx. 1.4× to suppress possible underestimate radon related dose). The methodology is commonly used on all Czech caves to guides effective dose estimation. The question is whether the methodology is fully correct (esp. in the case of cave-factor) as it is based on radon in houses measurements (not in caves as there are plenty of difficulties).

The goal of this study is to try carry out radon, aerosols, and other essential measurements to calculate effective dose directly (based on the ICRP recommendations) or at least to convert directly radon related values into effective dose. The value obtained by the direct way could be compared with the SONS's (official) values. As for some caves (e.g.

Bozkov Cave) the SONS's value is on the boundary between public and workers-with-radiation limits (the effective dose for guides in Bozkov Cave is 4-6 mSv $year^{-1}$), the more precisely evaluated value should have essential influence for the radon remedies or guides time spent in the underground restriction urgency.

Radon concentration had been measured continually by the Radim 3 radon monitor for the one year (2001-02-03). As the high relative air humidity makes serious problem, the special plastic box with desiccant ($CaCl_2$) has been used. Radon concentration values vary from approx. 500 Bq m^{-3} to 30 kBq m^{-3} (during summer values growth up by factor ~10 due to the air flow intensity and direction changes). Due to the humidity, the continual monitor for radon daughters had not been used (only short-time measurements had been carried out) – the radon equilibrium factor vary from 0.1 to 0.6 depending on air flow intensity at the measured place. As for air flow intensity, it had been estimated by short-time measurements too and it is low (5-10 cm s^{-1}).

One of the most important parameter in the dose evaluation (input parameter for dose model based on ICRP) is aerosol particle size distribution. The measurement of aerosol spectra in the field conditions is difficult and therefore it is very rare. Four-days measurement of aerosols (both with and without visitors) had been carried out. Aerosol concentrations have been found to be approx. 100-times lower in comparison with the typical outdoor atmosphere (the reasons are no aerosol source inside cave presence, very low aerosol-rich-air flow from outside into cave, and spacious internal surface for the aerosol deposition) which together with higher radon concentration should imply higher unattached fraction in comparison with common houses. A negligible influence of visitors movement inside cave (with the exception of big-diameter aerosol particles which are not able to originate inside cave due to extremely high deposition probability) results from the continual aerosols measurements.

From the factors described above, the effective dose should be recalculated without any significant simplification as in case SONS's methodology (no direct aerosol measurement had been carried out). But the resulting values are fully comparable with the "official", so the methodology commonly used for dose estimation is correct. On the other hand, some errors should be found in the direct measurement-calculation procedure, so, the more precise values should be expected in the future based on data measured.

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The Trend Analysis Results of Biomonitoring in the Neighbourhood of NPP Temelín

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For the past four years, FNSPE CTU in Prague, took part in monitoring the influence of NPP Temelin on the environment within 20 km radius of the plant, by way of atmospheric radionuclide deposits monitoring in bioindicators. The research will continue in the following years. Monitored area contained 29 sample-locations along eight radial profiles. As bioindikators were chosen: forest humus, outer surface of pine bark, Shreber moss, edible mushrooms and forest berries [1]. The gamma spectrometric method (with very good range of detection) was chosen to determine the presence of natural and manmade radionuclides. With a sufficient amount of measurement samples collected, it will be feasible to compare the potential radionuclide accumulation, against the reference "zero level", obtained in the year 2000 (before the start of the NPP operation), using trend analysis. The biomonitoring for year 2000 and 2002 also included assessment dosimetry and spectrometry characteristic of photon-fields at 15 selected points. With the exception of the identified ^{137}Cs (from Chernobyl accident fallout) it was not possible to identify among the measured spectra any significant contribution of any other radionuclides. The trend analysis didn't establish any ^{137}Cs concentration increase at the measurement points [2].

The measuring equipment consists of HPGe detector with built-in preamplifier (mfg. by EG&G Ortec), amplifiers 2022 Canberra, Source VN31060 Canberra, ADC built-in analyser, analyser model 4202 Canberra and a PC. Processing of measured spectra using the program SP DEMOS [3] in the range up to 3 MeV provided mass related activity of naturally radioactive elements ^{40}K, ^{226}Ra, and ^{232}Th in the first year and contaminant ^{137}Cs in all years.

The bio-monitoring for year 2000 and 2002 included assessment dosimetry and spectrometry characteristic of photon-fields (that is determination of reference background) at 15 selected points.

The most important task of this project is to describe the influence of NPP Temelin on radioactivity increase in its neighbourhood. Two model situations have to be studied. *Firstly*, one fairly large accident leads to relative extensive radionuclide escape and contamination of the neighbourhood of NPP. In virtue of the environmental contamination, radionuclides are accumulating in organisms living in places, where the radionuclides are deposited. It means that the escape of radinuclides from NPP can be proved by identification of these radionuclides, especially fission products, in samples which were taken in the surrounding of NPP after accident. The method of gamma spectrometry can be successfully used for such survey. The measurements carried out in the year 2000, i.e. before fuel activation in the first block of the NPP Temelin, detect the presence of ^{137}Cs, ^{40}K and uranium and thorium decay products. Uranium a thorium decay products, as well as ^{40}K, are radionuclides of natural origin. Radionuclide ^{137}Cs is a fission product and its presents in nature is related to human activities. Testing of nuclear weapons in the atmosphere, which were performed in the fiftieth and sixtieth years of the twentieth century, and nuclear accident in NPP Cernobyl are obviously the most significant reasons for its occurrence in nature. With the exception of ^{137}Cs, other radionuclides created by fission cannot be detected due to their low activities. The cause of the low activities is their short half-life in comparison with time of creation. The

measurements have been continued after the NPP Temelin was put into operation in the year 2001. Samples of Schreiber's moss, pine barks, forest humus, mushrooms, and blueberries have been collected every year. The analysis results were identical with the ones that were obtained in the year 2000. The samples contain the same radionuclides as the samples that were taken in the year 2000. Also their activities are comparable. Short-lived radionuclides were identified neither in the year 2000 nor in the following ones. This shows that no accidents with significant radiation escape have occurred during the entire time the NPP Temelin has been operating. *The second model* situation presumes that a small amount of radionuclides is continuously escaping and being deposited during the common operation of NPP. This long term continuous escape could be observed according to ^{137}Cs activity increase in the samples that are regularly collected for a long time. If the activity increase is not significant, the demonstration of the influence of NPP on environment presents a difficult task, due to a high fluctuation in the amount of radionuclides in live organisms. Therefore, if the activities in current sample are higher then in the samples that were taken in previous year, this phenomenon does not prove an actual increase. That can be proven only, if measurements are significantly higher then the activity fluctuation. The method of trend analysis has been used for result comparison and activity increase determination. Because ^{137}Cs is the only radionuclide in sample, whose presence is related to fission process in NPP, the trend analysis was performed only for this radionuclide [2]. The results of the trend analysis indicated (by selected 95% significance level) an increase of the ^{137}Cs mass activity in only four samples out of the 174 measurements (six types of samples at twenty nine points). Those four points are evidently noticeable statistic fluctuations, since the individual sites are not all situated within the prevailing downwind area from NPP. From this first analysis follows, that it will be necessary to test the mass activity dispersion for each sample type, in the next year. In the year 2003 we will select three locations, in which will be collected 6-10 samples from each type of bioindicators, to judge the mass activity dispersion. It is necessary (due to a very small number of the ^{137}Cs measurements (max 6 per one point), compared to statistically sufficient number of data points required for getting a relevant statistic evaluation) to take the resolution of this year's trend analysis only as point of reference. It will be used as a first assessment, to determine the best method for judging the influence of NPP on the environment. Also it will be necessary, for the vindication of potential result dependence on the sampling season (spring/autumn), to consider taking a greater number of measurements. All ^{137}Cs determinations are in a good agreement with previous years: relatively higher mass activity in the mushrooms (between 358–2560 Bq.kg^{-1}) and lower mass activity in the berries (units Bq.kg^{-1}).

For a reason of low values of bio indicators gamma activity, the measurement times are very long: from 14 000 sec (humus) to 30 000 sec (moss) – except dry mushrooms samples where the mass activity of ^{137}Cs is higher. The detection limit of ^{137}Cs was assigned 2 Bq/kg. From the year 2001 the surface area activity of the ^{137}Cs in forest humus is counted.

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ENEN Training Courses at VR-1 Reactor

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The VR-1 reactor is operated for the training of university students and nuclear power plant personnel, R&D, and information services for non-military nuclear energy. Training at the VR-1 reactor provides students in reactor and neutron physics, dosimetry, nuclear safety, and nuclear installation operation experiments. Students from technical and natural sciences universities come to the reactor for training.

The training reactor VR-1 as a state-of-the-art education centre in the field of nuclear engineering in Czech Republic was included to the European Nuclear Engineering Network (ENEN). ENEN is supported by the 5th Framework Programme of the European Commission and was prepared the future European Nuclear Education schemes, degrees and requirements. Course was organised in 2003 for demonstration the benefits of international co-operation for such mentioned activities and to promote the knowledge of students in nuclear engineering.

Three weeks "Eugene Wigner training course for reactor physics experiments" was held in four central European countries: Slovakia, Czech republic, Austria and Hungary. The main emphasis of the course was to perform reactor physics experiments on three different research and training reactors in three different universities: Faculty of Nuclear Sciences and Physical Engineering (Czech Technical University in Prague), Atominstitut (Vienna University of Technology) and Institute of Nuclear Techniques (Budapest University of Technology and Economics). The experimental work was preceded by theoretical lectures aiming to prepare the students for the experiments at the Faculty of Electrical Engineering and Information Technology (Slovak University of Technology in Bratislava). The course was an upgraded result of a long-standing similar co-operation between the above-mentioned four academic institutions in Vienna, Prague, Bratislava and Budapest

Twenty students (both undergraduate and postgraduate) from Slovakia, Czech republic, Austria, Sweden, Finland, Belgium, Slovenia, Italy, Switzerland and Romania was divided to into four groups with five students in the each group. During the first week, all groups together attended the preparatory theoretical courses in Bratislava. The second and third weeks the groups was rotated between Vienna, Prague and Budapest, were performed the reactor physics experiments.

Within "Eugene Wigner training course for reactor physics experiments" was prepared six experiments at the VR-1 Reactor:

- Properties of neutron detectors for nuclear reactor control
- Measurements of reactivity by various methods
- Calibration of control rods
- Study of nuclear reactor dynamics
- Digital control and safety systems of the research reactors
- Start-up and operation of the VR-1 reactor

The quality control and accreditation of ENEN assures a European added value, and guarantees of acquired knowledge of the participants were fulfilled requirements of the European Nuclear Education and the European Credit Transfer System (ECTS). The students' work was evaluated, and upon success the students was granted by certificate and ECTS credits (from 6 to 8).

Joint nuclear education in the ENEN consortium European Universities brings new potential of educational process for students, lecturers and researchers and can improve quality of education. As a next part ENEN activities at the VR-1 Reactor is being organised second Eugene Wigner training course for reactor physics experiments in May 2004 based on same principles as the first course organised in 2003.

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The Radon in Water Detection Unit "YAPMARE" Testing

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^{222}Rn is a naturally occurring, colorless, odorless, radioactive gas that commonly occurs in caves, mines and buildings as the result of diffusion from natural radioactive sources containing ^{238}U in the surrounding soil and bedrock (the common values of Radon concentrations in the depth of 1 meter underground are higher than 10 000 Bq/m^3). ^{222}Rn and its daughters present a great danger for human health (50% of natural radioactivity). Its half life of 3,82 days makes it a potential natural tracer for studying of transport processes with characteristic times below 10 days. Rn has been successfully to gain additional information about flow dynamics in a karst system. For example the increasing of the Rn concentration before earthquake was observed.

With a focus on the earthquake forecasting by detection of the Rn concentration in water, the detection unit YAPMARE was developed by the company CRYTUR Ldt.. The main part of the detection unit is a detection probe based on the Ø25x100mm YAP:Ce detector, made of monocrystalline YAP:Ce (chemical formula is $YAlO_3$ doped Ce) grown by the Czochralski method in Crytur Ldt. (YAP:Ce crystal advantages are in chemical resistance, nonhygroscopicity, good mechanical properties and is easy polishing. The high chemical resistance of YAP:Ce detector and Teflon shielding allow the usage of this detection unit in the measurements of activity of radionuclides not only in the clear water, but also in chemically aggressive solutions – remainder of radionuclides deposited on the Teflon surface can be easily deactivated by HCl acid). This detector is optically coupled to a Photomultiplier Tube and both are insulated with Teflon. The spiral groove is made in the Teflon case so that measured water could cover approximately 95% of the crystal surface. The detection volume in the groove is 12 ml. The detection unit is useful not only in the laboratory, but also in the field, since the probe was constructed as compact and sturdy as possible [1].

The detection chamber is filled through “Inlet” with Rn water. During the process of Rn decaying, alpha particles are formed. They interact with the scintillation detector and give a rise to scintillation photons. These photons are registered by PMT. The signal from PMT is amplified and discriminated and comes to MCA where its elaboration is processed. The process is controlled by special software program at PC. The results of measurement can be saved both as a spectrum or data [1].

The first test measurements indicated the influence of the gamma ray background, which can be minimized ten times by use of Pb shielding, with 25mm thickness.

After the first experimental measurement the probe was transferred to CTU, Department of dosimetry, to finish some testing measurement and calibration.

The YAPMARE unit testing was carried out with:

1. the gamma radioactive standards ^{137}Cs and ^{60}Co
2. dry (air) standards of ^{222}Rn and ^{220}Rn
3. high ^{222}Rn concentration water (Svornost mine in Jachymov – the radon concentration 17 kBq/l)

The results of the first measurements have demonstrated some advantages and also disadvantages of the probe. The main *advantages* are:

- linear dependence towards gamma ray and alpha ray
- very good time stabilization
- spectrometry results of the measurement
- can be used in the laboratory and in the field
- can be apply for water or air samples

The ^{222}Rn and ^{220}Rn standards were used for determination of individual peaks in spectra and observation of the ^{222}Rn (and its daughters) behavior and detection during theirs decay.

The main *disadvantages* (which can be complicated in situation of alpha calibration measurements) are:

- large size of scintillation crystal (gamma ray increases background)
- radon absorption in the Teflon microstructure by high radon concentration measurement (it is impossible to clean it by HCl acid thus it is necessary to wait between measurements for the duration of ten (10) ^{222}Rn half-life periods)
- thoron influence (in natural samples of water)

Measurement will be continued in the year 2004 (comparison with other radon detection systems) and finished by calibration of the probe.

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Upgrade of VR-1 Training Reactor Control System

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This contribution deals with the VR-1 training reactor control system upgrade. The VR-1 training reactor has been operated since 1990 by the Department of Nuclear Reactors FNSPE CTU in Prague. The reactor was designed and constructed by the Škoda Company in co-operation with the Faculty.

The VR-1 reactor is a pool-type light-water reactor based on enriched uranium (36%). Its thermal power is up to 5kW. The moderator of neutrons is light demineralised water that is also used as a reflector, a biological shielding, and a coolant. Heat is removed from the core with natural convection. The VR-1 reactor is utilised particularly for training of university students and nuclear power plant staff. Research at the VR-1 reactor is mainly aimed at the preparation and testing of new educational methodologies, investigation of reactor lattice parameters, reactor dynamics study, research in the field of control equipment, neutron detector calibration, etc.

The reactor I&C seem to be obsolete now and their upgrade is being carried out. The upgrade is being done gradually during holidays in order not to disturb the reactor utilisation during teaching and training. The first stage was the human-machine interface and the control room upgrade in 2001. During the second stage of the upgrade, the control rod drivers and the safety circuits were replaced. The third stage – the control system upgrade was carried out in 2003. Finally, a new protection system consisting of power measuring and power protection channels will be installed in 2004 or 2005.

The upgraded control system is based on a high quality industrial PC mounted in a 19" crate. The operating system of the PC is the Microsoft Windows XP with the real time support RTX of the VentureCom Company. The computer is equipped with 8 RS232 lines for communication with the reactor power measuring and power protection channels (the reactor protection system), with the RS485 (Profibus) line for communication with the Simatic control rod and I/O PLCs and with the Ethernet line for data transfer to the human-machine interface.

The software for the control system was developed according to requirements in MS Visual C. A large amount of work has been devoted to the software requirements to specify all dependencies, modes and permitted actions, safety measures, etc.

The control system receives data from the power measuring and power protection channels and compares them with safety limits, and it also controls the safety circuits. Furthermore, it calculates the average values of the important variables (power, velocity), and sends data and system status to the human-machine interface. Next, it receives commands and button inputs from the operator's desk and carries them out according to the reactor operation mode.

Finally, it serves as an automatic power regulating system. The information about the control system and the nuclear reactor operational status were enlarged substantially in comparison with the old system. Furthermore, complex tests and control rods diagnostics were added.

It was necessary to adapt the original power measuring and power protection system for the RS232 communication with the new control system. In the future, the RS232 lines for communication between individual protection system channels with the control system will be replaced by fibre optic lines. The communication units [4], originally developed for the human-machine interface upgrade, were utilised with new PLA firmware and control software. FIFO buffers for bidirectional communication were added. Furthermore, the power measuring and power protection system software was modified in an appropriate way. The data flow from individual channels was divided to displays and to the control system. Control commands from the control system to individual protection channels are also received by the communication units. The communication between the control system and protection channels utilises CRC check to guarantee reliable data transfer. Necessary changes of the original protection system software were carried out to utilise the communication units instead of original parallel busses for data exchange with the upgraded control system.

The complete system was thoroughly tested. In the first instance, simulated input signals were utilised for tests. The reactor was during these tests under subcritical conditions. The signals were generated by instruments with HPIB and VXI control. The signal generation was controlled by a PC with proper software. Next, the upgraded control system was tested during common reactor operation with standard active core configuration. The tests were oriented to both control and safety features of the upgraded control system.

The upgraded control system substantially improves nuclear safety, availability and utilisation of the VR-1 reactor. The reactor I&C upgrade continues with the protection system upgrade in 2004-2005. The complete reactor I&C upgrade brings the reactor I&C to top conditions and will enable a prolongation of their functionality and maintainability for at least 10 next years.

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New Quantitative Methods in X-ray Fluorescence Analysis

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X-ray fluorescence analysis (XRFA) is a non-destructive and multi-elemental analytical method making use of X-rays or gamma rays to invoke emission of characteristic X-rays in the investigated object. Spectrometry of the characteristic X-rays enables to recognize object composition. In this respect, qualitative and quantitative analyses are considered. The qualitative analysis denotes chemical element identification that is based on presence of X-rays of certain energies in the spectrum of characteristic radiation. The quantitative analysis is used for quantification of an amount of chemical elements, i.e. element concentrations are determined.

The quantitative analysis in XFRA is based on comparison of intensities of X-rays emitted from measured object and reference materials of known composition. Standard procedure of quantitative analysis comprises several steps. Firstly, reference materials are measured under well-defined conditions. Secondly, X-ray intensities, in fact corresponding net peak areas in measured X-ray spectrum, are compared with element concentrations and calibration curves are plotted. Next, samples and objects of unknown composition are properly prepared for analysis and then measured under the conditions of reference material measurements. Finally, the peak areas of identified elements in the X-ray spectra of unknown samples and objects are converted to element concentrations using calibration curves. Actually, the procedure of quantitative analysis is more complicated due to matrix effects that disable to plot simply the calibration curves in the some cases, because net peak area of the element of interest depends also on presence and concentrations of other elements.

The above quoted procedure of quantitative analysis calls for same measurement conditions of reference materials and unknown samples, i.e. same distances and angles between source of primary radiation, sample, and detector of characteristic X-rays. Furthermore, sample should be of homogenous structure and flat surface without irregularities. If these assumptions are not fulfilled, quantitative analysis could provide incorrect results.

Rapid progress in the development of X-ray detectors and sources of ionizing radiation made possible to construct portable X-ray fluorescence devices enabling in-situ measurement. Qualitative analysis can be easily performed for such measurement, but troubles are observed in quantitative analysis, because sample preparation is usually not possible and measurement conditions are hardly reproducible. While quantitative analysis is often desired, it is necessary to develop new quantitative methods in XRFA for in-situ measurements.

New quantitative methods in XRFA can be based on Monte Carlo simulation that denotes numerical calculation method using generation of random numbers for modeling of creation and transport of ionizing radiation in materials. Such calculations permits to estimate intensities of characteristic X-rays emitted from a sample for chosen set-up. Intensities of characteristic X-rays can be converted to detector response and net peak area in a virtual X-ray spectrum. Calibration curves are hereby plotted by Monte Carlo simulation instead of measurements of many reference materials. At least one measurement of reference material is recommended for Monte Carlo simulation to reduce uncertainty sequent on inaccurately

known intensity of a source of primary radiation and detection efficiency of an X-ray detector.

Monte Carlo simulations were performed with MCNP4C code (Monte Carlo N-Particle Code System) for a device for XRFA consisting of silicon semiconductor detector and X-ray tube representing a source of primary radiation. The set-up is described in detail in [2]. Once the Monte Carlo calculations were successfully verified by comparison with the results of experiments, effects of sample heterogeneity and variation of geometry conditions have started to be studied. In particular, influence of sample rotation and displacement, surface roughness, matrix effects, and composition heterogeneity on intensity of characteristic X-ray has been examined.

It has been demonstrated that Monte Carlo simulation can significantly help in quantitative XRFA. The described method could be used for all in-situ measurements or analyses of any samples that can not be modified before analysis. For example, one of the most important fields for application of this method is a study of archaeological and art objects.

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Perspective Molten Salt Nuclear Reactors

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The goal of this project was to involve gifted and apt students on the field of "Nuclear engineering", with specialization in "Nuclear Reactor Theory and Engineering" and "Nuclear Energy and the Environment" solving of tasks connected with nuclear transmutation systems and to offer them opportunity to present their achieved results on the seminars and conferences specialised in this topic, which are regularly held in the Czech Republic and abroad.

Main effort was to use our actual experience of the solving of nuclear facilities problems and to contribute it to the solving several questions concerning the blanket and to possible increase of transmutation systems safety in comparison to the present projects of advanced nuclear reactors. The goal was to overcome the problems of physics and of Accelerator Driven Systems (ADS) safety and to reach a level that enables a development of deeper scientific and pedagogical programme on this field.

In the frame of this project, studying of transmutation technologies was carried on. The search was extended by molten fuel problems for ADS systems and by existing or planned experimental facilities for research of the transmutation systems. In the centre of attention, there was compilation of available sources in order to formulate research programme of theoretical and experimental determination of basic ADS systems characteristics for the next period.

Activities were focused on the specific problems caused by interaction of very different subsystems (e.g. accelerator, subcritical reactor with molten salts, power section, chemical separation of transmutation nuclides, transport and storage of large volumes of high-radioactive materials). Further activities were focused on elaboration of the study that dealt mainly with physical problems of molten salt systems.

This project successfully interconnected research work of students and teachers with teaching in the framework of "Nuclear Reactor Theory and Engineering" and "Nuclear Energy and the Environment" specialization. At the same time, teaching of "Nuclear Reactor Theory and Engineering" specialization was improved considerably and it also lead to increasing involvement of students in the scientific and research activities of the Department of nuclear reactors.

This department is engaged in the ADS problems already for several years. It follows that the interest of students about this perspective way of further development of nuclear power facility, that enables production electric power without parasitic radioactive waste grew significantly. Some parts of ADS problems solved by students were far beyond requirements of their study programme. To solve selected variants of transmutation system, MCNP code based on the Monte Carlo method was used.

The above standard elaboration of student research work and thesis form the base material for several publications which will be presented at Workshop CTU 2004 as a poster presentation and at the conference about development of ADS systems. Furthermore, a summary paper about these problems was submitted on the seminar for students and staff of the Department of

nuclear reactors held at the department. The most interesting results will be published in "Bezpečnost jaderné energie" journal or in "3Pól" popularising journal.

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Numerical Solution of Flow and Heat Transfer by Molten Salts in Nuclear Reactors

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The described research project is focused on a thermal-hydraulic computations and analysis of an Accelerator Driven Systems (ADS).

Safety spent fuel disposal has been solving at research institutes all over the world for many years and the transmutation of long-life radioactive isotopes is appeared as a one way how to resolve this serious problem. Therefore new ADS systems are designed and computed in the many countries. These systems are designed as the subcritical reactors with external neutron sources, which provide high neutron flux. Research institutes, universities and companies in the Czech republic, which are associated in the "Transmutation Consortium of the Czech Republic", follow the ADS design with molten salts. These types of ADS have a mixture of molten salts as the coolant, which include small amount of dissolved nuclear fuel and transmutated isotopes. By virtue of profound impact of velocities and temperatures in the reactor core on the reactor control, and consequently nuclear safety, detailed and full thermo-hydraulic analyses of fuel-coolant flow in the rector core are needed for a good design of the ADS. Appropriate simulation computer codes, called Computational Fluid Dynamics (CFD) computer programs, are needed to calculate a flow in general geometry for liquids with volume changes as functions of temperature and movable heat sources.

The two CFD codes are available at the Department of Nuclear Reactors for the above mentioned purposes: PHOENICS 3.2.0, based on the finite volume method, and the module FlowPlus for the program package COSMOS 2.5, which is based on the finite element method. Calculations, were made with this tools last years, showed relevant differences between results of both numerical codes and the impact of optional numerical parameters used codes on the results [2]. Because the verification experiments are not executable in the condition of the Czech republic, different computer calculations and comparisons of the simulations are necessary in order to achievement of desired accuracy.

The CFD code Star-CD was bought at the Department of Nuclear Reactors at the end of the last year. The package consists of solver Star, preprocessor ProStar or ProAm. The preprocessor ProAm is the expanded version of ProStar and permits to built new mesh in complex 3D volumes and 2D areas. The new subroutines, written in FORTRAN language, can be easily included due to some special features supported by the flexibility of the package.

The effective composition of solver algorithm, which is based on the finite volume method, allows to modeling any geometric difficulty mesh tasks.

The Star-CD solver provides a rich source of models for turbulence, combustion, radiation and multiphase physics, it stands alone among industrial CFD codes in offering all models on all mesh types. Star-CD supports three meshing types: trimmed cell (predominantly hexahedral), tetrahedral and hybrid (mixed). All meshes can be refined in key areas of flow and include orthogonal near wall layer for accurate turbulence modeling. Star-CD allows to calculate a wide range of flow regimes and conditions: steady and transient,

laminar Newtonian and non-Newtonian flows; turbulent flows; incompressible and compressible (transonic and super sonic) flows; multiple variety of reference; a large variety of boundary conditions, including periodic, non-reflecting and moving boundaries.

It was chosen the geometry with two curves of angle 90 deg and two blockages, which simulate neutron source and graphite moderator, for the new calculations. The example was modeled in cylindrical coordinate system (diameter 0,7m, high 1,8m) with gravitation force direction up stream of the fuel-coolant. The inlet conditions of molten salt were: velocity 0.1m/s, temperature 888K. The average volume heat source was 1*108W/m3 in the core of diameter 0,5m and high 1m. The space allocation of heat source was computed according to diffusion equation for the subcritical reactors systems and programmed by means of fortran subroutines. The mentioned example corresponds to the central part of the proposed ADS core. The fuel-coolant mixture was chosen as the fluoride salt 44,5%LiF +10,9%NaF + 43,5%KF + 1.1%UF4, which corresponds to previous calculations. The thermophysical properties of the salt were programmed by means of fortran subroutines as a functions of temperature.

The model of mentioned theoretical ADS core was made in the all three CFD codes (PHOENICS, COSMOS+FlowPlus, Star-CD). However, owing to problems with the solver of Star-CD package, calculations and comparison were made only in the first two codes at present. Depth profiling of results and evaluations of all codes (suitability, accuracy, fitness for solving of given problem, etc.) are expected during one month.

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Dynamics of Liquid Fuel Reactors

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The one-dimensional code DYN1D-MSR developed in FZR [1] was used for the analysis of transients in Molten Salt Reactors - MSR. MSR is an old project, which is presently revised, because of its safety advantages, possibility to use the uranium-thorium fuel cycle and the potential to transmute the minor actinides. Most of the prior research on MSR was done in Oak Ridge National Laboratory – ORNL. The theoretical studies were crown by Molten salt Reactor Experiment – MSRE. The MSRE was based on an 8 MW_{th} thermal reactor with molten salt fuel moderated by graphite. It was constructed to prove the ability of the technology for a civilian energy production. The next step of the development was planed to be a 1000 MW_e Molten Salt Breeder Reactor – MSBR. However, this project was stopped in design basic phase.

MSRE Transient Benchmarks

The data measured during the MSRE in ORNL [2] were used for the validation of the DYN1D-MSR kinetics, especially of the delayed neutrons model. The fuel in this reactor is liquid and circulate through the core acting as a coolant simultaneously. This feature completely change the thermal-hydraulic – TH conditions and it also affect the delayed neutrons – DN production. The MSRE was constructed to prove the technology and to validate the predicted behavior. The operation of MSRE was very successful and many experiments was performed. From these ORNL MSRE experiments the measured data of one natural circulation experiment and three zero-power experiments were considered and used for the validation: *Effective loss of DN in steady state operation, Protected fuel pump start-up, Protected fuel pump coast-down, and Natural circulation transient.*

These four experiments were chosen as a benchmark to be calculated by the participants of MOST project [3]. The MOST project 'Review of Molten Salt Technology' is focused to the review of MSR advantages and difficulties. The benchmark was calculated by mean of several codes in several institutions. The cross-section libraries used for the calculation have been prepared by EDF with Apollo code [4]. The first calculation was focused on the DN leakage in the steady state operation. The ORNL measured data and the calculated results are represented in the terms of reactivity loss in pcm ($1pcm=10^{-5}$).

Code used / Reactivity loss	*EXPERIMENT (ORNL)*	*PoliTo* [1]	*DYN1D-MSR* [2]	*Cinsf1D* [3]	*SIMMER 3D* [4]	*SimADS* [4]
^{235}U fuel [pcm]	**212.0**	260.9	253.2	228.8	262.2	212.2
^{233}U/^{235}U/^{239}Pu fuel [pcm]	**100±15**	119.2	121.2	107.8	125.0	105.2

[1] Politecnico di Torino [2] FZ Rossendorf [3] Electricite de France [4] FZ Karlsruhe

The second and the third experiment were focused on the protected fuel pump start-up and coast-down transient. During these two transients a constant power was maintained. The fourth benchmark was focused on natural circulation experiment performed in ORNL. The reactor was operated at zero power (no circulation) when the secondary circuit was started. This cause the cooling-down of the fuel

and it is the origin of natural circulation. In the numerical model the inlet temperature and velocity of fuel was given as a forcing function and the calculated power level was compared with experiment.

MSBR Transients

After the successful validation of DYN1D-MSR code on MSRE benchmarks it was applied to several transients in MSBR. The geometric data used as the input deck for the calculations with thermal feedback were taken from the MSBR project description. The original core geometry was simplified for 1D purpose and four MSBR tasks were calculated using DYN1D-MSR: *Effective loss of DN in steady state operation, Unprotected fuel pump coast-down, Unprotected insertion of 300 pcm, and Unprotected overcooling of the fuel at core inlet.* During these calculations it was proved that the thermal feedback coefficient of graphite can be positive. This can be avoided by addition of Erbium to the graphite. The results of calculations with the Erbium in graphite are acceptable from the safety point of view.

Summary

The DYN1D-MSR code was successfully validated using the results of four MSRE experiments and the code is convenient for performing the dynamics analysis of the MSRs. The analysis of four transients for the MSBR was performed. The results of all calculations have shown that the dynamic behavior of MSBR is stable when the coefficients of thermal feedback are negative. However, the feedback coefficient of graphite can be positive in some cases and in those transients the power increase incessantly. The addition of erbium to the graphite can avoid this problem. However this should be an objective of more detailed future safety studies. Furthermore, it is a special feature of the MSR, that the fuel can be very rapidly drained from the core to the subcritical cooled drain tanks in all hazardous situations. Following the results, there should be enough time to drain the core in all cases, if the reactor will have negative thermal feedback.

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Radiation Monitoring System RMS VR-1 / MS2000 at VR-1 SPARROW Training Reactor

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Radiation Monitoring System RMS VR-1 is system for measurement of radiation state at VR-1 Sparrow training reactor and its neighbourhood. Original dosimetric system STADOS did not meet requirements of new legislation and after 15 years of its use the modernisation was necessary. STADOS was partly damaged during big floods in summer 2000.

The RMS VR-1 was derived from monitoring system MS2000, made by EMPOS-BQM, Czech Republic. The control part contain computer (notebook) and 17" LCD touch screen. The touch screen is used to provide current information about radiation situation to personnel and visitors of the VR-1 reactor. The system is specially designed for following BQM radiation detectors: GMS3, GMS3-V, VRS2. The probes are connected to the system with direct serial ports connection. Data from all probes are transmitted via RS485 twisted-pair copper cable, for the reason of simplified installation. Since the system is equipped to probes, transportable instruments may also be connected into the system via RS232/RS485. System RMS VR-1 includes another devices as JKA300n Monitor of Neutrons or KOPR06 Alfa Beta Continuous Air Monitor or devices for measurement of various quantities (temperature, pH, capacity etc.) on reactor VR-1.

The system software operates under the MS Windows 2000 environment. The PM32 programme is designed for monitoring of radiation levels, for receiving of alarms and fault reports, for storing of measurement data and for altering of probe parameters. The query interval is 3s for each device. DDECL programme (Dynamic Data Exchange Client) represents data on screens. Individual probes or devices are represented by icons, displaying current readings numerically and graphically (colour bar code). Normal status is green; alarm status has two levels - inquisitional (yellow colour) and emergency (red colour). The time dependence graph can be revealed for each probe or device by selecting the device icon and double clicking by finger on touch screen. All alarms are visibly and audibly identified on relevant probe, screen PC and touch screen. They are recorded in the event log. All events are automatically stored ton hard disk. Data can be transferred to other systems for review and long-term storage on CD disc.

The RMS VR-1 system contains 6 GMS3gamma probes, 3 GMS3-V gamma probes, 1 VRS2 gamma probe, 2 JKA300n Monitors of Neutron, 2 KOPR06 Air Monitors. These devices are situated inside the reactor hall. The GMS3 probe is basic unit for dose rate measurement of gamma radiation. Measurement range is from 100 nSv/h to 100 mSv/h, energy response is from 50 keV to 1,3 MeV, temperature range is from 0ºC to 50ºC. The probe is accommodated by the SBM20 GM counter tube. The GMS3-V is probe designed analogically for outdoor applications. It is waterproof with temperature range from -30ºC to 50ºC. Both type of probes have LED red alarm, which flash in time to the beeping of the dose

rate alarm. The VRS2 is wide range probe for dose rate measurement of gamma radiation. Measurement range is from 100 nSv/h to 10 Sv/h, energy response is from 50 keV to 1,3 MeV, temperature range is from -30ºC to 50ºC. This probe is configured as two channel detectors arrangement. GM tube (SBM20 type) is used for low range dose rate to 50 mSv/h, ionisation chamber is used for hogher magnitudes. Two updated neutron monitors JKA300n are located next to radial and tangential channel of VR-1 reactor.

The NB3202 dose rate meter (produced by TESLA VUPJT) has been used for environmental monitoring radiation situation around VR-1 reactor since 1993. Now it was replaced by RMS VR-1 system. This device is designed for continuous dose and dose rate measuring with very high sensitivity and low energy dependence in a wide energy range. Dose rate range is from 30 nGy/h to 10 Gy/h, basic measurement error < 15 %, energy dependence is from 20 keV to 3 MeV, temperature range is from -35ºC to +55ºC. Measurement unit contains a combined plastic scintillation detector with ZnS and NaI/Tl layer inside. Measured data (dose rate, dose, time derivation of dose rate, statistical errors) are transferred to the control part of RMS VR-1 system. The NB3202 is located on the roof of entrance building, 8 m up the ground level and at the distance about 150 m from the reactor. Data on the LED display in the hall building are actualised every 10 seconds.

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On-line Radiation-Induced Absorption Measurement of Scintillating and Light Guide Fibers in Gamma Radiation Field

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Light guide fibers, scintillating fibers, and wavelength shifting fibers are very important parts of particle and gamma detectors. They are used in high radiation environment so it is important to investigate their radiation hardness.

Radiation-induced transparency changes were studied by means of on-line induced absorption coefficient measurement during and after gamma irradiation. The set of fiber samples (scintillating, wavelength shifting, and light guide fibers manufactured by three companies) was studied at the Microtron Laboratory of the Czech Technical University in Prague (now at Nuclear Physics Institute AS CR, Rez). The microtron was used as the source of 21 MeV electron beam. The bremsstrahlung gamma radiation field in a broad range of dose rates was obtained when the electron beam was focused on the tungsten gamma convertor [1]. The dose rate in the central region of the sample was in a range from 2.7 to 28.5 $Gy.s^{-1}$ and the total absorbed dose was from 4.8 to 51.2 kGy. For the measurement of kinetics of induced absorption coefficient changes the 256 diode array spectrometer was used [2]. The transmission spectra were measured on-line and recorded in time intervals of 10 seconds for both the excitation and the recovery processes. After approaching the saturation level of the gamma ray induced absorption (which depends on the irradiation dose rate and time) the microtron was switched off and a recovery process was detected.

The scintillating fibers and luminescence shifting fibers were investigated and two major absorption bands with different time dependency were observed. The first one was in a range below 475 nm and the other one from 500 nm to 680 nm with a peak around 580 nm. The induced absorption coefficient is higher for all the scintillating fibers than those for the wavelength shifting fibers and it also increases with dose rate. Generally, the kinetics of both the build-up and the recovery processes for different scintillating and wavelength shifting fibers are very similar. Reversible and irreversible parts of induced absorption were observed at a wavelength of 580 nm for all the luminescence doped fibers. This confirms that there are two types of absorption centers. The first type seems to be stable in time for several hours.

The other type is represented mainly by short-lived centers, absorbing light during fiber irradiation. The induced absorption decays within one hour after ending the irradiation. The build-up rate is proportional to the dose rate. The decay rate is proportional to the square of the concentration of absorption centers because the absorbed centers (probably radicals) expire in the bimolecular reaction. The induced absorption coefficient is proportional to the center concentration. The measured data were analyzed. The agreement between the experimental data and theoretical kinetic model [3] confirms that induced absorption changes can be well described by the bimolecular interaction process.

A considerably different behavior of time and spectral dependencies of the induced absorption was determined for light guide fibers. An absorption band was observed in the region of shorter wavelength. On the other hand, the absorption peak in the region from 500 to 680 nm, dominant for fibers doped by luminescent molecules, was not observed. Generally, the induced absorption coefficient was much smaller for all the light guide fibers investigated. The induced absorption coefficient is also increasing with dose rate, particularly in the region of shorter wavelengths.

The influence of luminescent dopands to radiation hardness was observed for pairs of two similar fibers - scintillating fiber and the light guide fiber manufactured by one company. Absorption centers, absorbed mainly in a region of 520-670 nm, were detected in the scintillating fiber with a polystyrene (PS) core. This absorption band is not presented in the light guide fiber that also has the same PS core. From these results one can conclude that the centers absorbing this light are not caused by PS matrix, but by the additives of the luminescent molecules. This absorption band was caused by short-lived centers, which rise-up during fiber irradiation and decay within one hour after radiation. The radiation-induced transmission changes in the region of the emission peak of luminescence doped fibers due to a reduction of their fluorescence yield and, consequently, affected the scintillating fiber detectors performance.

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2D distribution of Neutron Flux in the Training Reactor VR-1 Sparrow

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The aim of our work is a purpose of 2D distribution of the thermal neutron flux in the training reactor VR-1 Sparrow. This experiment is based on measurement of the thermal neutron flux, which was made by two years ago [1]. The measurement was projected for standard core configuration called B1. The parallel plane of measurement was chosen at the distance of 35 mm from the edge of the core. The activation detectors which were used for the experiment were made from a high purity copper wire.

These wires were fixed to the plexiglass holders which were fixed to the desk, made from the same material. The desk was situated vertically in a distance of 35 mm from the side of core. Every wires were fixed to the desk with orientation to fuel elements. The material of the desk was chosen in a respect to minimal influence to reactivity (plexiglass has similar moderating properties as water) and in respect to requirement of the solidity that was needed to ensure fixed position in the ractor vessel.

The experiment was divided in four individual measurements. At first two wires were measured which were situated horizontally at 370 mm (center of core) and at 640 mm (30 mm above end of uranium in fuel elements) height from the base desk of the reactor vessel. Eight vertically situated wires were used for next two measurement. Which were fixed to desk in positions 10, 40, 70, 100, 140, 175, 220 and 270 mm from edge of core. Last measurement was realized because of we needed the higher density of measuring points. Two short activation detectors were used for this measurement. These activation wires were situated in the position 500 mm and 620 mm high from the base desk of the the core. The copper monitor was used to comprison of all measurements. This monitor was made from 1 cm long wire that was each measurement fixed to the same place of the plexi-desk. Wires was irradiated in the core with constant power 1 kW of the reactor, the time of irradiation was 1,5 hours.

The copper contains two main isotopes, ^{63}Cu and ^{65}Cu. The copper activation goes by two ways, one possibility is reaction ^{63}Cu(n, γ)^{64}Cu and second is ^{65} (n, γ)^{66}Cu. For us is most important the first reaction, because its halftime is 12,7 hours, the second reaction has halftime only 5,1 minutes and measuremnt of one wire was done after a few hours. The activity was measured after decay of the isotope ^{66}Cu by scintilation detector. Many 1 cm segments of the wire activation detector were measured that's why the measurement was driven automatically. The experimental facility WIRE-2 was used for processing of activity measurements. The facility WIRE-2 is equipment of departmet's laboratory and was designated for measurement of activation detectors and content of fission products in the fuel elements.

This facility consists from part that ensure step linear movement and from detection system. The moving facility consists from the step engine, from the bench for fixation of

holder with activated wire, and from shielding with detector window. The shielding is made from the steel and the lead. The detection system consists of detector under detector window, which enable to measure only a small segment of wire (in our case 1 cm), and from the multi-channel analyzer that read the output signal from the detector. Signals were digitalized and recorded to the PC. The data was evaluated by programm MCA, the output fom this software was spectra of each segment. The neutron flux was calculated from these spectra.

The output of our measurement was mesh of points in the plain 35 mm far from side of core. The shape of neutron flux are similar as hill without depression and local extrem. That is in agreement with our expectation because the plane of measurement was situated near the reflector peak. This shape of neutron flux was different from result of [1]. He measured in the middle of core and the shape of neutron flux was very indented. The reson of this difference is that in the center of core were sources of fast neutron (uranium fuel) and minimum of moderator and vice versa.

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Properties of Higgs Boson Produced with a Pair of Top-antitop Quarks in Proton-Proton Interactions with Energy 14 TeV

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At present, one of the most successful theory describing elementary particles is called Standard model. Assuming an existence of several elementary particles and taking into account the gauge invariance of SU(2) group, we can predict the existence of another particles, called intermediate bosons, which provide forces between particles. These bosons have recently been observed but unlike to the theory they are very massive. One of the possibilities how to provide them a mass in the theory is to assume an existence of another particle, which is called Higgs boson. Using special properties of this particle we have a theory, which describes very well observed properties of elementary particles. Problem is that Higgs boson has not yet been discovered in any experiment.

The main aim of the project was to create a method to find a Higgs boson in experiment ATLAS in CERN in Switzerland and from results to determine its mass and coupling to top quarks.

To investigate properties of Higgs boson we chose a special process where two protons collide and Higgs boson arises together with a pair of top-antitop quarks, another interesting particles. Among six known quarks, from the point of view of investigation of their properties, there is a certain exceptional position of the top quark, not discovered on the collider in Batavia in USA until several years ago. It is strange for its high mass (~175 GeV) because of which its estimated lifetime is about 10^{-24} s. Within this time it cannot hadronize, decays as a free particle and therefore its decay products preserve information about properties of this quark, mechanisms of its production and decays. Using this process we can also measure strength of the coupling between Higgs boson and top quark.

Neither Higgs boson nor top quarks can be seen directly in a detector because they decay very quickly. According to the Standard model the top quark decays in almost 100% into W-boson and b-quark and W-boson then decays into two quarks or into lepton and neutrino. In the mass range 80-150 GeV, the Higgs boson decays mainly into two b-quarks.

There are several channels to investigate, which can be divided according to the decay products of a pair of intermediate bosons arising from top quarks. When both W-bosons decay into quarks, we have a total final state with 8 quarks. Assuming all combinations of them, we are not able to determine with a reasonable precision, which two of them arose from Higgs boson, what is the main goal of the problem. Another case is when one W-boson decays leptonically and the other one hadronically. This possibility is more promising, but there are several groups already working on it. We investigated the case where the final state consists of four b-quarks (two b-quarks and two b-antiquarks), two leptons and two neutrinos. This case seems to be very good because there is a very little background with this final state. But there is another big problem. While momentums of leptons can be measured very

precisely in detectors, quarks are not directly observable, so momentums of them are measured with a poor precision and neutrinos cannot be observed at all.

First of all we have to construct equations to establish momentums of neutrinos. There are six non-linear equations, which use energy and momentum conservation laws of outgoing particles. These equations can be converted into a polynomial equation of fourth degree, which means that we can get up to 4 solutions for every input. For selection of the right one we do not have many possibilities. We must generate samples of various kinematical quantities with Monte Carlo generators and according to their distributions we can assign a probability to every solution.

When we know how to calculate momentums of neutrinos we have to determine which two b-quarks come from Higgs boson. Because we have four b-quarks in final state and we cannot discriminate between them, we have to consider all combinations of any two of them. For every combination we get different solutions for neutrinos and therefore different topology of whole interaction.

Totally we can get up to 48 solutions, most of them kinematically possible. Choosing the right combination and right solution of a set of equations is quite complicated process with disputable solution. Moreover there are two more problems which we didn't discuss above. One of them is that in real experiment we are not able to find tauons among leptons because they quickly decay into lighter leptons. So we have to consider only electrons and muons in our method. The second one is that the solution of equations described above is very sensitive to the precision of input parameters. But, as we said, the precision of measurement of quark momentum is poor.

The energy needed to produce process with one Higgs boson and two top quarks is very high and even presently biggest experiment in Fermilab cannot provide it. First experimental data, where our process could appear, should be detected on the collider LHC in CERN, but it has been not built yet. Nevertheless, exact methods of searching for the process, should be found before the collider will start to work. Therefore all methods are tested on the data generated with Monte Carlo generators which describe as exactly as possible the collider and a detector, which registers the arising particles. But even with the energy, which should be obtained with LHC (14TeV), the method we derived for a given final state, finds around two Higgs bosons per year. Methods using single lepton final states can find many times higher number of them and that channel is therefore much more promising for future investigations.

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Section 11

CHEMISTRY

Factors of Heavy Metals Mobility in Small Urban Streams

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The project aims at the research of heavy metals mobility in the stream ecosystem. Heavy metals behaviour within often changing conditions of urban small streams has not been quite clear till this time and its clarification results from the goals of the Directive 2000/60/EC of the European Parliament and the Council of 23 October 2000 establishing a framework for Community action in the field of water policy [2].

Heavy metals belong to the most dangerous contaminants getting to watercourses in urban areas. Most of them are strongly toxic for fishes and other aquatic organisms and via the food chain they get to higher trophic levels (birds and human) and have toxic, carcinogenic and teratogenic effects. The toxic impact depends on the form of incidence of the metal; they are toxic mainly as dissolved ions. Although heavy metals tend to bind into a solid phase (bottom sediment), where they are relatively unavailable for organisms, their behaviour and possibility of releasing to the water phase under changing conditions (pH, hardness, redox potential...) have not been quite clarified till this time [4].

Distribution of heavy metal between the water and solid phase can be described by Partition (Distribution) coefficient (Kd). Kd (unit l/kg or its logarithm more often) is the relation between metal concentration in the solid phase and concentration in water under equilibrium. Kd value changes with changing conditions, so it makes it possible to observe mobility of heavy metals.

A set of laboratory experiments has been carried out to find out equilibrium time of a metal distribution between the solid phase and water solution and to determine Kd dependence on various conditions of water environment, pH and hardness mainly, for chosen metals Cu and Zn. During experimentation standard and real sediment material have been used in batch adsorption tests to determine equilibrium time and Kd values. The batch adsorption test is based on EPA methodology [3]: a well-characterized solid material (sediment) of known mass is added to a beaker. A known volume and concentration of an aqueous contaminant solution is added to the soil in the beaker. The beaker is sealed and mixed until sorption is estimated to be complete (equilibrium time– this estimation was the first part of the experimentation). The solutions are centrifuged or filtered, and the remaining concentration of the contaminant in the supernatant is measured with Atomic Absorption Spectrometry. The concentration of adsorbate sorbed on the solid phase is then calculated.

During the first stage of experimentation – equilibrium time determination – real sediment samples and deionized water were experimented. The same concentration of the metal was batched into water phase, which was then added to known amount of sediment sample in beakers. The beakers were mixed for different time (within range1 day – 10days) and then equilibrium time was determined by comparison of measured remaining concentrations. While equilibrium time 5 days for Cu was estimated (Kd value between the 4th and the 10th day is relatively constant, with RSD 0,9%), Zn needs more time (10 days) for establishing of equilibrium. Within the first stage of experimentation significance of fixation by nitric acid was also investigated. Higher concentrations of metals were measured in water phase, when nitric acid was added, probably because of metals releasing from suspended solids present in liquid phase after centrifugation.

During the second stage of experimentation standard sediment samples and deionized as well as real water were applied. Highly risky metal concentrations at interval 1mg/l- 30 mg/l were dosed into liquid phase. This test was carried out for equilibrium time found out during the first stage of experimentation. No significant differences were found out between testing deionized and real river water (neutral pH and hardness of 150 mg/l) in case of Cu. Within choosing range of testing concentrations Kd value (its logarithm) for Cu 3,05 (RSD 3,29) resp. 2,92 (RSD 5,67) using deionized water resp. real river water was measured. Kd value for Zn 3,74 (RSD 1,67) with using of deionized water was measured within the same range of concentrations.

However most of metal is bound from water to sediment during test, concentrations in water still remain in risky levels, higher then ecologically acceptable limits of the 3rd class of CSN 75 7221 [1]. It can be caused by limited amount of sediment sample taking for experiment, in which all adsorption positions have been occupied. Moreover, a small amount of another metals was released from solid phase to water during testing, especially in case of Cu test, where Ni, Cr, and Zn were detected in water phase after testing. Cu showed higher ability of expulsion than Zn, in whose case only Cr and a very small amount of Cu was released during tests.

High buffering ability of river sediment was also showed during experiments, when standard solutions of Cu and Zn stabilized by nitric acid were batched and pH of water phase was decreased from 7 to 2. After establishing of equilibrium pH value about 7 was measured again in water phase.

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Properties and Reactivity of NiO-ZnO Mixed Oxides Differing in Their Origin

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Our earlier systematic research of the influence of genesis on the reactivity of mixed oxides tested by their hydrogen reduction has been concentrated predominantly on the NiO-ZnO systems prepared by thermal decomposition of crystalline nitrates of both metals [1], by calcination of coprecipitated basic carbonates [2] or by decomposition of precursors mixed in different combinations [3]. In the last case the precursor of the first series arised by evaporation of suspension of the basic nickel carbonate with $Zn(NO_3)_2$ solution to dryness and vice versa the precipitates of basic zinc caronate were mixed with nickel nitrate solution during the preparation of the second series. In all above mentioned cases the high degree of mutual interaction of both components in the final mixed oxides was proved and significant differences in physico-chemical parameters as well as in reduction behaviour of these systems were observed. The aim of the present work was to study the properties and reduction kinetics of an analogous system prepared from the pure oxide of one component (NiO or ZnO) in interaction with the soluble salt of the second component (zinc or nickel nitrate).

Two series of mixed oxides with various content of both components in the range
0-100 wt.% were prepared by thermal decomposition (4 h at 450^{o}C) of precursors. In series 1 the powdery nickel oxide of carbonate origin was mixed with required volumes of the 1,5
mol L^{-1} solution of zinc nitrate. These suspensions formed were evaporated to dryness at 120^{o}C , homogenized by grinding and then calcined. An analogous procedure was used for the preparation of the precursors of series 2 in which the powdery zinc oxide was mixed with the solutions of nickel nitrate. Selected samples of both series were heat treated at different temperatures and atmospheres. Parts of samples were irradiated prior to use with ^{60}Co gamma rays and by accelerated electrons (4 MeV) using a dose of 3 MGy in both cases. The reduction kinetics were studied partly by isothermal thermogravimetry in the range 350-440^{o}C and partly in non-isothermal regime at a heating rate of 10 deg min^{-1} up to 440^{o}C.

In contrast with earlier studied systems the absence of solid solution of both oxides in the whole range of composition demonstrates the lower degree of their mutual influence in both series 1 and 2. In spite of that the non-additivity of the specific surface areas and non-monotonous dependence of this parameter on the composition, especially with the series 1, different dispersity of microcrystallites of both components and resistance to sintering processes at additional heat treatment argue that both series under study differ not only from simple mechanical mixture but also from each other. It was found that with the series 2 the dissociative chemisorption of molecular oxygen takes place both on the dominant Ni^{2+}-Ni^{2+} centres and on the mixed Ni^{2+}-Zn^{+} centres, whereas with the samples of series 1 no additional mixed centres enhancing the chemisorption of oxygen are created. On the contrary the higher content of superstoichiometric oxygen in pure nickel oxide of series 1 when compared with

the same sample of series 2 is determined by different morphologic character of decomposed precursors – basic nickel carbonate or crystalline nickel nitrate. The pre-irradiation by gamma rays and accelerated electrons results in a pronounced increase of the content of chemisorbed oxygen with the samples containing excess of nickel oxide in both series. With the series 2 this increase can be attributed to the shift of equilibrium between various forms of oxygen in favour of the strongly bound ionogenic form. In the case of series 1, except previously mentioned effect, subsequent chemisorption of oxygen on the new centres created by irradiation takes place, too. Moreover, no differences between the effects of gamma rays or accelerated electrons on the samples of series 1 were found, whereas the mixed oxides of series 2 appear to be more sensitive to the irradiation with gamma rays. Likewise, the changes in the normalized content of chemisorbed oxygen after high temperature treatment of the samples in both series are different.

The maximum reduction rate as well as the rate constant of reduction monotonously and non-linearly decrease with increasing content of thermodynamically more stable zinc oxide in the whole range of composition for both series. Even though the kinetics of reduction of both series 1 and 2 can be quantitatively described in conformity with the shrinking unreacted-core model, the samples of series 1 show substantially higher reactivity. Due to higher surface areas, resistance to the sintering and therefore more porous texture, the transport of water vapour may be facilitated. With the samples of series 1 this leads to the acceleration of reduction and lowering of the activation energy. The partial reduction of the second component (ZnO) at higher temperatures takes place also up to the different degree with both series, depending on the origin and composition of the sample. The higher sensitivity of the samples of series 1 towards pre-irradiation both by gamma rays and by accelerated electrons manifests itself by the lowering of reduction rate in the region of prevailing content of nickel oxide. Because the maximum reduction rate characterizes the reaction on the surface or in the near-surface layers of the grain, this quantity may be affected by heat pre-treatment of the samples in an opposite manner when compared with the rate constant.

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Radiation Dechlorination of Tetrachloromethane in Various Types of Water

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The radiation dechlorination of various chlorinated hydrocarbons such as polychlorinated biphenyls (PCBs) [1], tetrachloroethylene (PCE) or trichloroethylene (TCE) [2] or chloroform [3] seems to be one of the most promising methods for the remediation of water [4]. The same is valid for carbon tetrachloride. The aim of this paper was to investigate the radiation dechlorination of carbon tetrachloride in aqueous solutions, containing various amounts of sodium nitrate, prepared from the water of three various origins: the distilled water, the well water and the river (surface) water. The well water was characteristic by an increased content of chloride ions (9.2 mg/dm^3) and higher concentrations of the nitrate- (5.1 mg/dm^3), chloride- (9.9 mg/dm^3) and sulfate- (24.0 mg/dm^3) ions were found in the river water.

All samples containing the tetrachloromethane from 1.3×10^{-4} to 8.3×10^{-4} mol/dm^3 and sodium nitrate from 0 to 100 mg/dm^3 were irradiated with accelerated electrons (linear accelerator UR-4-1200 TESLA MIKROEL, Ltd, dose rate of 1.5 kGy/s, doses up to 5.0 kGy) in sealed glass ampoules. The dosimetry was performed using the Fricke-dosimeter. The gas chromatograph CHROMPAC CP- 9002 with a capillary column equipped with EC-detector was used for determination of carbon tetrachloride-concentrations. The hardware and software of Data Apex comp. served for the data collection. The concentration of Cl^- -ions was determined electrochemically using the digital milivoltmeter with the chloride ion selective electrode in connection with the standard calomel electrode.

The first difference between the three types of water under study was found for the initial concentrations of the carbon tetrachloride: the samples prepared by identical dilution of the saturated aqueous solution of tetrachloromethane (5.2×10^{-3} mol/dm^3) in the distilled-, well- and river- water for to get the initial concentration of 6.8×10^{-4} mol/dm^3 contained of 2.1, 4.0 and 6.6×10^{-4} mol/dm^3 of tetrachloromethane, respectively. It means that the mostly polluted water (river water) retains significantly the volatile compounds.

The performed measurements showed that the concentrations of tetrachloromethane decreased and the Cl^- -ions concentrations increased with the dose of irradiation. These both changes were inhibited by presence of NO_3^- -ions. The highest degree of dechlorination α_{Cl}- was found for the distilled water (of about 95 %) and the lowest one for the river water (of about 52 %), both at the dose of 5 kGy. It means that the natural pollutants inhibite the degradation process. As a support for this idea serves the finding according to which the addition of sodium nitrate (100 mg/dm^3) reduced the α_{Cl}- values to 53 and 2 % for the distilled and river water, respectively. The radiation chemical yields G(Cl^-) determined for 100 eV increased in the order distilled-, well- and river-water ((5.0, 12.0 and 15.0)$\times10^{-2}$ eV^{-1} at the dose D = 1 kGy). These values decreased with increasing dose ((1.5, 4.0 and 4.5)$\times10^{-2}$eV^{-1} at the D = 5 kGy, for distilled-, well- and river water, respectively) as well as with increasing concentrations of the nitrate ions ((1.5, 11.0 and 13.0)$\times10^{-2}$eV^{-1} at the D = 1 kGy and 100 mg/dm^3 of sodium nitrate for distilled-, well- and river water, respectively). On the

basis of the above mentioned results it may be concluded that the radiation dechlorination of tetrachloromethane seems to be well performable in various kinds of natural water even if some pollutants (e.g. NO_3^- -ions) affect negatively this process.

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Evaluation of Effeciency of Adsorbent Materials for Organic (Humic) Substances Elimination from Water in the Porous Environment

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Ones of the element combination physical, chemical and ecological steps is also monitoring come into operation adsorbent material for stripping humic matters, which tie together on research from past years. Principles is simulation saturation (later also unsaturated) streaming waters porous environment behind continuous pressure measuring, temperatures (later sorptivity) in soil profile, further weight and moisture. On simulation oneself water about known concentration humic matters lets flow through gravitational on the way natural mother profile, across adsorbent and afresh mother profile accordant with real storage in terrain, so that in conclusion after hers drain off take the measurements of final concentration humic matters.

Humic matters (HM) induce considerable difficulties at water purification on drinkable waters, at final chlorination they are precursor production trichloro-methane (THM), which they have carcinogenic effects. Their stripping on water purification plant (WPP) is attached to economical loading. That is why get past minimize content HM in waters even before entry to the WPP...

Minimizations transfer of humic (organic) matters from mother porous environment into waters is very complicated process, which in pasts the top experts in their branch of work resolve - soil physicist and chemist, whose results have had more likely informative character.

In first period has been construction ground of simulator. That's made out of cylindrical tube, length 55 cm and width 30 cm. Tube has been cut off on three parts, which they are apart separated steel sieves about cell size cca 2 mm. For better re-fill, we can take to parts. Middle part (adsorbent part) is possible to make bigger or smaller, we can tack on or remove the parts. First and third part is integrated and there we can put mother profile. On first (upper), part it is possible put independent, sc. "reservoir" part, that be instrumental to accumulation-inputted water. Body of simulator is produced of light isolating stuff, to there could not come up photochemical reaction.

In second period, will possibility to use digital scale for monitoring vapour and sensor for measuring intake pressure. Measuring intake pressure requires very complicated technology that is need very expensive evaluation device.

Important part research will be analysis input and output of water, there for evaluation of the total quantity HM, we shall use direct analytical method, that are based on oxidation carbon those organic matters. For evaluation qualitative constitution HM, we were using extensive spectrum physical, chemical, physic - chemical, in some case biological method, that

exploited different from solubility HM in acid and alkaline environment. For fractionation solution and isolation HM, we can use columned chromatography.

Next, we shall use spectrophotometer for monitoring of the total share humic matters that are included in input and output water.

Generally they will usage laboratory methodology to assessment humic matters, that are applied in "VUMOP Prague 5 - Zbraslav" and next specialized soil science establishment.

Solving it´d be apply detailed analyses of input and output value and next appreciation practicability type adsorbents.

If we find to acceptable adsorbent stuff, we can start by projecting of filter into check - dams, or we can propose further solution.

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Impact of Different Anthropogenic Activities on Distribution of Heavy Metals in Small Streams

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Heavy metals (HM) belong to the group of the most dangerous substances entering aquatic ecosystems. HM issues, their mobility in aquatic ecosystems and their toxicological impact on organisms is still not very well understood, especially in environments where frequent and fast changes of conditions occur. This type of environment is present especially in small urban streams, where the urban drainage significantly changes the flow, physical and chemical conditions of water (pH, conductivity, hardness, redox potential, concentration of nutrients and pollutants, etc.). These changes can lead to a remobilisation of pollutants from sediment back to water. These substances become easily bioavailable for aquatic organisms and through the food chain enter a higher trophic level. This project is focused on the study of HM remobilisation possibilities and changes of distribution coefficients leading to remobilization. This paper presents preliminary results and compares the distribution coefficients from different streams and consequently biota sediment accumulation factors for organisms from these streams are also presented. These coefficients can be used together with other parameters to assess the ecological risk caused by HM present in the aquatic ecosystem.

The studied streams are impacted by different anthropogenic activities (urban drainage – combine and storm sewer outlets and mining). The first study stream is the Kocába creek (tributary of the Vltava River, south of Prague), which is impacted by mining activity. Lead and silver were mined since the middle ages and most recently uranium was exploited. The mining activities were discontinued in the early 1990's. The second stream is the Točnický creek (tributary of the Úhlava River), which was taken as a reference site to the Kocába creek. Both the watersheds have a similar geological background, but the ore deposit occurs only on the Kocába watershed. The others assessed streams are the Botič creek and the Zátišský creek, tributaries of the Vltava River in the Prague agglomeration. Both of these streams are impacted by urban drainage, the Botič (in the studied section) by two combine sewer outlets (CSO) and one storm sewer outlet (SSO) and the Zátišský by seven SSO and three storm sedimentation basins.

Concentrations of HM were detected in water, sediment and the body tissue of benthic organisms. Measured concentrations were used for the calculation of different coefficients (Hazard Quotient, Distribution Coefficient and Biota Sediment Accumulation Factor), which can help to assess the ecological risk of HM present. The Hazard Quotient (HQ) is a ratio between metal concentration in the stream sediment and toxicological criterion. When HQ value exceeds 1 (for one metal), an ecological risk is indicated. For calculation of HQ in bottom sediment the US EPA toxicological benchmarkers TEC (Threshold Effect Concentration) and PEC (Probable Effect Concentration) were used, because a Czech criteria for sediment evaluation is missing. The distribution coefficient (Kd) is the relation between a metal's concentration in sediment and its concentration in water and gives information about what medium is crucial for the risk assessment – it indicates whether an observed pollutant prefers binding to sediment or dissolving into water. Organisms living on the water sediment

interface get into equilibrium with the surface layer of sediment. The distribution of HM between the surface layer of sediment and pore water defines the portion available for plant and animal uptake. The uptake of pollutants by an organism is dependent on the ability of a particular organism to accumulate polluting substances. The ratio between the concentration in organisms and sediment is called the Biota Sediment Accumulation Factor (BSAF).

The ecological risk (assessed by HQ) in sediment occurs in consonance with TEC on all study sites from the Kocába, Točnický and Botič creek, regardless to the type of pollution occurring on each site. On the Zátišský creek, on only one sampling site, is the risk in consonance with TEC. According to the PEC values a risk is present only on the Botič and the Kocába creek, the concentration of HM in the sediments of the Zátišský and the Točnický creek do not reach values, which can cause a risk according to the PEC.

The Kd varied not only in space, from stream to stream, but also in time. The Kd for most HM (Al, Pb, Cd, Zn, Fe and Mn) on the Kocába creek indicated that these metals preferred to bind to sediment or suspended matter. On this watershed only As preferred to occur dissolved in water. A different situation was observed on the Točnický creek, Cd, Zn and As had very low (smaller than 3) values of log Kd, they occur mostly in the dissolved form, and thus are easily available for uptake by aquatic organisms. Fe, Mn, Al and Pb were present bounded in sediment and they are less dangerous for aquatic organisms than dissolved elements. On both urban streams (the Botič and the Zátišský creek), the distribution coefficients showed that all metals are bounded to sediment. And from this point of view do not represent to high risk for organisms.

The composition of the benthic community varies from site to site and each species of benthic organisms has a different ability to accumulate HM in their body tissue. This fact limits our ability to compare different sites and organisms from these sites. It is necessary to compare only the same species and organisms of similar age and size, to minimize inaccuracy. A few species, which occurred on most study sites, were selected (Hydropsychidae, Sphaeridae, Erpobdelidae, Assellidae) and their BSFA was calculated. On the Kocába creek, Hydropsychidae had the highest value of BSFA. The other species did not accumulate HM to levels higher than the concentration in sediment. The most bioaccumulated elements were As and Cd. On the Botič creek, Erpobdellidae and Assellidae showed the highest BSFA and Zn was the most bioaccumulated element. On the Zátišský creek, Erpobdellidae also had the highest BSFA, high values were also detected in Hydropsychidae and Assellidae. On all samplings sites, it was discovered that the different species have different abilities to accumulate different metals. An interesting situation was observed on the Zátišský creek, where the HQ did not indicate a risk, but most of the organisms showed higher BSFA than the same species on the Botič creek. It can be assumed that on the Zátišský creek, the metals are present in a more bioavailable form then on the Botič creek.

The results indicate that different geological backgrounds and different anthropogenic activities change the distribution of HM and their bioavalibility in an aquatic ecosystem.

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Influence of Selected Solid Promoters on Radiation Degradation of TCE

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Chlorinated hydrocarbons belong to the most dangerous contaminants of groundwater and possibly drinking water not only in Czech Republic, but also in many other industrially advanced countries. The groundwater contamination is result of industry development and agriculture intensification. Chlorinated hydrocarbons are generally non – biodegradable substances and their removal requires employment of multi-stage technologies, which are usually economically inconvenient (for example high - temperature combustion of polychlorinated biphenyls). Therefore, alternative and more efficient methods of contaminants removal are thoroughly studied.

Among the most promising methods belong radiation technology using both gamma (^{60}Co or ^{137}Cs source) and accelerated electrons irradiation. Efficiency of radiation treatment can be further increased by addition of various promoters to treated solution. For example, addition of ozone to irradiated solution of some chlorinated hydrocarbons may lead to genesis of additional free OH radicals and to increasing of efficiency of their removal (1). Research of influence of solid phase on radiolytic dechlorination is relatively new, although some results achieved in previous years are very promising (2).

This preliminary study focuses on effect of various solid promoters on efficiency of radiation dechlorination of trichloroethylene (TCE). Based on previous studies (3,4), bentonite, active carbon and nickel oxide were used as promoters in this research. Various concentrations of water solution of TCE were prepared, ranging from 8,37 x 10^{-3} mol/L (saturated solution) to 4,2 x 10^{-5} mol/L. Concentration of solid promoters also varied, ranging from 1 mg/mL to 5 mg/mL. Samples were sealed in thin-glass ampoules and irradiated using linear electron accelerator (electron energy 4 MeV). During irradiation, samples were continuously stirred. Doses applied varied from 0 to 5 kGy. Effect of irradiation was evaluated as the decrease of contaminant (TCE) concentration by means of gas chromatography and compared to increase of amount of final product (Cl^-). Chloride concentration was measured using standard chloride electrode. Samples with added solid phase were compared to the samples without promoter. Both series of samples were irradiated under same conditions.

Significant differences in efficiency of dechlorination were observed for various initial concentrations of TCE as well as for various concentrations and types of solid promoters. It was observed that degree of dechlorination is strongly dependent on initial TCE concentration. When samples of saturated solution were irradiated, no significant difference in total degree of dechlorination (evaluated for dose of 5 kGy) occurred between samples with and without addition of solid promoters. This may be caused by the fact that added amount of promoter was too low to have measurable impact on degree of dechlorination. On the other hand, shape of dechlorination curve distinctively changes when solid promoter is added to

solution, which is in accordance with supposed adsorption – desorption mechanism of dechlorination.

In the case of concentration 2,2 x 10^{-4} mol/L TCE, not only changes in shape of dechlorination curve occurred, but also sharp increase of radiation dechlorination efficiency was observed for samples with added promoter. Degree of dechlorination increases not only with the dose, but also with increasing amount of added promoter. Of the three studied promoters, active carbon surprisingly seems to have the least impact on radiation dechlorination.

In the case of the lowest initial TCE concentration under study (4,2 x 10^{-5} mol/L), solid promoters also significantly increase dechlorination efficiency. However, even when no solid promoter is added to solution, TCE concentration decreases under detection limit upon reaching the dose 2 kGy.

So far, the most promising seems to be study of TCE concentration about 10^{-4} mol/L. It is planned to involve more solid promoters to the study (zeolite, PbO, CuO, etc.) in near future and besides employing ozonization, also to investigate influence of solid promoters on radiolytic dechlorination of tetrachloroethylene (PCE) and tetrachloromethane.

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Bichromophoric Molecule with a Vibrational Probe

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Intramolecular electronic excitation energy transfer (IEEET) is one of the elemetary processes that can occur on in supramolecules. Such process can be looked at as an information transfer, and-potentially-could be used for information treatment and/or storage. Promising approach to the investigation of this phenomenon is a detailed study of photophysical properties of molecules containing two relatively separated chromophoric moieties (acting as a donor and an acceptor connected by a bridge), i.e. bichromophoric supramolecules exhibiting IEEET.

This contribution presents a study of solvent-dependent photophysical properties of such bichromophore: 2-(4-cyanophenylamino)-4-(1-pyrenylamino)-6-chloro-1, 3, 5-triazine (ABNTCAPy). The bichromophore contains a nitrile group (attached to the donor part) that shows characteristic stretching vibration. Presence of this group can be potentially useful for IEEET monitoring, due to the nitrile group sensitivity to the electron density in its microsurrounding.

The UV-Vis absorption spectra of ABNTCAPy and of its model donor and acceptor sub-parts were measured in various solvents in order to confirm its bichromophoric behavior, followed by an analysis of the bichromophore absorption spectrum against the sum of model donor and acceptor parts spectra. The following model species were used in order to perform such an analysis:

- models of the donor part
  - 2-(4-cyanophenylamino)-4, 6-dichloro-1,3,5-triazine (ABNTC2)
  - 4-aminobenzonitrile (ABN)
  - benzonitrile (BN)
  - aminobenzene (aniline) (AB)
- models of the acceptor part
  - 2-(1-pyrenylamino)-4, 6-dichloro-1, 3 ,5-triazine (APyTC2)
  - 1-aminopyrene (APy)
  - 2-(1-pyrenylamino)-4-methoxy-6-chloro-1, 3, 5-triazine (APyTCM)

Nitrile group presence in para-position to the amino group is responsible for appearance of a new absorption band around 297 nm. Assignment of this band is supported by UV-Vis absorption spectra of model compounds AB, BN, ABN and ABNTC2.

The ABNTCAPy behavior was studied in solvents of different polarity. Two parameters, F (ε, n) and E_T^N, were chosen to describe the solvent polarity. Lippert – Mataga polarity function (reaction field factor), F (ε, n), takes into account optical and electrical properties of the solvent only, i.e. relative permittivity and refractive index. The Dimroth and Reichardt empirical parameter of solvent polarity E_T^N is based on the experimentally established polarity dependence of the longest-wavelength solvatochromic absorption band of

the pyridinium-N-phenoxide betaine dye that was normalized with respect to its values in water and tetramethylsilane.

The main changes of the ABNTCAPy spectra with solvent polarity occur in the region of the band introduced by the nitrile group in para position to the amino group. The band is red shifted with increasing solvent polarity; DMSO and DMFA shift the whole spectrum. The bichromophore solvent-dependent bands were analyzed using nonlinear curve fitting of spectra with area version of Gaussian functions.

It was found that the band shift, as well as the ratio between absorption intensity of this band and the one corresponding to the acceptor subunit, can be statistically better described as linearly dependent on F (ε, n) rather then on E_T^N.

The bichromophore fluorescence emission band maximum wavelength and the band profile are very similar to those of the acceptor model species APyTCM. This fact can be explained via hypothesis that the bichromophore have only one emitting state which is localized on its acceptor subunit.

In order to examine an influence of the nitrile group on ABNTCAPy emission, fluorescence emission spectra of ABNTCAPy and ABTCAPy were measured. The spectral position, as well as the fluorescence emission band profile of both bichromophores (with and without nitrile group), are practically the same.

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Sorbents of Toxic Metals Based on Immobilized Humic Acid

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Industrial technologies and energetics generate enormous amounts of harmful environmental pollutants. The nature of some wastes, namely long-life radionuclides, requires their long-term storage in suitable repositories which, in addition to the natural geological barrier need a geochemical barrier based on suitable sorbents to immobilize the contaminants in case they penetrate through a geotechnical barrier. In situ permeable barriers based on sorbents have a potential for remediation of contaminated ground water. For large-scale use, these operations would be exceedingly expensive. Natural sorbents have been considered as promising inexpensive alternative, among them also humic substances (HS), a substantial component of natural organic matter produced by biomass degradation. HS are capable of strong interaction with metal cations by forming stable complexes and chelates with the functional groups (mainly carboxylic and phenolic), however, their solubility over a broad pH range precludes their use as sorbent material without suitable immobilization. In situ immobilization of HS in matrix of low-rank coals, particularly postsedimentary oxidized coal (oxihumolite), represent one of the most abundant natural resource of immobilized HS. Since the supply of naturally oxidized coal is limited, it would be convenient to treat the more abundant energetic brown coals to obtain material with sorption properties comparable to oxihumolites. This work has been aimed to investigate potential of artificially oxidized lignite as low-cost sorbents of selected radionuclides, in comparison with oxihumolite produced naturally by postsedimentary oxidation of parent coal from the same seam, and humic acid.

Coal samples collected from seam Antonín, Sokolov Basin, Czech Republic - lignite in Jiří mine, oxihumolite in Marie mine (J0 and M, respectively) – were sieved to 0.3-0.5 mm. Sample J0 was oxidized on air at 140°C, samples were withdrawn after 24, 50, 80, 120 and 200 h (J24, J50, J80, J120, J200, respectively). They were protonized by HCl. To study the role of bitumen, samples ME, J0E, M200E were prepared from samples M, J0 and J200, respectively, by extraction with toluen/EtOH (1:1) in Soxhlet extractor. Purified/protonated Aldrich humic acid (HA) was used for comparison. Samples were characterized by elemental analysis, infrared (DRIFT) spectroscopy, proton exchange capacity (PEC) was determined by the $Ba(OH)_2$ method. Dissociation of functional groups was studied by potentiometric titration. Leaching of HS from the samples was checked by spectrophotometry. Batch sorption experiments were performed with radiotracers ^{134}Cs, ^{60}Co, ^{152}Eu under conditions: V/m = 100 mL/g, I = 0.1, Cs, Co and Eu concentration 2.4×10^{-5}, 2.2×10^{-5}, 1.6×10^{-6} M, respectively, 24 h shaking, phase separation by centrifugation. Effect of pH was studied. Activities in solution were determined by gamma-spectrometry.

The oxidative elemental changes were most pronounced during the first 50 h, the higher O content in M was reached in J after 80 h oxidation. At the same time, H/C atomic ratio decreased. Extraction of bitumen (6-8 wt%) decreased content of both O and H. Structural changes in O functionalities were followed by the DRIFT spectroscopy. The increase of content of carboxyl groups with oxidation time was reflected by increasing ratio of peak intensities at 1700 (carbonyl stretching vibrations) and 1612 cm^{-1} (aromatic C=C bonds). The gain in phenolic groups was followed by the ratio of 3200 (phenolic –OH) and 2922 cm^{-1} (aliphatic C-H bonds) peak intensities. Effect of extraction was ambiguous. Changes in acidobasic properties of coal samples due to oxidation, i.e., the increase in O functionalities, were reflected by shift of titration curves to higher NaOH consumption, and increase in the PEC values. Comparing the PEC values with NaOH consumption at the end of titration showed that the continuous automatic titration was too fast to reach equilibrium after each titrant addition due to a worse accessibility of HS functional groups in coal mineral matrix. Extraction of bitumen changed character of titration curve and decreased PEC, especially in case of oxihumolite and strongly oxidized coal. In agreement with solubility of HA in neutral and alkaline solution, its leaching increases with pH. It was much higher for oxihumolite than for coal samples. Oxidation for 200 h increased significantly leaching of HS, but yet it remained much lower than in case of oxihumolite. Extraction decreased leaching of HS.

Sorption of Cs, Co and Eu was evaluated by the distribution coefficient K_d calculated based on activities of the radiotracer in solution. The K_d values increasing in the order Cs<Co<Eu reflect increasing charge of cation and ability of coordination-covalent binding to HS sites. Oxidation of coal increased K_d's with no improving after 80 h oxidation. Generally, K_d's increased with pH due to dissociation of the binding sites. K_d's of Eu (and with Co, to a certain extent) with M and HA, in alkaline region also with other samples, decreased with pH due to formation of soluble HS complexes leached into solution. Effect of extraction was negligible except for non-oxidized coal with Eu and Co, whose sorption in neutral and alkaline region was enhanced, possibly owing to suppressed leaching of HS.

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Complexation of Europium with Humic Acid: Modeling of the Data from Potentiometric Titration

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Humic substances (HS) represent a substantial component of the natural organic matter produced by biomass degradation in natural systems as soils, sediments, surface and ground waters. They are capable of strong interaction with metal cations including toxic metals and radionuclides by forming stable anionic complexes and chelates with the HS functional groups (mainly carboxylic and phenolic). The metal-HS complexes are fairly soluble which can facilitate environmental transport of the contaminants, on the other hand they can be retained by sorption on mineral surfaces. The chemical aspects of complexation and behavior of selected contaminants in systems containing HS are of a great interest especially in relation with the "performance assessment" at the long-term disposal of radioactive wastes produced in nuclear power plants. For description and prediction of the interaction of metal cations with HS, several models have been designed ranging from simple description by a set of binding constants to complex models allowing for the macromolecular, polydisperse and polyelectrolyte character of HS. All the models require experimental determination of the degree of complexation by a suitable method, e.g., ion exchange, ultrafiltration, electrophoresis, dialysis, gel-chromatography, and various spectrometric methods. In addition, advanced modeling requires also knowledge of the degree of dissociation of the acidic functional groups determined exclusively by potentiometric titration. At the same time, with a suitable model this method enables also to determine the degree of complexation. In the course of the project "Humic Substances in Performance Assessment of Nuclear Waste Disposal: Actinide and Iodine Migration in the Far-Field" (HUPA) within the 5th EC Framework Program, several approaches have been used to describe interaction of Eu (as an analogue of trivalent actinides) with Aldrich humic acid (HA) [1-3].

Determination of the degree of complexation of Eu with HA by potentiometric titration is based on description (modeling) of the titration curves characterizing neutralization of the acidic functional groups (carboxyl and phenolic) by NaOH. In the first step, HA is titrated in the absence of Eu to derive parameters describing its dissociation (blank titration). The second step consists in the titration of the same system containing a suitable amount of Eu sufficient to bring about a measureble increase in concentration of hydrogen cation exchanging with the Eu^{3+} cation, while also side reactions as Eu hydrolysis and precipitation must be taken into account. Besides that, the total concentration of the exchangeable sites (proton exchange capacity, PEC) has to be found by the back titration of $Ba(OH)_2$ exchanging on the totally protonized binding sites of HA.

In this work, the system of Aldrich HA (purified / protonated, 300 mg L^{-1}) with Eu total concentration $3{,}6\times10^{-4}$ mol L^{-1} corresponding to ~17 % of the PEC found (not included in the blank titration) at ionic strength I = 0.01/0.1 ($NaClO_4$) was titrated using an automatic titration station with a glass combined electrode. A 30 mL solution of HA (9 mg HA

dissolved under nitrogen in NaOH, 0,1 mol L^{-1}, standardized) containing an excess of $HClO_4$ to drop pH to ~2.5, and $NaClO_4$ to maintain the ionic strength, thermostated at 25 °C, was titrated with the standardized NaOH solution under nitrogen atmosphere. The blank titration was carried out continuously with the progress of titrant addition controlled automatically by reaching stability of the electrode signal. In case of titration in the presence of Eu, equilibration in the alkaline region was very slow probably because of the slow kinetics of Eu decomplexation from HA followed by its hydrolysis/precipitation and/or formation of mixed complexes, thus it was carried out discontinuously in single batches let to equilibrate up to 7 days.

Dissociation of HA (blank titration) was modeled assuming two types of the carboxylic groups (S - strong-acidic, W - weak-acidic) and one type of the phenolic hydroxyl groups (Ph). At the curve fitting, the PEC value was used as a constraint. The resulting set of protonation constants and concentrations of the binding sites was used in description of the system in the presence of Eu assuming following reaction with the S and W sites of HA:

$$Eu^{3+} + HAS^{3-} \Leftrightarrow EuHAS$$

$$Eu^{3+} + HAW^{3-} \Leftrightarrow EuHAW$$

$$EuOH^{2+} + HAW^{2-} \Leftrightarrow Eu(OH)HAW$$

The third reaction characterizes formation of the mixed complexes. Other reactions characterizing the model system are reactions of Eu hydrolysis, i.e., formation of the hydroxocomplex $EuOH^{2+}$ and precipitation of the solid $Eu(OH)_3$:

$$Eu^{3+} + OH^- \Leftrightarrow EuOH^{2+} \qquad Eu^{3+} + 3OH^- \Leftrightarrow Eu(OH)_3$$

In addition, protonation/deprotonation reactions of both types of carboxyl groups and phenolic groups, and neutralization of excess strong acid have been involved as stated above. For the modeling calculations, a computation code based on the method of the non-linear regression was constructed. Results of the modeling have been discussed in comparison with the results obtained previously in our laboratory by other experimental methods.

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Sorption and Desorption of Uranium on Waste Rock Material from Uranium Mining

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A central aim of environmental chemistry is to develop an understanding of processes at the microscopic level, and to develop models to simulate that behaviour, which may be used with transport codes to predict the fate of pollutants on the field scale. The work performed in our laboratory with waste materials from uranium mining was intended at obtaining suitable input data for modelling of uranium release and migration in the presence of humic acid in the waste rock piles region at Schlema-Alberoda (Saxony, Germany). The broad previous information about a representative rock pile in the region was compiled. The results of this case study were presented in a contribution [1] where it was mentioned that necessary observations and data for performance assessment modelling are still missing.

Waste material from rock pile No. 66 has been selected as representative material for the purpose of further laboratory study. Sampling of the rock was made by Forschungszentrum Rossendorf in collaboration with WISMUT Company. The sample was analyzed in co-operating institutions (elemental composition, mineralogy, total carbon, inorganic carbon and specific surface area) and in CTU (granulometry and exchangeable uranium). The determination of exchangeable uranium (U_{ex}) was performed by isotope exchange using ^{233}U with two basic solutions: (i) 10^{-4} M HNO_3 and (ii) simulated seepage water from Schlema-Alberoda (0.0175 M $MgSO_4$, 0.0091 M $CaSO_4$, 0.00258 M $NaHCO_3$). The experiments, with contact time of 14 days gave for both solutions the similar mean values of U_{ex} ($\cong$ 20 μg/g), which represented approx. 35 % of total uranium in the sample. This result was also compared with results received using standardized leaching procedure [2]. A very good agreement with a result of leaching by Morgan solution (1 M CH_3COONa, pH = 5 adjusted by acidic acid) showed that exchangeable uranium determined by isotope exchange encompass sorbed uranium and a part of uranium present in carbonate minerals.

Sorption/desorption studies were performed by batch and column experiments. In the main part of experiments we used isotope ^{233}U as a spike, as the analytical determination of the ^{233}U uptake/release by liquid scintillation counting (LSC) was at hand. Experiments performed without spiking were evaluated by ICP-MS determination of natural uranium. The uranium distribution data with the synthetic seepage water could be interpreted by a linear sorption isotherm ($K_d \cong$ 20 mL/g), with no significant dependence on the value of volume to mass ratio in the range studied (10-100 mL/g). The impact of humic substances, for concentrations of humic acid of 10 and 50 mg/L, was moderate. Only for higher concentration of added uranium, which caused the increase of equilibrium sorbed uranium to values greater than $2U_{ex}$, higher values of K_d (25-30 mL/g) were determined. Slow kinetics in batch arrangement was found with about two weeks required in order to obtain a steady-state distribution for volume to mass ratio in the range mentioned. The kinetics of ^{233}U uptake was modelled by our original approach that proved its usefulness for similar systems (e.g. [3]): as the best kinetic function was selected, by a formal statistical procedure, the function that respected also diffusion of studied contaminant into sorbing particle. It was observed an

ambiguous influence of experimental conditions (total uranium added, volume to mass ratio, content of humic substances, way of pre-equilibration of phases preceded adding of the spike) on the value of the characteristic constant of the selected kinetic function, which needs a further study. For this type of experiments it was stated, that for some conditions the measured uptake of ^{233}U would be better interpreted as a manifestation of isotope exchange of ^{233}U with natural uranium present initially in the solid phase (U_{ex}) than a representation of the uptake of total uranium added. Therefore the conditions and type of experiment were selected where the representation of the total uranium (added + exchangeable) using spike should be dominant. The conditions of elution experiments, which needed the equilibration of solid phase with the spiked solution of added total uranium concentration near to the equilibrium concentration determinated, were very close to those in the pile where preferably the release of uranium should take place. Such experiments were performed also without spiking. As results obtained by both the methods were very similar, a good physical model necessary for the determination of model parameters of uranium release from the pile seemed to be prepared.

The elution dynamic experiments were performed on small columns (inner diameter 0.9 cm, height of layer from 3 to 5 cm) with linear flow-through velocities 2.8 and 6.3 cm/h, for the conditions selected according to the results of batch experiments. The flow-interruption technique showed that non-equilibrium conditions existed during our flow experiments. The slower elution of uranium spiked by ^{233}U, comparing with the results of elution experiments performed without preceding spiking, showed that for dynamic arrangement a further study of elimination of isotope exchange should be completed.

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Critical Assessment of Dialysis, Ion Exchange and Ultrafiltration as Methods for Analysis of Metal-Humate Complexation

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Interaction with humic substances in natural waters and soils represents an important process affecting toxicity and behaviour of toxic metals and radionuclides in the environment. Therefore the formation of aquatic metal humate complexes and other forms of the interaction have been rather extensively studied. Existing data on metal ion humate interaction frequently contradict each other due to lack in critical assessment of experimental methods applied. This is especially true at low metal ion concentrations. This leads to lack in confidence in experimental data, process understanding and thus predictive geochemical modelling. Such a modelling is particularly important for performance assessment of nuclear waste disposal. Recently the role of humic substances in nuclear waste disposal became a target in a project of EC EURATOM Programme entitled "Humic Substances in Performance Assessment of Nuclear Waste Disposal: Actinide and Iodine Migration in the Far-Field (HUPA)". One of its objectives was to provide the necessary knowledge to improve confidence in own and published experimental results on radionuclide-humate interaction [1]. The approach chosen was the comparison and evaluation of results obtained with several experimental methods applied to the analysis of complexation of europium with Aldrich humic acid (HA) under similar experimental conditions. Europium was used as an analogue of trivalent actinides representing important components of spent nuclear fuel.

In this paper, results characterizing the applicability of three experimental methods are described: dialysis, ion exchange and ultrafiltration. The methods were tested in their radiotracer arrangement using ^{152,154}Eu. In order to work with a standardized HA, lyophilized sample of solid HA purified by a standard procedure was prepared and characterized by „baryta" method and acidobasic titration (for determination of total proton exchange capacity and proton dissociation characteristics, respectively), thermogravimetry and FTIR [1].

Standard conditions for complexation experiments were selected in order to enable comparability of the results: room temperature (18-25°C), preequilibration of europium with HA for 1 and 7 d, pH 4 and 6, ionic strength I (adjusted with $NaClO_4$) – 0.1 and 0.01 mol/L, HA concentration 10 mg/L, total europium amount in the system to obtain the following loading of HA with europium: 1%, 10% and 50% of total proton exchange capacity of HA present in the system divided by three (PEC/3). The degrees of europium complexation with HA (*%EuHA*) determined by individual methods were compared.

Two arrangements of **equilibrium dialysis** were tested: one with equal volumes of compartments of dialysis cell (1:1) and the second with unequal volumes (X:1 where X is the relative volume of the retentate compartment, containing Eu and HA). Dialysis 1:1 was tested using Spectra/Pore membrane (MWCO 1kDa) with initial concentration of europium 2.3×10^{-7}, 2.3×10^{-6} and 1.15×10^{-5} mol/L Eu. Slow establishment of equilibrium and large sorption of Eu (up to 30%) on the membrane and cell made the method not suitable for obtaining required data.

Dialysis with volume ratio 20:1 was studied under similar conditions as above with dialysis bags made of Visking cellophane tubing (MWCO 10 kDa) floating in retentate vessel. Large absorbance was found inside the bags after the experiment due to passage of HA through the membrane. Equilibrium was not established in 6 days. Thus the arrangement was found unsuitable for the purpose of the study.

Dialysis with volume ratio ~50:1 was studied with bags made of Spectra/Por Biotech CE tubing (MWCO 500 Da). No significant penetration of HA into the bags has been observed, a near-to-constant concentration of Eu in the bags was achieved after 6-12 days. Very significant sorption losses of Eu were found which, however, did not prevent obtaining correct values of *%EuHA*, if the losses were neglected in the calculation. This was due to predominant sorption of EuHA which remained in equilibrium with Eu^{3+} even after the sorption. This variant of dialysis can yield useful data representing a maximum possible value of *%EuHA* (in case of disequilibrium and of Eu^{3+} sorption the correct value is lower).

Ion exchange method was used in batch arrangement with Amberlite IR-120(Na). A non-linear equilibrium sorption isotherm of Eu^{3+} on Amberlite IR-120(Na) was determined (pH 4.1, I = 0.01 and 0.1). Equilibrium values of concentrations *EuHA,* Eu_{free} and of actual loading of HA were determined with 10^{-5} M Eu and 1-80 mg/L HA or with 10 mg/L HA and 1×10^{-5}-5×10^{-4} M Eu. Using the data obtained the stability constants of EuHA complex were calculated for each set of experimental conditions using so called charge neutralization model and plotted as a function of equilibrium concentration of Eu in solution (*EuHA* + Eu_{free}). Then the constants corresponding to required values of loading were used for calculation of *%EuHA* values at required values of pH and I. The results agreed well with *%EuHA* values determined by equilibrium dialysis. The ion exchange method yields reliable complexation data if the isotherm for distribution of uncomplexed metal ions between solution and ion exchanger is adequately investigated and a suitable model is used for evaluation of results.

Ultrafiltration was tested with two types of ultrafilters: Amicon YC50 (MWCO 500 Da) and Millipore PLAC (MWCO 1 kDa). The effect of sorption on the results and the efficiency of separation of Eu forms were studied using a newly designed arrangement [2] and two methods of evaluation. It has been found that although the sorption of Eu on the ultrafiltration cell can be rather large, efficient correction for it can be applied and the sorption need not result in a significant shift of complexing equilibria in the system. However, the ultrafilters used were unable to well separate EuHA complex from uncomplexed Eu, since they partially retained Eu^{3+}. This, together with incomplete retention of EuHA, lead to incorrect values of *%EUHA* which differed from the results obtained by the other methods. Unless good separation of complexed and uncomplexed metal forms and efficient correction for metal sorption on cell and ultrafilter are ensured, ultrafiltration based humate complexation data need to be interpreted with great caution.

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Influence of Fe Ions and Some Others Ions on Radiation Degradation of 1,1,2-Trichloroethane in Water

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Numerous applications of chlorinated hydrocarbons in industry have been cause of the contamination of environment by these hazardous compounds. Removing of these compounds from drinking and ground water, from municipal and industrial waste water appears to be a great problem of purification process. Chemical and biological resistance of these pollutants is a reason for low effectiveness of conventional pollutant disposal techniques. Et present increasing attention among environmental technologies is focused on processes involving formation of free radicals. The radiation degradation of target toxic species is one of these processes. The basis for this process is founded in the radiation chemistry of organic compounds in aqueous solution and fundamental studies have shown that complete degradation of these resistant compounds can be achieved by ionizing radiation treatment. Despite of the reaction mechanism of radiation induced dechlorination of chloro-organic compounds are still not completely understood, there are many information about degradation of such compounds as chloroform(1), carbon tetrachloride, tri- and perchloroethylene(2), chlorobenzenes, chlorophenols and some others. Reported results shown that doses ranging from ones to tens of kGy could effective decompose them. Additional research was directed to the optimization of the treatment process aimed at more economic conditions.

For following development of irradiation processing it is necessary to simulate real conditions of the polluted water occurrence. The influence of the compounds occurring in the water beside the target chloro-organic pollutants on the efficiency of radiation processing is one of the practical problems. During irradiation of water various radicals (OH, H, e^-_{aq}) are formed. These may react with the majority of components occurring in water system. Consumption of these radicals in parallel reactions with others components in irradiation system may substantially affect economy of purification processing. Irradiation of water system is carried out in the plant under condition when construction material may be corrodible. Products of corrosion such as Fe ions may also affect by this way efficiency of the degradation process.

Last year our attention was directed to the degradation of 1,1-dichloroethane(3). This study follows up with the 1,1,2-trichloroethane (TC-ethane). The aim of this work was to investigate the influence of EB-irradiation conditions and the effect of some scavengers (bicarbonates, nitrates, sulphates and Fe^{2+} and Fe^3 ions) on radiation degradation of TC-ethane.

The samples for irradiation were prepared by dilution of TC-ethane saturated water solution in distilled water or in solutions of relevant scavengers. The study was performed in the presence of oxygen in irradiated systems. The experiments were conducted in the concentration range 10^{-4} – 10^{-3} mol.l^{-1} of target compound and 10^{-4} – 10^{-3} mol.l^{-1} of scavengers. Samples were bottled to the glass ampoules (20 ml), sealed and irradiated.

Electron irradiation (4,5 MeV) was performed using linear pulse accelerator UR-4-1200

Tesla (dose rate 1,5 kGy/s). Doses were applied in the range 0-32 kGy. Dosimetry was ensured by means of Fricke dosimeter. Course of TC-ethane degradation was monitored using gas chromatography (GC), (CHROMPACK model CP 9002, ECD, DATA-APEX integrator). Amount of inorganic forms of chlorine was determined by selective chloride electrode. The degradation of TC-ethane was characterised by degree of degradation α(-TC-ethane) = $100.(c_0-c)/c_0$, where c and c_0 are actual and initial concentration of TC-ethane and by degree of dechlorination $\alpha(Cl^-)=100.c_{Cl^-} / 3c_0$, where c_{Cl^-} represents actual concentration of Cl^- ions (products of degradation). The degree of degradation α(-TC-ethane) decreases with increasing dose and α(- TC-ethane) of about 90 % was reached at dose 8 kGy. The degree of dechlorination $\alpha(Cl^-)$ reaches value of about 50 % at the same dose. The rest of organic bound chlorine remains in solution as the degradation products, especially dimers containing different number of chlorine. Degradation of these products occurred at doses 16-32 kGy, depending on TC-ethane concentration (determined by GC). Initial radiation yields G_i(-TC-ethane) were calculated from the dependence of TC-ethane concentration on the dose and reaches value of about 2,1 $10^{-2}eV^{-1}$. Radiation degradation proceeds as a reaction of TC-ethane with primary products of water radiolysis.

Presence of selected scavengers (10^{-3} mol/l) significantly influences the efficiency of radiation degradation of TC-ethane in water. Inhibition effect increases in the order nitrates, bicarbonates, sulphates. Lower concentration of scavengers (10^{-4} mol/l) leads to the decrease of the scavengers influence. Important results were achieved when effect of Fe ions was studied. Influence of Fe^{2+} ions was negligible but presence of Fe^{3+} ions (10^{-3} mol.l^{-1}) decreases efficiency of the process by about of 3x.

Based on the obtained results, study of radiation purification of real waste water systems in large volume pilot plant is planned.

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Section 12

BIOMEDICAL ENGINEERING

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Corrective braces are used for the treatment of spine scoliosis of children (deformation of chest curve). The brace pushes on child trunk and after a long time using it corrects pathologic spine curve. The brace is worked at this manner: it is made a plaster negative and then a positive form of child trunk. The orthotic according to his and orthopaedist experience deeps the plaster positive form at the place where the brace has to push on the child trunk. The plastic brace is then made according to this plaster form. The brace after its application pushes at the places, where the form has been deepen (the small shoe principle). The brace force effect is result of orthopaedist experiences only. The paper shows algorithms and computer programs, which are able to determine the stress state at vertebras and inter-vertebrae discs and algorithm and program for simulation of scoliosis treatment course. The theoretic conclusions ware verified with many treatment courses.

The finite elements method (deformation variant according to the Lagrange principle) was used for the stress state solving. It was supposed that the vertebrae bodies have no deformations and soft tissue is elastic. The potential energy was calculated only for the inter-vertebrae discs and lignums and for the pressed soft tissue region of the trunk. The inertia moment has to be determined for inter-vertebrae disc and lignum cross-sections. The cross-section is divided to triangles and the third parts of areas are concentrated to the side centres. Because it is no deformation between vertebrae centre and inter-vertebrae disc bounder, the central spine line is at this part straight. The follow algorithm is valid for the frontal and sagital plane, the planes will not be indicated by the plane index.

The difference between displacements and turning measured on the X-rays without and with a brace are the deformation of spine under brace force effect. The deformation is given by displacements and turning at the vertebrae centres

$$r^T = \left[w_i, \varphi_i, w_{i+1}, \varphi_{i+1}\right] \tag{1}$$

and the node forces and moments at the vertebrae centres are

$$R^T = \left[R_i \quad M_i \quad R_{i+1} \quad M_{i+1}\right] \tag{2}$$

It is valid

$$Kr = R \tag{3}$$

where stiffness matrix for the spine part between centers of neighboring vertebrates is

$$K = \begin{bmatrix} \frac{6k}{l^2} & -\frac{3k}{l}\left(\frac{2a}{l}+1\right) & -\frac{6k}{l^2} & -\frac{3k}{l}\left(\frac{2a}{l}+1\right) \\ -\frac{3k}{l}\left(\frac{2a}{l}+1\right) & k\left[2+\frac{3a}{l}\left(\frac{2a}{l}+1\right)\right] & \frac{3k}{l}\left(\frac{2a}{l}+1\right) & k\left[1+\frac{3a}{l}\left(\frac{2a}{l}+1\right)\right] \\ -\frac{6k}{l^2} & \frac{3k}{l}\left(\frac{2a}{l}+1\right) & \frac{6k}{l^2} & \frac{3k}{l}\left(\frac{2a}{l}+1\right) \\ -\frac{3k}{l}\left(\frac{2a}{l}+1\right) & k\left[2+\frac{3a}{l}\left(\frac{2a}{l}+1\right)\right] & \frac{3k}{l}\left(\frac{2a}{l}+1\right) & k\left[2+\frac{3a}{l}\left(\frac{2a}{l}+1\right)\right] \end{bmatrix} \tag{4}$$

where the beam stiffness is $k = (2EI)/l$, E,I are the module of elasticity and the moment of inertia of a cross-section at the inter-vertebrae disc and lignums place, l is thick of disc. The node force and moments R can be calculated from (3), the stress state at inter-vertebrae parts and vertebra can be calculated too. If it is completed the vectors r, R and matrix K for all spine the load between spine and soft trunk tissue can be calculated (the inner forces and moments are according to the action and reaction principle eliminated).

The pressed soft tissue can be considered as an elastic grunt. The brace pushes at a child trunk at the place, where the plaster positive form has been deepen; it means that the trunk surface (soft tissue) has at these places the non-zero prescribed displacements. Let the matrixes K_{above}, K_{below} be calculated for trunk part above and below the spine according to formulas for elastic grunt. The variation of potential energy of soft tissue part is

$$\delta E_p = \delta r^T [-K_{above} (r_0 - r) + K_{below} r] = \delta r^T [-K_{above} r_0 + (K_{below} + K_{above})] r. \qquad (5)$$

where r_0 is vector of trunk surface displacements. The vector r_0 can be calculated from minimum potential energy condition using (5). The r_0 elements are needed deepen distances at perpendicular direction to spine for the trunk plaster form according which is the plastic brace made. The analogical formulas are valid for medial and frontal planes.

The spine does not return to previous position after some time of brace application. The pathologic spine form is partly corrected. The correction depends on spinal curve type according to King. Let us suppose that the correction is percentage constant at a time interval. The correction is deference between the vectors y_1 and y_2 – spine displacements without and with brace (let us suppose that y_2 is constant in time)

$$y_1(t) - y_2 = k^t(y_1(0) - y_2) \qquad (6)$$

If $y_1(0)$ and y_2 are measured on X-ray at start of treatment ($t = 0$) and $y_1(t)$ is measured at time t=1 (time to 1st patient control is time unit), then the coefficient k can be calculated from (6).

The effect of cure was observed for various spine curve types and compared with computer model. The model and its parameters ware changed to be the same behavior of the model and reality. Many child patients are observed and the dependence between the spine curve correction and the spine stress state and a time interval of brace application are studied and the theoretical conclusions about the spine remodeling ware searched. The computer model was verified and it can be used for cure prognosis and searching of optimal brace form variant.

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Thermotherapeutics Applicators in Oncology

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Microwave Thermotherapy (Hyperthermia) is the new one of the methods of complex cancer treatment and is often used in other parts of medicine (e.g. urology or physiotherapy). Goal of this project was to identify the most often treated tumors, to design and to evaluate applicators based on the theory of evanescent waveguides.

This method is based on the fact that cancer cells respond to heat very different than normal tissue. In conjunction with others therapeutic methods, mainly with radiotherapy, an improvement in local tumor control and over all survival has been shown. Every Hyperthermia system has to have next parts: PC, which controls output microwave power based on the information from the thermometry system (invasive-thermistory and thermocouple or noninvasive-ultrasound and MRI), microwave generator which can operate at various frequencies, but we study mainly case of 434 MHz (local Hyperthermia) and 70 MHz (regional Hyperthermia), applicator and water bolus.

In cooperation with physicians from FN Bulovka we have been looking for types of tumors, where the benefit of hypothermia for patients has been shown. From many randomized, multicentric studies[1] it is clear, that head and neck tumors, tumors of the chest wall (mainly recurrences), malignant melanoma (metastasis) and sarcomas of soft tissue are very convenient for treatment by local Hyperthermia. From CT scans for radiotherapy's treatment planning we have found conditions for effective aperture (Head and neck, melanomas, sarcomas 8x6 cm, chest wall 12x20 cm).

Applicator for microwave thermotherapy is an important part of every Thermotherapeutic system, because it determines the distribution of electromagnetic energy in the front of applicator's aperture. Applicator provides radiation matching between complex impedance of biological tissue and 50 Ω impedance of coaxial exciting line as well. Evanescent Mode Applicator is a waveguide, which is excited under the cut off frequency. Entering capacity and inductive characteristic admittance of TE mode build up band pass filter for operating frequency. Reflection coefficient has to be better than –13 dB on the operating frequency 434 MHz, which is the most often for local Hyperthermia. Evanescent waveguide applicator operating at frequency 434 MHz with effective aperture 8x6 has been developed. It has been done with aid of numerical method (FDTD). Vector analyzer based on sixport has tested radiation matching. Distribution of absorbed electromagnetic energy (SAR) has been evaluated by thermovison system and muscle equivalent phantom. Good agreement between calculated and measured variables has been achieved. Equivalent circuit of evanescent waveguide applicator is evolving with aid of electromagnetic filed` simulator. Relations between inductive elements, coupling loop and characteristic inductive admittance has been solved with partial results. Original applicator with larger effective aperture (Effective aperture is nearly the same as physical aperture of applicator). The original one means, a hybrid between waveguide applicator and applicator based on the resonant loop. It could be very convenient in case of applicator for extremely large areas of treatment (e.g. for treatment of breast cancer).

The necessity of using water bolus with any microwave Hyperthermia applicator is a non-debated fact. It is used to obtain better contact between applicator and uneven surface of human body. Also it helps to eliminate hot spots and allows modify radiation patterns due to resonance effects in water bolus called volume and surface wave oscillation. It has been study with aid of numerical method, but the work is not finished.

In this contribution it has been shown development of evanescent waveguide applicator for the most often treatment tumors (head and neck). Effective aperture is 8x6 cm with possibility of increasing, operating frequency is 434 MHz. Equivalent circuit has been developed and radiation matching and SAR distribution was evalueted. In short time, it has been study the influence of water bolus to radiation pattern.

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Image Processing Based Motion Parameterization

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The research of a correlation between human body motions and electro-encephalograph (EEG) signals is one of the most interesting in the current neurology. One of the tasks solved within it is the image processing based motion parameterization.

Due to the complexity of relations between body motions and EEG signals the 3-D motion of the index finger as the basic simple body motion have been chosen for the parameterization.

Used finger motion sensing method has to be strictly non-contact, because each contact between a finger and a sensor could have a negative impact on the measured EEG signals. Therefore the presented method is based on video-recording.

The motion of the index finger is shot by two standard DV camcorders from two linear independent directions. Recorded videosequences are stored on tapes and consequently uploaded to a standard personal computer with IEEE-1394 interface. The scanned finger is marked by special marks, the concentric black circles. The finger motion is parameterized tracing these marks separately in both sequences (2-D parameterization).

At the first, the videosequences are pre-processed. All frames are converted from RGB to black-and-white representations, images with white background and black areas representing the marks on the finger. Firstly, the frames are converted to grey scale images. At the next step, the edge detection is applied. After that, the map of the edge density is computed over the whole image and the maximums of the edge density are found. The number of found maximums shall be the same as the number of the marks on the finger. Consequently, the small areas around the maximums are cut out from the image. The cut out areas are thresholded and pasted into the appropriate position on the white area with the same size as the original image.

At the second step, the mass centres of the marks are computed, sorted and stored in the mass centres matrix $\mathbf{C}_{ikn}$, where $i \in \{1,2\}$ is the coordinate index (row and column of the centre), $i \in \mathbf{N}$ is the mark index in the frame and $j \in \mathbf{N}$ is the frame index in the videosequence. Firstly, the centres of the marks are computed in each frame as the mass centres of the pixels belonged to the relevant mark. After it, the centres are sorted in each frame in the same succession as in the first frame.

The precision of the 2-D parameterization process was checked using the videosequence of 420 frames recorded in PAL standard (720 × 576 pixels color frames). Two parameters have been defined for checking the procedure precision – the mean difference and the relative error rate. The mean difference between the computed mark centres coordinates and the coordinates determined by manual process (they were considered as the real coordinates) was $d_{AV} = 0.34\,[\text{pixel}]$, the relative number of the marks with difference greater than $d = 5\,[\text{pixel}]$ is $\sigma_{5.0} = 0.48\,[\%]$.

After the 2-D parameterization we have two matrices $\mathbf{C}_{ikn}$. Each matrix includes a projection of the finger marks motion to the scan plane of the particular camcorder. All quantities describing the 2-D finger motion could be directly computed from the mass centres matrix $\mathbf{C}_{ikn}$. The parameterization of 3-D finger motion is computed from the mass centres matrices from both camcorder videosequences.

The space coordinates of the marks are computed using the non-perspective projection. All motions were traced relatively. It means, that there is no information about the real location of the mark, but there is only information about the change of this location. The vectors $d\bar{x}$, $d\bar{y}$ and $d\bar{z}$ – the changes of the centres locations in the base directions are computed from the vectors representing the changes of the centres locations in the base directions in the scan planes of both camcorders. For the better transparency the start point of the motions was set to the origin of axes and all motions were normalized to the unit cube.

The presented parameterization was tested on the set of videosequences with basic motions – vertical, horizontal and diagonal. The trajectory of outside finger mark (the mark placed on the end of the finger) was traced in each pair of videosequences. The real projections to the base planes, the front view, the ground view and the side view were computed for each motion.

The presented parameterization gives appropriate results used for the 3–D motion classification.

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Effect of the Preparation Conditions on the Properties of 3D Polymer Gel Dosimeters

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The polymer gel dosimeter is a new valuable tool used for experimental measurement of spatial (three-dimensional) dose distribution of irradiated volume [1]. This dosimeter fills up a gap in a variety of dosimeters used in radiation therapy. Its importance becomes more obvious as modern radiation therapy techniques such as IMRT or stereotactic radiosurgery experience wide spread among oncology centers. These modern techniques enable to create rather complicated dose distributions with steep dose gradients. When measuring these dose distributions with routinely used dosimeters, medical physicists often experience difficulties originating in insufficient spatial distribution of a dosimeter or impossibility to use a dosimeter for a three-dimensional arrangement.

The polymer gel dosimeter is an integral chemical dosimeter based on polymerization process that is induced by ionizing radiation. There are two principal components of the dosimeter – monomers and gelatin matrix. Free radicals are generated where interaction of radiation with matter occurs. The radicals initiate polymerization process of monomers. Matrix fixes created polymer at the place of its origin and prevents polymer from traveling away from the place. Presence of polymer causes local changes of some of dosimeter's characteristics. Currently, magnetic resonance imaging represents the most often mean of the gel dosimeter evaluation, although optical CT evaluation becomes increasingly popular.

Polymer gel dosimeter is independent on radiation beam's energy and it is also tissue equivalent. This enables to use the dosimeter also as a phantom of a part of a human body or a human organ. Unfortunately, gel dosimeter is sensitive to the presence of oxygen. Oxygen strongly inhibits polymerization process. Therefore, dosimeter preparation has to be done in oxygen free conditions. Recently, a new dosimeter formula including oxygen scavengers was published [2]. However, this new dosimeter's properties do not reach the properties of polymer gel dosimeter prepared in non-oxygen environment.

It was our aim to evaluate the dosimeter's properties upon a change of its pH grade. It has been proved that altering of weight fraction of sodium hydroxide influences melting point of the dosimeter and significantly changes its dosimetric properties.

Polymer gel dosimeter is the most resistant to temperature increase, if its pH grade falls into the range of 3.5 – 4.0. Above and bellow this interval, the melting point decreases. It is important to consider this aspect when preparing the dosimeter, because the melting point exceeds common room temperature only by a few degrees of Celsius. We have applied potassium aluminum sulfate dodecahydrate to gel's formula in order to strengthen rigidity of

gelatin matrix. Our assumption has been acknowledged by increase of the melting point by more than 2 °C.

Considering the dosimetric properties of polymer gel dosimeter, it has been observed that response of the dosimeter to absorbed dose significantly improves as its pH grade decreases. The dosimeter becomes more sensitive, the range of linear response region becomes wider, dynamic range extends, and background lever slightly decreases.

Sensitivity of the dosimeter with 0 % sodium hydroxide (pH = 2.20) equals to 0.38 s^{-1} Gy^{-1} and response to dose is linear up to 15 – 20 Gy. Meanwhile, common polymer gel dosimeter (1 % sodium hydroxide) shows sensitivity only about 0.17 s^{-1} Gy^{-1} and linearity up to 7 Gy.

To account both effects of sodium hydroxide, a compromise between dosimeter's temperature resistance and its dosimetric properties has to be made. The dosimeter with the formula including potassium aluminum sulfate dodecahydrate instead of sodium hydroxide seems to be the best choice. Its sensitivity 0.73 s^{-1} Gy^{-1} is unrivalled and linear and dynamic ranges are comparable with the most acid form of common polymer gel dosimeter [3,4].

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System MRI SISCO 85/310 - Putting into Operation

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The main activity of the MRI and NMR laboratory at IBMI CTU is nuclear magnetic resonance imaging - (N)MRI - as well as using a NMR as a spectroscopic method. Beside the basic scientific and educational work this lab is supposed to provide also measurement service.

The laboratory has initiated its research activities in summer 2003 by putting into operation the MRI SISCO 85/310 system. This system was donated to IBMI CTU in 2001 by Deutsche Krebsforschungszentrum Heidelberg (DKFZ), which cooperates with IBMI (former CBMI) since 1998 year. The pilot tests confirmed the readiness for operation within the parametrical limits assigned by the manufacturer. At this moment the training of operation staff as well as the search for experimental and educational partners and scientific program is being proceeded.

The laboratory is at the moment ready to conduct all basic scientific and educational experiments for all subjects interested from CTU. The meeting with potentional aspirants has already took place as well as more specific excursions with those interested from CTU faculties.

Last but not least to be mentioned are the negotiations concerning a common research laboratory of CTU and Charles University. Although the negotiations have not yet been finalized, there are good prospects of a concrete cooperation with the Physiological Institute and with the Institute of Immunology and Microbiology of Charles University 1st Medical Faculty. In addition, the donor of the device (DKFZ Heidelberg) is very interested in further development of the cooperation concerning MRI and NMR.

The operational costs are to be paid down from the budget of IBMI. About 350 000, - Kč is absolutely necessary for the essential maintenance of the MRI (such as liquid helium and nitrogen for the operation of superconductive magnet, gas helium and nitrogen for pumping up the liquid gases,..)

As to our knowledge, at this moment there are no other analogical devices such as ours except for one in IKEM in Prague 4 - Krc. The newly set up MRI laboratory is designed to be utilized for the needs of scientific and technical spheres as well as for the research medical purposes on small mamals. The vicinity of our workstation to the University hospital should also to be at the convenience of this target.

System MRI SISCO 85/310 detail description:

- *Magnet*, horizontal room temperature bore with diameter 310 mm (without shims) and length 940 mm
- *Coil*, superconducting (4.2 K) magnet coils, central field 2 Tesla (85 MHz for 1H,) current for field approx. 86 Ampers, nominal inductance 42 Henries

- *Shim System*, 8 superconducting shims, 15 room temperature shims, autoshim HW and SW at console and host computer system
- *Decoupler Options*, RF power amplifier for 85 MHz decoupler channel (200 W), 2nd RF decoupler channel for console system
- *Cryogen*,
    - Liquid Helium
    - Liquid Nitrogen
- *RF Transmitter*, broadband RF transmitter (amplitude and phase modulation), frequency range 9-85 MHz, resolution 1 Hz, phase continuous frequency switching (range <100 kHz), acquisition computer controlled phase (coherent frequency switching >100 kHz)
- *RF Observation*, 1 kW RF amplifier, 10-86 MHz linear observe power amplifier, maximum pulse length 20 ms
- *Imaging Coils, Coils for NMR Spectroscopy and Gradient Sets Specification*:
    - Magnet RT bore diameter 310 mm, gradient set diameter 225 mm
    - 2 Imaging coils $^{1}H/^{19}F$, inner diameter 80 mm & 135 mm
    - 6 surface or NMR spectroscopy coils:
        - $^{1}H/^{19}F$, inner diameter 25 mm
        - ^{195}Pt, inner diameter 13 mm, 15 mm, 25 mm
        - ^{13}C, inner diameter 24 mm
        - ^{31}P, inner diameter 20 mm
    - Gradient strength max. 3 G/cm
    - Rise time at maximum gradient <0.7 msec
    - Computer-controlled eddy current compensation with HPAG
    - Advanced gradient waveshaping
- *Host Computer System*, Sun Ultra Sparc 60, 1024 MB RAM, two CPU Module 400 MHz, Operation System Solaris 9, Varian VNMR software pack.

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Creation of E-learning System

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E-learning System MultiPeS

New version of system is using the most modern technology MS .NET, which secures easy comunication between platforms (32 bit / 64 bit) and large modulary of system. E-learning system MultiPeS is designed as an open modular system [1], which enables its simple further extension.

Information about learning courses are saved at standard format XML [2], which improves cooperation with other systems. System MultiPeS creates course which is exported in HTML format (for older explorers) and in XML formats for newer explorers (eg. Internet Explorer). The advantages XML format is separation learning text of his graphical presentation and simple and interactive control.

The best large advantage of e-learning system MultiPeS is that it can work in on-line (education at school, home study by internet) or in off-line (education with courses on the CD).

First step in preparation of an e-learning course in MultiPeS system is creation of a new project. The project is a group of all course parts (texts, figures, tests, sound tracks, or video sequences).

For simple orientation in learning text, two types of menu – normal and tree – are incorporated into the MultiPeS e-learning system. The teacher that creates a course can not only select Menu type but also construct Menu and attach various icon types to individual parts of the Menu.

The page is divided into three parts: menu – for simple orientation among individual learning pages, syllabus – references in large text (learning text exceeds one page), text.

In the project, there are predefined templates for creation of learning texts for the user. Similarly as with multimedia elements, it is possible to insert into the project new user templates or to generate templates directly in the project. When developing a new learning page, the user is asked about the page template he/she wants to use for the new page. After that the template's preview opens in right half of the screen (see figure 4).

In built-in editor there are following elements for development of learning pages available: text insertion and modification, text structuring (bullets, numbering), tables, references (in text, to another page), multimedia elements (figures, animations, sound tracks, video sequences), page background, insertion of scripts for extension of functionality of the learning page

Testing elements

Feedback [3] is very important for e-learning system. E-learning system must give information and knowledge but it must obtain information that student grasp educational text. Feedback is realised interactive tests with autamaticly survey. This feedback is good for continue survey of students' study. This main importance is self-survey of student. Student can according to self-survey repeat subject matter or he can obtain other informations. Results of interactive tests can be used to survey continue work of student.

When preparing testing exercises the teacher can use following elements:

- mark-off field
- switch
- text field
- push button
- window / hiding text
- figure

Pedagog decide about final face of test. He can combinate the elements and can make large scale interactive tests. Every question has set weight question and answer. Test can be limited by time.

Feedback is possible use to survey courses. If students do not pass interactive tests, e-learning course must be rewrite [4]. E-learning system MultiPeS includes special modul for creation of interactive survey tests.

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Biological signal clustering using Hidden Markovs Models

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Abstract
In this paper we concentrate on the problem of the number of arrhythmia beats-clusters selection presented in Holter ECG. We apply and compare several criteria for assessing the number of clusters and we show that, with a Gaussian mixture model, the approach is able to select 'an optimal' number of arrhythmia beats and so partition a Holter ECG. We conclude that only minimum description length and Bayesian selection method are suitable for our real-world electrocardiogram data.

Introduction
Holter signals are ambulatory long-term electrocardiographic registers used to detect heart diseases which are difficult to find in normal electrocardiograms. These signals normally include a quantity of beats greater than 10000. We have presented a method to extract significant beats from a Holter signal by applying unsupervised learning [1]. However, we have not dealt with the number selection of underlying clusters.

Methodology
Before any approach for selecting this number is considered the model that will generate the data under analysis must be selected. A natural choice is to consider that each arrhythmia group/cluster is generated by Gaussian distribution and that the whole data set can be described as a weighted sum of these Gaussian distributions. Several selection methods have been proposed to estimate the number of components of a mixture. The methods start by obtaining a set of candidate models for a range of values of k (from k_{min} *to* k_{max}) which is assumed to contain the true/optimal k. The number of components is then selected according to

$$k=\text{argmin}\{C(\Theta(k),k)\}, \quad \text{where} \quad C(\Theta(k),k)=-L(\Theta(k))+P(k) \tag{1}$$

where C is some model selection criterion, Θ an estimate of the mixture parameters assuming that it has k components, L is an log-likelihood corresponding to k-komponent mixture, P is an increasing function penalizing higher values of k. Whilst the first measure L decreases with the number of parameters, the second (often referred to as the 'Occam's razor' after the 13th century philosopher) increases as more parameters are estimated using a finite data set. The following criteria C has been examined: Bayesian selection method (BSM), Akaike's information criteria (AIC), minimum description length (MDL), minimum message length (MML), fuzzy hyper volume (FHV), evidence density (ED) and partition coefficient (PC) [2].

Results and Discussion

We have applied the clustering selection scheme to Holter signals from MIT Arrhythmia database. The signal were denoised using wavelet based filter and the baseline signal removal has been eliminated. Then the characteristic points of ECG signals as QRS complex, P and T wave were detected and each beat was consequently isolated [3].

Since each beat has a different length there is need for time alignment normalization of all beats to be able to model the beats by Gaussian distribution. We used the method of trace segmentation when all beats were normalized to the same length $d=250$ samples. The main assumption underlying the selection of the Gaussian mixture model is that each beat is represented as one point in the d-dimensional space and therefore similar beats will form clusters whose probability distribution tends to be Gaussian.

We connected the data from two leads, obtaining as a result 500-dimensional long waveforms. We tested the following three classes of abnormalities: ventricular escape (E), ventricular flatter wave (!) and premature ventricular contraction (V). In parentheses we follow the notation used in MIT arrhythmia database. Along with normal beats (.) we have in total four classes of beats. The sample beats were obtained by random selection over one record/patient from MIT database, which was in total 100 beats for each class. Taking into account the large inter-person as well as intra-person electrocardiogram records variability, the amplitude information as a feature vector is not sufficient to describe the underlying data structure as our experiments suggested. We applied wavelet transformation due to its superior temporal and frequency resolution. Still the dimension of data remained high; therefore, wavelet compression as a feature extraction method was performed [3].

Only the BSM and MDL estimated the model-order correctly. The MML and AIC did not penalize the more complex model, especially MML criteria, which is more conservative in that [2]. The FHV and ED measures are based on the calculation of the covariance matrix; this could be a source of computational errors (e.g.underflow). Finally the PC measure contains more local minima resulting in some cases in ambiguities of model-order selection.

Conclusions

We have presented a method for automatic unsupervised determination of the number of arrhythmia beats. We have analyzed several registers in the MIT database and shown that two particular measures are helpful in determining the correct number of clusters: Bayesian selection methods and minimum description length.

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Measurement of the Pulse Wave Velocity in Vivo

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A data acquisition is realized using purely non-invasive measuring mode, i.e. phonocardiography, in this project. A blood pulse wave velocity (PWV) in human arterial tree is determined by analyzing phonocardiographic (PCG) records. Two signals are needed as a minimum for an estimation of the pulse wave velocity. All of these signals have to be measured simultaneously from different sensing positions (palpable arteries) on a human body using electronic phonendoscopes. Manifestations of the pulse wave spreading in a cardiovascular system are recorded by developed measuring device. Recorded signals are transferred from this device to the computer, where they are saved for a next data processing (filtering, scaling, and analysis). The pulse wave velocity is estimated using a cross-correlation analysis of recorded phonocardiographic signals.

The pulse wave velocity inside the arterial tree is determined by the elasticity of the arterial wall, geometrical properties of the arteries and by a blood density. The pulse wave velocity was calculated using following formula

$$PWV = D/\Delta T \tag{1}$$

PWV – is the pulse wave velocity, D – is the distance travelled by the pulse wave between sensing positions, and ΔT – is a time needed to travel distance D by the pulse wave. The distance D between signal transducers was measured as a length of artery by measuring tape on a surface of a human body. This length D is only approximation of a real length of selected vessel segment.

The time delay ΔT of PCG measured signals was identified using cross-correlation function PCG_{12} of PCG measured signals, see equation 2.

$$PCG_{12}(\tau) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} PCG_2(t+\tau) \cdot PCG_1(t)dt \tag{2}$$

PCG_{12} – cross-correlation function of the PCG signals, PCG_1 – PCG signal from the first sensing position (a heart), PCG_2 – PCG signal from the second sensing position (left carotid artery), T – the time period of both PCG measured signals. A position of a maximum value of an assumed curvilinear cross-correlation function is the time delay ΔT.

Four young people were examined in this partial study. The youngest human tested was 21 years old and the oldest one was 25 years old. The tested group contained one female and three males. No diseases influencing cardio-vascular activity, i.e. results of this experiment, were known at all of them.

Obtained values of time delays of PCG signals varied from 0.02 to 0.08 second. Lengths of measured sections of arteries were from 23 centimetres to 31 centimetres. Pulse

wave velocities that are dependent on the length D and the time delay ΔT varied from 3.29 to 10.23 metres per second.

This experiment is not sufficient enough for validation. This experiment is only a pilot study of possibility to measure a pulse wave velocity with using phonocardiography, especially signal captured from electronic phonendoscopes. For the future we plan a large test with wide class of examined subjects.

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Complex Eye Movement Analysis and Its Use for Personal Computer Controlling

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The word “communication” origins from the Latin word “communicatio” which means to connect something. In a broader context it means any type of information transmission between individuals (in groups, societies, or populations) mediated by a set of codes (characters or signals) shared by sender (communicator) and receiver (communicant) using communication channels. We can identify many types of communication (e.g. direct and indirect). A special category is communication between man and technical systems capable of interaction (computers), another category is mutual communication between technical systems. Interpersonal communication is realised either in verbal form (using speech), or non-verbal form (using specific expressive means – body movements, gestures, mimics), while communication between a man and a computer is realised using a special device (computer periphery). Input information from the human is transmitted to the computer using one of the suitable interface, e.g. keyboard, mouse, trackball, or light pen. However handicapped people may have difficulties when controlling a PC by classical peripheries. This concerns people with motoric handicap that causes inability to control movements of arms and hands. Such people have problems with grasping a mouse, not speaking about fine manipulation with it. Since the computers have become common tools of work and have started to accompany us even in everyday life it is necessary to enable the handicapped people easier communication with the computers. That has been the motivation for us. We have proposed a solution that is based on recording eye movements and using them for communication between a person and a computer.

Observing the direction of view is used not only in medicine, but also in other areas, as for example psychology, ergonomic studies, marketing, arts; this principle may be used for an computer interface that can serve handicapped people. At present the most frequently used methods for recording eye movements are: search coil, electrooculography, monitoring reflected light by a photodetector, and videooculography.

In the project currently running at the Gerstner Laboratory, CTU Prague (working title MEMREC - Mobile Eye Movements RECorder) we are designing and developing a simple device for PC control.

The basic idea is fixing a small camera to the head of a person and recording the eye position in the coordinate system independently on the head movements (evaluation of the eye movements is done based on the deviation from balanced position). That means that the eye position has no direct influence on the cursor position on the monitor but it will determine the direction of its movement (as the joystick). To enable use of the system to people having a disorder of equilibrium organ that manifests as fast involuntary eye movements (nystagmus) it is necessary to introduce an insensitivity zone at detection of deviation. This zone must be adjustable individually according to the patient's handicap.

Using this "free" placement of the camera we remove the disadvantage, namely requirement of no head movement. The camera will be connected to the PC using standard

communication interface (USB) equipped with corresponding software and enables the handicapped person to control the PC simply by eye movements referred to rest position (view directly ahead). The MEMREC system is designed in such a way that the camera is another input periphery of the PC. The result will be a device that can be linked to any PC and used for control of all programs. In principle the camera would simulate a classical PC mouse extensible by an intelligent keyboard using a special user interface. Using this communication module the problem of compatibility of drivers between individual versions of systems or hardware platforms does not take place. The main requirements laid on the developed system are low price, simple installation and simple control.

The problem under solution can be divided into three basic areas:

a) recording of eye movements,

b) detection of pupil with transformation to the coordinate system,

c) design and development of an interface for intelligent data input.

After digitization of the videosignal acquired by the camera, the videosignal processing follows. The most important part of this processing is the detection of the pupil and transformation of its position to the coordinate system.

Simple control of the PC by the designed interface will help people with physical handicap to integrate fully in the society despite their handicap or at least to open the access to the latest information on the Internet. Since we use components that are easily available on the market and not very expensive the system will be reasonable for the handicapped people unlike many commercially available systems that are very expensive. We cooperate closely with the Neurological Clinic of the 2nd Medical School of the Charles University and Jedlicka´s Institute for Handicapped People. In cooperation with medical doctors we have identified other areas where this system may be applied as well.

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Ultrasonic Measurement of Elastic Properties of Cortical Bone

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The measurement of elastic coefficients is necessary for micromechanical modelling of the microstructure of bone tissue and for understanding bone remodelling mechanisms. A bone tissue is a generally porous anisotropic and visco-elastic composite material. For a small deformation rate, the assumption of infinitesimal strain and linear anisotropic elasticity is usually sufficient for description of preliminary material properties.

Several approaches of elastic constants measurements have been developed and applied for bone elasticity evaluation. Static mechanical tests (for example tension, compressive, bending and torsional tests) are currently used for assessment of elastic coefficients of bone. Elastic coefficients are possible to detect experimentally by means of dynamics tests (ultrasonic methods).

The purpose of this study is a measurement of elastic coefficients of cortical bone as at least orthotropic material [2] in its material symmetry via three ultrasonic experimental techniques [4]: contact technique, immersion technique and resonant ultrasound spectroscopy (RUS).

Contact technique is a simplest ultrasonic method of elastic coefficients measurement. Ultrasonic transducers are in direct contact with measured specimen by means of contact medium. Plane waves are transmitted from transducer to specimen in required crystallographic direction. Time delay and specimen thickness are measured. Velocity of longitudinal and shear waves are assigned from these quantities. Elastic coefficients are calculated from velocities in existing direction [3]. Two contact methods - the pulse transmission and pulse echo techniques are possible to employ for bone elastic constants measurement. Main disadvantages of contact technique are a reproducible acoustic coupling between the specimen surface and a transducer, and the specimen shape ought to enable measuring in a suitable number of crystallographic directions [2].

Immersion technique results from contact technique, but specimen is not in direct contact with ultrasonic transducers. The specimen is positioned between ultrasonic transmitter and receiver, immersed in liquid. The specimen is rotated in various directions and phase velocities at a broad range of directions are measured. This method is closely described in [1]. Diagonal elastic coefficients of specimen are obtained analytically from velocity measurements in principal directions and rest of the problem is possible to solve as multi dimensional optimization approach.

RUS is based on evaluation of specimen frequency spectra. The resonances are dependent on the specimen shape and dimension, and also on mass density, elastic properties of studied material. Given a priori knowledge about specimen geometry and the measured resonances, the all-elastic constants can be determined by iterative procedure solving the inverse problem. [4].

Ultrasonic immersion scanner was prepared in this project. It is mechanical-acoustic device for performing both reflection and transmission measurements. Design of this scanner assures various degrees of freedom among transducers and sample. The transmitting transducer is fixed and positions of the receiving transducer and the specimen is adjustable. Sample is fastened into a goniometer, immersed in liquid between both transducers and enables rotation around the goniometer axis. In particular, one can apply rotation to the target and move the receiver, laterally. This makes it possible to monitor the wave propagation occurring in a system, which obeys Snell laws, and thus measure shear waves velocities. Velocity measurements were presently performed on etalon composite CFRP (Carbon Fiber Reinforced Plastic) specimen by means of above described ultrasonic scanner. The CFRP is homogenous and anisotropic (transversally isotropic material symmetry) material with principal directions identical to the fiber direction. The acoustic impedances of used CFRP are comparable with ones of cortical bone. The specimen has a thick plate shape. Velocity of the wave propagating through specimen along various directions is well known from previous acoustic measurements as well as corresponding elastic constants. Further experiment will be performed on composite sample of pipe shape.

This paper refers about contemporary progress in determination of elastic constants of bone tissue by ultrasonic methods. Measurements on the artificial material are performed on immersion ultrasonic scanner and the methodology is compared with other ultrasonic approach, described in the contribution. General aim of this study is to develop optimal technique for mapping of bone elastic constants in principal bones of a human skeleton.

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Ultrasound-Based Temperature Monitoring for Hyperthermia Therapy

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Microwave thermotherapy (MT) is an important treatment in oncology. The basic technical principle of MT represents a controlled dosage of microwave heat energy into a tissue for a specific time interval. The equipment for MT consists of a high-frequency generator, applicator, regulation hardware (PC) and thermometer [1]. Effective MT requires maintaining the temperature distribution in the treated tissue in a predefined range. If the temperature goes below the range, the therapy becomes ineffective. When exceeding the range, not only tumour cells are affected, but also the "healthy" ones, which is not desired. Thus, the temperature monitoring of the treated tissue is a highly important part of MT.

At present the invasive thermometers are clinically used. However, these pose two main problems. The first is an increased risk of metastases formation. The second is measuring the temperature distribution in several discrete points only. There can be hot or cool spots in the tissue that are not found by invasive thermometers.

Non-invasive techniques of temperature distribution measurement solve the described disadvantages. One of these techniques is ultrasound and this is the approach we use in our project. The ultrasound B-mode images of treated tissue are obtained repeatedly during the thermotherapy process. The computer program processes the images and evaluates picture parameters such as mean grey scale value, gradient characteristics and other texture parameters. The changes of these parameters correlate with the temperature changes in the tissue.

Our clinical experiments were performed in the Valley Cancer Institute in Los Angeles, California, USA. The institute is equipped with several hyperthermia systems including two microwave systems and one ultrasound system. All systems are routinely and successfully used in daily patient treatments.

We performed 19 measurements on patients with breast cancer by using 3 hyperthermia systems. The first microwave hyperthermia system with the frequency of the electromagnetic field of 300 MHz was found unusable for our experiments. The electromagnetic field with the power of around 100 W was interfering with the safety circuits of the ultrasound machine which repeatedly disconnected itself from the power source. The field also interfered with the video signal recording. The second microwave hyperthermia system worked with the frequency of 915 MHz. Even though a more powerful signal was used here, it did not cause significant problems with other measuring equipment. We also tried some measurements with the ultrasound hyperthermia system. The results of these measurements are not as nice as the measurements with the previously mentioned microwave system, but they are also applicable for the temperature estimation.

The objective of data processing is to determine the distribution of temperature changes in tissue using image and texture analysis of ultrasound data [2]. To determine whether any texture parameter correlates with the temperature, it is necessary to eliminate all other possible influences on textures as much as possible. The data processing is organized in the following steps: 1) image registration, 2) image segmentation, 3) region of interest (ROI) selection, 4) texture parameters evaluation, 5) result interpretation.

Image registration helps to eliminate changes of texture parameters of a ROI caused by the patient movement and breathing during an investigation. Since our research heads towards online system for temperature monitoring, using a fast and automatic method of image registration is crucial [3].

Different tissues give different responses of texture parameters to the same temperature change. For the sake of correct temperature evaluation, it is necessary to segment an image into areas of the same tissue, e.g. tumour, by using an image segmentation method. Fortunately, we require finding only an area of a tumour or its subset. Thus, a simple dynamic threshold algorithm proved to be sufficient for segmentation of tissues in this project. Texture parameters are evaluated on rectangle areas (ROI) of segmented tissues. These areas – approximately of the size of 25 × 25 pixels – are determined interactively in the first image of the given measurement.

We performed a number of experiments in order to find a suitable parameter that describes temperature in the tissue. Our experiments proved that mean grey scale value of a ROI correlates best with temperatures spanning the interval 37÷44 °C.

Result interpretation is probably the most difficult part of the whole research. Dependence between mean grey scale values in ultrasound images and temperature changes in a tissue is explained by the dependence of reflected ultrasound power on the temperature in boundary areas of different tissues. Unfortunately, this dependence is slightly different for different tissues, though we already experimentally found an approximate formula describing this dependence [2]. Therefore, the challenging task is to determine various temperature models for boundary areas of various tissues.

The experiments showed us that the ultrasound image analysis method can be used for temperature monitoring in clinical treatment. The challenging task of the described method represents improvement of the part dealing with ultrasound data processing, especially with setting up temperature models for interface areas of various human tissues.

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System for Automatic Evaluation of Microwave Applicator in the Water Phantom of the Biological Tissue

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This paper is focused on the design and the construction of the system for automatic evaluation of microwave applicators, mainly of applicators for microwave thermotherapy.

Microwave thermotherapy is the treatment method, when the biological tissue absorbs the microwave energy and is heated up. The applicator is an important part of every thermotherapeutic system, because it determinates distribution of electromagnetic energy in front of applicator's aperture into the tissue. Therefore every applicator must be thoroughly evaluated before it can be used in the therapy.

Evaluation in the water phantom of the biological tissue means to measure the electromagnetic field power distribution in front of the aperture of evaluated microwave applicator in the media, which substitute the biological tissue.

The water phantom is the container, which is filled with solution NaCl in the water (strength of solution is 3 g/l). The complex permittivity of this solution is near to electrical characteristics of the biological tissue. The electric field strength is measured by the special probe (the shape of the electromagnetic power pattern is the same as the shape of the E-field pattern). There is a dipole antenna as a base of this probe. The voltage induced in this antenna supply the next important part of the probe, the LED. The optical signal from the LED is led by the optical fiber outside the phantom to the optical detector. The optical signal in this fiber is not influenceable by the measured electromagnetic field and the optical fiber affect minimally the measured field pattern. The output voltage from the optical detector is converted by the ADC to the digital form and processed by the computer. The probe is moved in the container. The position of the probe is controlled by the movement control unit, which communicates with PC.

There are many factors that influence on the proposal of the probe. The most important of them are:

- the dimension of the probe,
- the sensitiveness and the dynamic range of the probe,
- the resistivity to the corrosive solution.

The overall dimension of the probe must be as small as possible. This is very important for easy probe mobility and for minimally influence on the measured field pattern. The length of the dipole antenna must be small in comparison with λ (λ is the wavelength of the measured field in the phantom media). It is important to use different lengths of the probe antennas for different frequencies. The measured E–field strength is integrated along the dipole antenna and this can cause measured error and this error is dependent on the length of the dipole. The length have to be less than $\lambda/4$.

The sensitiveness and the dynamic range of the probe depend upon the length of the dipole and upon the type of used LED and other used components. The sensitiveness and the dynamic range should be as large a possible. It is necessary for measurement accuracy and for the distributed electromagnetic field pattern detail representation. The solution NaCl in the water is very corrosive and the probe must be resistant to this.

I use the red LED (wavelength of the LED radiation is about 650 nm). There is the Schottky diode connected antiparallel to the LED to close the electrical circuit. This diode is fast and it shows low resistance value in the conducting state. I chose it for its bushing shape (small) too. For the leading of the optical signal I use the plastic optic fiber (POF), the diameter of the fiber is 1 mm. There is the PIN diode as the optical detector. The analog signal is converted by the 8-bit ADC, which communicates with the PC by the means of the serial port.

The whole system is controlled by the computer. For the development of the control software I used the program language Delphi. It is possible to set up the dimension of area, in which the E-field pattern will be measured and the step of the measurement (the step can be smaller then 1 mm, bat this size is near to the dimension of the probe). The received data are saved in the text file and they can be processed by other software, i.e. Matlab or Microsoft Excel.

For the moving of the probe there are used three screwed poles and three step motors (360 steps per circle).

The system can be used for evaluating of other types of microwave applicators (i.e. applicators for industrial purposes), if the phantom media is changed.

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Multi-scale Methods for Biomedical Shape Evaluation

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The aim of the described project is to develop new description methods of growth and morphological parameters of dorsal root ganglia based on modern signal processing tools namely:

- wavelet packets,
- wavelet autocorrelation,
- wavelet power spectrum
- wavelet cepstrum

from sequences of microscopic images. The proposed project broadens long-term research project: "Application of Videometry for Neurotoxicity Testing" which is the part of general research topic "Engineering Problems of Biology and Biomedicine" supported by the Ministry of Education of the Czech Republic.

Changes in morphology of neurites growing out from dorsal root ganglia serve for quantification of the neurotoxic effect of tested chemicals (esp. drugs). Organotypic cultures of chick dorsal root ganglia are maintained in a semi-solid culture medium. This experimental setup represents a new toxicity test as an important alternative to tests carried out on test animals.

The main task of the project is investigation of suitable parameters, which would facilitate the quantification of the degree of toxic damage of ganglia. The tools used for this purpose are based on digital processing of images taken by microscopic CCD camera.

The new results were expected from the application of wavelet analysis and other shape description methods for characterization of morphological changes of neurites. The obtained results show usefulness of proposed methods. We focus on wavelet packets based shape descriptor in the next text.

Shape descriptors for comparing contours of planar objects in order to determine their similarity are important and useful for applications such as automated microscopy, image database search and quantification of shape changes.

Many methods had been applied to planar shape description, e.g. chain code, shape signature, polygonal approximation, autoregressive models, NURBS, Fourier descriptors, normalized wavelet descriptor and curvature scale-space.

Our proposed method for planar shape description is based on wavelet packets (WP). The method offers four advantages:

- non-redundant and complete representation of shape (this allows dense description and perfect reconstruction),
- multiscale approach (separation of local and global shape features),
- possibility to select the set of representing features according to their information contents (different shape classes can be described in a most desirable way, intra-class variance and inter-class separability can be optimized for given task), and
- invertible transformation (the descriptor can be used for localization and shape averaging).

The parameterized contour expressed as a signal in complex plane is decomposed to wavelet packets by standard scheme that includes low-pass resp. hi-pass filtering and downsampling. Wavelet packets correspond algorithmically to subband coding schemes and are numerically as fast as the FFT algorithm. From the standard wavelet families the Meyer wavelet exhibits desired symmetry and smoothness in corners.

The obtained full binary tree contains redundant information; the resulting set of wavelet packets must be selected as a graph in this tree. Obtained set of coefficients serves as a shape descriptor. The level of decomposition for certain packet is measure of scale. The set is composed from packets at different scales; thus it is possible to reduce the descriptor to important scales only.

In the feature selection process we used Euclidean distance from class prototype. Due to low computational complexity of the problem we use branch-and-bound search method. The result of procedure is set of wavelet packets coefficients determined by discrimination tree for non-redundant and complete description of shape.

The proposed method was successfully applied to evaluation of shape dissimilarity. The changes in shape of outer and inner contours of cultured dorsal root ganglia (DRG) were used for evaluation of the reaction of ganglia to toxic agents. Higher values of dissimilarity reflect the irregularity of the DRG growth. The time and concentration dependence of the dissimilarity number are in correspondence with previous studies.

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Establishing of the Basic Book Fund within the Biomedical Engineering at CTU

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Within the year 2002 was established Institute of BioMedical Engineering at Czech Technical University in Prague. The scientific branch biomedical engineering is relatively young comparing to the standard scientific branches within the universities in Europe and in the USA [2], [3]. This institute has played very important role because the biomedical engineering is high interdisciplinary and can allow a horizontal relations among the workplaces or groups within the CTU. There was also accredited Bachelor Study Program – Biomedical and Clinical Technology at the beginning of July within the CTU. The Institute of BioMedical Engineering has three main aims: 1. to coordinate and to perform a scientific activities within the biomedical engineering at the CTU, 2. to participate in educational activities, particularly in the field of bachelor study in biomedical engineering, 3. to coordinate all activities within the biomedical engineering at CTU and particularly in the case of an external relations (outside the CTU) as well. This contemporary situation results in the foundation of the basic book fund within the CTU. There are very good and useful books from this branch. Some of them are called „bible of biomedical engineering" [2], [3], [4] and were obtained in a few copies. The files of all books covered within the CTU grant no. CTU0318019 are available on CTU WWW page [1]. Majority of books is located at Institute of Biomedical Engineering in Kladno and a few books concerning the Magnetic Resonance Spectroscopy and Magnetic Resonance Imaging is located at the Laboratory of Magnetic Resonance in Albertov Building.

The brief list of books follows (because of the limited space for this extended abstract only a few bibliography entries is published):

J. D. Bronzino, The Biomedical Engineering Handbook, Vol. I., II., 2nd ed.,
J. G. Webster, Medical Instrumentation: Application and Design, 3rd ed.,
J. G. Webster, Bioinstrumentation,
L. A. Geddes, Principles of Applied Biomedical Instrumentation, 3rd ed.,
J. J. Carr, Introduction to Biomedical Equipment Technology, 4th ed.,
B. H. Brown, Medical Physics and Biomedical Engineering,
P. P. Dendy, Physics for Diagnostic Radiology, 2nd ed.,
J. G. Webster, Design of Pulse Oximeters,
J. G. Webster, Measurement, Instrumentation and Sensors Handbook on CDROM,
Zhi-Pei Liang, Principles of Magnetic Resonance Imaging,
Z. H. Cho, Foundations of Medical Imaging,
A. Webb, Introduction to Biomedical Imaging,
R. A. Powsner, Essentials of Nuclear Medicine Physics,
S. Webb, The Physics of Medical Imaging,
R. L. Van Metter, M. Sonka, J. Beutel, Handbook of Medical Imaging, Vol. I., II., III.,

W. Welkowitz, Biomedical Instruments: Theory and Design,
N. A. Donner, Design of Biomedical Devices and Systems,
M. Akay, Biomedical Signal Processing,
M. Akay, Detection and Estimation Methods for Biomedical Signals,
M. Akay, Nonlinear Biomedical Signal Processing , Fuzzy Logic, Neural Networks, and New Algorithms,
M. Akay, Time-Frequency and Wavelets in Biomedical Signal Processing,
R. C. Fries, Handbook of Medical Device Design,
R. C. Weast, Biomedical Engineering Handbook, 2nd ed.,
J. J. Carr, Sensors and Circuits: Sensors, Transducers, and Supporting Circuits for Electronic Instrumentation Measurement and Control,
S. M. Blanchard, Introduction to Biomedical Engineering,
L. J. Street, A Guide to Patient Care Technology: A Review of Medical Equipment,
Plonsey, Malmivuo, Bioelectromagnetism,
J. A. Jensen, Estimation of Blood Velocities Using Ultrasound,
E. M. Haacke, Magnetic Resonance Imaging: Physical Principles and Sequence Design,
P. Blumer, Spatially Resolved Magnetic Resonance: Methods, Materials, Medicine, Biology, Rheology, Geology, Ecology, Hardware,
K. S. Meacham, The MRI Study Guide for Technologists,
H. Gunther, NMR Spectroscopy: Basic Principles, Concepts, and Applications in Chemistry,
J. Hsieh, Computed Tomography: Principles, Design, Artifacts, and Recent Advances,
E. P. Papadakis, Physical Acoustics Volume 23 - Ultrasonic Instruments and Devices I,
E. P. Papadakis, Physical Acoustics Volume 24 - Ultrasonic Instruments and Devices II.

These above listed books from the field of biomedical engineering were complemented by the selected titles of the books concerning the medical terminology in English, English grammar, dictionaries, textbook of physics and by selected issues of specialized journals from the field of biomedical engineering.

This project was the starting point of the idea concerning the availability of the information resources from the field of biomedical engineering at CTU including WWW biomedical engineering portal as well. The main aim, i.e. to establish basic book fund from the field of biomedical engineering at CTU was realized. Because of a lot of books there were very advantageous conditions from the bookstore. From this follows that there was an important discount (app. 20%) and the whole process was very efficient. We would like to continue to this above-mentioned project with the new projects concerning the specific information resources from the field of Magnetic Resonance Spectroscopy and MR Imaging.

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Static Optimization in Muscle Forces Calculation

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Static optimization procedures were employed to find the muscle forces, given the net joint moment obtained from inverse dynamics. The solution of the force distribution problem, at many instants during the motor task, requires multiple solutions, one per each instant, to the static optimization algorithm. The solution solves the muscle redundancy by minimizing (or maximizing) performance criterion.

Elbow flexion and extension movements were recorded with the 6-camera 60Hz VICON Motion Analysis system across two movement speeds (slow; 1.1 rad/sec and fast; 2.8 rad/sec) and two loading conditions (unloaded and with a *4.2kg* bar-bell). The model of the elbow joint actuators for this optimization was comprised of four flexors: biceps brachii long head (BIClh), biceps brachii short head (BICsh), brachialis (BRA) and brachioradialis (BRD), and three extensors: triceps brachii long, medial and lateral heads (TRIlh, TRImh, and TRIlt).

The elbow joint reaction moment was solved using inverse dynamics. To simplify this early analysis, a planar model of the forearm, with one degree of freedom was used. The autonomous variable was elbow angle.

Inertia properties were calculated using an algorithm based on three inputs, human weight, height, and gender [3]. The positions of anatomically significant landmarks (e.g. muscle attachments) were taken from the anthropometric data of the Mayo study [2]. These data were then scaled using the length of brachium and antebrachium from the measured subject. Additionally, muscle physiological cross section areas (PCSA) were scaled using the circumference of brachium and antebrachium. Five nonlinear optimization criteria were used to calculate the muscle forces from the net moment [1]: (A) the sum of the square of all current muscles forces is minimized, (B) the sum of the square of the ratio between current muscle forces and maximum muscle forces is minimized, (C) the sum of the cube of the ratio between current muscles forces and PCSA is minimized, (D) the sum of the square of the ratio between current muscle forces and PCSA is minimized, and (E) the sum of the square of the muscle activations is minimized. An additional constraint was that all of the muscle forces were positive $F_i \geq 0$, because muscles cannot produce compressive forces.

The electromyographic activity (EMG) of the elbow joint actuators (BRD, BIClh, TRIlh, and TRIlt) were recorded using bipolar surface electrodes. Raw electromyograms were bandpass filtered (20-500Hz), rectified, and smoothed (using a RMS window of 75 msec). Raw maximum voluntary isometric contraction EMG_{max} data were processed similarly, and used to normalize the *EMG* data associated with the elbow movements. The optimization procedure was run using *fmincon* (MATLAB; MathWorks Inc., Natick, MA, USA)

Solutions, using the optimization criteria (A)-(E), identified the elbow flexors as sole actuators for these movements. Thus, using these criteria during the entire the flexion/extension cycle time, the net moment is met using flexor-muscle forces without concomitant extensor forces.

Comparisons of the criterion-based solutions are provided below. Mathematically, criteria (A) and (E) are the equivalent. In case (A) the most important factor is the geometry of the mechanism. In cases (B), (C), and (D) PCSA is the 'driving' factor. The moment arm for the brachialis is similar to that of the other elbow flexors; thus, all forces calculated by criterion

A were similar in magnitude. Using criteria (B), (C), and (D) where brachialis has biggest PCSA, the magnitude of the brachialis force was greater than that of the other flexor muscles. The fact, that the extensor forces were indeed not zero, was evidenced from the measured extensor *EMG*. Calculated and measured extensor activation (12) is not equal. The extensor activation was within 10% of flexor activation magnitude. Thus, when we need to know forces from all joint muscles, contractors and co-contractors, optimization criteria methods alone will not be sufficient. These optimization models also do not consider muscle dynamics (e.g. force / velocity and length /tension relations).

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An EMG-driven Models for Muscle Forces Assessment

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One method for estimating force in a single muscle is to use the EMG signal. Here, a dynamical model of muscle activation and contraction, such as Hill type model, must be used. The inputs to this model are (typically) the recorded and processed (after rectification, filtering and smoothing) EMG signal, and the recorded length and velocity of the musculotendinouos actuator. The estimated force does not depend on (imperfect) joint torque calculation via inverse dynamic and is computationally simple enough to potentially be applied in real time. Disadvantages of these types of models include the assumptions associated with the input data, such as EMG signal, and the muscle parameters of the model.
The normalized muscle force-length and force-velocity expression is used. The contractile element's force–length relationship $f_l(l_m)$ is a curve created by a cubic spline interpolation of the points on the force–length curve defined by [1], normalised to maximum isometric force. The $f_v\ (v_m)$ curve is also thought to scale with activation. The force velocity curve is also constructed as a natural cubic spline fit to data collected while the muscle lengthened and shortened.
Equations (1), (2), (3), are in many tasks, after simplification, based on elision of some elements of the basic musculotendon dynamics equation for EMG-driven models.
Four EMG-driven models were applied to the flexion/extension movement of elbow, with four different movement conditions (low and high velocity and movement with and without weight).

$$F_{m_i} = \frac{EMG_i}{EMG_{\max i}} A_i \sigma_i \tag{1}$$

$$F_{m_i} = c_i k_i A_i \sigma_i \frac{EMG_i}{EMG_{\max i}} \tag{2}$$

$$F_{m_i}(t) = F_{\max_i}[f(l) f(v) a_i(t) + f_p(l)] \cos(\alpha_i(t)) \tag{3}$$

Equation (1) represents the non-physiological EMG-driven musculotendon model [4], based only on maximal isometric force $F_{max}=A_i\sigma_i$ (where $\sigma = 40\ Ncm^{-2}$ is the same constant described above) and normalized EMG. Statement (2) represents a more physiological musculotendon model than in eq. (1) [4], where k_i is a muscle force–length factor and c_i is a weight factor. Commercially available SIMM software for musculoskeletal modeling [2] is the basis for EMG-driven model (3). This model also considers factors respected to force-velocity $f(v)$, force-length $f(l)$ and activation level $a_i(t)$ of contractile muscle component, force-length relation of passive muscle component and pennation angle $\alpha_i(t)$. This model corresponds with full Hill type musculotendon complex with neglected viscous element. The last EMG-driven model investigated was Virtual Muscle – system for muscle modeling [3].
This system provides an accurate model of muscle, based on experimentally obtained data that can be adapted to any fiber type and can be integrated into existing biomechanical models. This model also considers musculotendon dynamics.

These four EMG-driven models output musculotendon forces, using a variety of input parameters.
All EMG-driven models provided different net joint moment results than those calculated from inverse dynamics. The most divergent model was the Pritulsky model (1).
The findings demonstrate the range of forces predicted by the four models and the sensitivity of the models to the EMG processing. The sensitivity of EMG processing is best illustrated in the first two EMG-driven models, equations (1) and (2). Most problematic, was the assessment of electromechanical delay between muscle activation and force production. In some papers this delay as *40msec* value is used, but this value varies among muscles and depends upon motion style (cyclic, non-cyclic) [4]. The net joint moments calculated from forces given by EMG-driven models differed from the net joint moments calculated from inverse dynamics. The greatest difference was exhibited between the first EMG driven model (eq.1) and the inverse dynamics model.
One potential method of addressing these discrepancies is to use a hybrid optimization scheme [4], which assumes that EMG and kinematic information are inherently imperfect. Using this method, the net joint moments predicted from each method are used to adjust the EMG processing or 'weight' the EMG input eq.(2).

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A Comparison of Two Methods for Muscle Forces Calculation

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The calculation of muscle forces produced during complex activities is not trivial. Because these forces are under the control of the Central Nervous System (CNS), they are of interest to motor-control investigators. Additionally, these muscle forces are important considerations for orthopaedists, biomechanists, and physical therapists because joint contact forces, as well as muscle forces, must be estimated to understand joint and bone loading and pathology. Engineers may also use these models to develop new bone and joint replacements. Tendon force has only rarely been recorded directly in humans because these procedures are invasive, require surgery, and may be injurous. Consequently, there exists four general methods for estimating muscle and tendon forces during human movements: a) heuristic method based on statics or inverse dynamics which are based on simple assumptions for load sharing; b) an inverse dynamical approach involving processing of experimental motion data, modeling and static optimization to solve the muscle redundancy problem; c)an EMG-to-Force processing approach (EMG-driven models); d) direct dynamical approach involving model-driven simulations of the movement task.

Initially two methods, inverse dynamical modeling with static optimization and EMG-driven modeling, were employed to examine elbow joint flexion/extension motion. The elbow joint was selected because it provided a good visual demonstration, the motion is uniplanar, and the motion is uniarticular ('one degree of freedom'). First, we computed muscular forces from 'net joint moment' sing five nonlinear optimizations criteria. These criteria, provided solutions, minimized the joint-actuator forces at each data point. The sensitivity of these optimization criteria was then observed. After these initial runs, joint-actuator forces were then calculated using EMG-driven models.

Elbow flexion and extension movements were recorded with the 6-camera 60Hz VICON Motion Analysis system across two movement speeds (slow; 1.1 rad/sec and fast; 2.8 rad/sec) and two loading conditions (unloaded and with a *4.2kg* bar-bell). The model of the elbow joint actuators for this optimization was comprised of four flexors: biceps brachii long head (BIClh), biceps brachii short head (BICsh), brachialis (BRA) and brachioradialis (BRD), and three extensors: triceps brachii long, medial and lateral heads (TRIlh, TRImh, and TRIlt).

Static optimization procedures were employed to find the muscle forces, given the net joint moment obtained from inverse dynamics. Five nonlinear optimization criteria were used to calculate the muscle forces from the net moment [1]: (A) the sum of the square of all current muscles forces is minimized, (B) the sum of the square of the ratio between current muscle forces and maximum muscle forces is minimized, (C) the sum of the cube of the ratio between current muscles forces and PCSA is minimized, (D) the sum of the square of the ratio between current muscle forces and PCSA is minimized, and (E) the sum of the square of the muscle activations is minimized. The solution of the force distribution problem, at many instants during the motor task, requires multiple solutions, one per each instant, to the static optimization algorithm. The solution solves the muscle redundancy by minimizing (or maximizing) performance criterion.

One method for estimating force in a single muscle is to use the EMG signal. Here, a dynamical model of muscle activation and contraction, such as Hill type model, must be used. The inputs to this model are (typically) the recorded EMG signal, after rectification, filtering and smoothing, and the recorded length and velocity of the musculotendinouos actuator. The estimated force does not depend on (imperfect) joint torque calculation via inverse dynamic and is computationally simple enough to potentially be applied in real time. Disadvantages of these types of models include the assumptions associated with the input data, such as EMG signal, and the muscle parameters of the model.

The normalized muscle force-length and force-velocity expression in equation (15) is used. The contractile element's force–length relationship $f_l(l_m)$ is a curve created by a cubic spline interpolation of the points on the force–length curve, normalised to maximum isometric force. The f_v (v_m) curve is also thought to scale with activation. The force velocity curve is also constructed as a natural cubic spline fit to data collected while the muscle lengthened and shortened.

Four EMG-driven models to muscle force calculation were used [2]. First was non-physiological EMG-driven musculotendon model, based only on maximal isometric force and normalized EMG. Second EMG-driven model was update with muscle force-velocity factor. Third represented with passive and active muscle elements, with force-velocity, force-length factors, activation level and pennation angle [3]. The last EMG-driven model was taken The last EMG-driven model investigated was Virtual Muscle – system for muscle modeling [4].

The findings demonstrate the range of forces predicted by the four models and the sensitivity of the models to the EMG processing. The sensitivity of EMG processing was best illustrated in the first two EMG-driven models. The net joint moments calculated from forces given by EMG-driven models differed from the net joint moments calculated from inverse dynamics. The greatest difference was exhibited between the first EMG driven model and the inverse dynamics model.

One potential method of addressing these discrepancies is to use a hybrid optimization scheme, which assumes that EMG and kinematic information are inherently imperfect. Using this method, the net joint moments predicted from each method are used to adjust the EMG processing or 'weight' the EMG input.

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Mathematical Modelling of Spinal Load

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There is some evidence to suggest that the load of the lumbar spine influences the development of the spinal disorders. It is assumed that the low back pain could be caused by the excessive load on the spine [1]. The curvature of the lumbar spine is considered as important in development of the spinal load. On the other hand, in a clinical study of 108 patients with/without low back pain no differences were found in lumbar curvature between these groups [2]. This study is aiming to develop a model for calculation the load acting in the spine and determine a relationship (if this exists) between the low back pain and the load in the lumbar spine for various lumbar curvatures. Two models were developed for calculation the forces acting in the lumbar spine. The first model two-dimensional model is simple and provides a rough estimation of the load acting on the human lumbar spine in various levels. To improve accuracy of calculations a three-dimensional model was developed.

The load in the lumbar spine was calculated according to a simple static mathematical model for standing posture [1]. In this model two principal forces acting in the spine were assumed: the upper body weight and the force produced by contraction of the erector spine muscles. The weight of the upper body was divided into four partial weights: weight of the chest Wc, weight of the right and left hand (Wrh and Wlh respectively) and weight of the head Wh. It is assumed that the partial weights act in the center of gravity of the segment of the body. Their values for a man with body weight of seventy-three kilograms and positions of the centers of gravity of the segments were taken from literature [3]. In the two-dimensional model the equilibrium of the spine in one-leg standing is maintained by the force of erector muscle M that has a known direction and a point of application. It is assumed that it acts in the tangential direction to the lumbar spine and the perpendicular direction of the application point lies 50 mm from the lumbar spine. The value of force M is unknown and can be computed from the equilibrium of moments acting on the spine if the shape of the spinal curvature is known. Positions of the centers of lumbar vertebrae with respect to the fifth lumbar vertebra were obtained from literature [4]. These centers were fitted by a polynomial of the fourth degree to obtain the curve of the lumbar spine. Then the force of the erector muscle forces acting on the level of particular vertebrae can be calculated according a moment equilibrium.

Reaction force R acting on the particular vertebra can be obtained as a sum of the muscle forces and weight of the upper body. Reaction force R can be divided into two components, component normal to the body of the vertebra (compressive component C) and component perpendicular to the body of the vertebra (shear component S).

In order to study the change in the load with respect to the lumbar curvature, the shape of the spine was scaled by multiplication of the horizontal coordinate of the centers of vertebrae by scaling factor s. To describe the effect of the scaling, the centers of the vertebrae were fitted by a circle. The radius of the circle expresses the radius of the lumbar curvature.

After simulations it was shown that the highest normal force acts in the position of the first lumbar vertebra. The highest tangential force acts in the position of the second lumbar vertebra. An increase of the spinal curvature ($s<1$) causes an increase of the normal component of the force and a decrease of the shear component of the force. A decrease of the spinal curvature ($s>1$) causes a decrease of the normal component of the force and increase of

the shear component of the force. It holds except for the L1 vertebra. Different behavior of the forces acting on the L1 vertebra is caused by the method of scaling. The average relative change in compressive component C, with respect to neutral position (s=1), is 4.3% and -4.6% for the increase and decrease of the lumbar curvature, respectively. For shear components S, the average relative changes in the lumbar spine force are -28.1% and 25.6% for the increase and decrease of the lumbar curvature, respectively.

In clinical studies no correlation was found between the lumbar lordosis and the low back pain. It is in accordance to our results. The compressive component of the force is about one order higher than the shear but it is not much influenced by the change of the lordosis. It is possible that for the genesis of the low back pain the compressive component is important.

The calculated load in the spine should be considered as a rough estimation. Several simplifications were introduced in the model. In spite of it, the model results are in a quite good accordance with data found in the literature. The force in the extensor muscles M could not be related to any force in the anatomical structure. Therefore a new three-dimensional model of the spinal load was developed.

The three-dimensional model of the spinal load is based on the model of section in the transversal plane at the level of fifth lumbar vertebra which is widely used in the literature [3,4]. In this model ten muscles are considered with known physiological and geometrical properties (cross-sectional physiological area, position in the plane of section and direction of the muscle in the line of section). The number of the muscles exceed the number of the equilibrium equations for the fifth lumbar vertebra. Therefore a method of optimization was used to calculate values of unknown muscle force. The optimization method is based on the assumption, that a distribution of muscle force is optimized to a certain criterion. Within this work a new neurophysiologicaly based criterion was formulated that assumes minimalisation of the signal from the load receptors in the muscles, i.e. minimalisation of the response of the Golgi tendon organs. Based on the survey of literature [6] a linear and nonlinear mathematical expression of this optimization criterion was suggested. The problem of optimization was solved using linear programming and nonlinear optimization in a problem of the load of the hip joint. The results of the muscle activation pattern from the new criterion are in good accordance with muscle activation patterns obtained from other linear and nonlinear criteria and with the results of electromyografic measurements of the muscle activity.

The study presents a two and three dimensional model of the load at the lumbar spine. Load simulation in the lumbar spine was performed for various lumbar curvatures. It concludes that a change in the lumbar curvature does not influence the load in the spine extremely. A new type of the optimization function for static inverse dynamics modeling was proposed

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Uniaxial Tensile Test of Media and Adventitia of Human Aorta

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In the last few years there has been a significant growth in interest in the mechanical properties of arteries and some other parts of the cardiovascular system. The reason of this investigation is that diseases of cardiovascular system cause the most of deaths in the mature countries. The knowledge of the mechanical properties of the cardiovascular system is very important in development of new diagnostic techniques, artificial organs and therapeutic methods.

Realistic information about constitutive relations of a human tissue is one of the most important input to our engineering computing models. There are a many papers which describe constitutive equations for human aorta where is this artery assumed as homogenous continuum. This assumption is not so realistic because of its structure. The aorta is nonhommogenous continuum. If we do not consider composite structure of particular aortic layers, we can distinguish three basic parts. There are intima (very thin inner layer which is not so important from mechanical point of view), media (the thickest layer) and adventitia, respectively. Each of theme has own individual substructure which is based on composite configuration. We do not consider this composite composition in our paper.

Passive mechanical properties and constitutive equation of the arterial wall was studied by many authors, Fung, Humphrey, and Vorp for example. They performed uniaxial tensile tests in 70th. They observed basic mechanical properties during experiments with arterial wall considered as continuum. So, we can find many papers which describe mechanical properties of components of arterial layers as are collagenous and elastin fibres, respectively. But we can not find papers which describe mechanical properties of each layer. So, this is the reason why we decided to perform uniaxial tensile tests with arterial layers, with media and adventitia respectively. We did not consider an intima as important from mechanical point of view because it is essentially one cells layer only and so can not take over important load.

We performed our experiments with 24 samples of human aortic arterial layers which we obtained from Department of Forensic Medicine of University Hospital Královské Vinohrady. We had 14 media layers and 10 adventitia layers. Because of viscoelastic properties of arteries, which include relaxation and creep, each experiment consists of two parts. First part was preloading; ten pre-cycles were performed in a rate 6 mm per minute. A loading to failure posed second part of experiment and loading rate was 4 mm per minute. The loading during pre-cycles was restricted by the value of axial force 1.8 N. Experiments were performed in axial and circumferential direction. Tests were performed on MTS 858 MINI BIONIX, MTS corp. USA, in our Mechanical Testing Laboratory accredited by ČIA.

Our results show that adventitia layer is more compliant than media layer. We do not observe important differences between male and female specimens. In case of media the mean maximum value of the strain was 35 pct but in one case of male media was achieved 60pct. Strain in circumferential direction. Linear regression with polynomial regression function was

performed and we obtained as the most appropriate function a third degree multinomial. 6th degree multinomial was used in case of maximum strain 60 pct. A graph of these functions has always distinct initial part with low value of slope and approximately linear part follows. This second part has higher values of the slope. A point of inflexion was found in at end of second part. Approximately similar results were found in case of adventitia. But we can say that adventitia layer is more compliant than media because here were achieved higher values of strain. We hope that our results and our constitutive equations will be useful in computing modelling.

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Our Experiences with Residual Stress Analysis in Human Aorta Based on FEM in ANSYS

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Aorta is the biggest artery of the human body, where is loaded by same effects. The main of them are the cyclical wave of blood pressure, the axial stress in longitudinal direction and the residual stress in circumferential direction. Effects to the loaded state as forces from the viscous fluid, the mass forces adc., are failure. In the analysis model are include only the cyclical wave pressure of blood in the radial direction (16kPa), axial stress and the residual stress in circumferential direction. The residual stress is defined by residual deformation and is characterized by opening angel after radial cutting of an arterial segment.

Referential state for simulation is stress-free state of segment without load, it means opening configuration, and witch is characterized by its opening angel. Shape of segment without load as so as after load is circle or sector of circle, this is the most important hypothesis for calculation proportions of referential state. Residual stress is simulated by closing opening configuration (stress- free state) to the state before radial cutting of the arterial wall.

Model is axially symmetrical, therefore it is shaped only as one half of the segment for simplification. This half is loaded in its bottom part like this; in the front and back vertical angle is loaded in direction coordinate X, all of area situated in plane YZ is axially symmetric, the back area of segment is loaded in direction coordinate Z and its front copy is loaded in direction coordinate Z, but with displacement value of axial stress. Inner area is loaded by pressure 16 kPa (120 mmHg). The top area is created by 28 nodes. Each of them is loaded by displacement value in direction coordinate X and in direction coordinate Y. This nodes displacement values are calculated to the closing configuration (circle) and area of radial cutting was situated in the plane YZ. This problem is solved in competing software by choosing any point in space and suitable area can rotate round this point. So we need not calculation and pick loads for every nodes on area, witch is time exacting and lengthy.

There are two ways for creating material of arterial wall. The first way is throw constitutional formula and the second is throw stain-energy function. For strain-energy function and hyperelastic elements gives ANSYS some forms of Mooney-Rivlins theories or Blatz-Ko theory. Both of them are proposed for the rubber, therefore they aren't acceptable for simulating material of vessel wall. For soft tissue is typical growing modulus of elasticity with loads, but in this forms the modulus of elasticity are fallen with growing loads. The second chance is multielastic elements and multilinear elastic function. Multilinear elastic function approach non-linear stress-strain function in linear parts. Accuracy of this function is growing with amount points. It is important use the elements Solid 90 to have rather results. Elements Solid 90 tend better than for example Solid 45. Element Solid 90 are created by 20 nodes, witch is better for results quality, but the time of solution is three times longer than when we use elements Solid 45. Criterion of element alternative was theory of thick walls containers (on the inner area the pressure is 16 kPa and stress on outer area is zero). In program ANSYS is bringing ortothropy and non-linearity together not possible. All of models are elastics, non-linear, isotropic and nearly incompressible. Combination of non-linear and

orthotropy models is possible in the LS DYNA (extended program of ANSYS), but it is difficult to understand this program. We are used constitutional formula to creating the non-linear material. Set points are obtained from uniaxial tension tests.

When we use default values of convergence, the solution do not often trend to the results. It is possible to chance the values of solution controls (time at end of loadstep, number of substeps, max. and min. number of substeps). This values are selected to program do not knock on problem during convergence, witch it would led to instability solution. In range of loads (bottom and top areas) are unrealistic stress values after plotting results, because all of loads (pressure, axial stress etc.) are included in one step of load, therefore it is possible correct the results. All stress curves lead transparietal the thickness of arterial segment, and so we must pick the path sufficiency distance from both ends.

Normal stress Radial stress

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New Approach to Evaluate Risk of Aneurysmatic Rupture

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Aneurysm of the abdominal aorta (AAA) is of the most serious cardiovascular diseases. It is described as a distortion of the sub renal part of the aorta by more than 50%. The most dangerous event accompanying the AAA is a rupture of the AAA (RAAA), which is a common cause of death in patients with AAA. Processes, which cause aneurysm, are influenced by many factors and the exact aetiology of all types of aneurysms is not yet known. Many factors play an important role during the development of the AAA, mainly heredity, hemo-dynamic factors, such as type of a blood flow, hypertension and other vascular diseases – arterioscleroses, vasculitis and various ischemic diseases**.** There is also a separate group of people with Marfan Syndrome or Erdheim disease. Currently in the cardiovascular surgery a definite indicator for a surgical solution (removal) or endo vascular therapy is the diameter of the AAA and the speed of growth of the aneurysm.

At this time a great interest is given to a calculation method (based specially on the method of end elements MKP or other methods of numerical mechanics), which should determine the tension of the aorta's wall affected by the AAA. But calculating the tension so that the results can indicate accurately the borderline state of the aorta can be difficult with mainly material and geometrical difficulties. For this reason we have concentrated on other methods. Our goal is to find a method, which will predict the behavior of the AAA. The objective is to be able to answer this question: How is the aneurysm going to develop further? For this purpose we think it is possible to use the artificial neural network (ANN).

Neural network does not progress along classical algorithms but allows us to answer some questions, where there are no exact physical, chemical and other substances available. It manages to bypass this problem. In the propagator v1.0 program artificial network type back-propagation was created with these characteristics: Three layered ANN (one concealed layer), 7 entry neurons with linear transmission function, 1 entry neuron with sigmoid transmission function, 3 neurons in the concealed layer with sigmoid transmission function. The entry parameters for ANN learning were chosen from an average AAA selected from the last two measurements (with an interval between measurements of at least 100 days) and other information, which might influence the behavior of the AAA. (Age, ischemic heart disease, diabetes mellitus, hypertension, smoking, lung obstruction disease. The information about ICHS, DM, K, H, PP is entered with the help of logical 0 or 1. The value of the diameter of the aneurysm and the age appear in the model standardized from 0 to 1.From this information the patient receives an entry data vector. The exit model of the AAA is the scalar value of the diameter of the aneurysm 100 days after the last measurement, which was the entry to the ANN.

Mean difference between predictive values and real values was $m = 0.00015948$ [1] in the case of normalized values and $m = 0.0087714$ [mm] in the case of non-normalized data. We were obtained these results considering positive and negative values of predictive

diameters. Another situation arises if we take the residue (deviation) only as a positive quantity. If we take non standardized residue (in mm) in their absolute value, we get for the test file these parameters: e=0,7404562 ≈0,74 mm chosen diameter Maximum network error was 1,94 mm and minimum 0,04 mm (non-normalized data).

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Evolution of the Experimental Line of Physical Model of Cardiovascular System Circuit

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Simulation line of cardiovascular systém will be designed for setting velocity pulse wave in inserted sample of vein, thinwall tube and identification material properties of wall sample. This is a systemic circuit. 5 circuits were created in which were compared two possible simulations systemic resistance working on different principle. It was observed behaviour of individual line elements and their mutual influence. Done experiments shown optimal arranging of line elements.

Testing lines were put toghether from following elements: pulsater, viscoelastic impedance adapter, bellows pump, systemic resistance, stabilize chamber or elastic bag. Pulsater Superpump is controled by computer with own software and unite. It gives liquid high kinetic energy. viscoelastic impedance adapter iscoelastic impedance adapter is serialy connected with pulsater which partly absorbe energy of liquid. Pulsater runs bellows pump which is on suction and displacement having artificial valves commonly used during transplantation heart valves. Liquid flows from displacement through systemic resistance into stabilize chamber and back through suction valve to pump. As systemic resistance was used ball cover (throttle flow) and alternative systemic resistance developed by us (multiple ramification flow). From 5 circuits in 4^{th} was used as systemic resistance ball cover. Throttling of flow working liquid is common for simulation of systemic resistance in these lines. Last period brings other access of simulation elements systemic resistance, for example elastic bag or ramification flow. On ball cover was instaled resistance by 60% closing and full opening. For every resistance ajustment was done measurement with null and 70% elasticity viscoelastic impedance adapter of pulsater Superpump. During experiments was changed filling and possition of stabilize chamber in the line. In the circuit 5 with alternative systemic resistance was only changed elasticity viscoelastic impedance adapter as in the other circuits. Pulsations were generated 80 beats/minute. During high beat frequencies was made optical control pressure curves in measury program.

Circuit 1, 2, 3, 4 were with systemic resistance ball cover and in circuit 4 was put elastic bag. Circuit 5 was with alternative systemic resistance. Following problems occured in all circuits: shock during valve closing on pump suction, necessity of circuit isolation from unadvisable pressure waves, temporary drop pressure on displacement side of circuit. Suppression of shock closing suction valve was the most effective when was elastic bag, circuit 4. Suppression was not sufficient because of small bag volume. Advantage could be more elastic bag wall which would better absorbe liquid energy. Followed time pressure courses were best during setting circuit 2. Problem was shock on pump suction. We see solution in increasing volume stabilize chamber for suction with element absorbing energy from valve shock. During testing alternative systemic resistance circuit 5, occured all mentioned problems. Multiple ramification before resistance chamber is elastic. During

displacement every tube of ramification slightly increase volume and partly absorbe pressure energy. Occures “helping pumping”. Part of energy than takes off when closing displacement valve and part for pushing liquid through resistance chamber. Fast closing displacement valve makes shock which is immediately suppressed. When we change stiffness viscoelastic impedance adapter is possible amplitude of this immediate shock maximum reduce by half. All experiments show temporary drop pressure on pump displacement. We suppose that this phenomenon is linked with construction of bellows pump. During working cycle of pump is balanced pressure in pump and on displacement of pump. Liquid thanks smaller resistance fills space expanding bellows. Then comes again balance of pressure in pump and on displacement of pump and ends up grow of pressure into its maximum. This hypothesis will be proved by construction change of pump.

From experiments we see necessity to use stabilize chamber, with sufficient volume and element taking displacement and pressure waves in the line. Chamber could possibly be before suction of pump. Construction pump adaptation for elimination of temporary drop pressure on pump displacement. It is necessary change multiple ramification systemic resistance by smaller cross/section of tube ramification after taking off “helping pumping” and shock during closing valve displacement. Tests were very important for next development and setting line, analysis of behaviour individual elements in circuit and their influence and connections among them during pulsation flow.

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Development of the Intervertebral Disc Replacement

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Low back pain is a very serious disease, which attacks our population. This disease causes a significant damage of human health connected with important social and economic problems. Currently the most common spinal surgery procedure in treatment of low back pain is spinal fusion, in which two vertebrae are joined to eliminate movement. By abolishing motion it successfully relieves back pain, but it also significantly change the normal biomechanical properties of intervertebral disc. Eliminating the motion at one spinal segment will cause increased loads which have to be transferred to adjacent levels. The adjacent levels will have bigger premises for further degenerative changes of the intervertebral disk and facet joints. The solution of this problem is the total intervertebral disk replacement which retains the mobility of spine and also retains initially distribution of load in spine. The main disadvantage of current available artificial intervertebral disks is low ability for damping which is one of the most important properties of intervertebral disk. Another disadvantage is unlimited in axial rotation which is in spine limited with intervertebral disk and structure of vertebrae. Therefore the surgeons came with demand to develop a new total intervertebral disk replacement. The project development of a total intervertebral disk runs in Laboratory of Biomechanics of Man at the Faculty of Mechanical Engineering of the CTU in Prague. The purpose of this project was to design a new type of replacement, including assignment materials and verification their applicability. To carry out the stress and strain analyses of a new total intervertebral disk replacement, the finite element method (FEM) was applied. The designed total replacement of intervertebral disk uses two end-plates with convex surface on inner side. Between them is inserted an elastic damping core with concave surface on the outer sides corresponding with convex surface on end-plates. The plates are joined with a cage. The plates are composed of titanium, the cage is composed of biotolerant polyethylene and the core is composed of silicone rubber. The range of motion in implant respects the real motion in the intervertebral joint. The new designed implant solves the disadvantages of current artificial intervertebral disks. The implant damps the shock stress and loading due to properties of silicone core and interaction with cage. It has required limited range of motion while rotation and bending and additional it has different stiffness and different limitation of motion in its front and back side. There were designed two types of implant which differs in the method of ensuring the different stiffness of the implant in its front and back side. The desired different stiffness of the implant is achieved by cuneate character of the silicone core which generate unsymmetrical pre-load or the cage which is made from system of connecting elements which are distributed with variable consistence. The result was compared with a FEM model of the designed total replacement of intervertebral disk. On base on the results was verified the endurance of the implant.

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The Automated System for the Detection of Hydrodensitometric Body Composition

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This article describes the development and parameters of the automated system for measuring selected obezitologic parameters using hydrodensitometry which was conducted at our laboratory.

Hydrodensitometry, also known as underwater mass determination, is the reference method suitable for determination of the fat tissue content in human body. Such content is calculated from the density of body evaluated from the weight in the air and one in water bath after substraction lungs residual volume and the intestine gases (it is supposed to use values obtained by helium dilution method or calculations from vital lungs capacity). For the fat tissue content determination there are various equations used according to several authors (Siri, Brožek, Keys). The body density varies according to the hydratation of muscle tissue and the very density of the bone marrow and therefore applies a load to the computed values of fat tissue content. Hydrodensitometrics is applied for diagnostic purposes in diseases related to body composition, especially to obesity treatment and obesity-related diseases.

The main disadvantage of this method is discomfort for the patient and a necessity of exact assessment of the mass at appropriate moment. The patient has to sit on the special scale seat inside the large volume bath, expire, seal the nose and fully submerse into the bath, head inclusive. For a moment there absolutely no movements allowed, the seat should not swing (validity of the measurement is not ensured otherwise). Based upon a request from the 4th General Faculty Hospital and in order to reach the highest possible precision of measurements there was an automated system developed at our laboratory that provides the easiest possible operating features via computer controlled remote device suitable for all staff with common level of qualification.

The system consists of weight sensor on which the insulated galvanic patient's seat is suspended. Analog signal from the sensor is lead into the measurement and imaging block containing microcomputer Philips 80C552 as a core component. The block also contains 7segment/6digit LED display. The first 2 separated digits are intended for identification of operation mode and order of the parameters measured, the remaining 4 digits are spared for on-line monitoring of the body mass and other parameters recalled from the memory. The device is operated via remote control that fully replaces the keyboard situated beneath the display.

Some selected parameters of the measuring/imaging block:

Power supply voltage	24V/50Hz (3,75kV)
Communication signal	RS485 (5kV)
Signal from the weight sensor	from 0 to 5mV
Range of weighing	from -5kg to +45kg

Measuring/imaging precision 4 decades

The most convenient weighing procedure:
- the operator resets the scales via the remote control (or keyboard/PC, see below)
- the patient sits on the scale seat, expires, seals his nose and submerges (head inclusive)
- after the stabilization of the indicated values the operator saves the data via remote control
- the weighing (previous 2 points) is to be repeted several times (usualy 4 times)

All obtained data could be recalled, registered or used for computing obezitologic parameters, or optionally, using the RS485 - PC interface, the device can be controlled in on-line mode and all generated data can be processed, filed, printed or exported into text editor files. The software was developed in MS Visual Studio 6.0 environment in C++ language. After entering all relevant parameters (patient's weight, height, lungs residual volume RV [ml], optionally lungs vital capacity VC [ml]) it will compute BMI [-], density [-], fat percentage [%], fat mass (FM) [kg] and fat free mass (FFM) [kg]; the last 3 parameters 3 times, in accordance with the equations of the 3 most acknowledged authors (Siri, Brožek, Keys).

We trust our system will contribute to higher standards of medical care to the benefit of both patients and medical staff and that it will be used with success in diagnostics of civilization diseases and in its prophylaxis.

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The Equipment for Testing of the Influence of Galvanic Voltage and Currents on the Peripheral Blood Cells in Vitro

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This article describes the partial solution of the grant project “Galvanic features in the oral cavity. Experimental model and its practical improvement. Study in vitro and in vivo”, which is being conducted at the above mentioned laboratories (Institute of Dental Research as the leading investigator). The aim of the project is to specify the influence of galvanic currents and a voltage on the oral tissues as well as on the whole organism of the patient where they take place. The side effects of the galvanism will be evaluated in groups of patients through the methods in vivo, on the base of saliva immunological examination and in vitro with the lymphocyte blastic transformation test using metal salts. In the experiment we try to test the influence of galvanic currents and voltage on the peripheral blood cells in vitro, gained as a "buffy coat" from the transfusion department. The diagnostics and therapy of the galvanism effects in the oral cavity, incl. suggestion of its prevention, should be specified based on the comparisons of the effects of precisely defined currents and voltage values used at the study.

As the values of pathological voltage/currents vary depending on the particular study (values as low as 80mV are considered to be pathological in some whereas over 200mV in others, as for currents values from 3μA are described as pathological, where10μA is considered as distinctly exciting, in other studies the pathological values start only from 10μA) there is a necessity of comparing exactly defined voltages and currents within all above alleged ranges. For this purpose there were 2 sets of voltage generators developed (adjustable for 80, 200 and 300mV) and also 2 sets of current generators (adjustable for 3, 10, 20μA). The description of development of this device that is already being utilized for pursuing the experiments is the main objective of this paper.

The voltage generators consist of 3 independent sections containing fixed value voltage supplies (80, 200 and 300mV). A base for the voltage supply is made by reference LT 1004 (Linar Technology, U.S.A.), particular voltage sizes are set by the operational network of the appropriete OA. Power supplying is realised by 9 volts battery. The generators are equipped by the toggle switch (main supply) and by the indicators of on/off state as well as of the battery voltage drop below efficient level. If such need arises, the values of generated valtage could be easily adjusted and the characteristics of the voltage influence on peripheric blood cells would then be obtained in more detailed multi-point form.

The current generators consist of 3 independent sections containing fixed value current supplies (3, 10 and 20μA). A base for the current supply is an integrated current supply LM 334 (National Semiconductor, U.S.A.). The sizes of particular currents are set by the appropriete resistors. Power supplying is realised by 9 volts battery. The generators are equipped by the toggle switch (main supply) and by the indicators of on/off state as well as of the battery voltage drop below efficient level and a panel microampermeter with the range +/- 50 μA. If such need arises, the values of generated currents could be easily adjusted just by exchanging the resistors and the characteristics of the influence of current on peripheric blood cells would then be obtained in more detailed multi-point form.

The device is in fact already effectively utilized and some of the first statistically significant results are to be published in the 1st half of 2004.

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Various Approaches to the Human Respiratory System Modelling with Respect to Recent Clinical Requirements

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Despite the fact that conventional artificial lung ventilation (CV) is able to solve acute respiratory insufficiency in many cases, there still remain from 40 % to 60 % patients that do not take a profit from CV. Other ventilatory techniques are searched and studied in order to substitute CV especially as a "rescue" technique when CV fails. High-frequency ventilation (HFV) and tracheal gas insufflation (TGI) are some of the unconventional ventilatory regimens that are being tested in the treatment of acute respiratory distress syndrome (ARDS) in adult patients and are supposed to be more efficient in ARDS treatment than CV. These unconventional ventilatory strategies are very different from CV not only because of their principle, but also because of their totally different influence upon intrapulmonary (alveolar) conditions and gas exchange. Any direct measurements in the alveolar space, as well as measurements of ventilatory parameters changes along the bronchial tree, are practically impossible. Nevertheless these parameters are essential for a rational control and further investigation of these unconventional ventilatory regimens.

The aim of this study is to summarise main current requirements for the respiratory system modelling, to present two developed models of the respiratory system for evaluation of intrapulmonary conditions and description of gas exchange, to assess them and evaluate their precision and suitability for use in the clinical investigation and practice.

Investigation of the unconventional ventilatory strategies cannot be based on clinical trial studies only. Sophisticated and advanced methods of intrapulmonary conditions monitoring, the respiratory and chest wall mechanics measurement and evaluation of other parameters must be employed. These sophisticated methods comprise various modelling techniques of the human respiratory system that differs in the approach used.

Existing models of the respiratory system are very simple without any possibility to observe differences in the intrapulmonary conditions such as pressure and tidal volume distributions inside the lung structure. We have used a new approach to studying ventilatory parameters inside the lung structure for both CV and HFV. The new model has been developed on the bases of electro-acoustic analogy. The lung is considered as an acoustic system and an analogical electric circuit of the respiratory system according to the exact anatomical lung structure and its morphometry has been derived. The whole model [1] is divided into 23 generations of bronchi and it allows studying various parameters in each generation of the lung structure. The recent definition of ARDS comprises such criteria of this syndrome as allow the creation of a uniform group at first sight. The detailed analysis of ARDS leads to the conclusion that these ARDS criteria define a very heterogeneous group. This ARDS group inhomogeneity has been discussed in a number of studies, especially in those where the efficiency of complementary ventilatory methods, ventilatory strategies, inflammatory markers and ventilatory mechanics were examined. Lungs affected by ARDS are inhomogeneous, there are often various regions with the unaffected lung tissue and also regions characterised by the collapse of alveoli, overdistension, decreased aeration, etc. Concerning the new model, there is still no possibility to set different mechanical parameters

in one bronchial generation because of the complexity of computation. It is a great challenge to the future work to improve this model for modelling a wide spectrum of inhomogeneous damages of the lung tissue. It will be necessary to divide the model into independent sections, which will be computed separately. Another idea is to adjust the mechanical model's parameters in the compartments according to the set of real CT-scans.

Another problem consists in understanding gas exchange in the respiratory system, for which mathematical simulation of gas flow during artificial lung ventilation can be used.

Bases of the gas flow modelling during artificial ventilation have been described by Jongh [2], where a convection-diffusion equation is presented. In order to put the model into agreement with reality, we had to avoid several simplifications. The final model [3], represented by a convection-diffusion equation, is solved by numerical simulation. The developed gas-flow model describes gas flow only for one-dimensional case. This model still involves many simplifications. There are also other gas-exchange mechanisms in the lungs, which comprise for example "pendeluft effect" characterised by autonomous gas transfer within the lungs after the inspiratory phase that should be involved into the gas-flow models as well. In order to compare validity and precision of both the models, their predicted results are compared for the same initial conditions.

Several simulated parameters predicted by both the models can be compared, as for example distribution of tidal volume among bronchial generations, distribution of airflow, etc. Approximately the same results (error is less than 4%) have been obtained from both the models. In spite of the different modelling approach and methods of computation, both models yield the same results.

The electro-acoustic analogy model is the first model suitable for fast modelling of the intrapulmonary conditions along the real bronchial tree structure both during HFV and CV. The model is able to explain different behaviour of the respiratory system during these ventilatory regimens and it is useful for studying and introduction of HFV into the practice.

The gas-flow model is the first model, which can simulate influence of tracheal gas insufflation on CV and HFV. Simulated results explain the effect of TGI, undescribed increase of the oxygen offer on the alveo-capillary membrane during HFV and other phenomena observed during clinical experiments.

Both developed models are suitable for studying both CV and HFV. Importance of exact modelling occurs especially during HFV, where low tidal volumes are used and mechanical parameters of the respiratory system play a significant role in efficacy of the artificial ventilatory regimens.

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Section 13

CIVIL ENGINEERING

2-D Semi-Scale Testing of the Critical Detail of Building Envelope Provided by the Interior Thermal Insulation System

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In this paper, a 2-D critical experiment for the assessment of hygrothermal function of the critical detail of building envelope provided by the newly developed interior thermal insulation system on the basis of hydrophilic mineral wool material is presented.

The application of interior thermal insulation systems on building envelopes is not a natural solution but sometimes there is no other option available. A typical example is a historical building, where the facade has to be kept in its original appearance mostly, and the exterior insulation systems are excluded for that reason. In that case the development of such an insulation system would allow to prevent moisture damages and to upgrade the thermal properties of the envelope as the only reasonable option. A common solution to this problem consists in placing a vapor barrier just under the internal plaster on the surface of the insulation layer, so that both the insulation layer and the load bearing structure are protected against water vapor. However, this is a solution, which can perform well on the theoretical level only. In the practice, it is very difficult to avoid mechanical damage of water vapor barrier placed in such an inappropriate way. In addition, even in the case that the barrier would perform without mechanical damage, the absence of water vapor removal from the interior through the envelope in the winter period, when the air ventilation in the interior is usually limited, can lead to an undesirable increase of relative humidity in the interior and to the worsening of the internal microclimate. Therefore, new interior thermal insulation system, which should avoid failures of interior insulation systems given above, was developed.

In the presented 2-D critical experiment the designed insulation system is applied on the brick wall 600 mm thick, with a fixed window with a wooden frame. The composition of the investigated building envelope is formed from the exterior to the interior by load bearing structure, dual density hydrophilic mineral wool based insulation material DU by Rockwool Inc. of 100 mm thickness, water vapor retarder KAM on cement glue principle developed by Sakret Ltd. in the thickness of 10-15 mm and by water vapor permeable plaster FFP manufactured also by Sakret Ltd. with the thickness of 15 mm, see [1] for details of material parameters.

The described experiment is carried out utilizing a specially designed simulating and measuring technology for the analysis of hygrothermal performance of multi-layered building structures in the difference climate conditions. A semi-scale system for an analysis of hygrothermal performance of multi-layered building structures employed in this work consists of the simulation and the measuring part. The simulation part is composed by two climatic chambers for simulation of semi-real climatic conditions and by connecting tunnel for placing the tested sample. The measuring part consists of the device for monitoring moisture content by Time-Domain reflectometry method (Easy Test, Ltd) and the device for temperature and relative humidity measurement using the combined probes by Ahlborn, Ltd. Details of semi-scale system, measuring technology and sample arrangement can be found in [2].

The placing of the sensors was chosen regarding to the complex knowledge of fields variables and with respect to the supposed condensation zone. 2-D investigation of hygric and thermal fields in the studied specimen was the aim of the work. After the positioning of all sensors, the specimen is placed into the connecting tunnel and thermally and waterproof insulated from the tunnel walls in order to achieve two-dimensional heat and moisture transport in the tested structure. On the exterior side of the sample, climatic data for reference year for Prague are simulated. Temperature and relative humidity data typical for residential buildings are assumed on the interior side. The measurements starts with climatic data for October 20 and took place of 131 days, hence the whole winter period, which is the most critical part of the year from the point of view of water condensation, was simulated during experiment.

From the experimental results there is evident, that some overhygroscopic moisture was found in the brick wall during the whole time of the experiment, and a part of it remained there until the end of the winter period. However, it should be noted that the conditions of the experiment were more severe than in the reality. In the beginning of the experiment, the brick wall was freshly built in the laboratory, i.e. it contained relatively high amount of moisture and was at relatively high temperature. The climatic conditions of the end of October then have led to water condensation in a part of the wall. This water could not be fully removed from the wall during the winter period because of the limited possibility of water transport to the exterior and of the continuous transport of water vapor from the interior to the load bearing structure increasing the total amount of water in the brick. On the other hand, the hydrophilic mineral wool material DU remained dry during the whole critical part of the year, which is clearly a consequence of the high values of its moisture transport parameters.

On the basis of performed semi-scale experiment, it can be concluded that the analyzed brick wall provided by an interior thermal insulation system with hydrophilic mineral wool insulation and water vapor retarder on the surface of the load bearing structure exhibited a reasonable hygrothermal performance, particularly taking into account that the initial conditions were much worse than in the reality.

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Probabilistic Models for Time Variant Basic Variables in Structural Design

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Probabilistic methods become more and more frequently used design procedures enabling to reach well-balanced reliability of structures made of different materials and exposed to different actions. Actions on structures are often of time-variant nature and, therefore, attention should be paid to description of their time variation and combinations. Time-variant processes like snow load, wind pressure, or traffic load are often approximated by so-called Ferry Borges-Castanheta models (FBC) [1] or random functions like Gaussian processes. The aim of the presented research is to propose bounds on probability of failure P_f for combination of two non-correlated stationary processes X_1 and X_2 using FBC models.

FBC models are rectangular wave renewal processes with/without intermittencies (actions take sometimes zero-value). Intermittent process X_i is characterized by probability p_i that process is "on" and by the mean number of magnitude changes $N_i = T\lambda_i$ where T denotes lifetime and λ_i jump rate (the average number of magnitude changes of the rectangular waves in a reference time T_{ref}) [2]. Using outcrossing approach [1,2] lower and upper bounds on P_f may be determined.

Lower bound $P_{fl,Comrel}$ applied in the software product Comrel [2] computes P_f as probability of failure in an arbitrary point in time τ, for $t_1 < \tau < t_2$:

$$P_f(t_1,t_2) \geq P_{fl,Comrel}(t_1,t_2) = P_f(\tau) = (1-p_1)(1-p_2)P\{Z(R) < 0\} + p_1(1-p_2)P\{Z(R,X_1) < 0\} + (1-p_1)p_2P\{Z(R,X_2) < 0\} + p_1p_2\,P\{Z(R,X_1,X_2) < 0\}$$

where R denotes vector of time-invariant random variables and $Z(\cdot)$ stands for the limit state function. However, the bound $P_{fl,Comrel}$ gives rather crude estimate when processes are spike-like (for small p_i). An improved lower bound P_{fl} may be based on outcrossing approach. By intuition, P_f increases with the probabilities p_i. A lower bound P_{fl} is, therefore, derived assuming $p_1(p_2)\to 0$ for both the processes. This means that both the processes are "on" in each renewal for a very short period and no combination hence occurs indeed. The bound P_{fl} may be derived as a sum of the probabilities of failure $P_f(t_1)$ and the mean number of crossings from the safe domain into the failure domain [2,3]:

$$P_f(t_1,t_2) \geq P_{fl}(t_1,t_2) = P_f(t_1) + \int_R N_1 P\left\{Z(R) > 0 \cap Z(R,X_1) < 0 \middle| R\right\} + N_2 P\left\{Z(R) > 0 \cap Z(R,X_2) < 0 \middle| R\right\} dR$$

For processes without intermittencies the above-mentioned relationship should consider the probability that process starts in the failure domain and ends in the failure domain [2]. For intermittent processes this probability is of zero-value.

For the combination of X_1 and X_2 upper bound solution $P_{fu,Comrel}$ provided in Comrel may be rewritten as follows:

$$P_f(t_1,t_2) \leq P_{fu,Comrel}(t_1,t_2) = P_f(t_1) + (1-p_1)(1-p_2)(N_1+N_2)P\{Z(R)<0\} +$$

$$p_1(1\text{-}p_2)\int_R N_1 P\{Z(R)>0\cap Z(R,X_1)<0|R\}dR + (1\text{-}p_1)p_2\int_R N_2 P\{Z(R)>0\cap Z(R,X_2)<0|R\}dR + p_1p_2$$
$$\int_R\int_{X_2} N_1 P\{Z(R,X_2)>0\cap Z(R,X_1,X_2)<0|R,X_2\}dX_2 + \int_{X_1} N_2 P\{Z(R,X_1)>0\cap Z(R,X_1,X_2)<0|R,X_1\}dX_1dR$$

However, the upper bound $P_{fu,Comrel}$ leads to incorrect results for spike-like processes. When $p_1(p_2)\rightarrow 0$ then the processes are completely neglected as $P_{fu,Comrel} = (1+N_1+N_2)P\{Z(R)<0\}$. Although processes are "on" in each renewal for a very short period only, they still contribute to the resulting probability of failure.

Improved upper bound P_{fu} thus must take this fact into account. The upper bound is, therefore, written as:

$$P_f(t_1,t_2) \le P_{fu}(t_1,t_2) = P_f(t_1) + (1\text{-}p_2)\int_R N_1 P\{Z(R)>0\cap Z(R,X_1)<0|R\}dR +$$
$$p_2\int_R\int_{X_2} N_1 P\{Z(R,X_2)>0\cap Z(R,X_1,X_2)<0|R,X_2\}dX_2dR + (1\text{-}p_1)\int_R N_2 P\{Z(R)>0\cap Z(R,X_2)<0|R\}dR$$
$$+ p_1\int_R\int_{X_1} N_2 P\{Z(R,X_1)>0\cap Z(R,X_1,X_2)<0|R,X_1\}dX_1dR$$

This bound leads to correct results for spike-like processes. For $p_1(p_2)\rightarrow 0$ it leads asymptotically to the same probability of failure as the lower bound P_{fl}.

The lower and upper bounds on P_f using the above relationships may be easily calculated by means of standard methods for time-invariant analysis. Both analytical or simulation methods may be applied (FORM/SORM or Monte Carlo, Importance Sampling, etc.) [4].

Lower and upper bounds on failure probability P_f for combination of two non-correlated stationary time-variant processes using FBC models are proposed as an improvement of existing bounds provided in Comrel. Future investigation should be focused on verification of the developed formulas using Monte Carlo simulation method. Application of the bounds should be further extended for more independent processes and for correlated variables. Analysis based on FBC models would then become a very useful and powerful tool for calibration of newly developing codes and probabilistic structural design.

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Usage of GPS Technology in the Geodynamic Networks

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This paper gives report on two different usage of the GPS technology. In case of Geodynamic Network Cheb the highest accuracy was required while in case of gravimetric survey in region of Corinth in Greece the accuracy better than 5cm in height was sufficient. However the required accuracy was predominant, also the economical aspects played important role. It is well known the GPS technology provides the same or better accuracy than classical geodetic methods when one have to spend far less time on the measurements. In addition it is possible to perform measurement when the terrain is hilly and not providing an easy survey and no direct sight is necessary between two GPS receivers.

GPS Measurements in Geodynamic Network Cheb

The Region of the Cheb Basin in the western part of Bohemian Massif is one of the most seismic active areas in the Czech Republic. Besides obvious manifestations of geodynamic activity such as mineral springs and mofettes the earthquake swarms are typical signs of the proceeding activity.

The local geodetic network of 18 points in the most active area around Nový Kostel was established in 1993. It is spreading on 250 km2 with the longest baselines up to 10 km. In 1994 the new 8 points were set up out of active area to ensure maximum stability. This outer part of network is spreading on 1300 km2 with the longest baselines up to 40 km. The points were realized by 5m long vertical steel pipe filled and fixed with concrete. The 1.5m is above surface. The points provide compulsory centering of GPS antennas.

Thirteen campaigns were performed from 1993 to 2003. Four of them were performed in the inner part of network between 1993 and 1996 and nine ones in whole network between 1993 and 2003. In 1997 no measurements were done by lack of money. The dual frequency GPS receivers Trimble 4400 SSE were used and the new Trimble 5700 receivers were used from 2002.

Data were processed by Trimble software GPS survey and finally by Bernese GPS software. The network was connected to IGS observatories Wetzell, Graz and Gope, so the resulting coordinates can be easily transformed to ITRF. The uniform procedure was used in the all campaigns. The result is list of geocentric XYZ coordinates in a system practically identical to ITRF for every campaign. The Helmert six parameters transformation using all points of the network was used to compare the individual epochs with coordinates from 1994. The obtained residuals were subsequently transformed to local North, East, Up system.

The data from 1994 to 2000 processed by Bernese GPS software does not show any systematic horizontal displacement. The gained results seem to be an aggregate of random errors up to 10mm more than true displacements. If there are any displacements they must be of random type smaller than 10mm in one year or systematic displacement smaller than 2mm/year. Any larger values should be detected by GPS measurements. Also the differences in coordinates obtained from data from 2003 processed by Trimble Total Control software are smaller than 10mm.

GPS Measurements as a Part of Gravimetric Survey

GPS technology was used within the complex geodynamic research in the region of Corinth-Agio in Greece to determine position, especially the elevation, of the gravimetric points.

For this purpose it was necessary to built up a local network. It consists from 6 new points and 9 points of Greece national geodetic network. The local network was measured in the November 2002. All points except 6 new reference stations were measured in "fast static" mode with time of observation about 40 minutes. The data measured at the points of Greece national network allowed us to express obtained coordinates in Greece national system HGRS87/Peareus. Whole network was also connected to EUREF permanent GPS stations.

The gravimetric points were measured in "stop and go" mode when at least one receiver as reference station is running and the individual points are measured by receiver (rover) mounted on the roof of car. Usually two reference stations were running so there was possibility to check the results. Impossibility of usage RTK due to high hills and deep valleys leads to necessity to estimate the observation time by current circumstances. Gravimetric measurement at the point usually takes several minutes so the absence of RTK mode does not significantly increase the time spent at each point. According to our experience the observation time about 3.5 min. at one point is mostly sufficient.

The Trimble 5700 receivers with the Trimble Zephyr Geodetic antennas set on tripods were used as the reference stations and the Trimble 5700 receiver with the Trimble Zephyr antenna mounted on the roof of the car were used as a rover.

Before the coordinates of measured gravimetric points could be computed the network adjustment and connection to EUREF permanent station had to be performed. The coordinates of permanent station were obtained from week solution coordinate files of BKG and BEK analysis centres. This fact cause that computed coordinates of two points are not in ITRF system but in very similar one. All calculations were done by Trimble Total Software.

The coordinates of all points of local network were determined as a result of network adjustment when the coordinates of points connected to EUREF stations were took over from previous adjustment (connecting to GPS permanent station). These final coordinates were subsequently used for determination of transformation parameters to Greece national system HGRS87 and for processing the individual gravimetric points.

In case two reference stations were running two "independent" coordinates were obtained for each points. Differences obtained comparing these coordinates hardly ever exceed 20mm in horizontal coordinates and 50mm in height. If there were less visible satellites or they were in bad geometric configuration the observation time was increased. Under these circumstances only 13 points from 593 points were not successfully processed.

Some points were picked as control points. At these points repeated measurement was performed. Differences from repeated measurements did not exceed 100mm in elevation. The horizontal position was not compared.

The obtained maximum standard deviation values of 10mm in horizontal position and 20mm in height for points in local network, residuals after 3D transformation to the national Greece system and differences in height for repeated measured gravimetric points give us certainty the required accuracy was achieved.

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Checking Measurement of Building Constructional Height

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Increasing requirements for the geometrical precision of buildings, e.g. in accordance with ČSN 73 0420-2 Precision of Line and Level of Buildings - Line and Level Deviations and ČSN 73 0410-2 Geometrical Precision in Building - Execution Conditions, evoke a number of questions with respect to the line and level of buildings and checking measurements using geodesic methods [1]. For that reason, the focus of the research at the Department of Special Geodesy has been aimed at selected tasks in checking measurements [2] and improvement of technological procedures.

This paper deals with a proposal for the technological procedure of checking the measurement of the constructional height of a building at a narrow building tolerance. The trigonometry method with the utilisation of a total station has been selected for checking measurements while the results of measurements [3] have been re-assessed.

When compared with the usually used procedure, when the height of one or more marks materialising the level of a given storey (e.g. an edge) is determined, the setting of an auxiliary height point in the storey from the top is assumed. This point is stabilised at approximately 0.3 m from the edge using a special measuring mark that is to be marked on a horizontal ground-place of the structure, and that allows final centring of the reflecting prism as well as height determination (a small hemispherical projection). After surveying the height of the auxiliary height point, checking the measurement of the constructional height of the storey itself is performed by geometry levelling (e.g. using a digital levelling apparatus). This will allow for the determination of the height of the storey in a number of places and, simultaneously, it is also possible to check the horizontal levelling and evenness of the given building structure - floors in the previously marked out profiles or in a square network. In the case of larger buildings, we recommend fitting 2 to 3 auxiliary points on a storey that will then be interconnected by geometry levelling and the levelling order created will be levelled. The proposed procedure allows for achieving higher precision and reliability than the standard checking measurement. It is also necessary to point out that besides the trigonometry method that provides considerable benefits there are other methods of determination for the constructional height of the building, e.g. using a vertical tape on the facade, a manual laser distance meter and geometry levelling on stairs.

The proposed technological procedure utilises an electronic universal theodolite - total station (LEICA T 1800 for experimental verification) to determine the constructional height of a building using the trigonometric method. The position of the device is selected at an optimum distance of h up to 2h from the building, when its height equals h. A small reflecting prism in a special adapter on a pillar tripod is positioned on the auxiliary height point and height eccentricity is measured using a measuring rule. The inclined lengths are measured twice electronically, while the zenith angles are measured a total of four times when using the trigonometry method. The height of the horizon of the device is determined in a local system by measuring to a fixed height point stabilised at the foot of the building with use of the prism on a range rod. Atmospheric temperature at the station and at the determined auxiliary height points is also measured while atmospheric pressure is measured only at the bottom.

The technological procedure includes also the introduction of various corrections, e.g. of the measured camber from refraction and from the curvature of the Earth. The prism addition constant and the effect of convergence of plumb lines on the camber is also considered.

Introduction of the correction from refraction represents a considerable problem when measuring the constructional height of a building using the trigonometric method. The standard value of the refraction coefficient, k = 0.13, cannot be used as it is valid for surveying at triangulation passing high above the ground and with the usual climatic conditions in the Czech Republic. In the microclimate prevailing close to the building and, especially, close to its shell, the refraction coefficient may have different values, differing even in orders as well as by sign [4]. For that reason, the proposed technological procedure contains also the measurement of atmospheric temperature and pressure at the station and, moreover, temperature at the reflecting prism. Then it is possible to calculate the local refraction coefficient using a temperature gradient. However, it is recommended that measurement is performed of constructional height on the side of the building that is not beneath sunshine; the most suitable method is to perform the measurement when it is cloudy.

Verification of the proposed technological procedure has been performed on a completed building - a nine-storey building with the height of 25 m, in all across 6 storeys. The constructional height of each storey has been determined using the trigonometric method twice and once more using precise levelling in order to assess precision. In the case of both the methods, the measurements have been based on the same main height point stabilised at the foot of the building.

Precision of the proposed technological procedure has been determined as an external one, namely from quasi-real deviations. These deviations have been specified by comparison of the constructional heights measured using the trigonometric method and precise levelling (which is a more precise method in orders). The selective standard deviation calculated through all storeys amounted to s = 3.6 mm. If a limit deviation of the constructional height is given for the above mentioned type of building according to CSN 73 0210-2 for h = 25 m by the value of 30 mm, then the required standard deviation of the checking measurement a = 6.0 mm. It is obvious that the precision required in the standard can be achieved using the proposed technological procedure.

It can be said in conclusion that utilisation of the trigonometric method for checking measurements of the constructional height of the building is effective especially for taller buildings and also wherever other methods cannot be used because of various obstacles.

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Rheological Changes of Strength of Engineering Barrier Structural Elements Caused by Thermal Loading

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Research presented in this paper and performed in the Centre of Experimental Geotechnics (CEG) is connected with disposal of radioactive waste. Nuclear power plants all over the world produce very dangerous type of high radioactive waste – spent nuclear fuel. The task is to dispose the waste safely for very long time (hundreds thousand years).

Every country, which has power plants tries to build up deep underground repository of nuclear waste. The repository must provide isolation of waste from surroundings. This very special engineering construction consists of several layers – natural and engineered barrier. In the Czech Republic natural barrier is supposed to be granitic rock. Engineered barrier will be formed by container with radioactive waste and geotechnical barrier. Geotechnical barrier is made from special type of clay - bentonite or from bentonite based material. Also mixtures of bentonite with other materials can be used (e.g. sand, graphite).

Many different tests and measurements are carried out on bentonite material. The aim of the research is to have as many information about material behaviour as possible. Strength properties are only one part of the whole research.

High radioactive waste is supposed to load all parts of the repository by temperature. This paper deals with problems connected with changes of bentonite properties due to thermal loading. Temperature in the repository will not exceed 100°C. Changes depend on several factors as: water content of input material, time of thermal loading, percentage of admixtures. Dependence of strength properties on time of thermal loading is the result of tests.

Material used for tests is bentonite from Czech locality Rokle. At the beginning of research in previous years bentonites from different localities were tested. Research of many other parameters of bentonite resulted in choosing Rokle locality for further testing. Following mixture of materials is used for testing: 85% bentonite from Rokle locality (material is grinded), 10% of quartz sand from Provodín locality, 5% of graphite from Netolice locality. Sand is added into the bentonite to reduce the swelling pressure, which occurs in bentonite when it come into the contact with water. The reason for adding graphite is to improve dissipation of heat from the container with waste.

Research in this project was concentrated on strength properties of bentonite material. Uniaxial strength is one of the important parameters. Exceeding the strength may result in originating of cracks. These cracks may be potential ways for dangerous radionuclides. In case of container damage radionuclides can penetrate into surroundings of the container and even into living environment.

Cubic samples with edge 50 mm are used for testing. Samples are prepared from powder material by compacting in the pressing machine. Special steel mould for sample preparation is used. No special Czech standard exists for performing uniaxial strength test on samples made from bentonite. European standard EN 1926 Natural stone test methods – Determination of compressive strength is used for testing. Before test, sample is dried in oven for 70°C for 24 hours. Sample is weighted and its dimensions are measured. Total density is

calculated from these parameters. Then it is placed into the press and loaded continuously to its breaking. Maximal force is measured and uniaxial strength is calculated from this force and from the loading area of the cube. Tests are carried out in sets of six samples. Six cubes are loaded in the same direction as they are prepared, six are loaded upright to this direction. After the test small sample is taken and is used for measurement of water content.

Thermal loading: two different temperatures were applied to samples before testing: 80°C and 110°C. Time of thermal loading was 3 and 6 months. We want to know behaviour of bentonite material in very long-term time horizon. The aim is to perform tests with samples, which were loaded by temperature for long time before testing. Six months thermal loading can be regarded as long-term. At first one set of tests was carried out with samples, which were not thermally loaded before testing (results were used as reference values).

Results of tests: thermally not loaded material has uniaxial strength from 6,9 MPa (in the direction of compaction) to 7,3 MPa (upright the direction of compaction). Samples loaded by 80°C for 3 months: 8,9 MPa, 8MPa respectively.

From the performed tests it is evident that uniaxial strength increases with thermal loading. It seems good for usage bentonite in the structure of underground repository, which will be loaded by temperature.

It will be very useful in the next stage of the research to perform more tests with material loaded by temperature for longer time e.g. 9 months and even more (one year or several years). Results from the tests can be used as input parameters for mathematical modelling of repository structure behaviour.

Results of the research can be also used by Radioactive Waste Repository Authority (RAWRA) of the Czech Republic. It is a government organization, which deals with problems of underground repository of dangerous waste (as spent fuel from nuclear power plants) in the Czech Republic.

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Change of Plasticity of Sealing Materials Caused by Heat Radiation

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This project is connected with problems of radioactive waste disposal, which are solved in the Centre of Experimental Geotechnics (CEG) within the framework of other grants and research project. The aim of this project was to determine impact of thermal radiation (for different time interval from 1 month to several months) on plasticity of tested material. Results of this research can be directly used in design of underground repository of high radioactive waste structure.

In the Czech Republic underground repository is supposed to be placed in the granite host rock. And it is supposed that repository will be finished by year 2065. Granite environment will be natural part of multibarrier system. Inner part of engineering barrier will be formed by container with high radioactive waste. The space between container and natural barrier (geotechnical part of engineering barrier) will be filled by material based on bentonite. So it is a multi-layer barrier and its every part must be able (for defined time) prevent leakage of radionuclides to biosphere.

Basic material for geotechnical part of engineering barrier has to be bentonite based material. Bentonite has been chosen according to study of natural analogues. It is the only material, which has invariability of properties (rheological stability) for millions years. From geotechnical point of view among the most important bentonite properties belong: minimal permeability, high plasticity index and swelling ability.

Plasticity of the material is very important parameter as far as the usage of bentonite as sealing material is regarded. Plasticity is defined with usage of plasticity index. Plasticity index is the range of water content, in which material behaves as plastic. Plasticity index is calculated as difference between liquid and plasticity limits. Material with very high plasticity will be able to fill and seal joints and cracks in the structure of engineering barrier.

Sealing material in underground repository will be exposed to long - term impact of higher temperature (source of the temperature will be container with radioactive waste). Regarded that, it is necessary to make not only standard laboratory tests but also tests with material loaded by temperature for a long time prior testing.

Project has been solved by means of laboratory testing. As testing material has been chosen (regarded previous research in CEG) mixture formed by grinded bentonite from Rokle locality (85 %), quartz sand from Provodín locality (10 %) and by graphite from Netolice locality (5 %). Admixture of sand has to reduce high swelling ability of bentonite. Graphite has to increase thermal conductivity and therefore make easier the dissipation of heat from container with radioactive waste to the natural barrier.

Atterberg limits (liquid limit w_L and plasticity limit w_P) and index of plasticity I_P are measured for this mixture. At first these values were determined for material, which was not exposed to thermal radiation. For further tests samples were firstly placed into the drying

oven and exposed to heat radiation for different time interval. The time of loading by thermal radiation was 1, 3, 6, 12 and 18 months. It was possible to use also material loaded by temperature for longer time (12 and 18 months), because it was placed into the oven for some other tests before and needed amount of material was taken from it. The most tests were carried out with material exposed to temperature 200 °C. This temperature was chosen from safety reasons, in underground repository only lower temperature is supposed. Next tests were carried out with material loaded by temperature 80 °C and 110 °C, which are more similar to temperature in underground repository.

For material without thermal loading was found that according to Casagrande plasticity diagram (Czech Standard ČSN 73 1001 Foundation of structures. Subsoil under shallow foundations) plasticity is extremely high. It corresponds with requirement for sealing materials in underground repository of high radioactive waste.

Samples, which were exposed to long - term thermal radiation show decrease of liquid limit and therefore also decrease of plasticity index. Plasticity limit did not change by impact of thermal radiation. Decrease of liquid limit was only for material exposed to thermal radiation for 1,3, and 6 months. For longer time of thermal radiation than 6 months liquid limit practically did not change. Value of thermal loading has impact on decrease of liquid limit. Decrease of liquid limit was more significant for samples exposed to temperature 200 °C, for temperature 80 °C and 110 °C this decrease was lower.

In spite of decrease of liquid limit during the first six months of thermal loading plasticity of the material did not change. Plasticity remains extremely high, as it is for original sample without thermal loading.

Regarded the performed tests it can be said that long term thermal radiation does not have negative impact on plasticity of researched mixture. Research will be widen in next year by tests with material disposed to thermal radiation in time interval of even 30 months.

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Design of Methodology of Environmental Impact Assessment of Electric Power Stations

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Environmental impact assessment (EIA) is an important procedure for ensuring that the likely effects of new development on the environment are understood and taken into account before the development is allowed to go ahead. EIA is interdisciplinary and involves large numbers of different practitioners but most closely associated with professionals concerned with siting new development.

Foundation of the EIA process is a comprehensive investigation of expected and likely impacts on different environmental components such as flora and fauna, soil, water, air and climate but also human population, architectural and historic heritage. In addition to the decision on whether a project should proceed, an EIA will consider aspects such as project alternatives and mitigation measures that should be implemented if the development is allowed. The findings of EIA are presented in a document called an Environmental Statement or Environmental Impact Statement (EIS). An EIS is prepared for projects or actions which will have a significant effect on the human environment and assessment of power stations is a typical example [1].

The main goal in preparation of EIS is identify and predict likely impacts of a project. Impact prediction includes assessment of:

- **Direct/primary impacts** – that are a direct result of a development.
- **Indirect/secondary impacts** – that may be side effects of direct impacts.
- **Cumulative impacts** – that accrue over time and space from a number of developments or activities, and to which a new project may contribute.

All impacts may be **positive** (beneficial) or **negative** (adverse), **short**, **medium** or **long term**, **reversible** or **irreversible**, and **permanent** or **temporary**.

There are several standard techniques that can be used to aid impact prediction in assessment of most environmental components:

- **Checklists** – identify key impacts (but not generally suitable for detailed analysis).
- **Matrices** – used for impact identification and can also indicate features of impacts such as their predicted magnitudes and whether they are short or long term.
- **Flowcharts and networks** – can be useful for identifying cause-effect relationships and links between impact sources and environment or between primary and secondary impacts.
- **Mathematical/statistical models** – based on mathematical or statistical functions which are applied to calculate deterministic pr probabilistic quantitative values from numerical input data. The results usually require validation.
- **Maps and GIS** – maps can indicate feature such as impact areas, and locations and extents of receptor sites. GIS can analyze a number of layers.

While the investigation of expected impacts is quite clear and well-known, the problematic part of decision making is selection of preferred alternative of the proposed action. One of the applied tools for preferred alternative selection is TIEQ method (Total

Indicator of Environmental Quality). It is based on a list of criteria and its parameters such as amount of air pollution, waste products, waste water or social and economic factors. It is assigned a value of each parameter for all alternatives. TIEQ method uses multiple criteria optimization in particular benefit function. Philosophy of the TIEQ method is that input values for each of parameters are transformed onto non-dimensional partial benefits and a sum of each benefit for proper alternative is aggregate benefit function. It is applied that the higher value of aggregate benefit function the better alternative [2, 3].

This approach does not consider an uncertainty of evaluation and determination of the parameters. All of the input values in TIEQ method are deterministic. But this is not an accurate reflection of reality. Consequently was TIEQ method modified so that an input values could be defined as a stochastic variable. It means that for each uncertain variable are defined the possible values with a probability distribution. Disadvantage of such approach consists in a very complicated calculation of the aggregate benefit function and without computer technology is practically impossible.

During last fifteen years were developed available software tools, which can solve above-mentioned problem. One of them is Crystal Ball 2000, which works with spreadsheet models, specifically MS Excel spreadsheet models. Crystal Ball 2000 is based on Monte Carlo simulation, which randomly generates values for uncertain variables over and over to simulate a model. A simulation calculates multiple scenarios of a model by repeatedly sampling values from the probability distributions for the uncertain variables and using those values for the cell. Monte Carlo analysis has become popular because it is such a natural application of computer resource in the area of risk analysis and probability assessment.

It was written, that it is important to define a feasible probability distribution for each uncertain variable. The type of distribution is based on the conditions surrounding that variable. Distribution types include normal, triangular, uniform and lognormal. It is also possible use custom distribution by means of histogram of frequency. Selecting a distribution for an assumption is one of the most challenging steps in creating a Crystal Ball model.

The result of the original TIEQ method was a real number for each alternative. Optimal alternative has the higher aggregate benefit function. For TIEQ modified method it is a real number too, but it is also known a certainty – the percent chance that a particular forecast value will fall within a specified range. In addition it is possible to simulate a lot of different scenarios. A simulation tests showed that generally is better to use stochastic model than deterministic for a choice from alternatives. Usage of the stochastic approach is suitable especially in cases where input values are predicted with high level of uncertainty.

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Rainfall Simulator Aided Determination of Soil Erosion Characteristics

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The soil erosion characteristics are determined in laboratory conditions using the rainfall simulator of the Czech Technical University in Prague, Department of Irrigation, Drainage and Landscape Engineering. The device uses oscillating nozzles to produce an artificial rain with the similar characteristics as a nature rainfall event. The nozzles produce a flat water stream with 2.3 mm median drop size and are placed 2.4 m above the erosion pan, sized 0.9 x 4 m. The rainfall simulator is used to determinate rainfall-runoff relationships and soil erosion processes.

The runoff and erosion characteristics of a clay-loam soil have been tested. The basic soil characteristics are shown at the table 1. The total amount of 30 experiments was carried out with different rainfall intensities (40 – 60 mm/h) and the slope steepness (4° - 8°). The surface runoff, soil loss and the infiltration rate were measured at 5-min intervals during the rainfall events. The basic soil characteristics such as the soil density, moisture, grain size distribution and organic carbon are also observed. The experiments were run with two types of initial soil surface: loose or sealed and crusted.

Tab. 1: The basic soil sample characteristics

Soil texture class		clay-loam
clay	<0.002 mm	25 %
mould	0.002 – 0.063	58 %
sand	0.063 – 2.000	17 %
gravel	>2.0 mm	7 %
Organic matter	C_{ox}	1.77 %
Soil reaction		mildly alkaline
Permeability		strongly impermeable

The great number of measured data was obtained from the described experiments. The results show very different amount of surface runoff between the loose and the crusted experiments. During the loose simulations the runoff starts later after the beginning of the rainfall and the amount is lower than during the crusted one, but the quantity of drifted soil particles per litre is much higher, so the total amount of soil loss during the longer rainfall is higher.

The infiltration volume is highly dependent on the soil surface condition. During the crusted experiments it is very low because of the non-permeable surface layer. At the beginning of loose simulations the infiltration rate is high, but when continuing the rain, the infiltration becomes lower.

The soil particle size distribution was also observed during the experiments. It was evaluated separately for the primary soil sample, the soil particles in surface runoff and the residual soil in the erosion pan. Mostly the mould soil particles (diameter 0.002 – 0.06 mm) were washed away. After 15 experiments the soil sample contained 5 % lower amount of mould. The clay particles (diameter < 0.002 mm) are enough resistant to the soil erosion, after all the experiments the amount of this fraction was 5 % higher. The amount of sand (diameter 0.06 – 2 mm) and gravel (diameter > 2 mm) stayed at the same level. The results are shown at the table 2.

Tab. 2: Particle size distribution of the primary soil sample, washed away soil and the residual soil

	Particle size distribution [%]				
	clay	mould	sand		gravel
Primary soil sample	25	58	17		7
Washed away soil	21	70	9		0
Residual soil	30	53	16		9

The results of the experiments will be applied as input data for the mathematic simulation models predicting the runoff and erosion processes – Erosion 2D, WEPP, AGNPS.

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Functional Qualification and Optimization of Building Structures

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The objective of the research plan, VZ No. 1, is to increase the functional qualification and reliability of structures, namely by reducing the risks of appearance of serious faults and failures of structures and their parts in the course of their use. The current trend in designing building constructions is characterized by efficient exploitation of physical and mechanical properties of materials and constructions and by minimizing their reserves. The development of numerical methods, material engineering and theoretic models describing the behaviour of materials and constructions allows a highly efficient practice in designing structures.
The above-mentioned partial research tasks were subject of detailed investigation and analysis namely in the following areas:

- Effect of moisture content on the degradation of structures, effect of moisture content on major physical and mechanical properties of building materials, effect of moisture content on the failure mechanism of masonry constructions in compression.
- Residual structural safety and resistance of prefabricated wall units exposed to effects of extreme loads of emergency type. Reliability of contact padding systems used on prefabricated sandwich constructions of perimeter walls, and optimization of physical and mechanical characteristics of thermal insulators and thin-layer plasters.
- Optimization of structures and their parts, including designing cladding constructions, modelling of non-force effects, efficiency of selected rehabilitation methods, problems of fire safety and effects of high-temperature, biodegradation and additional padding in masonry and skeleton buildings.
- Modelling of statistically dependent effects of Monte Carlo load into a real probability system allowing evaluation of reliability and prediction of service life of precast-panel buildings and combined modelling of underground and other constructions and study of contact problems.
- Study of characteristics and optimization of selected composite materials in terms of requirements for functional qualification.
- Behaviour of backfilled arch bridges, problems of covers in concrete constructions, most commonly found faults due to drying and shrinkage of concrete and temperature changes, and optimization of concrete structural members.
- Experimental research into fatigue behaviour of beams with thin-walled corrugated web, research of stability behaviour of thin-walled beams under bending and compressive load, experimental and theoretic analysis of semi-rigid joints, purlin roofs, research of fire resistance of structures of steel, and research into composite steel-concrete constructions of buildings, research into steel and steel-concrete bridges (application of modal analysis, fatigue analysis using methods of fracture mechanics, twisting of bridge systems with curved plans, and research into thin-walled structures with timber-based elements).
- Research on selected types of geotechnical constructions affected by floods and their modelling. Analysis of the PLAXIS model with regards to practical implementation of

some methods improving the characteristics of foundation soils. 3D problems in geotechnical engineering and their modelling using the MARC/MENTAT system.

- Optimization of selected characteristics of asphalt mixes with high moduli of rigidity (modulus of rigidity, fatigue, relaxation), monitoring of temperature and asphalt binder type effect on respective characteristics.
- Development of methodology for optimized construction of high-capacity four-lane roads and motorways. Development of a load diagram of mean daily volumes of heavy vehicles and converted volumes of heavy trucks, including the percentage of individual classes of traffic load.
- Theoretic and experimental evaluation of sound-dampening elements imbedded in rail constructions. Design of new constructions and their acoustic monitoring.
- Exploitation of modern instrumentation in monitoring shifts and strain of building constructions. Comparison of measurement results obtained by using standard electronic theodolites with those coming from inertial GPS systems. Development of methods of detecting changes in General Linear Models models.
- Application of wavelet and hierarchic bases for pre-conditioning of systems created by discretization of elliptic differential equations.

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Impact of Floods on Technical and Ecological Stability of Small Urban Streams

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Urbanization represents the biggest impact on the natural relations between terrestrial and aquatic ecosystems. In this meaning, the most important effects of urbanization are changes in hydrological cycle and runoff processes. Increasing impermeability of the watershed, which is in relation with changes of vegetation cover, brings serious changes in hydrological behavior of the watershed. Changes in the stream/river components are caused, it means that the equilibrium between groundwater and surface water shifts to benefit surface water. Water volume, carried to the recipient during rain event, is significantly larger and flows in stream increase very quick to unnatural maximums. The amount of very fast carried water is missing during dry periods in ground water balance and low flows in impacted streams are even lower than before the impact.

Increasing water volume and frequency of high flows do not increase only requirements for a flood control, but also negatively affect an ecological integrity of a stream, including its flood plain, which is important hydrological component influencing fate of flood by its retention capacity.

In urban area two types of floods can be distinguished, natural floods (caused by natural hydrological regime) and artificial floods, which are caused by urban drainage. The impact of floods was studied on section of the Botič creek below the Hostivař reservoir, from km 10.719 to km 12.745. The stream is in study section affected by two combine sewer outlets (CSO) and one storm sewer outlet (SSO). After floods there is some time necessary for benthic community recolonization. This time was studied with help of samplers with artificial substrate. Data obtained from artificial floods as well as data monitored during and after 2002 flood, are presented, together with its evaluation and methodology used for this project.

Heavy metals (Cu, Cr, Ni, Pb, Zn) concentrations in water, sediment and benthic organisms were monitored since 1998. The quality of benthic community of the Botič creek has been observed as well. Concentrations of heavy metals (HM) before-flood and after-flood have been compared and two coefficients have been used within the risk assessment (The Distribution Coefficient (Kd) and The Hazard Quotient (HQ)). The kick sampling method was used for biological assessment. Biological indexes (Saprobic Index, ASPT and Diversity Index) were calculated. The Distribution Coefficients changed after floods. Kd values decreased in case of most metals it means that these elements do not prefer sediment as much as they did before the floods and they can be easily released to water. Concentrations in sediment during period 1998-2001 have been found out highly risky. Serious risk has been indicated in all sampling sites. The highest risk has been monitored below CSOs. Cu toxicity is dominant practically in the whole study section of the Botič creek but mostly below CSO1. Pb toxicity is significant in profile B4 impacted by CSO as well as SSO. After flood HM concentrations in sediment decreased. Cu is still major pollutant and the highest risk is still indicated below CSO1. No expected trend of graduated increase of HM concentrations in sediment after flood has been observed.

Concentrations of HM in body tissue of most common species of benthic organism were measured. There was a high variability of concentration among species and sampling sites. The ability of each metal to be bioaccumlated has changed after flood.
Biological indexes show difference before and after flood as well. Sampling was done in spring and in summer time. Diversity decreased at all localities after floods (with exception B2 and B3 in the spring). It can be explained by washed out of substrate, especially the smaller particles, and substrate became more uniform. Number of microhabitat types decreases and the stream became suitable for less number of species. Saprobic Index decreased on most sites. Only below the Hostivař reservoir increased.
Morphology of the stream changed during the 2002 flood, erosion of stream's banks increased, especially on sites, close to CSOs, where the natural erosion was enhanced by erosion caused by water coming from CSOs.
The runoff processes show significant impact of CSO1 on the Botič creek. Number of overflows of CSO1 during one year is lower than in case of CSO2, but the total volume of overflowed water in CSO1 is three times higher than in CSO2. Maximal discharges occurring once per year are six times higher in CSO1 than in CSO2. Hydraulic stress in stream caused by CSO1 is significant, whereas the impact of CSO2 is less important. The biggest hydraulic stress occurs during summer storm events, when the discharge in stream rapidly increases from annual minimal values to annual maximal values.
The CSO1 is the main source of artificial floods on the study section of the stream and does not cause only hydraulic stress, but according to the results of chemical monitoring it causes a chemical stress for aquatic community as well. Consequently biological quality is depressed.
The results show that the flood 2002 significantly impacted the stream, chemistry, morphology as well as biology. The quality of sediment increased, concentration of HM decreased. The diversity of benthic community decreased, but according to Si, indicating organic pollution the quality did not change too much. We can assume that the main reason of the benthic community changes was the hydraulic stress. The full recolonization of benthic community was not observed, because until end of vegetation season the discharge has been kept high due to decreasing water level in the Hostivař reservoir, discharge was very high and hydraulic stress did not allow full recovering of benthic community.

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Research into Non-force Effects and Aggressive Environment Affecting the Ageing of Historical Structures with Special Emphasis on Charles Bridge in Prague.

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Chemical analyses have proven constant presence of water-soluble salts non-uniformly distributed in the stone masonry and filler layers of the bridge structure. The high salinity of the bridge comes from earlier bridge treatment with halite, later carbamide, and biotite or non-biotite transformation of atmospheric oxides of sulphur and nitrogen into aggressive salts. Spreading salts and atmospheric pollutants lead to minor expansion joints and microcracks origination in sandstone. Due to the occurrence of ettringite, thaumasite and gypsum, porosity in the concrete slab increases. The results of chemical analyses from two dug holes (2002) fully comply with the outcomes of the preceding analyses. The bottom investigation in the vicinity of the bridge piers after the flood of Aug. 2002 proved erosion effects of the increased water discharge during the flood with streamlines typically deflected from the longitudinal axis of the piers, causing side scouring and damaging of the foundation bed, particularly of piers 7 and 8. The numerical analysis of characteristic alternatives of calculation models of the bridge construction showed a negative spacing impact of the concrete slab. The nature of the entire deformation of the bridge spans due to the effects of the vertical and temperature load shows a prevailing tendency of the breast walls deformation in the direction towards the inside of the bridge. During this deformation, adverse spacing effects of the concrete slab occur. The numerical analysis of the response of the stone bridge structure to the effect of the bridge pier rotation proved origination of the state of stress causing severe damage to the arch bridge construction, which might be followed by its total destruction. The analysis showed that the concrete slab raises the entire state of stress in all its components, thus decreasing the resistance and safety of the stone structure of Charles Bridge during floods.

- In 2003, on-site works included systematic sampling to complete the spectrum of historical building materials used in Charles Bridge in Prague (the materials are currently being processed). Based on this detailed macroscopic study of existing condition and failures of architectural structures, including monitoring of the efficiency of individual analytic methods assessing non-force effects on building constructions due to external environment, methodological procedures of monitoring and assessment of degradation processes of historical stone constructions were published. According to the plan, research into classification of degradation factors in terms of relevance for bridge constructions at various localities continued.

- In 2003, the second stage of photogrammetric survey of Charles Bridge followed, and the necessary data from the institute of hydrometeorology concerning the nearest vicinity of Charles Bridge was obtained. The data was statistically processed, and it is ready for comparison with the data currently read by the dataloggers mounted directly onto the Charles Bridge construction. Surveying works included taking pictures of arches XI-XVI. Further on, analytic processing of the data obtained from arches III-IV, VI-IX and XII was completed. A 3D model of the Charles Bridge construction is gradually being developed together with a database structure for a graphical information system of Charles Bridge. In co-operation with Masaryk University, the spectrum of samples of historical building materials of Charles Bridge in Prague was complemented. In order to study their physical properties, samples of building stone used for the construction of Charles Bridge, quarried from historical localities, were prepared.
- Chemical analyses (water-soluble salts) of all samples taken from the bridge in Regensburg and Litovel were carried out. At the same time, preliminary evaluation of characteristic microflora was performed. The samples previously taken from Charles Bridge were detected and analyzed for organic acids created by microflora. A simple model was developed allowing comparison of biodegradation processes in sandstone and arenaceous marl due to the microflora of Charles Bridge in a constant cultivation mode. Sample degradation by SO_2, mineral salts was modelled, and stone destruction due to frost cycles was simulated. The resulting volume of stone degradation was determined from the velocity of water absorption into individual materials. In July 2003, an extensive data set on the degree of salinity and presence of six groups of microorganisms on arches III, IV, VI and X was obtained. A network of 25 points was plotted on each of the arches from which the directions of physical and biological degradation could be seen, which would otherwise remain hidden in using point sampling.
- The methodology of monitoring comparative strain and deformation of the stone bridge construction of Charles Bridge was developed and implemented, and the first stage of measurements was carried out.
- The analysis and verification of input data for the structural analysis of the stone construction (computational model geometry, material model and development of background materials for temperature field modelling) was carried out, numerical analyses of the 3D model of the stone construction were completed, and an extensive analysis of the state of stress and deformation due to the effect of located strain – caused by temperature and changes in the footing bottom's shape was performed.

A predominantly negative effect of the concrete slab on the occurrence of mechanical failures and resistance of the stone bridge construction namely under temperature load and the load due to changes in the shape of the footing bottom was proven (bridge pier's tilting, sinking and shift during floods).

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Structured Approach to Estimation of Surface Runoff from Small Watersheds

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The theme of runoff from catchment (and flood risks as well) has – after the recent floods - become a much debated subject for both, expert and lay public. The increasing frequency of flood events in the Czech Republic (and in the whole Central Europe) made flood phenomenon a topical issue. The theme is closely connected with a quality and a protection of the environment. A question that has been asked by many is whether a more frequent occurrence of flood events is associated with a decreasing quality of the environment. The studies produced so far suggest that it is possible to achieve reduction of volume of surface runoff (which is the main cause of local floods) via land use changes in catchments. Generally, these changes have positive impacts, i.e. increasing the quality of the environment and/or enhancement of landscape. Therefore it is necessary to estimate production of surface runoff.

Currently, the rainfall-runoff processes in catchment together with prediction of extreme water stages and connected flood protection are being intensively studied by the team of researchers of the Department of Irrigation, Drainage and Landscape Engineering, Faculty of Civil Engineering at the Czech Technical University in Prague. As a part of this research project a so called "Structured approach to estimation of surface runoff from small catchments" is being developed. The above mentioned problematic is then studied on both global and local scale (large regions above 10^2 km^2 and small ones up to cca 10 km^2 respectively). The simulation of global scale has been already tested. The main aim of this project was a search for optimal equations to be used to estimate surface runoff characteristics. In the frame of the local scale just few basic analyses have been made so far - via the model of WMS. A possibility of using simulation model EROSION 3D has also been tested.

The key aim of presented project was a detailed analysis of the global scale of the "Structured approach to estimation of surface runoff from the small catchments", i.e. to use it for estimation of surface runoff from the small catchments. This included mainly searching for and testing of the optimal relationship usable for the automated analysis of the data via GIS. In the frame of the local scale procedure a system of precautions for chosen localities will be proposed using specialized hydrological computer simulation programmes. Testing of different software tools will follow. While designing precautions, the emphasis should be on changes in the use of land.

Different methods for estimation of surface runoff were tested for area of Central Bohemian District in the frame of global scale. Namely CN (Curve Number) method, rational method and SDR (Sediment Delivery Ratio) method were tested. All three methods work with majority of the most important factors, which influence surface runoff. The most important factors are: rainfall – intensity, duration and total volume, morphology – slopes, shape of catchment, types of soils, types of land use, area of catchment, soil moisture, etc.

Using CN method volume of surface runoff and peak runoff were calculated for each catchment. With rational method peak runoff for each catchment was calculated. Output of SDR method is a so called "sediment delivery ratio" that expresses ratio between soil eroded within the fields and sediment delivered into the streams. Because this ratio is mainly determined by surface runoff, we can use it as runoff characteristic. Every used method has its own advantages and weaknesses. The main problem is that all these methods are not independent because every method uses value of CN for its calculations. Fortunately, CN value is a parameter robust enough and it is not very probable that error will occur in calculations of CN. All used methods are simple and empirical but from the point of view of accuracy they are already obsolete. Their advantage is in applicability in GIS environment and in availability of necessary input spatial data. CN method and SDR method are suitable for open landscape and not for urban areas which means that results in urban areas will not be so accurate. Another weakness is that every single catchment is calculated separately and not with the respect to adjacent catchments or catchments upstream of the calculated catchment. Despite all above mentioned weaknesses all methods are useful for given purpose and they gave us reasonable results.

Based on analyses made so far CN method was chosen as the most useful of methods, which were tested. Reasons for this result were mainly wide usage of this method in our region and its use of almost all main factors influencing surface runoff. The peak runoff calculated via this method is more useful than total runoff volume because it also includes slope characteristics.

To be able to compare catchments of different areas all final results for whole catchments were recalculated to unit area. Because of lower accuracy it is better not to regard resulting numbers as real values and use them relatively - for comparison of catchments. Therefore, based on results from all used methods, catchments of 4^{th} order were categorised into ten categories. These categories were constructed so, that every category represents 10 percent of the solved area. Finally, maps were created, using all results available.

From resulting maps we can see that more endangered areas are those concentrated around the confluence of Sázava and Blanice, around Litavka and around the confluence of Berounka and Litavka. Relatively less endangered is an area in Labe valley. For more details contact please the author.

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Experimental and Mathematical Analysis of a Multi-Layer System of Railway Track

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The Czech Republic has launched a process of gradual modernization of selected, so-called corridor tracks, to allow for train velocities of up to 160 $km.h^{-1}$. The railway track construction must be designed in such a way to ensure long-term stability of geometric rail parameters. A necessary precondition for this is a sufficient bearing capacity of the substructure even in climatically unfavourable seasons, ensuring thus the overall needed bearing capacity of the railway track construction. In unfavourable geotechnical conditions, the design practice applies structural layers below the ballast bed using various building materials. Numerous geosynthetic materials are also applied to reinforce individual structural layers. In order to reduce noise and vibrations, elastic sub-ballast matting is used, too. No exact design method for the dimensioning of the track bed bearing construction, however, has been developed to-date, either abroad or in our country. Exploitation of innovative materials in the structural layers of railway tracks is solely based on empirical knowledge obtained from applications implemented at individual sites.

The project's concept is based on a mathematical calculation of the bearing capacity of a multi-layer track bed construction of the railway track, and verification of the results of a theoretical solution by means of experimental measurements carried out on a model of a railway track section in a 1:1 scale in laboratory conditions. Experimental measurements will apply a testing box of the Central laboratories of the Faculty of Civil Engineering, CTU in Prague.

The project's output will be an exact design method of the railway track bed bearing construction, which will not only allow designing track bed bearing constructions for various geotechnical conditions, but will also optimize these constructions with regards to cost-effectiveness.

The preconditions for reaching the project's objectives are completion of experimental measurements using a track construction model in a 1:1 scale in the testing box for:

- a track bed of unbonded layers,
- a track bed of unbonded layers with reinforcing synthetic geotextiles,
- a track bed of unbonded layers with sub-ballast antivibration matting,

the design of numerical models of the railway track construction, verification of the results of experimental measurements by means of a numerical model, verification of the two-dimensional solution of the numerical model of the railway track construction with the help of a three-dimensional model, the development of a new design method of the load-bearing construction of the railway track under various geotechnical conditions applying different track bed constructions.

The first grant project year (2003) was used for the completion of the following works.

Verification of the behaviour of the railway superstructure and substructure subjected to loading in the testing box was a basis for the design of measurement methodology.

Measurement methodology was designed and verified using a model of the railway superstructure and substructure construction. The following track bed construction was selected for verification:

- ballast bed 32-63 mm with a thickness of 35 cm,
- a layer of partially crushed gravel 0-32 mm with a thickness of 15 cm,
- rubber plates with a thickness of 54 mm simulating subgrade with a bearing capacity of 15 MPa.

The track bed was loaded with a half of a concrete sleeper B 91S with a piece of a rail UIC 60, which was exposed to a force of 50 kN. The loaded model was used for the measurement of the following parameters:

- sleeper, ballast bed and simulated subgrade subsidence,
- moduli of deformability on the ballast bed surface, on the surface of the layer of partially crushed gravel and on the surface of rubber plates,
- stress at the level of sleeper loading area, on the surface of the layer of partially crushed gravel and on the surface of rubber plates simulating the subgrade.

The measurements of moduli of deformability on sub-ballast antivibration matting of Phoenix VM 12-01 brand laid on a stiff base were made.

Experimental investigation of the effect of sub-ballast antivibration matting of Phoenix VM 12-01 brand on the overall bearing capacity of the track bed was performed. This investigation applied the following track bed model in the testing box:

- ballast bed 32-63 mm with a thickness of 35 cm,
- with and without a layer of partially crushed gravel with a thickness of 15 cm,
- sub-ballast antivibration matting of Phoenix VM 12-01 brand,
- stiff base (testing box bottom) or simulated subgrade consisting of a layer of partially crushed gravel with a thickness of 12 cm laid on a layer of rubber with a thickness of 30 mm, which was laid on a stiff base (testing box bottom).

The project's results and their exploitation in the operational practice of the Czech Railways will contribute to a more objective design of the load-bearing construction of the railway track. At the same time, they will facilitate the design of a construction with optimum cost-effectiveness. The analysis of the railway track construction also represents a general solution of the distribution of force effects due to railway operation within the construction of a multi-layer track bed system. The project is aimed at developing an innovative design method for dimensioning the track bed construction using standard building materials as well as geosynthetics, or using sub-ballast antivibration matting.

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Impact of Using CT Imaging on Estimation of Soil Hydraulic Properties by Inverse Modeling

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To quantitatively predict water movement in variably saturated and naturally heterogeneous porous media, the hydraulic properties of the media have to be determined. Performing laboratory infiltration-outflow experiments on large undisturbed soil samples, along with the detailed analysis of their results, can serve as the first step to adequate modeling of soil water movement. The second step may involve inverse modeling, carried out to find an optimal set of parameters for the simulation model. This makes it possible to decrease uncertainty associated with the description of the behavior of water in soil.

Experimental setup [3] with automated data acquisition for undisturbed soil column was used. The soil under study was coarse sandy loam from Korkusova Huť, Czech Republic. The core sample was taken from the second soil horizon. The sample had 18.9 cm in diameter and was 25 cm high. An unsaturated flow through the soil column was established by tension infiltration disc. Three tensiometers at heights 7.5, 12.5 and 17.5 cm below the top were inserted into the column to measure pressure head. Constant pressure heads controlled by tension infiltration disc were consecutively set equal to -9, -6, -3, -1 and +1 cm.

Preferential flow of water is a subject of interest in many studies and has been observed in variety of soil types. KH coarse sandy loam represents highly heterogeneous soil of wide particle size distribution and exhibits preferential flow and flow instability [1]. A one-dimensional dual-permeability simulator S_1D_Dual was used. The code was developed from the earlier single-permeability program HYDRUS 5 [2]. In S_1D_Dual, the pore space is represented by a dual-permeability system [4], consisting of the matrix flow domain (MFD) and the preferential flow domain (PFD), in which the PFD occupies a certain fraction of the bulk soil. Model is based on the Richards` equation and hydraulic properties of unsaturated flow are approximated using van Genuchten`s expressions. To simplify the description of spatial variability of soil hydraulic properties, simple scaling procedure is used.

The internal structure of the soil sample was visualized by means of X-ray computed tomography (CT). CT, as a one of non-invasive imaging methods, has an excellent potential to provide this information. 3D images were constructed from 2D images of contiguous 1 mm thick horizontal slices. The slice-image field of view was 8 x 8 cm^2 and the image matrix size was 512 x 512 pixels, resulting in the in-plane resolution of 156.25 x 156.25 μm^2. The image intensities are given in relative Hounsfield unites (HU) with values ranging from 0 for voids to 4095 for most dense parts of the sample. The obtained information is not restricted to the distribution of the solid phase only. CT images provide also information on the distribution of low–density regions (e.g. big pores). It is possible to approximately assume that these pores represent the potential preferential pathways. To make the flow simulation more

realistic, we calculated scaling factors of hydraulic conductivity and porosity according to the chosen threshold value of 1000 HU.

Solution of the inverse problem for unsaturated flow is a tricky job which mostly depends on the structure of the hydraulic model, uniqueness of the model parameters and on the magnitude of the measurement errors. At best, solution can represent an approximation of the optimum accompanied with an estimated uncertainty.

To estimate soil hydraulic properties, inverse modeling of infiltration-outflow experiments with undisturbed soil column was performed. Commercial software package PEST (Waterloo Hydrogeologic), based on the Levenberg-Marquardt algorithm, was used as a parameter estimator. The hydraulic parameters were optimized in the least-square sense. The objective function was composed of separate contributions of cumulative inflow and outflow (recorded at the top and at the bottom of the column) and tensiometric data (recorded at the three measurement levels). This has been done separately for each of the experimental runs corresponding to the different values of pressure head (set by the disc tension infiltrometer), as well as for the combined runs. The observations included in the objective function were weighted to reflect two different types of data. Three parameters were optimized in both domains (MFD and PFD). A sensitivity of the PFD parameters was very low, due to low percentage of preferential flow domain in the system.

The uniqueness of the inverse problem was improved by combined optimization of experimental runs with different boundary conditions (top pressure heads). An extensive study, to capture the impact of including CT information on the optimization, was conducted. Three independent initial estimates for four separate cases of incorporating CT information were examined. Including CT information into the description of the column internal structure yielded up significant improvement in terms of the fit between simulated and measured values.

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Fatigue of Girders With Undulating Web

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In this contribution are described fatigue tests and subsequent theoretical research of fatigue resistance of WT girders (girders with thin-walled undulating web). Their web is from 500 to 1500 mm in depth and 2, 2.5 and 3 mm thick. The slenderness ratio is up to 500. Web of girders is made of steel St37-2G (fy = 215 MPa) and the wave amplitude is 20 mm. Flanges are made of standard steel (S235, S355). Considering high resistance of web in shear buckling we can save up-to 30% of material in comparison with traditional girders.

Aim of this research was to specify fatigue category of WT girders under i) predominating shear and ii) local cyclic loading. This classification is essential for designing WT girders as crane beams.

Research was divided into two main parts: experimental and theoretical one. There were two basic sets of experiments in the experimental part. Set of 10 girders under predominating shear and set of 10 girders under local loading with transverse eccentricity 20 mm. These experiments started in 2001 and finished during 2002. Tested girders were WTA type (2 mm thick web) with depth of web 500 mm and flanges 200x10 mm made of S235 steel. The span of the former set of experiments was 1700 mm and of the latter one 850 mm.

All tests were finished when visible crack had appeared. In case a crack did not appear before reaching 3 millions cycles the stress range was considered as under fatigue limit.

There were two kinds of cracks in the web of the first set girders. Three cracks have appeared at the flange-web weld and the rest of them at the vicinity of mid-span stiffener. Cracks grew rapidly in both cases.

Only one kind of cracks has appeared during tests of the second set. It was at the top of the web under load location. Speed of all cracks decreased when being exposed to loading after crack appearance.

Standard statistical evaluation procedure was used in accordance with Annex Z of Eurocode 3 for both types of loading.

With the help of regression analysis the characteristic detail category was determined as 40 MPa with non-standard slope of S-N curve $m = 9.445$ for the shear stress.

The statistical evaluation of fatigue resistance under local loading gave experimental mean value of the fatigue category (corresponding to 2 million cycles) as 431.7 MPa.
The evaluation of pseudo-stress led to a fatigue strength curve 316 with the slope 7.401. Reasonable pseudo-stress values are easily available using formula for effective length l_{eff}, derived in the project.

These tests were described at Workshop 2003 [3].

For the year 2003 was decided to prepare complex experiment with moving local loading. The aim was to verify results of previous experimental and theoretical analysis. However, it appeared to be very complicated technical problem.

A special test rig had to be developed for this experiment. The hydraulic loading cell was stable, however the girder was moving in horizontal direction along longitudinal axis. The girder was loaded as in local load fatigue tests (F = 90 kN) via crane rail 30 x 50 mm. The transverse eccentricity of crane rail was (as in the former tests E) 20 mm. Movement of load was enabled by real sized crane wheel with diametr 260 mm. The girder was supported by the same crane wheels at span length 1 m and was positioned so that the load acted above

wave amplitude in the middle of movement cycle. Both flanges were supported in horizontal transverse direction by rectifionable heavy-duty polyamide wheels. The load capacity of these wheels was 200 kg.

Girder movement of ± 70 mm in longitudinal direction was imposed by movement generator (straightforward saw mechanism). The girder was connected to the mechanism by steel tie-bar (square tube 30 x 3 mm). The mechanism was equipped with contact switch to count the number of cycles. Operating frequency of the mechanism was 80 cycles per minute (1.33 Hz).

A strain gauge element was placed between moving mechanism and tie-bar. It was used to measure force acting on the saw mechanism.

Two rough estimations were made. Combination of shear stress range and local stress range was used for both of them according to Palmgren-Miner rule of damage accumulation. As the first assumption the full theoretical stress range was used. I.e. shear stress range is equal to double value of theoretical shear in the web and local stress range is equal to maximal value of local stress (the full unloading of hot-spot). According to this assumption the crack was to appear at 11.2×10^3 cycles. Apparently this was lower limit of number of cycles.

The second assumption was based on result of numerical solution however with different geometry. The stress ranges according to this numerical solution led to assumption of 487×10^3 cycles to collapse. As some dimensions of numerical model (flange thickness, rail height) were bigger then the dimensions of tested girder this number of cycles was expected to be the upper limit.

During the experiment an unexpected problem with enormous crane rail wear appeared. This increased loading of moving mechanism (4 kN with worn-out rail, 2 kN with the new rail).

The first crack has appeared at 286×10^3 cycles at weld toe within loaded area. The crack was visible from only one side. At this moment worn upper rail was replaced with the new one. The girder was loaded up-to 515×10^3 cycles but with minimal increase of crack length (up-to 1 mm on both sides). During experiment (340×10^3 cycles) an unexpected another crack has appeared at the edge of web above support wheel. It was produced by enormous stresses in the web when the supporting wheel was behind end stiffener. This crack was not evaluated because of uncertain range of stresses in this area.

It can be concluded that experiment with moving load roughly proved results of basic fatigue tests. The second test with moving load is under progress.

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Database Gathering and Analysis of Moduli of Deformation Measured at Selected Sections of Modernized Czech Rail Corridor Lines

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Since 1993, a modernization process of selected railway tracks, so-called transit corridors, has been in progress in the Czech Republic. One of the most significant parameters for the acceptance of already completed railway sections from the contractor by the owner (i.e. Czech Railways) is sufficient load-bearing capacity of the substructure and rail bed. Load-bearing capacity is determined on the basis of plate load tests carried out with a rigid circular plate, and it is characterized by the modulus of deformation E [MPa] [1]. According to Czech Railways Instructions in force (S4 Substructure, S3 Permanent Way), the modulus of deformation of formation, the modulus of deformation of substructure body subgrade and the modulus of deformation at sleeper loading surface level is determined. The measured data must comply with the minimal required values, and it is an essential part of the project of actual performance of respective railway track sections.

The aim of this project was collecting information on plate load tests which were conducted at modernized sections of Czech Railways, its processing in the form of an electronic database and data analysis.

The database is conceived as a relational database whose data tables are mutually interconnected by links, so-called relations. The database structure design included all the necessary data for data collection and the requirements for database outputs. The database is designed for collecting data up to 3 layers under the sleeper loading surface, 5 layers under substructure body subgrade and 5 layers under formation, altogether 13 layers at the most. For data collecting, an integrated part of railway corridor I in the section of Brandýs nad Orlicí – Přelouč was chosen. Seven interstation double track sections in an overall length of nearly 50 kilometres were processed. Data on 1122 carried out plate load tests from 458 measured localities was recorded.

Data analysis was focused on the monitoring of track bed behaviour in terms of load-bearing capacity. One of the monitored parameters was homogeneity of load-bearing capacity in three levels – on formation, on substructure body subgrade and on the level of sleeper loading surface. Each track section was statistically analysed and graphically illustrated. Homogeneity characterized by standard data deviation shows significant deviations in comparing individual track sections. The analysis of material modulus of deformation was focused on the most frequently used materials – gravel in rail bed and granulated gravel in the structural layer. Calculation of the material modulus of deformation E is based on the method of multi-layer DORNII system. Results show that the estimated values of material modulus of deformation are not achieved within the modernization process [2]. However, it is possible to presume that the values will go up by consolidation due to railway traffic.

Also the effect of geotextilies imbedded in the structural layer on the load bearing capacity of substructure body subgrade was monitored. Geotextiles can serve several functions (reinforcing, separative, filtering etc.) in the track bed. Especially by using

reinforcing geotextiles, a significant increase in the load-bearing capacity of substructure body subgrade with regard to load-bearing capacity of formation is evident. By analyzing the structural layer of granulated gravel, it was possible to determine a relation between the load-bearing capacity of formation and substructure body subgrade at different thicknesses of granulated gravel. A characteristic feature is linear dependence with decreasing tendency – by raising the load-bearing capacity of formation the difference between the load-bearing capacity of substructure body subgrade and the load-bearing capacity of formation is decreased. If the minimal required value of load-bearing capacity of formation is exceeded more than twice, this difference works out to be near zero or is even negative. In such case, there is no longer use, in terms of load-bearing capacity, to construct the structural layer of granulated gravel because the function of the structural layer is especially an increase in the load-bearing capacity of substructure body subgrade.

The created electronic database of moduli of deformation, filled up with the data from interstation parts in the section of Brandýs nad Orlicí – Přelouč in a length of almost 50 kilometres, proved very good possibilities for a detailed analysis of track bed behaviour in terms of load-bearing capacity. In the case of adding the missing data on load-bearing capacity into the substructure database or the permanent way database, a large data space can be created for effective monitoring of load-bearing capacity issues in standard practice of Czech Railways.

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Analysis of Cyclically Loaded Joints Using Method of Component

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Combining different materials within a structure taking advantage of their respective qualities makes the structure more competitive and economic. Combination can be realised by using the composed members where two or more materials act together being connected in shear. Other possibility is to connect two members made of the different materials into so called "mixed structure". The objects of this research are the joints of the mixed structures. The range of material combinations is however wide, so this research was focused on connections between the steel and concrete member only.

The majority of actions loading the structure is assumed to be quasi-static and its "common fluctuation" is taken into account by different reduction factors. Because it is not clearly defined what "common fluctuation" is and because there are moreover the accidental cyclic loads, the alternative procedure allowing assessment in these cases should be established.

There are three methods, used frequently in the recent civil engineering, that allow defining the model for repeated loading. The first one is the finite element method (FEM) used for modelling of whole joint. This method can reach the accurate solution comparing to the reality. The precision by this method however requires large input of data, which is complex even in case steel components under cycling and which is limited in the case of the concrete parts of the joint. The crucial for the solution convergence are the contacts between steel and concrete and between steel bolts and plates. This problem is moreover emphasised by uncertainties in the initial gap sizes. The disadvantage of this method is long time necessary for defining models with different geometry and for solving such complicated model. The traditional method is curve-fitting procedure; sometimes called mathematical model. Firstly, the mathematical function is defined, having the similar shape as moment-rotation (M-Φ) relationship of the experimentally obtained curve. Then the changes in shape of experimental curves are described by comparing the (M-Φ) curves of the geometrically similar joints differing in several material and geometrical parameters. Final relation is a function of above mentioned parameters. The model defined using this method can give very well fitting (M-Φ) curve but it is limited to a joint geometry not too different of those for which the model was established. The mathematical function contains several curve-fitting constants that have not direct physical explanation. The third used method is the simplified analytical method. The basics of this method is to simplify the joint to the mechanism containing elemental parts for which we assume the behaviour based on its physical role in the joint. The model defined using this method gives very simplified (M-Φ) curve but it allows describing the variety of joints with different geometrical and material properties. The influence of each part is also better visible. Moreover there is also possible to combine the above mentioned methods (e.g. to use FEM for modelling parts of joints and to use the

analytical procedure to assembly the parts behaviour curves into the curve of whole joint response as was published in [1]).

For this research the analytical method was chosen. The well known method of components used up to the present time mostly for monotonic loading is applied for the cyclically loaded steel-to-concrete joint. The model for cyclical loading is established based on the monotonic one; but important modifications of component behaviour are necessary. The joint is divided into the same components as for the monotonic loading. The most important components for the selected end-plate type of joint are equivalent T-stub, anchor bolt and concrete in local compression.

For the equivalent T-stub it is assumed that unloading path of the force-displacement (F-δ) curve has the same slope as initial loading path. The Bauschinger effect is included, so the limit of elasticity in subsequent compression is influenced by the strength reached in the previous tension hemicycle. There is the change in the static model when the load changes from compression to tension. The slip due to the hole clearance is neglected. Bolt bending is neglected.

The assumption of the anchor bolt effective length is similar to the monotonic loading, i.e. 8 times the anchor diameter. The slip between concrete and anchor is neglected as well as the anchor bending. For the concrete in local compression we suppose the unloading part of the (F-δ) curve having the same slope as the initial loading path. Plastic deformations are allowed. Post peak behaviour is not included (for the practical cases it is never reached). Loading in tension is not allowed for this component. The trilinear (F-δ) curve based on monotonic ultimate strength is adopted for all these components. The initial stiffness is calculated similar the monotonic solution.

Three above mentioned components were calibrated on test prepared in the laboratory of Faculty of Civil Engineering of Czech Technical University in Prague in 2001-2002 [2]. The model was checked against the tests of the whole joint carried out by Dunai et al. [3]. The simplified version – the prediction model was developed. The prediction model was used for design of standardised connection applicable for joining a steel beam to a concrete wall. The model is an integral part of the author's PhD. thesis.

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Integrity of Structure by Connection Design

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The paper presents the results of work into topic of structural connections under exceptional loading conditions. It summarised developed analytical methods for the determination of the rotation capacity and robustness of simple connection of steel structures – header plate connection used in multi-storey administrative and industrial buildings. The structural integrity under exceptional loading conditions, fire, earthquake etc., is achieved by robustness and deformation capacity of its members and connections. The robustness of members depends on it deformation capacity and resistance to ultimate tensile forces. The robustness of connections depends on its rotational capacity and on its resistance to ultimate tensile forces.

The work is based on the component method. From test results and numerical simulations simple analytical expressions for the deformation capacity and ultimate resistance of the major component are derived. These values are subsequently used for the determination of the rotation capacity and the robustness of the complete joint. Comparisons with tests on whole joints indicate a good agreement between analytical and experimental results. The method is fully consistent with the present rules of prEN 1993-1-8 and extends them to the numerical estimation of the rotation capacity.

Three basic parameters describe the behaviour of connections: strength, stiffness and ductility. In simple connections, the ductility is achieved by a sufficient rotation capacity. Although there do exist well-elaborated methods for determination of the initial stiffness and strength of beam-to-column joints, there are no generally accepted procedures for the determination of the rotation capacity. The estimation of the rotation capacity is very important in practical applications where may improve and substitute the deem to satisfy criteria used in practice. It is therefore evident that an analytical prediction model for the determination of the rotation capacity for design applications is needed.

The main task is to determine the deformation capacities of the basic component of a joint the end plate/column flange in bending and bolt in tension. The deformation capacity of components has been studied by several researchers. Faella et al. [1] carried out tests on T-stubs and derived simple estimation for the deformation capacity of this component. Kuhlmann and Kuhnemund [2] performed tests on the column web subjected to transverse compression at different levels of compression axial force in the column. Some authors have tried to extract the information of the behaviour of single components from the tests on a whole joint. Based on the test results of other authors and partly on our own tests, combined with FE analysis, deformation capacities for all the relevant components may be established. Single components are then represented by non-linear springs, and appropriately combined in order to determine the rotation capacity of the joint.

The typical simple connections are connections with header plate, angle web cleats and fin plate. For these connections, the most important components that may significantly contribute to the rotation capacity of the whole joint are: column web in compression, column web in tension, column web in shear, column flange in bending, fin plate, angle cleats and end-plate in bending. Of all components under consideration, the T-stub behaviour of column flanges and end-plates is the most complex. Besides bending of the steel plates, the deformations of bolts, nuts and washers are also involved. Three collapse modes are possible to distinguish. In well design simple connection the collapse mode one (creating four hinges in the end plate) may occur only. For this component simple analytical expressions were derived based on our own tests [3], test from literature and appropriate numerical simulation. Deformation capacity of the component can assumed as 0,4 m or calculated more precise, where m is the distance from the bolt centre to the beam/column web.

A simple mechanical model for the joint behaviour composed of non-linear springs representing the relevant components can be established. The rotation capacity is primarily determined by the deformation capacity of the component with the lowest strength. E.g. in case of the end plate connection with end plate on full height of the beam web the rotational capacity may be calculated as

$$tg\phi_{Cd} = (m \cdot sin\, artg(2\,m / 12\,t_p)) / h_r\,, \tag{1}$$

where t_p is the end plate thickness and h_r is the distance from the top bolt row to the lower edge of the end plate.

The presented work brings complex as well as simple analytical prediction methods for the calculation of the rotation capacity and robustness of plate connection. The findings ware summarised into the tables applicable in design practice for header plate connections. An important feature of the presented method is its compatibility with the procedure given for the analysis of joints in Eurocode prEN 1993-1-8. The proposed method gives simple numerical expressions for the deformation capacities of joint component, while the initial stiffness and strength of components can be assessed according to the common rules. A comparison with the test results shows good agreement and the calculated rotation capacity is lower than the measured values.

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Aplication of Projective Error Estimation in Adaptive Solution of Nonlinear Problems

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Recently the authors have discussed error estimation procedures and adaptive mesh design based on recovery of stresses, strains and other gradients for linear problems. Application of such methods to practical engineering analysis is widely available today. In last year we were engaged in the extension of the methodology to nonlinear problems. At first glance, it appears simple because the solution is generally obtained by successive linearization, however several difficulties arise. The applications in our research are focused on static problems of elasto-plasticity, common in engineering.

Generally, due to path dependency of the solution in materially nonlinear analyses, the loading is applied in an incremental manner with an iterative linearization, using the Arc length method [1] in each increment. The iteration is usually continued until a suitable norm of variables falls under a prescribed tolerance. Depending on the tolerance used in the termination of Arc-length iteration, an additional error to that due to discretization will occur in the computational process. We mainly focused on the discretization error by assuming that the magnitudes of the increments and tolerance used are sufficiently small to make the iteration errors secondary.

The observed error is function of the loading and the decision of remeshing, while the nonlinear computation is being carried out, requires important engineering judgement. An appropriate norm of variables must be devised to monitor the accuracy of the solution helping to recognize the necessity of remeshing.

Various measures of error are adapted by investigators. The majority use either the L_2 norm of displacements or the energy norm. Some, however, use local indicators i.e. values of plastic strain or gradients of total displacement. This kind of criterion is usually used in localization problems and can only indicate the existence of error but not its magnitude. We use energy norm computed from recovered stresses, which have proved to be the best in linear problems. The norm will be slightly adapted to suit plasticity problems. Obviously, success of this error estimation is depended on exactness of recovery method used and therefore we took the advantage of SPR (Superconvergent Patch Recovery) method [2], which has shown excellent performance in linear problems.

The majority of investigators compute error on the whole domain, it means also in plastic zones. Therefore they use incremental energy norm. In *n-th* increment the corresponding error is computed and added to the total error reached in increment $n - 1$. The total error is stored at integration points and after generating a new mesh, corresponding values must be constructed for the new integration points. However, we proposed different method. Firstly the accuracy is controlled in elastic zones only. Therefore, in every increment the total error is computed again, thus it is not necessary to store the values. Secondly the error is compared with the prescribed limit, which is not, however, constant over the domain. The highest accuracy is required on elements close to plastic zones.

In adaptive computation it is usually required for every element to satisfy the condition $\eta < \eta^p$, where η^p is the prescribed relative energy error norm. According to the value of the prescribed error, the investigated domain is divided into three subdomains:

1. subdomain is composed by elements, whose plastic deformation is zero and stress state is not close to the yield surface. This is defined by

$$\phi < \frac{f(\sigma,\kappa)}{f(0,\kappa)},$$

where f is the function of plasticity, 0 is the zero vector, σ is stress on the element and ϕ (0;1) is limit "distance" from the yield surface, which is chosen (e.g. 0.1). The same procedure as in the linear adaptivity is used, where the uniform distribution of the error over the whole subdomain is supposed. Then the bound of error for i-th element is

$$\|e\|_i \le \eta_e^p \sqrt{\|u\|^2 / ne} = e_m^p \ ,$$

where η_e^p is the prescribed percentual error for elastic elements, ne is the number of elements on subdomains 1 and 2, $\|e\|_i$ is the energy error norm for one element and $\|u\|$ is the energy norm of displacement for subdomains 1 and 2. The value ξ_i gives information about resizing the element

$$\xi_i = \|e\|_i / e_m^p \ .$$

2. subdomain is composed by elements, whose plastic deformation is zero and stress state is close to the yield surface, thus

$$\phi \ge \frac{f(\sigma,\kappa)}{f(0,\kappa)} = \beta \ .$$

Here we do not assume the uniform distribution of error over the whole subdomain and the bound of error for i-th element is

$$\|e\|_i \le (\eta_p^p + (\eta_p^p - \eta_e^p)\beta/\phi)\|u_i\| = e_m^p \ , \ \ \xi_i = \|e\|_i / e_m^p \ ,$$

where η_p^p is the prescribed percentual error for plastic elements.

3. subdomain is composed by elements, whose plastic deformation is nonzero. Because these elements have passed through the second subdomain, they have already the required size and we can assign on them $\xi_i = 1$.

Now we have ξ_i for every element and new characteristic size of element is defined as

$$h_{new} = h_{old} / \xi_i^{1/p} \ ,$$

where h_{old} current size of the element and p is the degree of the polynomial expansion. With information about new element sizes we can generate a new mesh.

Advantage of this method is better reaction on extension of plastic zones, the mesh is refined already before rise of plasticity. We carried out numerical verification of the efficiency of proposed method and for simple examples it performs correctly. In the future work it will be necessary to verify this method on more complex examples with various plasticity conditions.

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Corrosion Effect of Bentonites and Bentonite Mixtures with Graphite Content 0 - 10 % (w/w)

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A deep repository of high radioactive waste has to be built till 2065. The repository is a very special engineering construction, especially extreme requirement on safety and lifetime. The solution of safe isolation of high radioactive waste is a multidisciplinary problem. The isolation of waste will be provided by a multilayer system. This system will consist of the container with radioactive waste, engineering barrier (at present this barrier is supposed on bentonite base) and natural barrier (which is formed by suitable host rock - granite, clay etc.). These engineering barriers will retard a contaminant transport to surrounding geosphere in case of container corrosion.

Bentonite is considered as the main structure material for engineering barrier for its properties as sorption, swelling, plasticity e.g. Required lifetime of engineering barrier is 100 thousand years. It will not be allowed to come to degradation of required parameters (impermeability, swelling ability, plasticity, strength, sorption etc.), which would threaten a safety function of the barrier.

Bentonite belongs to group of clay soils; a characteristic trait is layered structure and hyperfine particles. Mineral of *montmorillonite* $Al_2 (Si_2O_5)_2(OH)_2$ that has trilayer structure, is a dominant component in bentonites. Overall properties of bentonites as plasticity, sorption, swelling e.g. are bound exclusively on the montmorillonite component.

The Czech Republic has large supply of bentonite in many localities. The bentonites extracted and treated by activation (It means natrification of bentonites) are magnesium-calcium bentonites or calcium-magnesium bentonites. Natural sodium bentonites are not found here. The bentonite from domestic supply is supposed to be used in the deep repository.

Corrosion is understood as spontaneously running process of material degradation by the surrounding environs. Processes, which cause corrosion damage, have a physical-chemical character. Electrochemical reactions are the most frequent case of corrosive action. The three groups of metal corrosion exist – *electrochemical, gas and physical dissolution* and the corroding process can exhibit in following forms: general, pitting, slotted, intercrystalline, stress etc.

Standard ISO 8407 permits a determination of corrosion effect by static method. The results of these tests give first information about properties of bentonites and their mixtures, about the possibility to choose bentonite or its mixture (with sand and graphite)with lower corrosion effect and good geotechnical properties. Thermal conductivity of sealing material is increased by addition of graphite to bentonite. The sand as admixture is used for decreasing of swelling ability.

Water suspension of bentonite and its mixture was prepared as 10 wt % suspension. The conductivity and pH-value of 10 % suspension and ultra-pure water was measured in regular time interval (during 28 – 35 days). A metal sheet was put into the suspension after

(28 – 35 days). The conductivity and pH-value of suspension and water with metal sheets were measured in regular time interval. The sheets were taken out (after 28 – 41 days) and purified in 20 wt % HCl with 5 g hexamethylenetetramine per 1 l of solutions and after in water and acetone.

Corrosion mass loss per unit of area, corrosion speed at mass loss, corrosion speed at dimension loss and mass loss are defined from measured values as indicator of general corrosion.

Higher attention was turn to material from locality Rokle, because it was used for construction of physical model of repository for radioactive waste, which was built in the Centre of Experimental Geotechnics on the Faculty of Civil Engineering in Prague. This bentonite was used with aspects of good geotechnical properties, low value of the corrosion effect obtained from first group of the test and sufficient reserves of bentonite in depository.

The tests with thermally loaded (200 °C) bentonite RMN (industrially grinded bentonite from locality Rokle) and its mixture (admixture sand and graphite) were made with sheets – steel class 11 and copper. Corrosion effect gently increased with thermal loading, dependence on loading time was not found in time interval 14 – 42 days for RMN and in time interval 14 – 140 days for mixture - 85 % RMN, 5 % graphite and 10 % sand.

It was found that presence of graphite, which is added to bentonite improved its thermal properties, did not show increasing corrosion effect. In other side value of corrosion speed at dimension loss is about 20 % lower for mixture (85 % RMN, 5 % graphite and 10 % sand) than for bentonite without admixture. The test was carried out with steel class 11 declared by standard. Corrosion tests with mixtures (80 – 90 % RMN, 0 – 10 % graphite and 10 % sand) are finished in this time. These tests will show dependence of corrosion effect on graphite content and influence of thermal loading.

Research on bentonite based engineering barrier designated for safe underground disposal of highly radioactive waste is special multidisciplinary issue. An underground repository is the engineering construction with an extremely long service life requirement. To obtain findings enabling design of such construction, all experimental tool and procedure must be used.

The clay properties give an eventuality to use acquired knowledge not only for disposal of highly radioactive waste but also for other contaminated waste.

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Irrigation Constructions Problematic and Exercise Documentary Movie Creation

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The main purpose of this project was to create the teaching document about irrigation construction quality and quantity changes after 1989. Authors of this film are problematic irrigation and video creating specialists. The last teaching movie "Irrigation constructions" created by prof. Holý and doc. Vrána has been created in 1976 in Faculty of Civil Engineering of the Czech Technical University in Prague, Department of Irrigation, Drainage and Landscape Engineering. Its purpose is to complement "Irrigation constructions" lectures for specialization "Water constructions and water treatment" and "Environmental engineering" and is used successfully for many years.

The amount of irrigation water in Czech Republic is given by climatic conditions. Growing season is from April to September, average amount of rain water 672 mm is not distributed uniformly during a year. A water need of field plants is not supplied by rains in average year in the most product regions. That is why irrigation is needed. Regardless, field plants are not irrigated at this time. Additional irrigation is focused on crops that could not be grown without irrigation (early potatoes, vegetables). Extremely wet year 2002 with dangerous flood in August (total amount of 866 mm rainfall) contrasted with year 2003 when the climate was extreme hot and dry. Latest data from CHMI shows that in period from 1.1.2003 to 30.9.2003 was measured less than 500 mm of the rain water, what means less than 80% average value and a big part of the republic notes even less than 60% of total rainfall. Considering this fact the irrigation condition has been ideal for recording this film. Latest shots were recorded at Sparta football stadium in Prague on December 5th 2003.

Significant changes happen from 1976 till now. Changes of endowment politics after the velvet revolution, changes of agricultural companies conditions (privatization the main irrigation equipment, energy costs growth, opening foreign markets) and also a technical progress modified using irrigation extremely. Ministry of agriculture of the Czech Republic determines the total area of agricultural soil 4 279 876 ha and there were constructed irrigation systems on area of 153 804 ha until 1996, what is about 3,59 %. Privatization of main irrigation equipments during 1997 – 1998 gave new alienees irrigated area about 131 543 ha by "land fund" data. Regardless, it was found only small part of active irrigation systems properly working.

Number of typical irrigation systems localities has been visited during solve of the project. For example rest of the historical irrigation systems in Babiččino valley in Ratibořice, with irrigation of meadows, intensive using of irrigation systems Předměřická a.s. and Agrocomplex Ohře a.s. Bohušovice, with prosperous vegetable production, irrigation system Labe V., První Labská a.s. with a lot of small farmers and specific problematic of water supply, different ways of hops irrigation in Žatec are typical Czech areas visited. In Morava region vegetables irrigation systems Brod–Bulhary–Valtice and Podivín–Lužice around

Břeclav, wine cultivations region Valtice and the biggest irrigation reservoir Nové Mlýny has been visited.

Author of this film has also been invited to Slovakia to visit private tobacco farm Slavkovce and private vegetables farm Bánovce in locality of Eastern Slovak lowland. Typical shots have been taken there. Experiences of main irrigation system (around Zemplínská Šírava) entrepreneur Ing.Godočík has been provided them.

The second part of the film is information and shots of modern automatic irrigation systems. All realization process of automatic irrigation system on family house garden was allowed by Hypša garden company Kosmonosy. Bigger automatized systems, so called "turf irrigations" of sport areas (golf and football playgrounds) have also been taken. Golf playground Konopiště, Bechyně, Ketřany u Písku and Čertovo Břemeno - Jistebnice were visited to take typical shots and different realization possibilities of the systems. Irrigation of football stadium was recorded on Sparta Praha stadium. Structure of automatic irrigation system was caught on park garden of Prague Castle – Na Valech garden too.

Concerning age of the systems - authors tried to cover all kinds of the systems – new constructed by present requirements (AIS) and problematic of previously constructed systems, too. Some of them are used and in order (e.g. pump station) but other constructions are broken or totally destructed. Special shots have been recorded, e.g. uncovering pressure deformation fibreglass tube.

Because of initiatory solving of this grant project and the problematic situation with searching project documentation and owner of irrigation system after privatization, this project was very time consuming. During 5 months has been shot about 12 hours of raw record and visited several tenth localities and business meetings. Last editing changes and tutorials with shot subjects before final version presentation for making a soundtrack in AVIC CTU Prague are made at this time. Results of this project have never been published in text form. Articles „Irrigations 2003" and „Student works about irrigation" are prepared. They will be published during 2004. Finish of animations and final version is still in progress. Poster presentation on seminar „Hydro melioration yesterday, today and tomorrow" organized by VÚMOP Prague in spring 2004 is also prepared.

Many students, which prepare their diploma work on theme irrigation construction, participated on this project because of its size. These were: Adriana Rondevaldová, Lukáš Landa, Petr Formánek, Jana Nevědělová, Kateřina Macháčková and Ing. Boris Vološ. Doc. Ing. Karel Vrána, CSc. was invited to final modifications as a consultant. ČVUT Praha, FS VUT Brno a SvF VUT Bratislava they all will be use this film for teaching. It will be offered to other applicants too.

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Application of Data Mining Methods in Decision Processes

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The increasing volume of data in modern business and science calls for computer-based approaches for extracting useful information from recorded data for the purpose of better and more efficient decision making. As the data sets have grown in size and complexity, there is an inevitable move from direct hands-on data analysis toward indirect, automatic data analysis using more complex and sophisticated tools. Data mining is the entire process of applying computer based methodology, including new techniques for knowledge discovery from data. Data mining is considered to be the nontrivial extraction of implicit, previously unknown, interesting, and potentially useful information (usually in the form of knowledge patterns or models) from data. The extracted knowledge is used to describe hidden regularity of data, to make predictions or to aid human users in other ways. The demands from various real-world applications in decision making increase the importance of data mining.

The convergence of knowledge from several disciplines and corresponding echnologies mainly from the field of statistics, machine learning, database modeling and other related fields has created an opportunity for data mining in scientific and corporate environment.

The general, experimental procedure adapted to data mining problems is an iterative process involving the following steps: problem statement and initial hypotheses formulation, data collection and data understanding, data preprocessing providing an optimal representation for data mining technique, selection and implementation of appropriate data mining technique, model interpreting and drawing conclusions which should help in decision making. In practice, the implementation is based on several models and selecting the best one is an additional task.

In recent years there has been an explosive growth of methods discovering new knowledge from raw data. Data mining has become a frequent topic for decision-makers because it provides valuable, hidden business and scientific intelligence from a large amount of historical data. The increasing number of scientific, technical and economical applications brought educational requirements also in civil engineering.

The aim of the educational project “Application of Data Mining Methods in Decision Processes” is to introduce the class of new progressive data mining methods in the lectures of optimization modeling, dominantly in the subject Decision Theory (both in master and doctoral degree programme) as well as in diploma and other individual student projects. The educational project is focused on the assessment of appropriate data mining methods in various stages of decision processes in building industry and civil engineering in general.

Data mining software tools supporting the process of data mining vary from data mining products provided by database management system vendors to products of vendors offering statistical analysis packages.

For tutorial purposes, the previously purchased statistical and mathematical software tools (STATISTICA Basic and MATHEMATICA) have been extended in this educational project with modules supporting data mining techniques such as multivariate exploratory techniques (cluster analysis, decision trees, factor analysis), power analysis, neural networks,

fuzzy logic and module enabling access to various types of databases. The main issues related to software were the extendibility so that the software product is ready to allow new methods to be incorporated, integration with databases as well as integration of uncertain reasoning techniques into data mining algorithms. Listed references [1] – [4] are current publications with a tutorial overview of principles underlying data mining algorithms and their applications in decision processes.

Two diploma projects dealing with the problem of integrating data mining methods into the decision making processes in the field of building industry have been recently assigned. One project is in the field of predictive modeling for the purpose of strategic management and concentrates on information support for the various phases of strategic management in building company. Data mining in this context can provide a strategic advantage in developing, defining and deploying competitive business strategies. Such support enables sustainable competitiveness and long term corporate development. Second diploma project focuses on knowledge discovery in databases of companies and covers the process of looking in database in order to find hidden knowledge patterns or regularities.

Two other current student projects are in progress with the emphasis on fuzzy logic and neural networks techniques and their contributions to uncertain reasoning in decision processes within civil engineering applications. For artificial neural networks applications, analytical problems are identified in which high input dimension and relationships exist within data that are either not fully understood, data that exhibit significant uncharactizable nonlinearity or in cases where potentionally stable patterns in the data are subtle or deeply hidden (such as credit risk analysis or sales prediction). The extension of association rules to fuzzy association rules and the exploitation of uncertainty by using fuzzy logic is the main goal of this project.

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Efficiency of Injection Materials

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Devaluation and damages of buildings due to floods in August 2002 represent serious economical losses. In case of monuments belonging to the national heritage material losses are accompanied by irreplaceable cultural losses.

During the fast remediation of flood consequences the successive damage was often caused by extensive implementation of insufficiently verified remediation means and unsuitable technological procedures. Practical experience has proved the need for verification and fast implementation of efficient methods and procedures.

The main approaches of the grant project include creation of a self-contained database of remediation methods and materials and creation of the catalogue of faulty remediation procedures obtained by survey in situ and inspection and long-term monitoring of applications of remediation means in-situ after floods.

The grant project has comprised a theoretical, laboratory and experimental investigation of material samples from structures affected by flood and exposed to various outer effects and impacts, testing and verification of acquired knowledge on partial practical applications. The results achieved within the work on the grant project base on a relatively extensive field and laboratory investigation.

Rising damp in masonry is often the cause for expensive restorations of older buildings and monuments. The observed damages result mainly from dissolution, transport and precipitation of salts in the pore space of brick and mortar or from the increase in volume by freezing of moisture.

Horizontal chemical grouts are one of additional water-proof methods in masonry. This part of grant project dealed with possibilities of efficiency evaluation. Research technique of evaluation simulating real construction on masonry columns is presented. Preparation for experiment for laboratory verification of efficiency of remediation injection means under various conditions and exposed to various impacts (salts, moisture, temperature) and analyses of applied methods were carried out.

The aim of this partial task is to give an insight into mechanism of moisture transport in porous brickwork applied by injection materials by experimental results. Efficiency of these injection methods – damp cutoff or damp limiting - is final main criterion.

Laboratory scale tests are carried out on columns of standard size bricks placed in the vessels serving as a model for water migration. Such a column is intended to represent part of a wall. So capillary action and evaporative behaviour have been studied in laboratory scale at different test condition. Before test the bottom bricks were saturated by immersion. The upper surface of these sheets serving exclusively as a contact medium for monitoring of moisture transport. For each tested materials there are two columns applied by injection material and one serving as reference.

Within the partial task of the grant project special attention was paid to evaluation of methods dealing with measurement of moisture in brickwork. Various non-destructive

methods used for measurement were studied with special focus on the brickwork under salt loading. Based on the experiments it was proved that suitability of the respective method strongly depends on the content of moisture and salts in brickwork. The recommendation concerning application of the measuring methods in practice is proposed and was use for carried out laboratory tests as well.

The results achieved within the works on the grant project are presumed for use in experiments dealing with verification of selected remedial measures and further processing, so further experimental studies and tests are in progress.

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Long-term Experimental Verification of Influences of Redevelopment Treatments on Deterioration Processes in Damp Brickwork

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The deterioration of materials with age is not a process which appears to be capable of being stopped. The general mechanism of ageing is essentially one of weathering. The wide range of diurnal temperatures, water, frost, chemical attack and solar radiation can all occur to exposed materials. The ravages of the weather are variable and can make severe demands on any materials.

During last decade renovation and reconstruction of a wide range of buildings increased and evoked a need for extensive application of new remedial materials and techniques. But the implementation of a number of new, insufficiently tested materials and unsuitable use of some technological processes without acquired knowledge and disrespect for behaviour of building materials in various conditions could cause serious failures and successive damage.

In this respect a number of examples of considerable demage inflected insuffiently verified, unsuitable techniological processes and materials applied during renovation of structures are presented.

For this reason the reliability assessment of selected remediation means has been presently subject of special attention in area of research.

The grant project developed design of procedures for testing the quality of remediation materials, mainly methodology and recommendations concerning laboratory verification and testing of injection materials. The project includes laboratory and experimental investigation of injection material samples and redevelopment plasters exposed to various impacts (salt, moisture, temperature) testing and evaluation of remediate procedures applied under various conditions.

Laboratory scale tests are carried out on columns of standard size bricks placed in the vessels serving as a model for water migration. Such a column is intended to represent part of a wall. In order to simulate historical brickwork the bricks used in test were made in the begining of 19^{th} century and obtained during demolition of historic building.

So capillary action and evaporative behaviour have been studied in laboratory scale at different test condition. Before test the bottom bricks were saturated by immersion. The upper surface of these sheets serving exclusively as a contact medium for monitoring of moisture transport. For each tested materials there are two columns applied by injection material and one serving as reference. Efficiency of these injection methods – damp cutoff or damp limiting - is final main criterion.

The pilot test of laboratory verification of effeciency and durability of remediation measures (injection materials, redevelopment plaster) with regards to slowing down or eliminating degradation processes in relation to material type and the environment is carried out and fulfilment of grant plan goals as well.

The results achieved within the work on the grant project are presumed for use in experiments dealing with verification of selected remedial measures and further processing. In order to quantify these findings further experimental and laboratory testings are in progress.

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Experimental Research of Structural Materials and Technologies

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The research aims of the research project MSM 210000004 were in the year 2003 pursued by the research teams from the departments of Physics, Building Structures, Structural Mechanics, Concrete Structures and Bridges, Steel Structures, Geotechnics, Road Structures and from Experimental Center and Center of Experimental Geotechnics of the Faculty of Civil Engineering of CTU as well as by the researchers from Klokner Institute of CTU (mainly from the Experimental Department). The main research topics of the project are following:

- aging and durability of concrete,
- biological degradation of structural materials,
- micromechanical properties of the concrete structures and concrete reinforced by fibres,
- experimental research in steel, timber and composite materials and their technologies,
- research on bentonite (construction of underground radioactive vastes deposits),
- self-compacting concrete,
- geotechnical properties of mixtures of soils and brown coal combustion fallouts,
- rheological properties of road materials.

The main rersearch results of the year 2003 are the following:
1. In the field of composite steel-concrete structures the experiments were accomplished concerning interconnection of the concrete beam with the perforated steel strip under repeated loading as well as the repeated loading tests of the structural joints parts. In the fire safety design field, the shear stiffness of the thin-walled beams were studied under normal temperature as a preparation stage for the high temperature testing. The panels were tested under fire conditions in order to improve the whole structure reliability by proper choice of the panel connection to the bearing structure. In the field of non-destructive timber testing methods, the combination of the penetration and ultrasonic methods were studied.
2. The response of the broad spectrum of building materials (cement based materials: concrete and cement composites, insulating materials and bricks, burned as well as unburned) to the external environment changes were studied by new measuring methods (especially those used for temperature and moisture dilatation detrmination).
3. The elevated temperature effect on the mechanical behaviour of cementitious composites was studied on samples under direct exposition to the elevated temperature and also after temperature exposition. At the same time, the hygric properties of the cementitious composites were studied under varied conditions by different testing methods.
4. The suitability of the nanoindentation was studied as a metod for assessment of the quality of the concrete structure. In paralel, the mathematical model describing volume changes of the fibre reinforced concrete has been verified.

5. In the field of the self-compacting concrete, the long-term mechanical properties of the self-compacting concrete were studied with emphasis placed on the effect of various types of admixtures based on carboxyl ethers. The properties of the fresh concrete mixtures were analyzed, as well as the strength and modulus of elasticity time evolution. Especially, the role of domestic microfillers was examined and the concrete durability test were started.
6. In the field of the underground radioactive vastes deposit research, two models simulating vastes deposit service conditions are presently studied: (a) large volume physical model MOCK–UP–CZ, (b) the prefabricated barrier wall from the bentonite blocks. The barrier is tested under high temperature and water saturation conditions, the barrier temperature, pressure and moisture changes being continuously monitored to acquire all the necessary data and details for an optimal design of the multibarrier system.
7. The combined application of the focussed mathematical modelling and diagnostic testing allowed to predict and verify causes of premature distress and reduced setviceability of several important road and highway pavements. The asphalt mix fatigue testing results obtained served as a basic support knowledge in discussions on the innovation process of the Czech pavement design method.
8. In the field of the landscape recultivation, the visual monitoring of the slope of the testing field is performed periodically, the recultivation material beeing mixture of stabilized soil and local clays. Inspite of incurred cca 15 m long and 0,6 m deep gap (crack) in the slope, the installed detector did not indicate any slope motion. The gap infringes the slope massive under the recultivation layer, the shrinkage of applied material in combination with other effects (shear strength mobilization, e.g.) being the possible cause of the defect. The test results obtained did not show the expected increase in recultivation material cohesion.
9. The effect of the soil microflora on mass decrease of modified SBS resins was studied after one-year exposition to the garden soil enriched by nutrient supplements and suitable germicides were searched for to prevent further possible decay of SBS resins.
10. The research activities at the Klokner Institute concerned the extremal loading effects on resistance of materials and structures, the determination of deformation characteristics of composite materials, the experimental verification of long-term volume changes effects, the experimental study of brittle materials and the development and verification of different diagnostics and measurement methods.

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Measurement of Height Gradients of Wind Energy at the Site of Křemešník

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Energy use in the Czech Republic is becoming more and more dynamic as determined by economic conditions. A number of wind power stations have been built. The most serious shortcoming of installation of wind power production in the Czech Republic is the fact that some power stations were erected in places totally unsuitable for the exploitation of wind power. As a result, some wind power stations are not functional, or they never achieve their designed output. This uncontrolled development should be directed so as to ensure that the invested financial means will create wind farms close in their performance and nature to wind farms constructed within the European Union, e.g. in Germany, Denmark, Sweden, Great Britain, Spain and Greece.

As part of work on the reported grant project, the research team focused on designing and testing methods of measurement of height gradients of wind power.

Selection and Description of the Measuring Site

Data from meteorological stations cannot be used for the calculation of the optimal location of a wind power station as the measurements are conducted at the height of 10 m above ground. Theoretical conversion to heights at which rotors of wind power stations can work is rough and cannot become a reliable basis for the selection of the right site. In order to gain reliable data, it is necessary to measure height gradients of wind energy. It requires measurement of changes taking place between the ground and the elevation of up to 50 m – 100 m where the wind rotors function. To build such a tower for experimental measurement only is extremely costly, therefore a site with a completed tower had to be assumed. The tower was found in the region of the Czech-Moravian Highlands on Křemešník Mountain (763 m above sea level). It markedly overtops the surrounding landscape and there already existed a 52 m high measurement tower of steel construction.

Measuring Equipment and Measurement Centre

The measuring devices consisted of a wind computer situated in the measuring centre, anemometers attached to the steel tower placed at the height of 30 m, 38 m, and 50 m, respectively; a wind vane as an evaluation unit; and a personal computer. Further, the measuring equipment included a measurement tower of steel construction, 52 m in height, and a cable connecting individual sensors with the measuring centre.

Measurement sensors

- Anemometer P6121 providing a high-resolution output signal of 20 pulses per 1 m wind path;
- Wind direction transmitter P6220 for the measurement of wind direction within the range of 0 to 360; and
- Wind computer designed for continuous logging of wind velocity and wind direction. It also allowed for statistical evaluations providing frequency distribution of wind speed and wind direction for each sector of the wind rose.

Conclusion

In conclusion, this measurment was a unique measurement, the significance of which will be substantial for installation of wind power stations. The measured values of energy curves of wind potential can lead to the calculation of the future output of wind power stations.

This project is being conducted with the participation of Ph.D. student Ing. Jan Pytel and undergraduate student Jakub Římal.

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Water Regime of Spoil Heaps during Primary Succession

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Primary succession stage on the spoil heaps offers suitable conditions for the study of interactions between soil organisms and the environment. The development of upper soil horizons is determined by both global and local factors, such as climatic and topographic conditions, physical and chemical characteristics of initial soil forming substrates.

The object of the study was to improve knowledge about the influence about the influence of the soil biota during spontaneous primary succession on the soil physical properties of the upper soil horizons and water regime.

The study was realized on colliery spoil heaps located in a post mining landscape in the Sokolov coal mining district (North-West Bohemia). Study plots were situated on cypris clay spoil and overgrowth by spontaneous vegetation. The same technology of heaping was used at all plots, resulting in longitudinal parallel ribs, about 1,5 m in height, distant about 6 m from each other. The ribs form treatments at each plot, one wet (depressions between ribs) and the other dry (top parts of ribs). No manipulation has been provided on the plots since heaping. Three plots (cca 1 ha each other) differing in age (10, 15 and cca 40 years since heaping) were used for the study.

Two experimental treatments on each plot has been established (one on the top part and the other in the depression). Soil moisture content distribution was measured using the Dielectric Soil Moisture Meter (Kuráž, Matoušek, 2002). For each treatment access tube from plastic material has been built up in the soil profile allowing the measurement of soil moisture content till the depth of 70 cm (with the increments of 5 cm until the depth of 30 cm, than in the 10 cm increments until the depth of 70 cm). Soil moisture content has been measured during vegetation period in the one month time step. The time intervals of the measurement were chosen with regard of the aim of the measurement – evaluate the influence of the topography and vegetation cover on the soil water regime. The measured data were calibrated on the moisture content using a gravimetric method.

Water retention curves were determined for the estimation of the variation of a water retention capacity. The undisturbed soil samples (4-6 replicates for each treatment) have been taken and using suction apparatuses (until the soil suction of 100 cm) and pressure ceramic plate extractor (for higher suction) the retention curves were experimentally determined. van Genuchten approach was used for the approximation of retention curves. A new method based on the genetic algorithms has been developed for the evaluation of the retention curves (Kuráž et al, 2003).

The Guelph permeameter method was used for the field measurement of the saturated hydraulic conductivity in two replicates for each treatment. Because problems with the cracks in the soil profile occurred especially in dry periods, in parallel with the field measurement the undisturbed samples have been taken and hydraulic conductivity was measured in the laboratory.

The results of moisture content measurement proved distinct differences due to wave forms of the forming of the heaps and the age of the experimental plots. Very significant variation was obtained for the experimental plot I – the age of 10 years, where the differences in the dry periods reached 20-30% by vol. in top layers. For deeper parts of the soil profiles

the differences decreased to the range from 15-20% by vol. The similar conclusions are valid for other experimental plots, but the differences between dry and wet variants are not such significant as for experimental plot I. The differences between wet and dry variants in wet periods have decreasing trend, mainly in the top layers. The moisture content distribution in layers deeper than 15 cm differs again more significantly due to the low hydraulic conductivity of soil profile.

The approximation of retention curves is based on the van Genuchten approach, six independent parameters used to be optimized. We decided to leave only four parameters for optimization procedure – saturation moisture content will be based on the result of laboratory treatment and residual moisture content will be equal to the Pf = 4,78 (hygroscopic number). Than the genetic algorithms approach has been used for approximation of retention curves. Results of treatment of retention curves of quite different shape proved the usefulness of the proposed method.

The measurement of hydraulic conductivity as a basic soil hydraulic characteristic proved the limits of field estimation of this parameter. During dry period, when the system of "cracks" and macro pores is forming, the measured value of hydraulic conductivity corresponds to the flow in macro pores only. On the other side, in wet period, when the system of cracks is closed, the property of soil matrix is measured. That is why the range of hydraulic conductivity varies in 3-4 orders. If we will compare results of measurement in top parts and depression parts, the values of hydraulic conductivity are higher in top parts for all experimental plots.

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Computational Analysis of Hygrothermal Performance of Interior Thermal Insulational Systems Based on Four Different Materials

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The application of interior thermal insulation systems on building envelopes is not a natural solution but there are practical cases where their use is quite logical. A typical example is a historical building, where the facade has to be kept in its original appearance mostly, and the exterior insulation systems are excluded for that reason. In that case the development of such an insulation system would allow to prevent moisture damages and to upgrade the thermal properties of the envelope as the only reasonable option.

In our computational analysis, we have chosen a limestone wall with the thickness of 500 mm as the load-bearing structure, which can be considered as characteristic for Czech historical buildings. On the external side there was lime plaster with the thickness of 20 mm. To this basic structure there was applied the interior thermal insulation system consisting of water vapor retarder, insulation material and internal plaster. The thickness of water vapor retarder was 10mm. We assumed no air gap between the water vapor retarder and the old structure. We considered glue or mastic as the water vapor retarder, which was applied directly on the old structure. We have chosen four different materials as thermal insulation, with the thickness of 100 mm. Insulation I was hydrophilic material with low value of hygroscopic moisture, Insulation II was hydrophilic material with higher value of hygroscopic moisture, Insulation III hydrophobic material with low value of water vapor resistance factor and Insulation IV hydrophobic material with higher value of water vapor resistance factor. In the internal side there was light plaster with the thickness of 10 mm.

The physical properties of basic materials were partially obtained from material database in the computer code DELPHIN 4.1 and partially measured in our laboratory. The physical properties of insulation materials are given in Table 1. Our aim was to analyze the hygrothermal performance of the designed systems with different insulation materials and to find the best water vapor resistance factor and moisture diffusivity for the water vapor retarder.

Table1. Material parameters of insulation materials

	ρ [kg/m^3]	c [J/kgK]	κ [m^2/s]	μ [-]	λ_{dry} [W/mK]	λ_{hyg} [W/mK]	λ_{sat} [W/mK]	θ_{sat} [Vol %]	θ_{hyg} [Vol %]
I	150	840	$1 \cdot 10^{-7} \cdot e^{0.0485 \cdot \theta}$	2	0,04	0,048	1,1	95	0,16
II	230	1000	$2 \cdot 10^{-8} \cdot e^{0.0523 \cdot \theta}$	2,5	0,06	0,072	0,4	88	22
III	280	840	$5 \cdot 10^{-13} \cdot e^{0.1486 \cdot \theta}$	3	0,055	0,066	1,2	31	0,73
IV	30	1300	$2 \cdot 10^{-11} \cdot e^{0.0475 \cdot \theta}$	50	0,04	0,1	0,56	97	0,1

For the calculations we employed the advanced software tool DELPHIN4.1. Contrary to other software packages for modeling heat and moisture transport working with temperature and relative humidity only, DELPHIN4.1 also includes capillary pressure as one of the basic state variables, which makes it possible to determine the transport of liquid moisture with much better precision and reliability. For the interior insulation systems this is a crucial factor because liquid moisture is almost always the basic cause of defects and failures.

The proper initial and boundary conditions of the model are crucial factor affecting the reliability of the calculations. Therefore, the calculations should be done for exactly the same situation as it will be done in the practical reconstruction on building site. First, the boundary conditions for the external side should be as accurate as possible. This can be achieved by using the meteorological data for the locality as close as possible to the real object. Second, the initial conditions should be realistic. To this point, the calculations should be done first for the construction without the interior insulation system. Third, the calculations with the interior insulation system should be started exactly in the same time of year when the real reconstruction will begin.

In our calculations, we chose the 1st of May as the starting point, when we assumed the application of the insulation system on the load-bearing structure was done. For the insulation systems, there were taken initial values of field variables corresponding to values inside. The systems with interior thermal insulations were exposed from inside to constant conditions (temperature equal 21°C and relative humidity equal 70 %) and from outside to climatic conditions corresponding to the reference year for Prague.

We have chosen two critical profiles in the evaluation of performance of the envelope, A-A´, B-B´, where the profile A-A´ was between water vapor retarder and insulation material, profile B-B´ was between old structure and water vapor retarder. In these profiles we had calculated the dependence of the overhygroscopic water mass content (OWMC) on the time.

For the Insulation I we found the optimal value of water vapor resistance factor equal to 100 and the value of moisture diffusivity equal to $1.10^{-12}e^{0.0923.\theta}$ m^2/s. The maximum values of relative humidity were then about 92 %. The Insulation II was found to perform in an excellent way, for the values $\mu_{ret} = 5$ and $\kappa_{ret} = 1.10^{-10}e^{0.0923.\theta}$ m^2/s was relative humidity far from the condensation limit. The Insulation III had very bad hygrothermal performance and we did not succeed in looking for appropriate values of water vapor resistance factor and moisture diffusivity. The Insulation IV exhibited a similar behavior as the Insulation III but for the values $\mu_{ret} = 100$ and $\kappa_{ret} = 1.10^{-14}e^{0.0923.\theta}$ m^2/s were the values of relative humidity around the condensation limit.

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Thermal and Accidental Action Models for Bridge Structures According to Eurocodes

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Project Thermal and Accidental Action Models for Bridge Structures According to Eurocodes supported by the Ministry of Transport of the Czech Republic was focused on the development of background materials for National annexes to Eurocodes EN 1991-1-5 Thermal actions [1] and EN 1991-1-7 Accidental actions [2]. Two different types of action models recommended by Eurocodes EN were analysed during the three year project and compared with valid Czech standards ČSN and nationally implemented preliminary documents ČSN P ENV facilitating decision about Nationally determined parameters [3,4].

Eurocode EN 1991-1-5 [1] deals with thermal actions in construction works. Bridge decks are split into three groups with respect to the used material (concrete, composite or steel). For national application of EN 1991-1-5 [1], models of uniform temperature component and temperature difference component need to be verified. Thermal actions and their combinations with traffic loads were analysed in comparative studies in co-operation of the Klokner Institute with bridge design companies Promo, Valbek and Faculty of Civil Engineering, CTU in Prague. Probabilistic methods and theory of structural reliability were applied for credibility analyses of theoretical models of thermal actions.

The uniform temperature component for three types of bridge decks is based on the relationship between the extreme shade air temperature and effective (characteristic) temperature recommended EN 1991-1-5 [1]. The Klokner Institute developed in co-operation with the Czech Hydrometeorological Institute two maps of isoterms of annual maximum and minimum shade air temperature taking into account definitions of Eurocodes. Temperatures were evaluated in selected meteorological locations. The estimates of the maximum and minimum temperatures are based on Gumbel distribution. For the Czech Republic, the average maximum shade air temperature is +37,4 °C, the average minimum shade air temperature -31,3 °C. Both maps of izoterms will be used as background documents during the preparation of National Annex to EN 1991-1-5 [1].

Two alternative approaches are recommended in EN 1991-1-5 [1] for determination of vertical temperature difference component. The linear temperature difference component is based on measurements and evaluation conducted in Germany, the non-linear component on an experimental and theoretical research of UK. Temperature components take into account effects of different surfacing thickness. The reduction of non-linear difference component recommended in EN 1991-1-5 [1] is inconsistent with reduction of linear difference component (represented by reduction surface factor k_{sur}). Linear difference model for composite bridges seems to be unrealistic and should be further calibrated. The comparative analyses made in Klokner Institute confirm this experience [3]. It is expected that theoretical models specified within the project will be compared with experimental measurements on selected Czech bridges in the next few years.

EN 1991-1-7 [2] gives general guidance concerning categorisation of structures including bridges and recommends alternative design procedures for determination of accidental impact forces. Three classes are proposed for structures with respect to consequences of failure: a class CC1 is recommended for low consequence, class CC2 for medium and class CC3 for high consequences. Some parts of the structure may be treated as belonging to different classes. Classification of different types of structures, selection of alternative procedures and specification of nationally determined parameters is left open for national decision. EN 1991-1-7 [2] provides also general guidance for risk analysis of a hazard situation.

Alternative procedures for determination of accidental impacts models due to lorries or derailed trains were analysed and compared with Czech national standards ČSN and prestandards ČSN P ENV. The static equivalent accidental actions given in EN 1991-1-7 [2] are considerably greater in Eurocodes than in Czech standards. Theory of risk engineering was applied to make decision about models of impact forces in some types of roads (motorways, country roads, urban areas, court yards and parking garages). It was shown that upper values of recommended impact forces should be used for the design of bridge supports located near the traffic lines if no effective safety measures are available.

Theoretical studies made within the project are supplemented by practical examples of structural design or risk analysis facilitating to be applied by users [4]. The project outcomes will serve as a basis during preparation of the National annexes to EN 1991-1-5 [1] and EN 1991-1-7 [2] taking into account real conditions in the Czech Republic.

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Risk Assessment in Structural Design

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Probabilistic methods for designing of civil engineering structures and other engineering systems [1,2] are commonly based on the assumption that an event (failure) F given a certain condition (hazard situation) H, is unequivocally described by inequality $g(\boldsymbol{x}) < 0$, where $g(\boldsymbol{x}) = 0$ is the so called limit state function and $\boldsymbol{x}$ is a realisation of the vector of basic variables $\boldsymbol{X}$. If the joint probability density $\varphi_{\boldsymbol{X}}(\boldsymbol{x}|H)$ of basic variables $\boldsymbol{X}$ given the situation H is known, then the conditional probability $p_F = P(F|H)$ can be determined as

$$p_F = P(F/H) = \int_{g(\boldsymbol{x})<0} \varphi_{\boldsymbol{X}}(\boldsymbol{x}/H)\, \mathrm{d}\boldsymbol{x} \tag{1}$$

It is well recognised [4] that the described concept has several deficiencies. Important deficiencies originate from uncertainties in the definition of the limit state function $g(\boldsymbol{x})$ and in probabilistic models of basic variables $\boldsymbol{X}$ given the condition H. However, the most significant and essential deficiency of probabilistic design methods based solely on equation (1) is the lack of consideration for all hazard situations H_i and the relevant consequences of unfavourable events. To reduce this drawback, methods of risk analysis and assessment have recently been developed [2] and applied (e.g. [3,4]).

The risk assessment of a system attempts to cover all possible hazard situations that might lead to unfavourable events related to the considered system. The hazard situations include gross errors in human activity and accidental actions such as impact, explosion, fire and extreme climatic loads. Identified hazard situations (including accidental and common design situations), designated generally as H_i, are assumed to occur with a certain probability $P(H_i)$. If the failure F of a structure due to a particular situation H_i occurs with the conditional probability $P(F|H_i)$, then the total probability of failure p_F is given as:

$$p_F = \sum_i P(F/H_i)\, P(H_i) \tag{2}$$

The conditional probabilities $P(F|H_i)$ must usually be found by a separate analysis of the respective situations H_i. Equation (2) can be used for harmonisation of the partial probabilities of failure $P(F|H_i)\ P(H_i)$ corresponding to the situations H_i, and for the following risk consideration.

In general, the hazard situations H_i may lead to a number of events E_{ij} (e.g. collapse, excessive deformations, full development of the fire, impact). The consequences of the events E_{ij} are expressed by one-dimensional utility components C_{ij} (e.g. by the costs expressed in a certain currency). If the consequences C_{ij} are uniquely related to the events E_{ij} then the total utility (risk) C related to the hazard situations H_i is given as [4]

$$C = \sum_{ij} C_{ij}\, P(E_{ij}|H_i)\, P(H_i) \tag{3}$$

Several methods have been developed to analyse risk (fault tree, event tree, causal networks). A promising method seems to be provided by Bayesian decision analysis using decision trees or Bayesian (believe) causal networks [4].

An important question concerning risk assessment is what happens when we compare obtained results with acceptable limits. International standard ISO 2394 [1] provides a limit

for an individual risk of fatal injury per year by the value 10^{-6}. If there are more endangered persons in one accident, the acceptable risk is usually expressed [4] as

$$P(R > N) < A\, N^{-k} \tag{4}$$

where R is the assessed risk (number of fatal injuries), N denotes the acceptable number of fatal injuries, and A and k are suitable parameters. Three variants of these criteria are commonly used:

- upper bound for $A = 0{,}1$ and $k = 1$,
- middle level for $A = 0{,}1$ and $k = 2$,
- lower bound for $A = 0{,}01$ and $k = 2$.

The upper bound indicates the uttermost (most benevolent) acceptable limit, while the lower (more severe) bound shows generally acceptable limits. The region between the lower and upper limits is often denoted by the known abbreviation ALARP (As Low As Reasonably Possible). If the assessed values are within the ALARP region, it is recommended to decrease the assessed risk as much as possible. It is interesting to note that the middle level of the limit for $A = 0{,}1$ and $k = 2$ has been accepted as an accepted risk level for the road tunnel in Westerschelde in the Netherlands.

It should be emphasized that the above-described criteria include casualties (social consequences) only and do not consider any other (economic or political) consequences. Combination of different types of adverse consequences remains an open question.

The most important contribution of risk analysis and assessment consists in systematic consideration of various consequences. Several techniques are available at present: decision trees, the Bayesian belief networks and influence diagrams. Available experience indicates that the Bayesian belief networks provide a transparent, logical and effective tool for analysing engineering systems. It should however be underlined that any analysis of an engineering system is always dependent on assumed input data, often of a very uncertain nature. The input data should be estimated with due regard to the specific technological and economic conditions of a given system. In particular, the economic, social and environmental consequences of adverse events should be further investigated.

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Characterization of Organic Matter in Water

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Natural organic matter (NOM) present in ground and sourface waters is a complex heterogenous mixture composed of humic acids, fulvic acids, low molecular weight acids, carbohydrates, proteins, and other compound classes. Aquatic humic substances (HS) are responsible for 40 – 80% of the dissolved organic carbon (DOC) in many surface waters and these are primarily responsible for the color of natural water. Yeh and Huang (1) have proposed that the organics in natural water are fractionated into humic acid, fulvic acid, hydrophilic-acid and a neutral fraction. However, the structure of humic substances is still not well known. But the major functional groups present in humic acid are carboxylic acids, phenolic and alcoholic hydroxyl groups, keto groups and quinoid groups (2). The following reasons explain why HS must be removed from water: (a) HS have a potential for bacterial regrowth; (b) when disinfectants are used in water treatment processes, they lead to the formation of toxic disinfection by-products; (c) HS can form complexes with heavy metals present in the water, as a consequence, they reach the consumer since they cannot be precipitaded in the water treatment plant.

NOM can be characterized by nonspecific parameters; important examples include organic carbon content (i.e. dissolved organic carbon concentration – DOC) and ultraviolet absorbance in the range 254 to 280 nm. Among all the different parameters for characterizing NOM of a given water, UV_{254} and specific ultraviolet absorbance (SUVA = UV_{254}/DOC) has often correlated well with disinfection by-products (DBP) formation (3). By combining both DOC and UV absorbance into a single parameter, SUVA provides a quantitative measure of the aromatic content within the organic carbon. In addition to correlating with disinfectant reactivity, SUVA has also been correlated with the removal of DBP precursors using a range of different treatment technologies (4).

The objective of this research was to investigate the character of NOM in humic waters from Flaje catchment, situated in Ore Mountains. Water samples were collected from Rašeliník Brook, Flájský Brook, Rašeliník Brook, Mackovský Brook and Fláje reservoir as well since 2001. Samples were analysed for pH, DOC, UV absorbance, PTHM and PHAA. SUVA parameter was calculated as the ratio of UV absorbance at 254 nm (m^{-1}) to DOC (mg $C.l^{-1}$). PTHM and PHAA was carried out using a method adapted from Standard Methods for the Examination of Water and Wastewater 1992. The method involved buffering samples at pH 7, chlorinating samples with excess free chlorine and storing the sample at 20^{o}C for 7 days to allow the reaction to approach completion. The total THM (chloroform, dichlorobromoform, dibromochloroform and bromoform) concentration was measured using a gas chromatograph.

The results show that all waters exept water from Mackovský Brook were rich in humic material. Their SUVA values were higher than 4 $m^{-1}.l.mg^{-1}C$ that means, that the water contains mainly hydrophobic material (humic and fulvic acids). Seasonal changes were observed as well. What about the PTHM and PHAA, good correlation with SUVA was found.

The concentration of organic substrate in the water that could be utilized by heterotrophic bacteria, designated as biodegradable dissolved organic carbon (BDOC) in all water samples was also measured. This parameter were estimated as the difference of DOC concentrations measured before and after a 30 d incubation at 20°C with indigenous bacteria [5]. It was found, that all waters in Flaje catchment are mainly of humic type whereas the BDOC values represents approx. 20 – 25% of the total DOC content.

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Measurement of Temperature in Concrete Bridges

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Temperature stress ranks among variable loads. It is an important load in bridges entering the resulting combinations of loads and together with other loads, it influences the design of the construction. According to a structural action of a concrete bridge – in particular of frame bridges – the temperature effects may resolve in some variants of design combinations.

European Standards are currently being introduced in to the system of ČSN Standards in the Czech Republic. At present EN 1991-1-5 Thermal actions is being introduced, a substantial part is devoted to temperature changes in bridges. This European Standard will be translated in to the ČSN system and it will contain a National Annex (NA). This annex will specify postulates reffering to climatic conditions in the Czech Republic. It is necessary to have a sufficient amount of data on the behaviour of bridges in relation to temperature.

In 2003, temperature measurements were installed and started – always in one cross section of the two following bridges:

- Highway bridge (D8) across the Vltava river, the right bridge structure from Prague
- Tramway bridge (Hlubočepská estakáda) on tramway line from Hlubočepy to Barrandov

Both bridges are made of prestressed concrete and they have a one box girder.

In the case of the highway bridge across the Vltava river, the advantage of already inserted heat detectors was taken (they were buried in concrete during the time of building), which were used by the Klokner Institute for measuring the development of hydration heat. In a cross section in the middle of a side span across the Vltava river, 15 detectors are situated (4 in the top slab, 6 in walls and 5 in the bottom slab), 1 is led out of the box girder to measure outer temperature. By means of a CTU grant a datalogger allowing 16 accesses for scanning and short – term storing of data was installed. The temperature is measured once an hour in every detector, which means 384 data per day. Every 14 days the data are transported to a notebook. The measurement was started in July 2003 and so the extreme summer temperatures, which affected the Czech Republic in 2003, were recorded.

In the case of the tramway bridge, all preparatory works had been run before the measurement started. Between November 2002 and January 2003, heat detecting elements were compiled and tested in cooperation with the Experimental Center of the Faculty of Civil Engineering. They were embedded by epoxy resin to be protected from wet concrete during the building of the bridge. The chosen cross section is in the stationing of km 0.600 of the new tramway line from Hlubočepy to Barrandov. In two stages, on 3rd and on 11th March, the heat detectors were fixed to a conventional reinforcement shortly before the pouring of concrete to the particular section of the bridge. The measuring couldn't start until the indoor wiring of the bridge was completed in October. In November, a protective steel box for PC was made, which was fixed to the left wall. The Cables from heat detecting elements were connected with a measuring card (16 accesses) and a testing measurement was started. The data are transported to a floppy disk every 14 days. 14 heat detecting elements are buried in concrete in the cross section, 1 measuring the values inside the box girder and 1 outer shade air temperature. Every hour's recording is processed by a program made by the Experimental Center of the Faculty of Civil Engineering. It means 384 data every day, analogically to the

highway bridge. Because there hasn't been obtained a more extensive set of data until now, the evaluation hasn't been done yet.

Temperature changes in bridges are divided into two components:

- A uniform temperature component
- A linearly varying temperature difference component (contingently non-linear)

The uniform temperature component depends on the minimum and maximum uniform bridge temperature component – $T_{e,min}/T_{e,max}$. The results of this temperature component are in length – element's changes in a unrestrained structure. $T_{e,min}/T_{e,max}$ is derived according to a type of bridge deck (steel deck, composite deck and concrete deck) from a correlation with the minimum and maximum shade air temperature – T_{min}/T_{max}. For the highway bridge, according to [1], $T_{e,max}$ = 41.0°C. Experimentally $T_{e,max}$ was measured in detector, which is located 20 mm from the top surface of the top slab in the axis of the box girder. $T_{e,max}$ = 36.3°C was measured on 4th August between 7 and 8 pm. The outer detector recorded T = 31.7°C at 7 pm, and T = 29.9°C at 8 pm. These values weren't the maximum shade air temperatures of the time. That was T_{max} = 34.1°C on 13th August 2003 at 2 pm. At that moment, T_e = 31.4°C only. According to max. temperature values, the summer of 2003 belonged to one of the hottest in the last few decades. That is why $T_{e,max}$ according to [1] is much too high. The evaluation was worked up from a set of data obtained between 25th July and 19th December 2003.

The linear temperature difference component is characterized by the heating and cooling of a bridge deck's upper surface, which leads to the maximum heating $\Delta T_{M,heat}$ – the top surface is warmer and the maximum cooling $\Delta T_{M,cool}$ – the bottom surface is warmer. The horizontal component is considered only in particular cases. Conforming with [1] (including a depth of bridge surface), for a concrete box girder $\Delta T_{M,heat}$ = 10°C, and $\Delta T_{M,cool}$ = 5°C. Experimentally, $\Delta T_{M,heat}$ = 8.4°C on 3rd August at 6 pm and $\Delta T_{M,cool}$ = 3.1°C on 10th December at noon were measured. The maximum temperature gradients are determined as maximum temperature differences measured in the top slab's heat detector and in the bottom slab's heat detector located always 20 mm from the outer surface of both slabs in the axis of the box girder. The temperature gradients in the walls (only in concete) don't reach these maximum values. Left wall: $\Delta T_{M,heat}$ = 3.9°C, and $\Delta T_{M,cool}$ = 0.9°C and right wall: $\Delta T_{M,heat}$ = 4.0°C, and $\Delta T_{M,cool}$ = 2.9°C. The value of maximum heating gradient is attainable only in the summer season. That is why $\Delta T_{M,heat}$ can be considered as a representative result. On the other hand, the maximum cooling gradient occuring in the summer and winter season can't be seen as definite.

The results of the evaluation of measured values for the highway bridge across the Vltava river in 2003 are the following:

- $T_{e,max}$ conforming with [1] is much too high (about 4.7°C)
- $\Delta T_{M,heat}$ conforming with [1] accords with the measured maximum heating

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Vibration Based Damage Detection of Structures

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The ability to monitor deterioration degree and detect damage of a structure at the earliest possible stage is very important. There can be found many different kinds of damages on reinforced concrete structures, namely mechanical damages due to cracking, corrosion of the reinforcement and deterioration of the concrete due to chemical actions from environment. In many cases cracks are hidden by secondary structures or damages are located inside the structure only visible through the change of the overall properties. Current damage detection methods require that the vicinity of the damage is known a priori and that the portion of the structure being inspected is readily accessible. The need for methods that can be applied to complex structures led to the development of methods that examine changes in vibration characteristics of the structure. Methods and procedures, which use results of an experimental modal analysis for estimation of a degradation degree of a structure, is suitable to verify on simple structural elements, when we know their damage state.

The influence of damage increase of simple reinforced concrete slabs on change of their modal characteristics was monitored in a dynamic study. Four reinforced concrete slabs with dimensions 3.2 m x 1.0 m x 0.1 m were made for the purpose of the test. Slabs were simply supported on two opposite sides with the span 3.0 m and cantilevered ends 0.1 m. The state deterioration of slabs was done by static loading and dynamic fatigue loading. The slabs were tested in four points bending to get a constant bending moment in the mid-section of the slab. Static loading was imposed in four steps (load by its self-weight, load effect equals to a theoretical limit of the crack initiation, load to the first real cracking in the lower part of the beam, load to the half of the ultimate moment). Then we continued with a dynamic fatigue load, which was induced by harmonic force. The amplitude of the dynamic load was chosen to achieve a stress range in the main reinforcement $\Delta\sigma$ = 220 MPa, which would caused the end of a service life of the beam after 500 000 cycles. The fatigue load was done in four steps (load to the half of the theoretical lifetime – 250 000 cycles, load to the theoretical lifetime - 500 000 cycles, load to the 750 000 cycles and load to the end of the real lifetime).

Before the test and after each load step the dynamical response of the slab was measured with a separate test arrangement. For the excitation of the beam the electrodynamic exciter ESE 11 076 was used. During the measurement the random driving force was used. The vibration of the excitation weight of white type (this is characterized by a constant value of function of time depended displacements of the weight in a frequency domain from 5 to 200 Hz) was controlled by a signal generator which is the part of the measuring station VCS 2550. The exciter was placed in the two fifths of the slabs span near to the left edge of the slab. The position of the point of excitation was designed to be able to excite basic bending modes of natural vibration of the specimen. Values of the Frequency Response Function $H_{rS}(if)$ were obtained as an average from ten measurements**.** The window length of the time signal processing was 8 s, the frequency range of the window was set to 200 Hz.

The excitation force was measured indirectly by measuring the acceleration of the excitation mass. The acceleration transducer B12/200 HBM was placed on the excitation weight. The response of the element onto forcing by the exciter was measured by ten inductive acceleration transducers B12/200 HBM in a chosen net of points on the upper face

of the slab. They were connected to the amplifier KWS 673.A7 HBM and from there an analogue signal was taken to the measuring station VCS 2550B Spectral Dynamics.

The change of modal characteristics was monitored and confronted with the damage state of the beams. Modal characteristics of the slabs, which were measured after each loading step, were mutually compared. Changes of natural frequencies $\Delta f_{(j)}$ and changes of damping frequencies $\Delta f_{b(j)}$ of the slabs were computed. For the comparison of natural modes, modal assurance coefficients $MAC_{(j,j)}$, coordinate modal assurance criterions $COMAC_{(p)}$, changes of a mode surface curvature $CAMOSUC_{(j),x}$, changes of a modal flexibility matrix $\Delta[\delta]$ and curvatures of changes of a modal flexibility matrix $\Delta[\delta]''$ were used. Tests of the slabs were carried out in laboratories of Civil Engineering Faculty CTU in Prague.

Determination of degradation degree of structures has become a very important problem today. Many scientists not only in the Czech Republic but also abroad are interested in damage detection of structures based on changes of their experimentally determined modal characteristics. Many interesting pieces of information about the deterioration of reinforced concrete structures can be obtained based on analysis of changes of experimentally obtained modal characteristics of these structures. It's suitable to use mainly changes of natural frequencies. For localization of places with crazing induced by load increase during experimental and theoretical studies there proved good the use of COMAC, CAMOSUC, change of a modal flexibility matrix and especially the curvature of change of a modal flexibility matrix.

For acquisition of reliable data for appreciation of monitored structure based on COMAC, change of a modal flexibility matrix and a curvature of modal flexibility matrix there is very important to consider carefully character and number of natural modes, which should be used in their computation. For determination of CAMOSUC there is the most suitable to use the basic natural mode (the 1st vertical bending mode of natural vibration), for higher natural modes CAMOSUC doesn't give as good results as for the 1st one. For reliable analysis it is important to obtain reference data about dynamic properties of investigated structure in undamaged virgin state, optimally before starting its operation.

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Analysis of Geodetic Networks for Buildings and Structures Monitoring

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Geodetic network is the base for many surveying tasks and works. Sometimes, the regular national networks (like Czech Uniform Trigonometric Network or Unified Level Net) are not suitable for intended work, e. g. for precise setting-out of complicated structures or for deformation monitoring. Frequent reason is low accuracy or bad configuration of points. In such cases the local geodetic networks have to be created with required parameters. For reaching these requirements is necessary to make a project of new-designed network. Analysis of accuracy, mathematical-geometrical optimization and robustness analysis are desirable to be done. But practical surveyors do that rarely, because it's time consumptive and theoretically pretentious. This project continues in research of optimal design of networks, finds suitable measuring methods and wants to be helpful in introduction the results to the practice.

For studying of the parameters of networks was firstly used a model of 3D-virtual net: pyramidical in shape, variable in height. The advantage of this model is that all geometrical features are exactly known (without any discrepancy). For three model heights were generated all possibly measured values in several orders of accuracy (distances, horizontal and vertical angles, height differences). For this model the influence of the Earth curvature was neglected, all values were computed in idealized space, where direction of gravity (vertical) is throughout the same. The influence of height differences to the horizontal position accuracy of points was tested; possibility of common adjustment of all measured data in the net (all computations together) was analyzed and proven. Problems were found in the second step, when the approach was applied to the real network Mariánská (experimental local high accurate 3D-net in the Ore Mountains, regularly measured, used as an etalon for measuring methods and instruments). The curvature of the Earth and deviations of the vertical cause the evaluation of measurement corrections complicated (height differences above all). These corrections are necessary for the projection of measurements to the orthogonal reference system (x, y, z). It's important for exact solving of wide-spread nets. Another way to obtain right result is using of local spherical coordinate reference system (not orthogonal). Local longitude (L), latitude (B) and reduced height (H) can be used in relation to the reference point. Then no corrections of measured data are needed, but modeling of a propagation of errors is more difficult. In addition there are large differences between values of angular coordinates and it's necessary to compute with two types of units: two angles (B, L) and a distance (H). Both approaches are possible, there is effort to find easy computation method for simple use in the practice.

This is the first partial result of the project. Positive influence of measured height differences included into common combined adjustment of 3D-networks has been verified and demonstrated. But difficulties with conversion of directly measured values to the orthogonal local reference system remain, still waiting for finding suitable computation method. [1]

The network Mariánská is also used for testing new measurement methods and instruments. The coordinates of all six points of the net are measured every year (for more than 10 years). All possible combinations of angles, zenith angles and slope distances are regularly taken. In addition precise levelling is applied to obtain exact height differences. Also the equipment used for these regular measurements have to be gradually modernized.

During the last three stages (years) has been innovated the equipment for levelling – traditional optical level (Zeiss KoNi007) was replaced by digital one with the same declared accuracy (Sokkia SDL-2 / Zeiss DiNi22) and rods with invar code-scale. The amount of measured data taken by both instruments (separately and simultaneously; totally more than 750 measured height differences) was analyzed and compared. Although the resulting accuracy of the digital levelling is not better than traditional, it is applied (for next regular stages) to the whole network because of it's time saving and elimination of many negative influences. Automatic measurement, data verification and storage completely eliminate personal error and restrict some accidental impacts (auto-check of measuring conditions like length and height of the line of sight). The accuracy can be slightly increased by using fast auto-repeated rod-reading (e. g. 4×) without sensible loss of time. In addition the order IV to order III of levelling was changed.

The project includes also research of possibility of real-time processing of actually measured data by total station (not only post-processing). For this purpose the unique Leica GeoBASIC – TPS compiler and simulator has been purchased. It offers the development environment that makes possible to create special application "on-board" software for total stations Leica. It opens wide range of possibilities of computing, statistical testing and pre-processing of measurements during the work. Experimental use is being prepared for the trigonometric measurement in the network Mariánská in stage (epoch) 2004. The new instrument Leica TC1800 will be used instead of the high accurate but no more reliable enough Kern E-2. The first test measurement (without GeoBASIC) using Leica TC1800 was made in stage 2003. It has been confirmed that its hardware is able to replace the current instrument. The on-board software for control, check and analyzing of each special unit of combined observation is being actually created. The next opportunity to check the GeoBasics abilities for real-time work is the new 3D deformation measurement of the cable-bridge over the Berounka river in Radotín (damaged by the floods in 2002). The units of observation will be taken using the on-board software early in the year 2004. The real-time checking and evaluation can rapidly decrease the working time, eliminate many errors and blunders, improve results and increase their reliability. In addition some results can be obtained immediately without the necessity of the post-processing.

It is the next result of the project: step-by-step innovation of regular measurement methods in the high accurate 3D network Mariánská. Transition from traditional to the digital levelling has been finished; changes in trigonometric measurement methods and instruments are tested and successively introduced. [2]

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Construction and Demolition Waste Reduction and Recycling

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In all communities it has always been common practice to retrieve valuable materials from waste, for example metals and building materials. After some decades in the twentieth century with an extensive "use-and-throw-away" philosophy, it has been realized that we cannot continue this uninhibited use of natural resources and pollution of natural resources and pollution of the world with waste.

Natural disasters, e.g. earthquakes and technical – or human-made – disasters, especially wars, cause enormous amounts of buildings and industrial waste. In many countries, developed as well developing ones, building and construction wastes are considered as harmless, inert materials that do not cause any trouble at all. However, these wastes represent huge masses of materials, which are often deposited without any consideration, causing a lot of trouble and inviting illegal deposit of other kinds of waste and garbage. The amount of building and construction waste reaches considerable figures. According to some studies and investigations carried out in EU countries an amount of building and construction waste equal to 500-1000 kg per capita is generated.

Building waste material consists mainly of concrete, masonry, limestone, timber, roofing shingles as well as asphalt paving, asphalt roofing, gypsum wallboard and composite depending on the construction type. The percentage differs according to the construction/demolition practice and habits of the particular region or country. In building waste a larger percentage of paper, plastic, and timber is expected, otherwise in road construction the concrete fraction will be much larger together with a significant amount of asphalt.

Whether the building and construction waste originates from clearing up after natural disasters or from human-controlled activities, its utilization by recycling will provide opportunities for saving energy, time, resources, and money. Moreover, recycling and the controlled management of building and construction waste will save use of land and create better opportunities for handling other kinds of waste.

In principle, all masonry and concrete waste can be recycled and reused. In order for the recycled materials to be marketed as a substitute for primary raw materials, it is necessary that the recycled materials satisfy the given technical specifications. Masonry and bricks can be crushed and used as gravel. Crushed bricks of good quality can be used as aggregate in low-grade concrete. Bricks of high quality can be cleaned and reused as new bricks. The wood fraction of building and construction debris is only recyclable. Clean and de-nailed timber and boards can be reused for new construction, and unpolluted wood can be shredded and used for gardening, farming, etc. Recycling of metal by scrap industry has taken place for many years. At the moment, the recycling of metal is performed all over the world as normal routine. All other waste materials including paper, plastic, rubber, etc. are being recycled in most developed countries.

Nevertheless, from the strategy of preventive protection point of view, there are three major steps how to prevent waste: reduction, reuse and recycling. Waste reduction means not

creating waste at all. This is one of the basic principles of sustainable building. By this method you not only conserve natural resources but also save money, because you reduce purchasing, handling and disposal costs. Designers or architects try to prevent waste by preferring designs that use materials efficiently. It is not always possible to avoid generating waste in the first place so the next best choice is to find methods to reuse reusable materials. When it is not possible to avoid or reuse excess materials, then recycling is the best method.

At present, very limited amounts of building waste are recycled, the majority being deposited into landfills. From a purely economic point of view, the recycling of building waste is only attractive when the recycled product is competitive with natural resources in terms of cost and quality. Recycled materials will be normally competitive where there is a shortage of both raw materials and suitable deposit sites. With the use of recycled material, savings can be obtained in transportation of building waste and raw materials. In a market economy, the choice between recycled and natural materials depends upon price and quality. The economic barriers can be overcome by introducing economic instruments, which encourage recycling and the use of recycled materials.

The building and construction industry is generally quite conservative and therefore it is necessary for it to adopt cleaner technology and integrated resource management. Demolition and crushing techniques for the production of recycled materials are well known and based on traditional technologies. However, it is crucial to take on new approaches, e.g. careful sorting of building waste either at the production site or at a special treatment site. Optimal handling and recycling of the construction waste depends on the materials being sorted in situ and in coordination with demolition process. It is therefore necessary to alter the traditional methods of demolition and introduce selective demolition. Since selective demolition needs more time than traditional demolition, it is strongly recommended to implement methods of selective demolition into building and construction project in detail.

Besides new methods of demolition there exist new green practices utilizing building and construction debris. It is now commonly recognized that recycling construction waste is an important component of environmentally responsible design and construction.

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Building Construction and Sustainable Development

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An analytical study "Technical trends in development of building construction in the Czech Republic with respect to requirements of Sustainable Construction" have been performed within a framework of the long-term project “Building Construction and Sustainable Development” supported by Ministry of Industry and Trade of the Czech Republic [1]. The research was focused to following key issues:

- Overview and analysis of research and developmental trends in the field of sustainable construction of buildings in EU and around the World.
- Legal steps in the field of sustainable construction in EU and World context.
- Technical analysis of existing housing stock in the Czech Republic respecting new requirements.
- Expected strategy steps in the field of building construction with regard to enter of the Czech Republic to EU.

Issues of sustainable development became an undisputed part of majority research projects in the World and in the European research area. Within priorities of research orientations dominate problems related to quality of a built environment. Buildings - the most significant part of the built environment – have a large-scale potential for achievement of required qualitative improvement in environmental, economical and socio-cultural parameters i.e. in basic areas of sustainable construction. Buildings in EU consume in average about 40% of all produced energy and produce approximately 30% of CO_2 emission and 40% of total waste. Modernization of existing buildings and construction of new buildings oriented on reduction of environmental impacts can significantly contribute to improvement of quality of the built environment as well as condition of the environment in general.

The performed LCA analyses of selected representative buildings showed differences in energy efficiency and environmental quality of buildings built in the Czech Republic in different time periods, using different technologies. The designs of those buildings were based on different requirements according to standards valid at that time.

The LCA evaluation was performed for existing stage of buildings and for two proposed scenarios of complex modernization. Scenario A represents standard approach used in contemporary renovation process. From energy point of view such technical standard of the building fulfills current standard requirements (according to ČSN 730540-2 - 2002 and Reg. 291/2001 Sb.). Scenario B represents complex modernization using best available technologies (BAT). From energy point of view the modernized building using BAT approach is getting close to the passive energy standard.

Environmental profile used in evaluation process of buildings consists from three groups of criterions:

- Embodied energy, embodied CO_2, embodied SO_2.
- Specific heat use, use of primary energy.
- Amount of used materials in the building structure (renewable materials, recycled materials, recyclable materials, primary natural sources), materials from demolition of building (fully recyclable materials, partially recyclable materials, non-recyclable materials, wastes).

The best results in evaluation of existing stage of buildings were achieved in the case of contemporary designs of buildings designed in low energy standard. This includes also two sustainable buildings for housing designed within a framework of project "Building Construction and Sustainable Development" in the last year (see [2] and [3]).

Proposed strategy steps, principles and concepts in the development of technical solution of building design and construction are as follows:

- Modernization, reconstruction, refurbishment of settlements
- Decreasing of energy use in operation of buildings
- Use of renewable energy sources and renewable material sources
- Use of high-performance construction materials (high performance concrete, composite materials etc.
- Use of recycled materials
- Implementation of intelligent control systems for control of quality of internal environment
- Use of energy efficient house appliances
- Implementation of water saving systems

The high potential for improvement of technical, energy and environmental parameters of existing building stock in the Czech Republic is evident. However, up to this time, in the Czech Republic was built only a small amount of buildings in the standard going near to the "sustainable" level. The step by step improvement of the average standard of the CZ building stock (from the sustainability point of view) is possible, but it is conditioned by (1) development of technical basis (know-how, database, product base, technology of production and construction etc), (2) development of legal support for implementation of sustainable principles in building practice and by (3) implementation of economy stimulation.

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Inclusion of Historical Map Series into DIKAT-P System for Specification of Detailed Localization of Real Estate Cultural Monuments

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Abstract

The project recapitulates and evaluates all available historical maps from Czech Republic territory. And it analyzes availability and chances of historical data source exploitation for specification of detailed localization of real estate cultural monuments too.

The project designs the optimal way for transformation conversion selected historical maps to the digital form. Digitalized historical maps can be modified and we can integrate these historical maps into the information system for specification of detailed localization of real estate cultural monuments – DIKAT-P.

Information System DIKAT-P

Today the information system for specification of detailed localization of real estate cultural monuments named DIKAT-P makes possible administration and refreshing digital map of real estate cultural monuments, interactive creating, complementing, revising and deleting tematic layer of digital map, importing data to the coordinate system in old exchange format, map layout ascertaining by defined scale, choosing raster data and working with them, differentiating real estate cultural monuments by color and displaying photografical representation of real estate cultural monuments.

This system with function for inclusion of historical map series can help us with detailed localization of real estate cultural monuments and we will be able to differ protects margins for each real estate cultural monument. detailed localization of real estate cultural monuments is aggravated by different maps, different coordinate systems, different way of cartographical map editing and by schrinkage of map paper.

Our the oldest cartographical map series and their integration into the DIKAT-P

Detailed localization of real estate cultural monuments needs studing lot of historical maps. Inclusion of historical map series into DIKAT-P can contribute to more accurate localization of real estate cultural monuments. In the first we must digitalize and transformate historical map to the datum of United trigonometric cadastral net and then we can use this histrorical maps for precise localization of real estate cultural monuments.

The digitalization of historical maps is very expensive and consequently we must thoroughly select what historical map will be integrated into the DIKAT-P and what will not.

The Mikuláš Klaudians map (1517) was the first separate map of the Czech territory. There are circa 280 towns, villages and castles in this map. This map and all maps from this time (Crigingers map – 1567, Aretins map 1619, Stichs map – 1676 and Vogts map – 1712) are not very detailed and we can not find some information about several objects.

These maps were designed without measurement, the distances on the maps were only assessing by people live there. Therefore we can not use these maps for precise localization of real estate cultural monuments.

Cadastral mapping

"Berní rula" and "Terezian cadastre" was the first and second experiment with accounting all real estates. Real estates position was defined only by commune toponomy not by map or measurement.

Cadastre as established by Emperor Joseph II was more perfect than any other existing cadastre. Surveyor must survey all fruitful pieces of land in villages in one year. They must establish pieces of land acreage and yield from each piece of land. The Josephs patent determined who can measure and how.

This is the first cadastre where the pieces of land was measured therefore this cadastre is more accurate than previous cadastres.

Cadastre of 19th Century in Austria Empire, "Stable" Cadastre

There has been already geometrical representation in stable cadastre. All pieces of land must be surveyed, displayed and described. Surveying, displaying and describing must be executed jointly for all Austria Empire except Hungary.

The stable cadastral map series is something nonesuch. It is very far-reaching, detailed, high-quality and accurate. In is the first large scale cadastral map series.

This cadastral map series is come down to today because the maps was very carefully archived and we can constantly find in this map many information about real estate cultural monuments. This maps are very available to inclusion into the information system DIKAT-P for their accurate, large scale and far-reaching.

Conclusion

Digitalization of historical map series and their inclusion into the information system DIKAT-P makes possible better and more elementary access to this maps. And this historical maps will be better protect against damage because all people will work with digital copy of map not with analog original.

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Solving of Particular Problems Regarding ZABAGED Update

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Abstract

The project is engaged in selected problems connected with ZABAGED (Fundamental Base of Geographic Data) actualization with cadastral data. The project compares types of the ZABAGED and cadastral features, their localization accuracy, possibilities of ZABAGED and change cadastral data contemporary visualization and investigates possibilities of cadastral change records for ZABAGED changes identification and eventual adoption of some types of features, e.g. buildings and administrative boundaries.

Project Goals

Major project goal is found possibilities cadastral data exploitation for ZABAGED (Fundamental Base of Geographic Data) actualization. Partial aims are detailed analysis of cadastral data structure in relation to ZABAGED, cadastral data selection in new exchange format from cadastre of real estates, possibilities of creation software for automated data processing and possibilities of ZABAGED and change cadastral data contemporary visualization.

Pros and Cons ZABAGED Actualization with Cadastral Data

Major reasons for ZABAGED actualization with cadastral data are the same vast region – over the Czech Republic, the same map coordinate system – datum of Unified trigonometric cadastral net, cadastral data actualization in the course of each change, digital vectorial large-scale cadastral map on the 15 percent ground of the Czech Republic. And ordinary geo-database actualization is very expensive so it is very efficient making use of additional data source.

Major reasons against ZABAGED actualization with cadastral data are following. Technological method is created and new method of actualization may give trouble because the time schedule is very intensive. The map scale for ZABAGED and cadastral maps is not the same, same data from cadastre must be generalized. And ZABAGED actualization is practiced in the short time interval in accordance with terrain.

Brief Description of ZABAGED

Fundamental Base of Geographic Data (ZABAGED) is topological and vectorial topographical digital terrain model. It is drawn from Base map of Czech Republic in scale 1:10 000. This database is geographical information system and it integrates vectorial graphic and data attribute.

ZABAGED conception is described in [4] and description of ZABAGED development in the article [1] e.g.

New Cadastral Exchange Format

When the department proceeded to information system cadastre of real estates, the new exchange format has been implemented. The new exchange format is of validity from 1st January 2003 and it compensates for old exchange format in version 1.3.

It is the text file with extension "*.vfk". All data are stored in one file, this file is compose of head and data blocks. Czech character coding is ČSN ISO 8859-2 (ISO Latin2) or WIN1250.

Each tense from text file starts by character &H apropos of head tense, by character &B apropos of block tense and by character &D apropos of data tense. Each tense stops by characters <CR><LF>. Log entries in tenses are separated by semicolon.

Suitable Types of Features for ZABAGED Actualization

Criteria for object selection are following. Type of feature must exist in ZABAGED and in cadastral data too. And we must have same matter for ZABAGED actualization with cadastral data.

Suitable types of features for it are building or block of buildings, bridge or culvert, street, railway, electrical lead, transmission towers, section line of terrain units, points of horizontal control and points of vertical control.

The Localization Accuracy and the Conclusion

The localization accuracy each database is good. Building and transmission towers planimetric deviations are in centimeters till meters. Railway localization accuracy is very good too.

The largest deviations are at section line of terrain units because the section lines of terrain units are very difficult and they are generalized in ZABAGED in contrast to cadastre.

There are some alternate for ZABAGED actualization with change cadastral data:

In first option we localize places where same change was in last time and we evaluate these changes in accordance with orthophotomap.

In second option we adopt some types of features with small planimetric deviation, e.g. buildings, electrical lead or transmission towers. Some types of features can be only adopted, some must be generalized.

In third option we can adopt section line of terrain units from more accurate database and then we can integrate databases, ZABADED and cadastre together.

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The Measurements of a Model Staking Network for Construction of a Bridge over a Deep River Valley Using Terrestrial Methods and a GPS Methods

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In practical geodesy, the construction of precise staking geodetic network for technologically ambitious work in rugged landscape (in the case of this project the building of a bridge over a rocky river valley) is often required. As a typical example we can mention a three storey steel construction of a bridge on the by-pass highway north of Prague. For the precision assurance of the basic control in surroundings of the construction (for the time of building duration) is necessary to take into account the quality of positional and vertical locating of staking network and the efficiency of its construction. A configuration of the points in the network won`t be typical by reasons of land topography and requirement of the construction (one can`t use leveling f. e.). Those facts will influence methods and possibilities of classical terrestrial measuring in this coordinate network with distances shorter than one kilometer. The aim of the project is to compare the precision of classical terrestrial measurements of the developed network with the precision of the measurements by a GPS (*Global Position System*) set and assess the possibility of substitution of expensive and time consuming terrestrial micro-network definition by fast standard GPS [1].

In regard of our work results applicability we toke step in building and measuring of a network which can occur in common practice. We used scientific knowledge especially in the question of surveying accuracy analysis and valuing gained results. On the banks of river Vltava north of Prague six points were stabilized. We realized them by five granite blocks and one spike in the road. Each triad of points was situated on one of the shores. For electronic measurement of distances and horizontal angles we used total station Geodimeter 620 with accuracy 2mm+2ppm in distances measuring and 0.5mgon in angles measuring. Differences in elevations in triad of points were determined by leveling. The “problematic” elevation difference between the two shores we appointed by simultaneous measuring of eccentric vertical angles on special metrical cylinders. Theodolite Zeiss 010A was used for measuring between two chosen points in eight laboratory units with an interval of half an hour. As we noticed before we defined spatial dimension of our network by GPS observation too. Three two-frequency GPS survey units Trimble 4000 and one Trimble 5700 unit was used. The vectors were surveyed from satellites by fast static method with elevation mask 15°,5 sec data record and epochs of the sessions fluctuated between 45min to 5h 25min. The longest epoch was important for superior assignation of elevation difference between the two shores as we argued before. For annexation to ETRS89 (*European Terrestrial Reference System 1989*) short sessions on the two points DOPLDOP (*Complement of Czech zero frame campaign network*) and post-processing computation with support of current commercial software was applied [2].

For the conversion of spatial coordinates to national co-ordinate system (*S-JTSK*) and normal elevations by see-level (*Bpv-system*) the WJProtra program was used. In relation to

conservate the network inner accuracy seven identical points were allowed for. The measurement of transversal distances variety reductions was made. For consideration of distances specificaton, its standard deviation was determined at value 1.2mm. Thus our network was adjusted [3] by terrestrial surveying as a free-network and collocated to GPS-network using Helmert`s transformation with estimate standard deviation of distance 2.0mm, of angle 0.63mgon and of coordinate 1.3mm. Relatively complicated treatment of eccentric vertical angles to determine elevation differences cross the valley was undergone [4]. The standard deviation of elevation was 2.1mm.

To compare both designed methods, it is necessary to compute differences at the virtual connections of points at first. In our case average aberration was about five millimeters. At second, it is possible to study residual variances resulting from adjusting of the network. Average difference in coordinate at the identical points was 3.2mm. The altitudes of the points in the network were determined by GPS and the elevations in the triads were comapred with the levelled ones. At the points with fine signal reception the maximal differences reached 1.0mm, however the variations at GPS difficult accessed points were in centimeter order. The difference between trigonometric elevation and GPS determined points on the opposite banks reached 13mm.

Finally the precise geodetic network was built, using two discrepant methods and aligning them. We beg leave to state that the GPS observation is more effective than the classical terrestrial measurement especially at the places difficult to access. There exists a possibility of network dimension definition by fast standard GPS methods, if the points are carefully located for quality satellite signal reception and the desirable time of surveying is respected. In our case, when the two points with the worse satellite signal reception are eliminated, the average difference in coordinates decreases to 2.1mm. In our case the classical distance measurement on long surveyed vector differs from direct observation by GPS within one millimeter. Nevertheless, the elevation obtained from GPS observation is necessarry to verify by classical terrestrial measurement to get correct values. We hope in frequent testing of the network by the faculty, using variable methods of measurement and computation. The frequent measurements of the network can be used especially for the refraction estimation in such non-typical conditions. The practical utilization of the network for building of the highway bridge is also possible.

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Modeling Pesticide Leaching in Hawaii Oxisol

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Groundwater pollution is a major national issue in many countries because of the common use of groundwater for drinking purposes; on that account leaching of five pesticides and one non-reactive tracer was investigated during the extensive field experiment at Kunia site, island of Oahu, Hawaii State, USA (Gavenda et al., 1996). The principle objective of this contribution is the description of the fate of applied pesticides and their transport through the vadose zone. The experiment was conducted for the period of 131 days from June 1, 1989 to October 9, 1989. Three plots (8×8 m^2) were established on well-drained site on gentle slope with low probability of overland flow generation during heavy rainfall or irrigation episodes. The soil at the Kunia site is deep and weathered silty clay Oxisol. Although, the soil is rich in kaolinitic clay, it is highly aggregated. It was shown by previous studies that aggregate structure of Hawaiian Oxisols contributes to accelerated leaching of chemicals. Five pesticides were selected to represent a broad variety of chemicals currently in use in agriculture. The chemical properties of the selected pesticides differ widely: from the relatively well-sorbed up pesticide to the leaching prone one and from the persistent pesticide to the quickly decaying one. In addition, sodium bromide was applied during the experiment as a tracer for the water movement visualization. All pesticides and bromide were mixed together in a container and applied uniformly over the experimental area. A layer of straw was spread over each plot within several hours after pesticide application to limit erosion and enhanced evaporation and also to prevent photodegradation of the pesticides. The plots were irrigated using a sprinkler technique, which delivered about 10 mm per hour. Daily rainfall and pan evaporation data were collected at the distance of 100 m from the experimental plots during the experiment. Soil samples for pesticide and bromide extraction were collected in 2, 6, 10 and 19 weeks after the pesticide application. The same samples were used to measure water content. Beside the field experiments, the degradation study and sorption tests were conducted in the laboratory. Distribution coefficients and degradation rates were measured in the laboratory for each applied chemical and soil horizon. First order kinetic model was used to calculate degradation rate coefficients and half-lives. Hence, extensive hydrological and soil chemical database was acquired with emphasis on subsequent simulation study.

To gain better understanding of all phenomena, which take place during the complex solute movement in the subsurface, numerical modeling of the pesticide transport and other related processes is used. From the evidence of relatively deep penetration of bromide tracer in response to natural rainfall and irrigation, it has been concluded that the aggregated soil behaves preferentially. This conclusion indicates the necessity to apply a numerical model capable of simulating water movement and solute transport through the preferential pathways. Two conceptually different models were chosen, one (S_1D_Dual) with dual-permeability based approach (Vogel et al., 2000; Ray at al., 2004) and the other (MACRO) is based on a kinematic wave equation for solving the water flow in the macropore domain (Larsson et al., 1999). The dual-permeability approach assumes that the porous medium consists of two domains with different hydraulic properties. Water flow in the dual-permeability model is described by a pair of Richards' equations for the macropore and the matrix pore systems.

Similarly, a couple of convection-dispersion equations is solved to model solute transport. The exchange of solute between the matrix and the fracture domains is assumed to be proportional to the local pressure head difference and the concentration gradient between the two pore systems. Similarly to the dual-permeability model, the MACRO model accounts for macropore flow by dividing the soil porosity into two flow systems or domains (macropores and micropores) each characterized by a flow rate and solute concentration. In MACRO model, though, Richards' equation and the convection-dispersion equation are used to model soil water flow and solute transport in soil micropores only, while a simplified capacitance type approach is used to calculate fluxes in macropores. The mass exchange between the flow domains is calculated using approximate physically-based expressions, based on effective aggregate half-width.

Dissipation rates were calculated from the total mass of each pesticide in the soil profile. As expected, these rates somewhat differ from the degradation rates determined by the laboratory measurements. The dissipation rate is, by definition, the composite loss of pesticide due to all mechanisms, including microbial and chemical degradation. Our simulations were run with two distinct decay rates, associated with the two last mentioned degradation processes. The pesticide transport is strongly influenced by the water flow dynamics. Thus an appropriate description of the water movement during the field-scale experiment is fundamental. With help of models capable of incorporating the macropore flow component, the prediction of the pesticide leaching in aggregated soils can be more precise. Other important parameters which control the pesticide fate in the porous media are the decay half-life and the sorption coefficient. The results of simulated concentration profiles show in most cases quite good agreement with measured pesticide penetration. More specifically, the simulated resident concentrations in the soil profile match the measured values in terms of one order of magnitude. However, some uncertainties in simulation of the pesticide leaching remain unexplained, e.g.: the bromide breakthrough simulation suggests clearly the necessity of including preferential flow effects in the model, on the other hand, in a few cases, classical Richards' single-permeability approach predicts deeper penetration of pesticides, compared to the measured breakthrough, indicating overestimation of the pesticide mobility (even though no preferential flow is considered).

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Biological Stability in Drinking Water Distribution System

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The maintenance of the quality of water from the outlet of the treatment plant to the consumer tap is a major concern of water distributors. From a microbiological point of view, this maintenance must be characterized by a stability of biological features, namely bacterial growth from biodegradable organic matter, and protozoan bacterivory which must be not detectable. However, drinking water distribution systems are continuously exposed to a flow of biodegradable organic matter, which can represent around 20 – 30 % of the total dissolved organic carbon, and a flow of bacteria, fungi, protozoa etc., coming from the water treatment plant but also from incidents (break/repairs) on the distribution network itself. These microorganisms can grow in this ultra – oligotrophic environment and colonize the all drinking water distribution system. The highest density of microorganisms occurs on the surface of pipewalls where they are organized in microcolonies (biofilm) that are mixed with corrosion products and inorganic precipitates. The increase of the number of bacteria in tap water samples may be explained by the growth and shear of the biofilm with transport of the detached organisms into the water.

During the last years, different studies were carried out in full scale distribution networks, focusing on the role of the biodegradable organic carbon (BDOC) in distribution systems. It was shown, that this parameter in the finished water was the major controlling factor of bacterial dynamics when free chlorine was depleted. The different studies agree to conclude that the control of biodegradable organic carbon remains one of the prime objectives to achive biologically stable water. This solution, in addition to reduce bacterial growth by limiting the nutrient sources, offers two additional advatages: removal of organic matter initially reduces the formation of undesirable disinfection by-products (DBPs) during chlorination and also increases the stability of the chlorine residual in the distribution system by reducing chlorine demand.

Proper monitoring of the microbiological quality of water in the distribution system also requires the development of hydraulic and biological models [1,2].

The objective of our work was the study of biological stability of drinking water supplied from WTP Plav to the water tank Hodušín. Six places were chosen as locations for monitoring and taking samples for the analysis of the main characteristics of the drinking water: WTP Plav, WT Hlavatce(inlet/outlet), WT Zdoba(inlet/outlet), WT Varta, Sudoměřice (inlet/outlet) and WT Hodušín(inlet/outlet). The parameters in the physical and chemical analysis included temperature, turbidity, pH values, alkalinity, hardness, concentrations of dissolved oxygen, iron, manganese, chloride, UV absorbance, COD, DOC, free chlorine. Water samples were collected in water tanks according to a systematic sampling programme. BDOC parameter was used for evaluation of the biological stability of water in given distribution system. This parameter based on DOC analysis numerates the resistance of water

to bacterial growth. BDOC concentrations were estimated as the difference of DOC concentrations measured before and after a 30 d incubation at 20°C with indigenous bacteria [2].

BDOC levels at the outlet of the WTP Plav were between 0,12 and 0,26 $mg.l^{-1}$ whereas in the outlet from WT Sudoměřice the values from 0,10 to 0,50 $mg.l^{-1}$ were measured. It was shown, that the BDOC values in outlets from all water reservoirs were higher then in their inlets.

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Fatigue of Asphalt Mixes in Pavement Performance Assesment

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The aim of the project is to obtain new knowledge on fatigue processes taking place in asphaltic layers of flexible pavements through combination of experimental research and computer modelling and to make use of it in the revision of the Czech flexible pavement design method. The computer modelling is based on the use of the microstructural modelling of the asphalt mix components having viscoelastic and viscoplatic behaviour. The experimental part of the research is accomplished with the aid of the NAT (Nottingham Asphalt Tester) device. The NAT device is a unique testing equipment, allowing monitoring of selected rheological properties of asphalt mixes (stiffness modulus, creep, fatigue). The fatigue testing is conducted under controlled (constant) level of the applied stress. During the experiment, the growth of the deformation and decrease of the stiffness modulus are monitored untill the complete damage of the test sample. The fatigue research is presently pursued within scope of the GA ČR research project 103/02/0396 „Fatigue of asphalt mixes and flexible pavement design optimization“ and also under the MDS ČR research project 803/120/117 „Asphalt pavements of new generation in Czech Republic“.

In the year 2002 the experimental research was directed toward:

- monitoring of fatigue resistance properties of selected asphalt compacted mixes (AKM, OKH, VMT, ABH and ABS) at temperatures 15 °C and 27 °C,
- monitoring of values of stiffness moduli od asphalt mixes in the temperature interval from 0 °C to 40 °C; in the mix AKMS preparation the admixture FTP (Fisher – Tropsch Parafin) was used, allowing manufacturing of asphalt mixes under distinctly lower working temperatures. The advantage of these liquefaction admixtures is the minimization of adverse effects on environment associated with production and laying of asphalt layers.
- monitoring of the relaxation properties of asphalt compacted mixes in the range of low temperatures,
- transformation of results obtained at the Road laboratory in the seventh decade of the last century in the course of fatigue testing on trapezoidal samples.

The laboratory tests on the asphalt mixes prepared with the FTP admixture did not support the assumption that asphalt mixes produced and laid under lower working temperatures would posses less favourable mechanical properties. The values of stiffness moduli determined at temperatures 27°C and 40 °C as well as the results on mix resistance against permanent deformation are better than those obtained for mixes without the FTP admixture.

New results were obtained also in the field of the computer modelling. The computer modelling is based on the application of the multivolume microstructural modelling method and the recent efforts were focussed on improving numerical stability of the solution procedure and on enhacement of the modelling capacity by increasing the allowable number of microcomponents present in the asphalt mix structural model. Further numerical experiments were oriented on verification of several approaches allowing to take into account

also viscoleastic properties of individual structural elements. In progress are also studies on incorporation of mix viscoplastic properties in the mix structural model.

Close attention has been also paid to the practical application of the obtained research results in pavement practice. An important example of such an application is given by the analysis of the causes of the insufficient performance of the Prague Radial road in Brno. The diagnostics results (impact deflection testing, core drilling and control pit evaluation) and laboratory findings were analyzed using computational models to evaluate overall-performance of the pavement as well as contributions of individual layers to the observed distress formation. The results on proper assesment of the insufficient bonding of layers and the experimental results on fatigue properties of non-standard asphalt mixes were used to arrive to the conclusion that the adverse effects may be ranked in the following way:

- insufficient support of the asphaltic layers by the base and subbase layers and subgrade,
- inadequate thickness of the asphaltic layers,
- improper bonding of asphaltic layers (binding course AB over base course OK),
- inadequate quality of the asphaltic layers.

The theoretical assesment of the actual state of the analyzed pavement on the basis of diagnostics measures and laboratory testing was proved to be in full agreement with the reality. The succesfull prediction of the starting point of the pavement damage mechanism and description of its further evolution may be used in process of forming pavement damage models of broader application spectrum, which research is also a part of the research activities in scope of the GAČR project 103/02/0396.

The knowledge acquired in the process of project solution was also used to support the CTU standpoints in discussions on the current innovation efforts regarding the Czech pavement design procedure TP77. Our opinion is that the process of pavement exploitation (deterioration) is too complex to be controlled by the fatigue characteristics derived from standard fatigue laboratory tests (even if they are EU standard tests). The so-called performance-oriented design procedures must be based on much more complex knowledge of pavement damage processes so that further extensive research must be devoted to this goal.

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Progressive Composite Steel-Concrete Element

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The contribution deals with two bending tests of real-size composite steel and concrete girders with span of 7500 mm. The two tests denominated EX1 and EX2 differ in level of shear connection. The static experiments were carried out in Structural laboratory of Faculty of Civil Engineering of CTU in Prague. The girder tests supplemented large series of push tests of connectors Stripcon performed at CTU in Prague.

The composite girders consisted of steel girder with undulating web WT- flange dimensions 200x10 mm (S235), web 500x3.0 mm in case EX1, 2.5 mm in case EX2 (St37-2G) and concrete ribbed slab 1500x120 mm. The slab was concreted into thin-walled trapezoidal sheeting of Vikam TR60/235-0,75 (S320G) with ribs orthogonally to the beams and acting as permanent formwork. The slab was reinforced by minimal mesh reinforcement as required by Eurocode 2. The shear connectors Stripcon TR60/235 (made from steel S280GD) [1] were supplied by Hilti Corporation and produced in Czech Republic. Each connector was fastened to the beam flange through the sheeting by 8 nails Hilti ENPH2-21-L15. Girder EX1 was designed with full shear connection with level of $\mu = 117\%$ (in total 16 connectors per span of the girder), where $\mu = 100\%$ matches the connection corresponding to plastic capacity of the composite beam cross section. Girder EX2 had extremely low level of shear connection corresponding $\mu = 44$ % (in total 6 connectors).

The loading was placed in the fifth of the span and realized through pair of hydraulic jacks PZ60 connected in parallel way. The loading of the first test (EX1) was controlled by force while in the second test (EX2) by displacement of the central load cell. The procedure of the loading followed the same two-phase pattern. In the first phase, given by elastic behaviour, each loading was followed by unloading. In the second phase, plastic one, the loading continued after settling down both of the deflections and stresses of the current loading up to the collapse.

Response (deflections and strains) was monitored longitudinally in 5 cross sections, in 0L, L/4, L/2, 3L/4 and L. Within cross sections the transducers and strain gauges were placed symmetrically on bottom fibres of bottom flange of the steel girder, on bottom fibres of upper flange of the steel girder and upper fibres of the slab. Other transducers of inductive type IWT302 were used to monitor slip between the concrete slab and steel beam at span ends. The electric transducers and strain gauges Mikrotechna C120 for steel and HBM 100/120 LY 41 for concrete parts were treated by data processor HBM UPM 60 and PC. In time of the testing the basic material characteristics for steel and concrete were evaluated.

Test EX1 was finished after reaching full redistribution of stresses corresponding to calculated plastic moment capacity. The deflection was large, nevertheless no buckling of undulating web was monitored as the shear capacity was significantly higher (Fb = 270,2 kN) in comparison to shear at collapse (F = 192.8 kN). Test EX2 terminated due to extreme deflection after approaching the calculated capacity of the partial shear connection. The slip grew up rapidly after the load reached approx. 50% of its theoretical elastic value. Ductile connectors and low partial connection are sources of this behaviour. Again, buckling of undulating web did not take place.

In the case of full shear connection the theoretical plastic strength of the girder agrees well with the test collapse capacity. Strong non-linearity of deflection appears after reaching approximately 80% of the theoretical elastic loading. This behaviour well corresponds with distribution of slip between slab and steel beam. The measured deflection at mid-span for value of theoretical elastic loading is roughly double in comparison with the calculated one.

In the case of partial shear connection (μ = 44 %) the collapse capacity reached only 95% of the shear connection capacity that value is critical for the girder strength. Because of proximity of girder elastic strength and calculated capacity of partial shear connection the large slip between the slab and steel girder (with following collapse of the shear connection) appeared accompanied with extreme deflection of the girder. The measured deflection is in agreement with the elastic calculated one until reaching roughly 75% of its maximum elastic value.

Simple preliminary linear calculations (common standard design in accordance with Eurocode 4 [2]) proved that experimental strength capacities of the girders are in good agreement with the calculated values, however, the deflection are due to flexibility of the connectors (slip in the shear interface) larger. The elastic calculation of deflections for the tested girder with full shear connection was correct up to 80% of the elastic strength of the girder, while the real maximum deflection value for the elastic girder strength was roughly double to the commonly calculated one. In the case of tested girder with partial shear connection the similar conclusion was valid up to 75% of the elastic strength of the girder. Buckling shear capacity of the undulating webs in both tests was higher than shear at collapse of the girders.

Preliminary evaluation of experimental investigation results proved practical applicability of the new progressive composite girder having shear connectors Hilti Stripcon and steel girders with undulating web. The use of connectors Stripcon in composite girders loaded in bending resulted into much more ductile behaviour in comparison with other traditional connectors, e. g. welded headed studs.

Complete results evaluation and comparison with numerical nonlinear FE analysis together with parametric study of these composite girders will be followed. Another test of the similar composite girder and dealing with interaction of buckling of the undulating web and partial shear connection is under process.

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Progressive Composite Steel-Concrete Structures

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Novel structural forms in composite steel and concrete structures enlarge material base of modern structures and pertain to progressive trends in structural design. Recently some highly efficient elements were introduced into practice, namely steel girders with undulating web produced by Zeman+Co GmbH (Wien), figure 1 [1] and thin-walled shear connectors developed by Hilti Corporation [2], which are fastened to beam flange by powder actuated fasteners and called Ribcon or Stripcon, figure 2.

More details on WT girders, practical design and strengths in shear, local loading and fatigue may be found in [1], [4]

Stripcon shear connector is suitable especially for use with metal decking whose waves run perpendicularly to axis of the beam. The connector is made of cold formed steel strip of 80 mm width, with a shape corresponding to the wave of the trapezoidal sheeting used as a formwork, the wave of the connector being however higher. Holes are cut in the connector for penetration of concrete and the connector is fastened to a beam by 4 fired nails in its each valley, figure 3.

Both newly developed connectors (Ribcon and Stripcon) are certified for use in Czech Republic in accordance with ENV 1994-1-1 (Eurocode 4) based on research [3] resulting in design strength of the connectors. As for Stripcon (made from steel with yield point f_y = 300 to 400 MPa) the following characteristic shear strength and partial safety factor were derived:

$$P_{Rk} = 18.4 \text{ kN} \qquad (1)$$

per one nail Hilti ENPH2-21-L15 (marked #515693), i.e. 147.2 kN per one connector having 8 nails,

$$\gamma_v = 1.3 \qquad (2)$$

The values are applicable for concrete characteristic strength f_{ck} = 20 to 45 MPa and the shear connector is classified as ductile in accordance with Eurocode 4.

While some further research of girders with undulating webs and Stripcon shear connectors is under way [4], [5] no mutual use of both elements was realized up to now. This paper describes real size experiments for combined use of both of them in composition shown in figure 4. The investigation covers both full and partial shear connection to analyse full range of the use in structures. The possible application is envisaged in floor beams of multi-story buildings having larger spans (> 6 m) as contemporarily required for administrative buildings.

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Design of Building Parameters by Means of Theory of Tolerances

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Presented abstract is based on the paper presented in the conference Building Simulation 2003 [1]. The paper describes the use of the theory of tolerances in thermal network models that are built as electric circuits. A calculation of new values of model parameters is based on the assessment of relative sensitivities of model elements. The method is explained in a case study where thermal comfort is analysed in a designed office building in summer. Tolerances make possible to quickly find a new parameter value for the desired air temperature decrease. The limitation of the method is in using differential sensitivities that can be used for relatively small changes of parameter values.

Introduction. The analysis of the thermal dynamic behaviour of buildings or rooms can be performed by means of the models based on an analogy to the electric circuits that use resistances, capacitances and heat sources [2]. Optimal model parameters and building parameters are assessed by means of repeating the analysis, it means an iteration process is applied.

Method. The proposed method is based on the direct calculation of the model parameters that can be influenced by the building designer. Generally, these are: the shading coefficient of windows, the absorption of the building envelope surface, the thermal capacitance and the thermal resistance of the building envelope and also the thermal capacitance of internal building structures. The method is focused on the passive components of the whole complex system.

The main steps of the process are:

1. Analysis of designed building – calculation of internal air or surface temperature for initial structure parameters.
2. Formulation of goals = desired changes of internal air or surface temperature.
3. Finding out the importance of model parameters - sensitivity analysis of the thermal model.
4. Calculation of new model parameters by means of the theory of tolerances.
5. Changes of physical parameters and selection of suitable materials and components.

Relative sensitivity is expressed in equation [3]

$$Sr_x^F(p,x) = \frac{\partial \ln F(p,x)}{\partial \ln x} = \frac{\partial F(p,x)}{\partial x} \cdot \frac{x_0}{F_0}$$

The result of the calculation of the sensitivity function after the substitution $p=j.\omega$, where j is imaginary unit and ω is radian frequency, is a complex figure. Real part expresses the amplitude sensitivity. The imaginary part epresses the sensitivity of the phase delay to the change of parameter x. Graphs of functions $ReSr^F_x(j\omega)$ and $ImSr^F_x(j\omega)$ are sensitivity characteristics of the model parameter x_i. Relative tolerances make use of relative sensitivities that will be used in an example.

Example. As an example, the calculation of parameters in an administrative building in summer is presented. One room with a light-weight envelope is investigated. The zone model is built as a five-node thermal network.. Resultant values of internal air temperature are

influenced by changes of the external environment, this means by time-dependent changes of solar radiation and air temperature.

The impact of external air temperature changes is negligible compare to the radiation. Considered elements are: thermal conductance of the building shell U_w, thermal transfer conductance between the shell and the interior U_i, thermal transfer conductance between interior and surrounding building structures U_s, their thermal capacitance C_s, thermal capacitance of the building shell C_w, thermal capacitance of the interior (air and furnishing) C_i, controlled heat source G_o for heat passage through the window, controlled heat source G_w for the description of heat flow to the external wall. Heat source values include the size of elements and a transmittion or an absorption coefficient. G_L represents heat loss from the surface of the building shell.

Results. The analysis is performed in a frequency domain by computer program [1]. Calculated temperature peak for the initial model values is 27.3°C. The most sensitive model parameter is the heat source that describes the heat flow through the window. Parameters with higher relative sensitivity values influence internal air temperature values more than other model parameters [4]. Another important element is also thermal capacitance of internal building structures.

Parameter G_0 was chosen and its new value was computed from the equation

$$\frac{\Delta F}{F} = \sum_{i=1}^{N} Sr^{F}_{x_i} \cdot \frac{\Delta x_i}{x_i}$$

and relative sensitivity value. New G_0 value was 0.219 W/K (original 0.292) and from this element value new value of the shading coefficient (s) was calculated. The implementation of the solution is possible by using drapes with s = 0.583, coating on glass surface, s = 0.62 or venetian blind, s = 0.551. For the verification of the result, internal air temperature was calculated with new G_0 value. Maximum air temperature in the room achieved 26°C.

Conclusion. The final decision should consider also architectonic and economic limits of the chosen solution. The described method can be used for fast design of structure parameters. A computer program for computing relative sensitivities has been developed.

The important fact is the application of differential sensitivities. It means that we can work only with relatively small changes of the parameter values. It depends on the sensitivity charecteristics. For G_0 values it is possible to find stable results of relative sensitivities for wide range of nominal values. In the described case study, the investigated parameter was changed by 25,5 %.

The comparison of the calculated air temperature peak for the new parameter value and the desired air temperature peak shows good accuracy of the method.

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Material Model of Fibre Reinforced Concrete - Inverse Analysis

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For application of fibre reinforced concrete in structural members it is necessary to ensure not only appropriate technology for production, but also adequate methodology for design. For structural analysis constitutive models of fibre reinforced concrete are needed. Submitted problem was directed to some aspects of material properties determination on the basis of laboratory testing. In terms of cross-section analysis as a fundamental step in structural design,
conventional procedures are normally based on the stress-strain (σ–ε) response of the materials involved (i.e., concrete and steel) and the deformations across the critical section. Along the lines of such σ–ε approaches, the models for the behaviour of SFRC have replaced those for plain concrete in the design of fibre concrete structures and the tensile response of the concrete is taken into account, instead of being neglected.

The task is to obtain stress-strain diagram of fibre reinforced concrete, when relationship between load and deflections is known from four-point bending test on a prism. One type of such a procedure (called inverse analysis) is described and results of inverse analysis are used in structural analysis to compare the results to tests. Effects of shear on deflections and consequences for determination of material parameters are also discussed.
Two different calculation steps have been pursued: the first one determines the curvature of a section of a specimen depending on its deflection and subsequently the bending moment acting on the beam which is caused by load. The other step used relation between flexural bending moment and curvature derived from the load-deflection curves of the tested beams for determination of stress-strain diagram. Both steps have in common that they use the same stress-strain relationship as in the σ–ε design method so that the efficiency of this design method can be assessed.
Material characteristics under compression could be determined from compressive test in the same way as for plain concrete. The tensile behaviour is affected by various effects, moreover by a type and dosage of fibres, and could be expressed by several parameters, such as: Young's modulus, flexural tensile strength, the stress drop in a post-peak part of stress – strain diagram and the residual values of tensile stress and ultimate tensile strain. Some of these parameters could be determined quite easily; setting of others is more complicated.
At the first step a relation between load and deflection is obtained from the laboratory bending test, subsequently curvature of the mid span of the beam on the basis of deflection of mid span is derived and corresponding acting moment is calculated.
A program was made to calculate the whole distribution of the moment curvature curve from load deflection curves obtained from bending test and plotted.
In design process the stresses in steel fibre reinforced concrete can be derived from a stress-strain diagram. In the described procedure as a possibility the behaviour of the concrete fibre material in compression is modelled according to Eurocode 2, i.e. the compressive strain is limited to –3.5 ‰. The ultimate strain of the material in tension can be limited to 25 ‰. In

case of steel fibre reinforced concrete with additional reinforcement, this value is valid for the position of the reinforcement.

In the second step a stress-strain diagram in tension is determined in such a way, that resulting behaviour of the test specimen in the calculation model is the same as results obtained from the test. The stress- strain diagram is simplified by lines and could be described by five parameters. The procedure is repeated with changing parameters until the required accuracy is satisfying.

A program was made to generate a great number of different parameters, which can simulate scattered distribution of material properties in a set of specimen. On the basis of the well-known normal equations of least square linear regression the case with most suitable parameters is chosen. The procedure can be repeated and the most precise values of parameters can be determined. To verify the stress – strain diagram resulted from the described procedure, FEA was used. Testing prism was modelled under the same loading scheme as during the test and load deflection curve from analysis was compared with load deflection curve from the test.

A complete design approach should ideally consist of a methodology or strategy that includes the specifications for experimentally obtaining the material parameters needed for the design and the procedures for interpreting the results, the formulas or steps used in the design of the element or structure, and an indication of the limitations and reliability of the approach. In reality, however, most structural design is based on empirically-obtained code equations that are loosely based on elasticity or plasticity theories and or on experience-based serviceability criteria.

The formulation and utilization of more rational approaches has led to progressive revision and modifications of existing design codes. Along these lines, new methodologies seem to be promising but are not yet able to provide a complete basis for a new generation of design codes.

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Determination of Material Parameters of Concrete by Using Artificial Neural Networks

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Advantageous properties of fibre concrete have been known for three decades, though the fibre concrete is not applied as structural concrete in a greater scale so far. The reason might be in unsatisfactory models of fibre concrete behaviour, where a number of material characteristics should by determined for the stress – strain diagram needed in structural analysis. Material characteristics under compression could be determined from compressive test in the same way as for plain concrete. The simplest and low-cost laboratory test to determine tensile material characteristics is a bending test, where a load – deflection curve is obtained. The tensile behaviour is expressed by several parameters, such as: Young's modulus, tensile strength, the stress drop in a post-peak part of stress – strain diagram and the ultimate tensile stress and ultimate tensile strain. Some of these parameters could be determined quite easily; setting of others is more complicated. This entry deals with a probabilistic approach to determine material parameters of fibre concrete. An inverse analysis procedure based on the application of neural networks is used. Interest in neural networks has expanded rapidly lately. Much of the success of neural networks is due to such characteristics as nonlinear processing, parallel processing, etc.

Artificial neural networks are a category of computer algorithms that solve difficult problems via the cooperation of highly interconnected but simple computing elements (or artificial neurons). These networks have ability to learn some target values from a set of chosen input data. In general the processing elements of a neural network are similar to the neurons in the brain, which consist of many simple computational elements arranged in layers. The input layer consists of a number of neurons that are interconnected to each of the elements in the input vector to feed external information into the network. One or more hidden layers with arbitrary numbers of neurons are interconnected between the first (input) and the last (output) layer. The output layer produces the computed output vectors corresponding to the solution.

The neural network based inverse analysis technique initially consists of performing a certain number of Monte Carlo simulations (approximately 30 simulations) corresponding to a direct analysis in order to obtain a certain number of samples – the output curves load – deformation as a function of input parameters corresponding to the training set of neural network. Then the neural network is trained and it becomes possible to perform the inverse analysis – to input a curve load – deformation and discover the parameters that would correspond to the given input curve. To train the network, the weights of connections are modified according to the information it has learned. The network learns by comparing its output for each input pattern with a target output for that pattern, then errors are calculated and an error function propagated backward through the net. To run the network after it is trained, the values for the input parameters are presented to the network. The network than calculates the node outputs using the existing weight values and thresholds developed in the training process. The process for running the network is extremely rapid, because the system only calculates the network node values once.

In the analysis are choosed wanted parameters of stress – strain diagram and remaining parameters are determined in some manner. A direct analysis to obtain the result used as a training set is performed. Then the neural network back propagation with one or more hidden layers runs. The data are randomized each training pass. Weights are adjusted and then the test and validation sets are run through the network. Proper network generalization is assured by monitoring the test set fitness as training proceeds. Every time a new best set fitness is found, the neural network's configuration is saved. When a better test fitness has not been found for a number of passes or the maximum number of training presentations has been reached the training is terminated.

Formulas presently used for fibreconcrete have not been verified for a wide range of fibreconcrete types and structural sizes. In such cases a spatial statistical distribution of the characteristic material parameters could be helpful to evaluate the parameters characterizing the statistical distribution for a given response of the structure following an inverse analysis problem. The searched parameters here are the mean value and standard deviation of the indeterminate material parameter that define the Gauss density function. The input is an experimental curve load – deflection and the output is the spatial distribution. So, by means of such a procedure it would be possible to determine the distributions for several problems where an experimental analysis is impossible to be realized. For example if the finite elements of the discrete problem are too small, it would be impossible to determine by means of experimental tests the needed parameter.

The probabilistic approach compared to stochastic one could lead more quickly to a solution of inverse analysis problem and thus a better material model could be found. Neural networks seem to be a good probabilistic method, which gives quite soon converged solution and improves the inverse analysis problem solution. The above described approach is also capable to take into account size effects.

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Development of Deflections in Prestressed Concrete Bridges

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Prestressed concrete bridges are very sensitive to long-term increase of deflections. In particular, large bridges (exceeding 100 m span) exhibit in many cases a gradual increase of deflections during a very long time of service life (even after more than 30 years). This phenomenon has paramount importance for serviceability, durability and long-time reliability of such bridges. The costs of reduced service life of structures due to excessive deflections and cracking caused by shrinkage and differential creep can be enormous. This is why a reliable prediction of deformations of bridges during their construction as well as during their service life is extremely important.

There are many reasons for the deflection increases that are usually coupled together. The problem solved is directed to result of them, material aspects being among them. Realistic prediction of concrete creep and shrinkage is a basic requirement for achieving appropriate prediction of deflection variations in concrete bridges. Such an analysis is obviously able to take into account all changes of the structural system during the construction process. The authors developed an Internet page, which makes a creep and shrinkage prediction accessible to designers. The web address is www.fsv.cvut.cz/~kristek. This design tool gives values of creep and shrinkage strain (after filling in the boxes for all data on the concrete) as well as the creep coefficient instantly.

The investigations on the effects of the differential shrinkage and drying creep on time variation of deflections of prestressed concrete box girder bridges were carried out at four levels:

1. a parametric study performed on a bridge segment to investigate the origin and time development of curvatures and axial strains and their coupling and to assess the significance of the both phenomena;
2. an analysis of a model box girder cantilever composed of five segments that were studied individually at preceding level;
3. prediction of time histories of deflections and additional stresses in a realistic long-span prestressed concrete box girder bridge due to the differential shrinkage and drying creep;
4. comparison of the deflection histories measured on several outstanding European prestressed box girder bridges with the values predicted by the available mathematical models.

It has been found from this study that the curvatures of a box girder bridge in the cantilever stage first increase over a long period, but then they reach a maximum and afterwards they decrease. The magnitude of deflections strongly depends upon the flange thickness differences. The maximum deflection is reached at relatively very old age of concrete. After the maximum point, the shrinkage rate of the thick bottom flange becomes greater (eventually much greater) than the shrinkage of the thinner top flange (which has at that time essentially finished its shrinkage). The result is a delay in the onset of significant downward deflections of box girders, which gets shifted to a much later period than it would be expected according to common level of understanding.

Considering that the creep effects play a dominant role in increase of deflections of prestressed concrete box girder bridges, such a process may be - in the case of a rheologically homogeneous structure acting in its final structural system - approximated by the relation, that is based on the difference in creep coefficients considered in the age of concrete at loading and in the age at the investigated time multiplied by a multiplicator.

The intention is to determine such a value of the multiplicator, so that it could be obtained - via the deflection prediction function of increments - the best approximation of measured deflection values as well as of the prediction of deflection variations also during the future bridge service.

Only the first several measured deflection values for the first period of the bridge performance are known. A method to improve the prediction of deflection variations based on short-time measurements was presented. Its use is mandatory for highly deflection sensitive prestressed concrete box girder bridges.

It was considered that the deflection variations are updated only by one parameter. The basis relation may be re-arranged to the form, in which the creep effects (after selecting a suitable creep model prediction) are globally expressed by a known function. According to the well-known normal equations of least square linear regression we obtain the shape of the approximation function.

Realistic prediction of concrete creep is of crucial importance for achieving good assessment of the bridge structural performance. Concrete creep is very complex phenomenon involving several interacting physical mechanisms on various scales of the microstructure, which are influenced by many variable factors. Therefore, a relatively high degree of sophistication in a realistic prediction model is inevitable. An additional cause of the complexity of any realistic model is the need to provide the average effective creep properties of the cross section, which, due to drying, have nonuniform creep properties. A prediction model, called B3 [1], has been shown to give good agreement with the bulk of the test data available in the literature.

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Composite Box Girder Bridges with Corrugated Webs

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New types of composite steel - concrete structures were built in the last few years. The trend to reduce the dead load resulted in the design of structures where the box girder is composed of concrete top and bottom slabs and steel webs. The webs are made of steel corrugated plates or they are replaced by steel truss usually with tubular sections. Advantages of the corrugated steel web, in comparison with a concrete web and a plane steel web are above all the following ones:

- Lower own weight of the structure,
- Effective application of the prestressing force – the corrugated steel web practically does not obstruct introducing of the prestressing into the concrete parts of the structure (so called "accordeon effect"),
- Stability of the corrugated web against buckling – no other stiffeners are necessary,
- Corrugated web is very rigid in the transversal direction, which contributes to high rigidity of the whole cross section,
- Requires less of labour work and shorter time for construction.

For the verification of the statical action of these structures, a parametrical study was carried out, which solved the following problems:

- determination of the relation of rigidities of particular types of structures,
- determination of influence of the structural arrangement of different types of composite structures on their own weight and on the effects of prestressing.

For this reason, four types of structures were compared: fully concrete structure (with concrete slabs and concrete webs) and structures with concrete slabs and with steel plane webs, steel corrugated webs and with webs replaced with steel tubular diagonals. These structures were analysed under actions caused by their own weight, pure normal force, pure bending moment, pure torsional moment and prestressing by strands curved in the vertical plane.

From the point of view of rigidity of the structures, it is possible to create several results:

- from the point of view of the behaviour under a normal force or bending moment acting, the most rigid structure is that with concrete webs, on the contrary the less rigid ones are the structures with corrugated steel webs and with tubular diagonals. These structures behave practically in the same way, which is close to the state, when only slabs act. The difference between the value of normal stresses at the concrete slab of the

structure with plane and corrugated steel webs is approximately 16 % in the case of acting of normal force and approximately 5% in the case of bending moment acting,

- normal streess in the corrugated steel web has the highest value just at the concrete slab, that is caused by the rigid connection between the slab and the web. The web than has to have the same strain as the slab in this area. In the direction toward the neutral axis, the value of normal stresses quickly decreases owing to the pliability o the corrugated web (so called "accordeon effect"). Maximum value of normal stresses in the corrugated web is approximately 30 % higher the maximum value of the stress in a plane web,
- it means, that it is possible to determinate an effective height of the corrugated steel web, similarly as the effective width of concrete or steel slabs caused by the effect of shear lagg,
- from the point of view of behaviour under torsional moment acting, the structures with concrete, plane steel and corrugated steel webs present the same values of shear stresses, that is caused by the fact, that the value of the shear flow arround the box cross section is the same in all the cases,
- values of the longitudinal bending moments in the corrugated steel web present an analogical diagram of the values with values of normal stresses, it means that they rise the maximum value at the connection of the web with concrete slab and they quickly decrease in the direction toward the neutral axis.

From the point of view of the effects of the own weight and prestressing, it is possible to say, that:

- own weight of the all composite structures considered was approximately 25 % lower than the own weight of the fully concrete structure,
- only a minimum difference was found between effects of prestressing on the structure with plane and with corrugated steel webs,
- normal stresses in the bottom slab, caused by prestressing, are at the structure with steel webs approximately 20 % higher and at the structure with tubular diagonals approximately 35 % higher than those at the fully concrete structure. The total compression stress, which includes the influence of the own weight and the prestressing, is at the structure with steel webs approximately 40 % higher and at the structure with steel diagonals approximately 60 % higher than at the fully concrete structure.

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Graffiti Removing from Facades and Their Cleaning

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One of the aims of researchers in the field of experimental aesthetics in relation to facade soiling and cleaning has been to develop a model which predicts the change in ascribed aesthetic value of building facades as they progress through cycles of soiling and cleaning.

Building facades pass through cycles of change as soiling accumulates on the surface of stone. The speed of this change varies considerably as building materials vary in their susceptibility to the influence of weathering, but all material, and so every facade, alters in appearance after long exposure to atmospheric pollution, wind and rain. Research shows that many modern buildings, for example those with exposed precast concrete exteriors or harled surfaces, quickly develop patterns of staining through rainwater run-off which are unrelated to any underlying architectural features and may look unkempt after only a few years. Many old buildings that have developed accumulations of soiling over long periods of time may display an aesthetic quality that enhances the appeal of the building. Indeed, the expectation of some buildings is that they will be soiled (e.g. castles). Soiling on buildings which is either consonant with the underlying texture of the building facade (e.g. that producing shadow like effects on rock faced ashlar stone) or enhances other architectural detail and features can, within certain limits, enhance the aesthetic appeal of buildings. Conversely, soiling which is dissonant with the underlying texture of a building (e.g. heavy soiling which obscures colour) or is unrelated to the building's underlying architectural features tends to be viewed as aesthetically displeasing. Many modern buildings are constructed of materials, or have designs, which do not allow for consonant weathering and soiling patterns. When soiled, they are visually less acceptable than buildings which, through the materials used or design features, allow for longer periods of consonant weathering.

Soiling changes the perception of facades and can be thought of as progressing through a sequence, with facade cleaning interrupting progression and returning the building to an earlier stage in the cycle. On surfaces which have an uneven texture (e.g. rock faced and tooled stone), light soiling initially lodges mainly on horizontal and outermost surfaces of the stone. Similarly, light soiling around architectural detail adds to the visual complexity of the building, increasing contrast and shadowing effects. Verhoef (1988) argues that in northerly cities of Europe, soiling can emphasise architectural designs that for much of the year would be lacking definition due to the absence of sharp, well-defined shadows.

Moderate soiling of building facades can result in a change in the visual appearance of buildings, which interacts with the underlying architectural features or stone surfaces. This type of soiling changes the visual complexity of the building by obscuring some detail, colour and texture, while at the same time adding a pattern of soiling which was originally absent. This interactive effect differs with stone type. On rock-faced and tooled surfaces a heavier build up of soiling may be more aesthetically acceptable than it would be on smooth or polished stonework. While soiling may be initially related to the underlying architectural surface (e.g. in bedding planes of sandstones), patterns of soiling eventually arise which are

unrelated to the underlying detail. Continued soiling eventually leads to a complete blackening of the surface of the building that reduces the visual information of architectural details and obscures the colour and shadowing effects. In effect, the visual complexity of the building is reduced by the heavy soiling on the facade. Entire buildings may progress through this pattern of heavy soiling in a relatively consistent way. Different facades designs and stone types may soil at different rates.

After construction, a building might be thought of as having a certain initial aesthetic quality. After a number of years of weathering, where accumulations of soiling are consistent with the architectural features and the stone texture, complexity is increased and aesthetic value rises to a peak. Thereafter, it begins to decline as soiling increases, becoming unrelated to underlying architectural features. As soiling becomes increasingly heavy, complexity is reduced and aesthetic value decreases to a point where the whole facade is blackened and complexity is at a minimum. The point to which a façade returns, and the subsequent soiling effects, may well depend on the method chosen for cleaning and on the success of the cleaning process; an inappropriate cleaning method may, for instance, affect the initial aesthetic value of the façade.

The relationship between soiling, architecture and aesthetics is complex and is subject to differences of opinion between individuals. The main point is that soiling need not always be aesthetically detrimental and can sometimes be aesthetically beneficial.

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Horizontally Curved Composite Steel and Concrete Bridges

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Introduction

Horizontally curved composite bridges are becoming more common nowadays. They are commonly used on highway ramps and interchanges. The modern solution for these bridges is the curvature of main girders. This curvature deduces additional loads, which must be considered in the structural analysis. The influence of this load depends mainly on the span and the radius of curvature. This effect can be reduced by appropriate number of cross frames. The aim of this work was to develop a new method, which determines the warping to bending stress ratio and lateral deflection of bottom flange. The next outputs are practical recommendations for modeling of horizontally curved composite steel and concrete bridges for structural static and dynamic analysis. The project is divided to four parts.

Verification of modeling technique with modal analysis

Although there are many bridges with curved I-girders in world, there is no bridge of this type in Czech Republic. That is why the continuous straight composite bridge with three spans in Vráž was chosen. Experiment was done with help of Department of Building Mechanics at Faculty of Civil Engineering at CTU. The exciting force generated by electrodynamic exciter was measured by three force gauges. The response of bridge was measured by ten accelerometers in 28 cross sections. The random white noise signal with spectrum 0 to 20 Hz was used. Theoretical spatial FEM model was created in NEXIS software. The web of main girders and concrete desk were modeled by shell elements, both flanges and web stiffeners were modeled by beam elements. Main girder was rigidly connected to the deck by short beam members. Calculated natural frequencies and mode shapes were compared to those, obtained by experiment. Very good correlation between experiment and calculation is a proof, that the chosen modeling technique is correct.

Verification of modelling technique on NUS Experiment

In 1999 prof. Thevendran from National University of Singapore did an experiment, where five horizontally curved I-beams with concrete deck were tested [3]. Each specimen had different radius of curvature. The results from specimen with R=60 m were used in this work for verification of modeling technique.

The computer model was also created in NEXIS software. The web and concrete deck was modeled by shell elements, both flanges and deck-beam connectors by beam elements. The model was loaded by 200 kN force. The geometrically nonlinear analysis was used. The correlation between analysis and experiment was also very good; the average error was between 2 and 3%.

It is a next proof, that the chosen modeling technique is correct and that it can be used for modeling of horizontally curved bridges.

Parametrical study

The parametric study was done for determination of influences of different parameters on warping to bending stress ratio σ_w/σ_b. It was used the same technique, which was verified in

experimental part. Following table shows a summation of created computer models. The total number of created models of horizontally curved bridges was 48.

Bridge span	Radius of curvature [m]	Number of cross frames intervals
L=20 m	R=100, 300, 1000, 2000	N= 1, 2, 4, 5, 10
L=30 m	R=100, 150, 300, 1000	N= 1, 2, 6, 10
L=50 m	R=100, 150, 300, 1000	N= 2, 5, 10

This parametric study helped to understand the behavior of horizontally curved bridges and served as an "etalon" for creation and verification of a new method.

The method derivation

The method is based on assumption that bottom flange acts as a continuous beam on elastic support. It is known, that the lateral load q depends mainly on normal stress in the bottom flange, and radius of curvature. This load act on continuous beam with N spans, which lays on elastic foundation with stiffness C and which is also elastically supported in cross frames locations with stiffness C_{mz}. The bending moments M_c can be calculated on this beam. The formulas for calculation of these stiffnesses and loads were developed. Also the effect of the bending moment M_g, caused by global torsion of cross section was included.

The method verification

The new method was used to calculate warping stresses in the same bridges, which were used in the parametric study. These results were compared with results from FEM models and with results from two approximate formulas. The results obtained by using of new method are very accurate to the results from FEM models. Average difference is usually between 5-10%. These results are also much closer that two approximate formulas (1) and (2).

Conclusion

This article recapitulates the results of dissertation, which deals with the analysis of horizontally curved bridges behavior. The new method for the determination of warping stresses diagram along the bottom flange. The method was verified and the accuracy checked by extensive analysis on number of spatial FEM models. This method is based on elastic principles and it can be used for elastic analysis of composite curved bridges with I-girders.

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Flood Risk Analyst

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In urban areas it is common to start new constructions in areas endangered by floods. This brings increased number of endangered inhabitants and accumulation of risks of potential losses on economic and cultural objects. These areas shall be assessed as flood areas, their active zones shall be determined and the utilization of the flood areas shall be reasonably regulated.

First, we shall analyze the characteristics of the flood development and determine the potentially endangered area. Based on the results, we are able to identify the flood exposure and the prospect of losses and decide upon utilization of specific parts of endangered areas. The risk analyses are essential for making responsible flood layouts and taking short- and long-term measures in the field of flood protection.

The Water-administration office is obliged to determine flood areas based on the proposal of the administrator of a waterway (according to the Water Act). Furthermore, in urban areas and in development areas according to a municipal plan, the Water-administration office is obliged to determine active zones of the flood areas based on the proposal of the administrator of a waterway. The active zone, in compliance with the executing notice , is supposed to be the area that drains the main part of the total flow rate and therefore jeopardizes life, health and property.

Neither the Water Act nor the executing notice states any explicit method to determine active zones. In practice plenty of different methods are used.

Recently, a simulation of a flood situation using a numerical model for a given nominal discharge forms a base for determining the range of a flood area.

Outside urban area, 1D numerical model of free level water flow is feasible. In fact, it is sufficient to determine the inundation line for Q5, Q20 and Q 100.

However in urban areas, using of 1D model is troublesome. Determination of an active zone is based on estimate, better on the inundation line for Q20. 2D numerical model seems more appropriate, since it enables better concept of a potential flood situation. We obtain the water level distribution throughout the analyzed area together with a water flow direction and velocity, which has significant impact on the amount of losses and threat to life of citizens. Such data enable us to quantify better the extent of risk for different types of objects and determine precisely the possible economic losses.

Geographic information systems (GIS) make processing of flood areas easier and faster. They enable the data analysis and further presentation to experts and general public. Results can be easily brought up to date. Further, results can be interconnected with other information sources (e.g. real estate cadastre, registry office) and utilized actively during possible flood situation.

For this reason, we started to develop the extension for ArcGIS with working name flood risk analyst, „analyzátor povodňových rizik“ (APR) at the Department of Hydraulics and Hydrology.

Flood risk analyst enables fast post-processing and analysis of results from numerical models. Input data are text inputs from a 2D model (for every design point: x and y coordinates in a chosen coordinate system, water level dimension, velocity dimension in the direction x and y) or from a 1D model HEC-RAS (export file for GIS applications) and digital model of a terrain.

We use various types of maps according to required outputs, e.g. 1:10 000 maps, ZABAGED, ortophotomaps, cadastral maps, registry office.

After data loading, the water surface layer is generated using a chosen geo-statistical method or method for creating the digital terrain model. Then, the raster layer of depths is constructed as a difference between the water surface layer and the digital model of a terrain. Furthermore, the APR generates the raster layer of velocities and the layer with depicted velocity vectors, based on input data. Raster size can be adjusted as needed; base size of the raster is 2x2 meters.

The next step is the risk analysis. The APR enables to determine the rate of flood risk in dependence on depths and velocities for various types of objects or criteria (constructions on solid foundations, persons, children) using methods by different authors (e.g. Fink & Bewick, Black, ACER, Petraschek). These criteria were expressed analytically for the need of computer processing. Based on compiled equations and using functions of the raster calculator of the Spatial Analyst (extension for ArcGIS) that enables to execute mathematic and logic operations with raster data, the APR generates particular thematic layers for each of a chosen criterion.

Based on previous experience, connection of a map of risk areas according to Fink & Bewick and a map of velocity vectors brings the best results for determination of an active zone. Such connection enables to define the most endangered areas. Present vectors help to connect single areas of danger, but to preserve main outflow ways. Thematic maps of danger for people and children are suitable as additional criteria. None of the criteria itself specifies the active zone exactly, of course. A single criterion cannot include all possible situations that can occur, since it offers solid backgrounds for an expert decision.

The APR outputs enable comparison of different solutions of flood protection from the point of restriction of areas with a high risk.

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Multiobjective Optimization of Structures

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Nowadays rapid growth of computer performance enables new developments in Civil Engineering and related areas. Especially within the field of structural mechanics, the modeling of individual materials and therefore the prediction of structural response is more accurate than in past decades. However, development in the design of structures does not reflect the above mentioned progress. Hence, our effort is to develop a robust design tool for reinforced concrete frame structures and to raise traditional design methods to a more effective level.

Every design, as such, is actually an optimization task, where the designer, in agreement with his experience, constraints and principles given by standards or Codes of Practice, is choosing the most suitable solution. From an algorithmic point of view, this problem is usually handled with single criterion optimization. Multi-objective nature is then resolved via summations, different weighting methods, penalty approaches, etc. For example, the author of this contribution used in his previous research [1] the total price of a structure as the unifying variable among different antagonistic constraints. As an unfavorable result, however, the multi-modal behavior of the objective functions is obtained and difficult to solve. On the other hand, there is a possibility to use so-called multi-objective methods, which, in general, solve the problem as a whole in terms of selected constraints and/or objectives. The multi-objective approach is based on an idea of dominating solutions, i.e. there is no solution that is characterized by the better values of all objective functions than the dominating one, called Pareto optimum. A set of these solutions is called a Pareto front. This idea can be then included in any of stochastic optimization tools, usually in the form of independently stored population of Pareto solutions. New solutions are then selected and/or replaced depending on their distance from the already found Pareto front.

The difference between single and multi-objective optimization is not only at the programming level, but also in the system of gathering information from an output. While in the case of the single-objective optimization, the designer is forced to use usually one global optimum found by any algorithm, in the latter case there is a set of different solutions and the designer can simply decide and choose the appropriate structure. After the selection of objective functions, the total price and maximum deflection in our case, the studied problem is to be defined. It would be highly desirable to solve the whole design problem as one optimization task but the number of all possible solutions is too high for realistic frame structures. Therefore, it appears to be inevitable to split the process of structural design into two parts - the detailing of a reinforced concrete *cross-section* and the optimization of a *whole structure* in terms of basic structural characteristics such as types of materials, dimensions of elements or profiles of steel bars. The main goal of the first part is to fit an interaction diagram of a RC cross-section to a given combination of load cases. Efficient procedures for fast evaluation of internal forces for a general cross-section and stress-strain relationship were proposed in [2]. This task, for a given reinforcing bar diameter, is then reduced to simple checking of admissible combinations of reinforcements. The second part of a frame design focuses on the proportioning of building blocks. The goal is to find the best combination of

discrete inputs. The aim is to simultaneously optimize the total cost of the structure as well as the maximum deflection of structural members. For the single objective case, our experience [3] shows that a modified version of the genetic algorithm based procedure called the Augmented Simulated Annealing method is capable of solving this combinatorial task. In this contribution, the multi-objective approach is introduced to tackle several conflicting objectives. The Strength Pareto Approach algorithm (SPEA) [4] is used for the determination of trade-off surfaces for two selected criteria. The key ideas of this algorithm can be summarized as follows: storing non-dominated solutions externally in a second, continuously updated population, fitness assignment with respect to the number of external non-dominated points that dominate it, preserving population diversity using the Pareto dominance relationship and incorporating a clustering procedure for reduction of the non-dominated set. Moreover, all these features are actually independent of the form of crossover and mutation operators. Therefore, it is possible to use operators developed for the single-objective optimization problem [3] without any changes.

The results of the SPEA algorithm revealed that there are several non-dominated solutions for the solved examples. It can be concluded that even for these rather elementary design tasks, Pareto-optimal fronts are non-convex and non-smooth due to discrete nature of the optimization problem. These facts justify the choice of the selected optimization strategy and suggest its applicability to more complex structural design problems.

In the undergone research, a computational strategy for multi-objective optimal design of reinforced concrete frames was introduced. The procedure essentially relies on the efficient evaluation of internal forces applied to fairly general cross-sections and constitutive laws [2]. The performance of the selected solution strategy is demonstrated on illustrative examples. In the future, analysis of more complex structures together with implementation of the present algorithm into the C++ FEM code SIFEL will be considered.

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Use of Artificial Neural Networks for Control of Watertreatment

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Of the many processes and operations used in water treatment, coagulation and floculation require a unique combination of chemical and physical phenomena for producing a water acceptable for human consumption. These are essential pretreatment processes for the removal of finely divided particulate matter which will not settle out of suspension by gravity in a economical time frame. Aggregation of fine particulate matter into larger particulates by the use of coagulation and flocculation facilities permits cost – effective removal in subsequent solids separation processes.

Fine particulate material is removed from water by addition of inorganic chemicals that accelerate the aggregation of the particulates into larger aggregates. The chemicals used in this process include metal ions such as aluminium or iron, which hydrolyze rapidly to form insoluble precipitates, and natural or synthetic organic polyelectrolytes, which rapidly adsorb on the surface of the particulates. These aggregates are then removed from the water by sedimentation, flotation, or filtration through granular media.

Selection of the type and dose of coagulant depends on the characteristics of the coagulant, the particulates, and the water quality. The interdependance between these three elements is understood qualitatively. Prediction of the optimum coagulant combination from characteristics of the particulates and the water quality is not yet possible. As consequence, each coagulation problem must be solved empirically. Traditionally, optimum coagulant doses are determined using jar tests. However, jar tests are relatively expensive and take a long time to conduct. In addition, as a result of the length of time it takes to conduct jar tests, they cannot be used to respond to rapid changes in raw water quality and thus are not suited to real-time control [1].

In recent years, artificial neural networks (ANNs) have shown some promise for modeling water treatment processes. The main advantage of ANNs compared with more traditional data-driven approaches, such as regression analysis, is that they are highly non-linear, universal function approximators.

In the first stage of our research we have focused on the control of the coagulation-flokulation-sedimentation process, which can be considered as a separate part of the whole water treatment process. In the following research further independed processes are intended to be included (filtration, disinfection). Coagulation process is continuous and it includes design of the proper coagulant dose.

To control the coagulation, flokulation and sedinemtation process the Internal Control Model (ICM) concept was used. Basic idea of this model was established by Garcia a Morari [2] for linear multidimensional system. For non-linear systems was concept of ICM firstly used by Ekonoma and Morari [3]. The principle of the ICM is based on cooperation of two independant mathematical models, where the first one represents the simulation model of the studied process (process model) and the second one is the control model. The system can be often extedned by filter, which works as the preprocessor of the input data.

Significant feature of the ICM is given by the inverse character of both the models [4]. The control model is constructed as the inverse system to the process model. This feature can be easily kept in the case of linear systems and the application on the non-linear systems is obviously difficult. For this non-linear systems the neural networks technology presents very useful tool to perform both the simulation and the control model. Control system (ICM) can be derived from sufficiently long historical data. It should be point out that this sufficient amount of data should contains all the reprezentative states of the system to be control to allow the neural networks learn from history. This operation measurements of the plant should contain appropriate control action also. In our case the control action is given by the coagulant dose.

For design of the neural process and control model it is very iportant selection of input variables, which affect all the processes iside of the chemical reactor. The user do not have to solve mathematical formulation of processes, but he should supply complet list of circumstances which completely drive the studied process. In our study following variables were evaluated as most important: inflow to the water treatment plant, COD, air temperature, pH and the coagulant dose $Fe_2(SO_4)_3$.

Described ICM concept was implemented to control the Plav water treatment plant in South Bohemia. The control system was calibrated on the data from the period of 2001 and 2002. Consequently was the model tested on the data from 2003. The results can be considered as very heartening and we intend to include further processes in water treatment.

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Accuracy Evaluation of HP 3852 System for Measurement of Engineering Structures

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Aim of the present study is to evaluate an accuracy of dynamic measurement of data acquisition system Hewlett- Packard 3852. The assessment of the accuracy is of most importance for measurements on most structures in civil, mechanical and transport engineering. Some accuracy evaluations of dynamic measurements have been realized recently [1], [2].

The accuracy of A/D converter in high speed voltmeter HP 44704A (plug-in card, 16 bit, 100 kSa.sec^{-1}, noise rejection for gain 1: 70dB) has been tested. Also the influence of presence of plug-in measuring modules in mainframe has been evaluated. Transfer of data to PC Pentium was enabled by GPIB (IEEE-488) interface. The data were analyzed by software package LabWindows CVI 5.01. The accuracy of measured signal was expressed by effective number of bits (ENOB). The signal was connected to multiplexed input HP 44711A (plug-in card, high-speed FET multiplexer, 24 balanced channels, cross-talk between channels 35 dB, sampling frequency 100kHz); signal was harmonic (77.77 resp. 61.035 Hz) generated by precision, ultra-low distortion synthesized signal generator (Stanford Research System DS-360). It has been found that the effective numer of bits depends on sampling frequency and gain. The results are shown in the Table 1.

Table1 Accuracy of measured harmonic signal, HP 35852 system, no plug-in modules in mainframe

	Scale	10.24 V	2.56 V	0.32 V	0.040 V
	Gain	1	4	32	256
Sampling frequency [kHz]	Testing Frequency [Hz]	Number of effective bits	Number of effective bits	Number of effective bits	Number of effective bits
100	77.77	14.45	13.36	13.18	10.98
50	77.77	14.45			
20	77.77	14.46			
10	77.77	14.58	13.40	13.21	11.07
5	77.77	14.58			
2	77.77	14.59			
1	0.777	14.60	13.39	13.17	10.98
0.5	0.777	14.58			
0.2	0.777	14.58			
0.1	0.777	14.56	13.38	13.18	11.00

Transfer of data has been realized by 2 types of IEEE-488 interfaces: HP 82335 (Hewlett-Packard) and GPIB-PCI (National Instruments). In case of HP 82335 the SICL (Standard Instrument Control Library) has been used. It has been found that the type of interface (HP or NI) doesn't influence the measured data.

Table 2 Accuracy of measured harmonic signal, HP 35852 system, plug-in modules in mainframe

	Scale	10.24 V	2.56 V	0.32 V	0.040 V
	Gain	1	4	32	256
Sampling frequency [kHz]	Testing frequency [Hz]	Number of effective bits	Number of effective bits	Number of effective bits	Number of effective bits
100	61.035	13.13	11.19	11.04	9.77
50	61.035	13.16	11.18	11.08	9.80
20	61.035	13.17	11.21	11.06	9.88
10	61.035	13.14	11.16	11.03	9.80
5	61.035	13.14			
2	61.035	13.14			
1	61.035	13.14	11.18	11.03	9.81
0.5	61.035	13.14			
0.2	61.035	13.14			
0.1	61.035	13.14	11.17	11.04	9.80

Conclusions:

The dependence of signal noise (effective number of bits) on sampling frequency and gain has been evaluated. The influence of presence of plug-in measuring modules in mainframe has also been evaluated. It has been found that the effective numer of bits is strongly influenced by gain (13.36 vers. 10.36) for mainframe free of plug-in modules resp. (13.13 vers. 9.77) for system full of plug-in modules. Effective number of bits is almost independent on sampling frequency; max. effective number of bits has been obtained for max. sampling frequency.

It has been proved, that the system HP 3852 has sufficient accuracy for dynamic measurements of engineering structures with some limitations described above.

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Genetic Algoritms in Optimal Design and Optimal Control of Non-linear Structures

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To design modern structures it is often necessary to consider different non-linearities, either in material modeling or geometric behavior of structures. The latter one could arise for example from subjecting a given structure to large displacements and rotations. Then the construction phase, when particular components are placed to total structural assembly by large motions, should be also placed under control. Ever increasing economical demands require that the problem of optimal design and optimal control be placed on a sound theoretical and computational basis. Namely, optimization methods can be called upon to guide the design procedure and achieve the desired reduction of mechanical and/or geometric quantities. Similarly, the control methods are employed to provide an estimate of the loads and the minimal effort in placing the structure, or its component, directly into an optimal (desired) shape.

Both of these tasks, optimal design or optimal control, can be formally presented as the minimization of the chosen cost or objective function specifying precisely the desired goal. The main difference between the two procedures concerns the choice of the variables defining the cost function: the design variables are typically related to the mechanical properties (e.g. Young's modulus) or geometry of the structure (e.g. particular coordinates in the initial configuration), whereas the control variables are related to the loading applied on the structure in order to place it into desired position. Rather then insisting upon this difference and treating the optimal design and optimal control in quite a different manner (as done in a number of traditional expositions on the subject), we focus on their common features, which allow a unified presentation of these two problems and the development of a novel solution procedure applicable to both problems.

In our research we focus on exploration of two different formulations of the previously mentioned coupled problems. The first approach, the traditional one, considers optimization problem and the problem of nonlinear mechanics separately on two different levels of solution. On the first level, an iterative optimization method is used to solve the problem of optimal design or optimal control. For one evaluation of cost function for a given variation of design or control variables, other procedure at the second level of the solution procedure is called. Again, an appropriate iterative numerical method is used to get corresponding displacements and rotations. These are sent back to the optimization process and with them the cost function is evaluated. It is possible to say that the communication between the programs on these two levels is reduced to a mere minimum: so-called sensitivity for optimization code and design or control variables for the finite element code for mechanics. From an optimization point of view, the nonlinear mechanics equilibrium equations are reduced to a mere constraint with respect to the admissibility of a given state of the structure, i.e. its displacements and rotations.

The second approach uses the traditional method of Lagrange multipliers (e.g. see [4]) to solve the problem of optimal design or control and of the non-linear mechanics simultaneously. The mechanical equilibrium equations are promoted from constraint to one governing equation to be solved in a coupled problem of this kind, and the intrinsic

dependence on state variables (displacements and rotations) with respect to optimal design or control variables can be eliminated turning all variables into the independent variables. For the sake of clarity, this idea is also developed within the framework of a discrete, finite-element-based approximation, thus providing the finite element model including the degrees of freedom pertinent not only to displacements and rotations, but also to optimal design and/or control variables. A detailed development is presented for the chosen model problem of 2D geometrically exact beam (e.g. see [3]).

As an optimization algorithm, the method based on genetic algorithms is used. In particular, we employ the SADE algorithm (e.g. see [1,2]) and its modification called GRADE, which uses cross-over operator based on a simplified gradient. Two simple examples of optimal control (for traditional formulation) were tested with both optimization algorithms and it was proved that the GRADE algorithm is more efficient.

Then the comparison between traditional and simultaneous formulations is performed on optimal control and optimal design using the GRADE algorithm. During the solution, the two principle characteristics of each approach come out. The first one is the number of optimized variables. The traditional approach considers as independent variables only design or control parameters. On the contrary, within the simultaneous approach, among optimized variables are included also Lagrange multipliers, displacements and rotations and that implies a more complex optimization process. The second difference is the evaluation of a cost function. At this point the simultaneous approach is much more efficient, because in this case for a chosen variation of all its variables only a residuum composed of equilibrium equations and other criteria defined in cost function is evaluated without any iterative process. Using the traditional approach, for one evaluation of the cost function it is necessary to call other iterative process to solve equilibrium equations and that significantly increases the overall time of computation. For all chosen examples of optimal design or control, simultaneous formulation brought better results, both in terms of precision as well as computational time.

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Information System Public Construction Contracts

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Information System Public Construction Contracts is part of Research plan our department, I am working on creation design of this system. Similar system is already working on internet address www.centralni-adresa.cz and serve to public all public order's and auction. But is unusable for specific building order's, because does not contain some basics specifications. This system does not use for scheduling realization building orders and proposal portfolio of project public construction contracts.

Designed system

Basic demand on information system was set thus:
- Easy accessibility
- Simple operation
- Well-arranged provided information and their topicality
- Low purchase price and operating costs

Like optimal solution of these demands is show database operating at internet.

Information system would hold following information:
- Name of submitter, ICO, address, contact info.
- Object of order, method of submission OVS, evaluative criteria, number of received offers, most high and lowest supply price.
- Information about selected contractor – name, ICO, address, supply price.
- Date conclusion of a contract, contracting price, termination date.
- Evaluation of order – real price, real termination date.
- Supply budget in electronic shape (in specific data format).

From designed system is already two segment realized and was run in test operation at Internet address www.vsz.cz. But because this internet address was only lend for one year is not working now. From designed system isn't realized segment witch gathering tendering budgets yet.

Data entry is fragmented to the three phase:

- At publish contest (OVS)
  - Information about submitter (name, ICO, address).
  - Information about order (object of order and its description, range of order, point
  - of delivery and contact person).
  - Information about contest (competitive time, evaluative criteria, date, time and place opening cover etc ..).

- After subscription of contract
  - Information about process contests (number of received offers, most high and

lowest supply price).
  - Information about selected contractor (name, ICO, address, supply price].
  - Information about contract (date conclusion of a contract, contracting price and termination date).
- after termination of order
  - data about order (real price, real termination date)

This new information system serve significant benefits for submitters also for potential contractors. Should has been this information system finished and supplement for public building orders already operating information system on www.centralni-addresa.cz, it would great effect in using public resources

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The Internet Capabilities in Civil Engineering

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All companies using Internet as an integral part of their businesses activities are international. The successful Internet companies will achieve a benefit for owners, general and specialty contractors, architects – engineers, distributors and product manufactures. Shorter schedules and lower costs through project portals can be benefit for owners such us more detailed documentation being made at these portals can be helpful. Better information about the progress and better control of project costs can be benefits for the general contractors. Wider exposure of general contractors and others are benefits for the specialty contractors. Architects – engineers can be benefits in preparation and documentation of construction services and projects designs. Talented architects – engineers, developers and marketers located anywhere in the world can create a virtual better qualified teams collaborated on specific projects despite being thousands of kilometers apart and work more effectively while minimizing time, distance and organizational barriers. The distributors of manufacturer products are an integral part of the delivery chain via Internet and decrease cost of the products which are benefits to owners.

Definition

- CommerceNet – non profit industry organization set up to accelerate the transformation of the Internet into an open marketplace. Its members worldwide include hundreds leading banks, electronic firms, telecommunication companies, Internet Services Providers, providers of on-line services, on-line software and services companies.
- Commerce Server – Web server specializing in managing and supporting a company's electronic buying and selling processes. The server must be able to accept messages, data, transaction inputs and results from the other servers. An electronic commerce environment requires the following components:
  - Digitally formatted content and services.
  - Merchant services.
  - Transaction management.
  - Payment mechanisms.
  - Order fulfillment.
  - Customer service and support.
  - Data reporting and analysis.
- Cryptography – mathematical discipline of coding (encryption) and decoding (decryption) messages. Encryption (enciphering) converts data into an unintelligible numerical form; decryption (deciphering) converts the cipher back to its original form. The oldest and best-known technique for encrypting data is DES – data Encryption Standard. DES is a symmetrical cryptographic scheme (both sides in a transaction must use the same electronic key values to encrypt and decrypt messages). An asymmetrical key process allows each party to use a different key require a third party - a key certification authority.
- Digital Markets – virtual markets (iMarkets – Internet markets) that are mediated by the Internet. Electronically mediated transaction take place at marketspace.

- Digital Signatures – a code attached to an electronically transmitted message that uniquely identities the sender. It is an encrypted description of the contents of an electronic document.
- Electronic Commerce (e-commerce) – the general term for Internet processing of a growing variety of transactions. Internet business models can take many forms and can provide services, content, products, or its combinations.
    - B2B - business to business activities typically associated with e-commerce in Civil Engineering's industry. Businesses are the customers of the Internet companies and are provided services that enhance their competitiveness.
    - B2C - business to consumers are based on selling services or consumer products to the general public.
    - C2C - customer-to-customer transaction via the Internet.
    - C2B – customer-to-business - the most important activities (checking, comparing, analyzing quality and price before baying) in e-commerce.

The Challenges

- Development of codes and standards to eliminate the trade barriers on products and services.
- Resolve the issues of Internet taxation.
- Decrease cost of the Internet connection for consumers in the Czech Republic.

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Behaviour of Perforated Shear Connector in Composite Steel and Concrete Structures

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At the Department of Steel Structures of Czech Technical University (CTU) in Prague many experiments (push-out tests) were carried out during last years with perforated shear connector for composite steel and concrete beams. There were used shear connectors of the 50/10 [*mm*] with 32 *mm* inside openings and connectors 100/12 [*mm*] with 60 *mm* openings. Moreover the smaller connectors were tested in four modifications of their position as: simple connector and parallel arrangement of connectors, which have mutual distance 100, 150 and 200 *mm*. As the bigger connector is determined mainly for bridges also fatigue tests are in progress.

Composite steel and concrete structures are widely used in civil engineering during last period. The main advantage of using of composite beam with concrete slab in compression and steel girder in tension is well known. Nevertheless there is a never-ending problem how to provide the strong and simple shear connection between concrete part of girder and steel one and how to determine its behaviour.

There are many types of shear connectors used for steel and concrete structures in Europe and in the Czech Republic at present day. Headed shear connectors are most popular now for their relatively simple applications and good static appearance. The design data are collected and standardized in Eurocode 4.

All the time new ideas are presented in the field of shear connectors. One of them is perforated shear connector originally developed by Leonhardt (1987) in Germany. The additional research of perforated connectors with two different sizes of openings has been carried out at CTU since 1990's, see [1]. Author aimed his effort to deeper investigation of behaviour of these connections in reinforced concrete exposed to static loading. This paper is mainly focused on perforated shear connector with opening 32 *mm* in diameter in basic arrangement from view of numerical simulation.

Standard push-out tests are extremely expensive if we take into account minimum quantity of experiments, which are necessary for statistical evaluation. By the reason numerical model of such a test is being prepared.

Rapid development of computer technologies allows creating methods suitable for modelling problems with material nonlinearities as well as contact problems. Among wide range of these methods FEM (Finite Element Method) seems to be best fitting for push-out tests with perforated shear connector.

In our case numerical simulation sets itself a task to confirm results obtain from former experimental research, i.e. to prepare model, which, after calibration, can fully substitute tests in labs. On the basis of the model parametric study of perforated shear connector with different degree of reinforcement and concrete strength in compression, eventually shape and spatial arrangement modification, will be carried out.

Numerical model consists, due to symmetry along two perpendicular planes, of a quarter of standard push-out specimen connected with perforated connector with 32 *mm* inside openings. All phases of numerical analysis (pre-processing, processing, post-processing) are made in FEM program ANSYS.

Due to material nonlinearity of both steel and concrete parts it was necessary to focus on behaviour not only by uniaxial state of stress, but also triaxial one, see [2], [3]. Problem of concrete behaviour comparing to steel is much more complex. Basic difference between steel and concrete is obvious by uniaxial state of stress. Steel is characterized in that stress-strain diagram is identical in tension and compression, while concrete has significantly different behaviour in tension and compression, see [4].

Steel parts (steel girder and connector) were modelled using material model - multilinear elastic stress-stain relationship. The most suitable element for steel seems to be 4-node element SHELL41 with 3 DOF (translation in x, y, z direction). The element allows simulating plastic behaviour and can be exposed to load acting parallel to its own plane.

In our case below mentioned material model for concrete was used - multilinear elastic stress-stain relationship for uniaxial state of stress and combination of several plastic criterions (as Drucker-Prager, Chen and Rankine criterion) for biaxial state of stress. Far and away element with ability to cracking in tension and crushing in compression is 8-node element SOLID65, which was used for reinforced concrete slab modelling. Very important feature of SOLID65 is a possibility of reinforcement inside element by smeared rebars. We took advantage of it for reinforcement in directions that do not influence shear capability of perforated connector. In odd direction perpendicular to plane of connector 2-node element LINK8 was used to simulate real, non-smeared reinforcement. Both elements SOLID65 and LINK8 have 3 DOF (translation in x, y, z direction), which ensures numerical stability of the whole model, see [4].

Nowadays numerical simulation of standard push-out test is in the last phase of verification. The most important characteristic is following relationship - applied force versus slip between concrete slab and steel girder. Next step is comparing experimental data and data obtained from FEM analysis. All results will be part of author's PhD thesis.

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Steel and Concrete Composite Integral Bridges

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Research into the behaviour of steel and concrete composite integral bridges has been carried out at the Department of Steel Structures at the Czech Technical University (CTU) in Prague for three years. The way to design these structures is being investigated and a program for integral bridge analysis is being developed.

Traditional beam-type bridges include expansion joints and bearings in order to accommodate the thermally induced movements. As practice shows, these structural members are the most vulnerable points in highway bridge construction. Using of de-icing salt contributes to wear of these members and the insufficient maintenance causes breakdowns, which may affect behaviour of a structure and therefore require expensive remedial works.

In case of integral bridges there are no expansion joints and no bearings between the superstructure and the substructure and no movement joints between parts of the superstructure in case of continuous integral bridge. The initial costs of these structures are lower and less demanding maintenance is required. Removing these members is convenient but also may cause problems.

Compared to the behaviour of traditional beam-type bridges, the behaviour of integral bridges is more sophisticated because of the structure – soil interaction. This interaction must be taken into account when designing an integral bridge. Also cyclic loading of the abutment embedding soil should be considered.

Frame abutment integral bridges with rigid beam – abutment connection has typical structural configuration. Rigid connection can be achieved by designing a reinforced concrete pile-capping beam. The abutments of an integral bridge has to be sufficiently flexible in order to accommodate thermally induced movements so steel abutments are normally designed. Separately acting (single) piles for supporting a deck beams and/or sheet piling or high modulus piles creating a wall can be used. Other information about integral bridges and typical structural arrangements can provide [1].

As mentioned above, the integral bridge removes the problems associated with bearings and expansion joints that may occur when no or insufficient maintenance is carried out. From analyses cited in [2], the purchase costs of an integral bridge in comparison with a "non-integral" bridge are less. Considering the maintenance costs and the financial losses due to traffic difficulties when repairing the structure, it is obvious, that for medium span lengths, the integral bridge should be suitable solution.

In addition to the economic advantage, other advantages are:

- the structure is more resistant to accidental load action or earthquake;
- bridge erection is quicker;
- there is no water leakage to lower parts of the structure (which removes the problems associated with using the weathering steel).

Removing bearings and expansion joints also means that the deck of an integral bridge does not act separately. Whole structure including bridge abutments and especially surrounding soil must be analysed because of the deck-abutment connection. This means that the analysis and also design of an integral bridge is much more complex compared to similar "non-integral" beam-type bridge. Considering the amounts of construction and project costs it is obvious that the design complexity is not so important.

As mentioned above, the computer program is being developed to simplify integral bridge analysis. Soil – structure interaction and also non-linear soil behaviour is taken into account. The analysis is based on an iterative calculation of displacements in discrete points of the abutment. Spring model of abutment surrounding soil was chosen. Comparison of methods of geotechnical analysis is possible to find in [3]. Response of the soil corresponds to stress-strain curve of the soil defined by the user. Different types of this relationship can be defined.

Program Feat 2000 developed by SCIA s. r. o. is used for creating of a structural model and for structural analysis.

The durability of many of the highway bridges built in the second half of the last century in the Czech Republic has not reached the designed lifetime and they need expensive repair works. Integral bridges can be an alternative solution for short or middle span length bridges. Since these structures remove the problematic components even as bearings and expansion joints, they should not require expensive maintenance. The integral bridges are not common structures in the Czech Republic. For more information about the first integral bridge in the Czech Republic see [4].

Nowadays the computer program mentioned above is being developed which is the main aim of the author's PhD thesis.

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Brownfields Regeneration Strategy

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During the last decade the problem of brownfields is very sensitive for most of the industrialized countries. The same is valid also for the Czech Republic where the consumption of virgin land (greenfields) for new construction is very high for growing purposes of trade, infrastructure and house building. At the same time former industrial, mining, agricultural and military used sites lost their function and became derelict.

Number of brownfields is very difficult to estimate, because there is no an accepted and agreed definition of brownfields. But very broadly we can estimate the number of places and total area as a comparison with countries as Belgium or last East Germany. Nathanail et al (2003) indicate that the current estimate of brownfields in England is 66 000 ha, for Germany 128 000 ha, Netherlands 9 – 11 000 ha, Belgium/Wallonia – 9 000 ha but point out that comparisons are difficult because of the different definition used in each country.

To react on this situation some countries are trying to define some policy toward this problem. For example UK defined target 60% of all new housing on brownfields, Germany estimate that roughly 122 ha of greenfields are lost per day, with the target to decrease this number for year 2020 to 20-30 ha per day.

Encouraging the reuse of the formerly developed and/or industrially contaminated land raises complex issues that require multidisciplinary solutions and integrated management strategies. The EC funded "Concerted Action on Brownfield and Economic Regeneration Network – CABERNET – was established in January 2002 to enhance the regeneration of brownfield sites by developing an intellectual framework to structure ideas and stimulate new solutions. Definitions of CABERNET are as follows:

Brownfield sites have been defined as:

- have been affected by the former uses of the site and surrounding land,
- are derelict or underused,
- have real or perceived contamination problems
- are mainly in developed urban areas,
- require intervention to bring them back to beneficial use.

In the Czech Republic there is no special ministry responsible for coordination of the process connected with priority utilization of brownfields for new construction or for redevelopment although the Ministry for local development is playing main role up to now. Team of the Research Grant "Environmental Aspects in Civil Engineering" has the advantage of the wide variety of specialists, to be able to help to solve this multidisciplinary problem. Up to now main activities are connected with environment geotechnics but the point of view of architects, town planners, sociologists and economists is also ensured.

Roughly we can estimate three basic areas with brownfields in the Czech Republic – Vanicek (2003).

- Prague – has a special position because the developers are looking to find the appropriate places for new constructions in the capital of the Czech Republic,
- Old industrial cities – Ostrava, Plzen, Kladno.. – there are many regions where heavy industry as metallurgy were stopped and these regions have a different degree of contamination of soils and underground water,

- North – Bohemian Brown – Coal Basin – this area is strongly affected either by huge amount of clayey deposits, which are excavated and stored before mining of brown coal or by large amount of other waste materials as flying ash from electric power stations or as chemical waste materials from chemical factories situated there. Again with high potential of contamination.

The decision making process whether to use greenfields or brownfields for new construction depends on many different factors. Some of them were mentioned previously – Vanicek, Chamra (2001) and these factors are connected with needed support from the public sector – municipality or state support – so we can distinguish between sites with private planning, public-private partnership or with public planning.

According to Voltagio (2001) the process of redevelopment can be divided into seven basic stages:

- Site identification,
- Initial site assessment (Phase I Investigation)
- Economic assessment
- Detailed site assessment (Phase II Investigation, if required)
- Project development and financing
- Cleanup planning and execution
- Redevelopment of property

To attract the developers to use brownfields the owner, very often the municipality, has to declare not only that there is the brownfield site but also which stages of the process of redevelopment were done in advance. The economic assessment is after that easier and quicker and the decision can be as quick as for greenfields.

From the above mentioned 7 stages you can see that the role of civil engineers and especially Geotechnical engineers is very important, due to the fact, that

- Site investigation (Phase I and II) and partly Site identification,
- Remediation
- Foundations of new structures

are falling in charge of classical or environmental Geotechnical engineering. Therefore the orientation of our research is on these above-mentioned stages and we are fully prepared to cooperate with municipalities to prepare as much information as possible. First practical experiences from this cooperation were obtained for Rokycany town and new strategy is prepared for towns in North parts of Bohemia.

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Soil Water Balance in the Medieval Three-Field System

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The origins of the Bohemian Forest villages are broadly connected with medieval arable technological improvement. Geographical settings of terraced field systems are discussed within the broader context of landscape occupation history. Since Medieval ploughing technology was developed, field complexes have been composed of bundles of parcels (terraced fields), which are usually formed in strips. The long and continual development of arable land has influenced the physical properties of the soil. Hand-in-hand with soil skeleton sorting and removal, the humic topsoil had been translocated and accumulated at the field edges. This paper deals with soil hydrology as well as environmental archaeology. We aim to describe the soil water regime on the terraced field complexes. The soil water balance has been observed since August 2001. Soil water tensiometers have been installed on four places in two field systems. The suction head recorded is in direct relationship to the soil moisture. The precipitation, transpiration and leakage totals, depicted in the charts in cumulative form, show the soil water regime stages. The parallel terraces were built by shoving humic topsoil. According to their soil structure, soil water storage of this pedon is strikingly higher than that of the other ones. Moreover, the accumulation stage prolongation is typical for the soil water regime here. The radial type of field complex shows more types of soil water regimes. Accumulation stage prolongation is not so visible, only leakage total has decreased in comparison to daily transpiration totals. The interpretation of former arable field terraces in the system of the Medieval and Early Modern period together with three other field systems are discussed in terms of traditional land use and the colonization of the forest. The process of functional change from arable fields into pastureland probably started in connection with climate deterioration in the 17th Century.

The water regime was constrained by the sorting of the soil skeleton during agricultural activity and the hardening of the edges with sorted out stones. As a result of single direction ploughing the topsoil was reconfigured and the soil was generally modified in each diagnostic horizon. Those changes in soil profile significantly influenced water transport and its efficiency for evapotranspiration. The water regime of soils is studied by tensiometry, which is the most frequently used method of continual soil water monitoring today. Here a suction head measures frequency at intervals of one or two days according to the relation expressed by the van Genuchten function. The thus expressed dynamic of soil water and hydraulic capacity defines the ability for water retention. A single direction model based on Richards's equation also simulates the soil water regime. It is represented by the quantification of the particular balance components of the water regime. The soil water regime was designed for warm, moderate and cold vegetation seasons. Concurrently actual data from tensiometrical measurement were evaluated.

The hypothesis about the rising water retention of terraced fields has been validated. The parallel terraces of the Hnojnice site system shows marked enhancement of the soil water

supply, but proportionally according to the soil profile thickness. The influence of the radial terraces of the Řepešín site on the water regime is obvious in several aspects. First of all through a reduction of soil profile thickness under askant-arranged stone edges. This creates a zone of infiltration, which, in comparison to standard soil, decreases the general soil water supply. Secondly, it enables rapid water passage through the soil profile. The accumulation of more humic topsoil on tangentially oriented terraced fields in Řepešín is not as large as in the case of the Hnojnice parallel terraced site. However, significant modification of water passage relations has been recorded in marginal areas of the Řepešín radial field system, where the edges between the fields diverge in sub-radial fields. Despite the considerable altitude and extreme slopes the soil water regime was optimalized and made farming possible.

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Experimental Investigation of Mechanical and Physical Properties of Sandstone

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It the laboratories of Klokner Institute several tests of basic mechanical and physical properties of sandstone material were performed. Sandstone masonry units were employed in many historical structures built in Middle Ages. These characteristics will be used as input data for numerical modeling on arch stone bridges structures and similar structures.

Basic mechanical and physical properties of structural material - sandstone - were investigated in the laboratory of the Klokner Institute. These properties were determined only on pattern material taken out from localities, where most of the masonry elements were quarried and employed in construction and in historical reconstructions of Charles Bridge in Prague. The results of investigations are establishing source data for numerical modeling the historical structures loaded by indirect actions.

The previous technical studies presented [1] that structural masonry units have origin in the most places in the Czech Republic. From the petrographical point of view sandstone samples are from the region of Kamenné Žehrovice (Carboniferous period), from the environment of Český Brod (Permian period), from Brandýs n. Labem, Nehvizdy and Vyšehořovice (Cretaceous period), from Hloubětín, Hořice and Božanov (Cretaceous period). Recent tests were carried out on specimens taken from quarries in Božanov (in the Table 1. signed B), Kamenné Žehrovice (D) and Vyšehořovice (V). Material properties of the specimen have not been influenced by atmospheric, biological and mechanical actions. Assessment of the material properties have been performed both in accordance to standard methods and also nonstandard methods:

- compressive strength in accordance with by the ČSN EN 1926,
- tensile strength after nonstandard method proposed by KI,
- flexural strength in accordance with the ČSN EN 12372,
- fracture energy Gf in accordance with Rilem Recommendation FMC1,
- stress-strain diagram in compression in accordance with the KI method,
- static modulus of elasticity in compression in accordance with the ČSN 72 1165,
- coefficient of thermal expansion in accordance with the KI method,
- determination of water absorption at atmospheric presure in accordance
- with ČSN EN 1925.

The results were summarized in the KI Test Reports [2]. Only fracture energy results are presented in the following rows. Fracture energy G_f is defined as total amount of energy necessary to create one unit area of a crack [3]. The arrangement of the test is similar to three-point bend test, the beam is weakened by notch.

Test results are presented in the Table 1.

Table 1. Fracture energy G_f

Specimen	Width [mm]	Length [mm]	Area (total energy) [N.mm]	Weight [g]	Max force [N]	Fracture energy G_f [N/mm]
B1	39,40	161,9	139,49	541,6	861	142,3
B2	40,30	161,8	135,70	568,8	931	132,8
B3	41,16	161,9	129,90	564,0	925	124,2
D1	40,35	160,5	166,60	577,2	1431	160,4
D2	40,10	160,4	131,17	247,0	560 *)	129,8 *)
D3	40,71	160,4	178,23	570,2	1361	170,7
V1	40,01	161,8	59,68	463,6	593	60,5
V2	40,25	160,3	62,90	449,0	513	64,1
V3	39,20	160,6	57,26	454,2	618	55,5

*) not involved into average value

Experimental investigation performed in the Klokner Institute laboratory proved that fracture energy of sandstone strongly depends on the locality where the specimen were taken out:

- quarry Božanov $G_f = 133{,}1$ N.mm^{-1}
- quarry Kamenné Žehrovice $G_f = 165{,}5$ N.mm^{-1}
- quarry Vyšehořovice $G_f = 60{,}0$ N.mm^{-1}.

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The Application of Dielectric Method for Determinate Distribution Humidity of Soil Devastated Areas (Brownfields) in Conditions of Czech Republic

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This project dealt with application of a Dielectrical method for determining distribution humidity of soil in site that was affected by old ecological risk. The project called "Pilot study: Evaluation of Demonstrated and Emerging Technologies for the Treatment of Contaminated Land and Groundwater" is from 1985 focused on solving problems caused by contaminating the land and groundwater in industrial areas of developing countries. The study is leaded by United States of America in cooperation with Germany and Netherlands.

In presented work the results of periodical measuring the soil moisture and other physical characteristics of the areas affected by old ecological risks (brownfields) in urban areas of the city agglomerations were evaluated. The moisture was measured using a Dielectric soil moisture meter (Kuraz - Matousek, 2002) and then obtained values were recalibrated by a gravimetric method. To realize measurement, access casing pipes (HDPE) were installed in reference points located along the boundary of research area. These drill holes were installation into the depth of 80 cm; the measurement was done in intervals of 10 cm until it reaches the depth of 70 cm. The soil moisture and other properties were measured in each of 6 installed borrow pits in 14-days intervals. The aim of the measurement was not to assess water regime dynamics in full range but to compare the change courses of moisture and water supply in site only. The measured data were recalibrated to the moisture values in % of volume using a gravimetric method. Simultaneously the disturbed soil samples were withdrawal to determinate the soil moisture values in % of weight. These values were recalculated into the % of volume on the basis of known volume weight determined from withdrawal undisturbed soil samples with volume of 100 cm^3.

To collect useful information and data preparation, the special interest territory in eighth Prague district was chosen, concretely the part of former CKD area – Moury (near the metro station Kolbenova). Some necessary data was already available for this area (Ekohydrogeo Zitny processed for the whole area the ecological audit in 2002). Therefore the part of this information was used to save up the financial spending of project.

On the basis of results and experience obtained from this project, the similar measurement will be then possible to carry out on the different types of brownfields. The solution was divided into the several sections as follows:

– choosing the research area (with ecological risk),
– obtaining the basic data about the chosen area,
– building the measuring net, and
– process of measuring and evaluating the obtained information due to assessed methodology.

General handbook for using the UMS/SISIM program in the form of user manual translation arose during the solving project as a part of the methodology, and also it will be a

part of dissertation thesis of this project author. The manual in Czech language will serve as a basis for the interrelated project. The outputs obtained from this project will be also again used in new project focused on "Software tools for classification of brownfields – the application and check of the UMS/SISIM exposure models in the conditions of the Czech republic" that was nominated to the IGS CVUT 2004.

The most important output from this project is describing the distribution of soil moisture and its changes during the measurement in chosen area by means of 3D graphs that will give information about lay-out of the soil moisture in separate layers of the soil profile in objective and well-arranged form. The differences in soil moisture rate are described in colors. The part of this output is also the proposal method for next using such area in respect to the water regime.

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The Analysis of the Unsteady Thermal Behaviour of the Building II

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The modern tool for the analysis of the unsteady thermal behaviour of the buildings are dynamic simulation programs, their using began more often in progressive design offices and of course in the academic environment. There are some foreign dynamic simulation programs with universal use for analysis of the thermal performance of buildings, for example TRNSYS, ESP-r, etc.. These programs are well known and respectable, but they are very expensive and their use is very complicated for common user.

European standard EN ISO 13792 describes two simplified methods for analysis of the response to the load from internal and external thermal heat sources (solar radiation or air temperature). These simplified methods allow evolution of some simplified dynamic simulations programs, which must be at first compared with respectable programs, or with experimental long-term data measured in-situ.

An existing data for verification are only for complicated buildings, which cannot be analysed by these simplified programs. There is so far only a few such reference models based on measured data and no such model exists in Czech Republic but one – ours.
To get necessary verification data we started measuring of the response to the load from thermal heat sources in simple reference model.

Suitable building for our reference model (simple shape, any interaction with other buildings or users behaviour) was little observation building located on the roof of the Faculty of Civil Engineering in Prague.

We began with measuring in our reference model in May 2002. In the end of the year 2002 we get second observation building for purpose of measurement located near by the first one on the same roof.

Reference model number one is only one rectangular room without windows, with only one glassed door. Roof is made of metal sheets without insulation; walls are made of metal sheets panels with glass wool insulation. The floor was insulated with polystyrene boards covered by wooden based boards. Reference model number two was identical with model number one, but there were made some changes. Roof was insulated by glass wool insulation. Walls were from inside insulated by glass wool and walled by bricks. The floor was insulated with polystyrene boards covered by wooden based boards.

The measurement in this simple buildings is carried out by means of Ahlborn measuring devices and sensors which collect data describing the internal and external air temperature and humidity, global solar radiation, CO_2 concentration (initial data for air change rate calculation) and internal surface temperatures.

Together with measuring we are creating verification model. Measured data are compared with other data from computer simulations, especially with data from program Simulace 2002. Program Simulace 2002 is developed by one of the co-authors of this project, Dr. Ing. Z. Svoboda.

There are measured data for variants with different cladding, with different shading of the glass doors and with different internal heat sources.

One of the final results of the measurement will be the year courses of the external air temperature, total solar radiation and air humidity and the year courses of the internal air temperature and humidity together with the surface temperatures, air change rate and internal heat gains. The final result of the measurement will be perfectly organized data file with all years' courses and precisely defined verification model.

This project is important because of measured dates, which should serve for verification of new dynamic simulations programs and for their comparing. Originality of this project is in data measurement in the simply model building, with exactly defined construction. Final results (data file, verification model) could be internationally used.

This measurement is supposed to be carried out without interruption until the summer of the year 2004.

Project continue on the last year's grant project "The Analysis of the Thermal Behaviour of the Building", which we were solving last year.

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Brownfields x Greenfields

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A strong restructuring process has been taking place recently in most of the industrialized countries and also in the Czech Republic since the last decade of the 20th century. It is associated with cutbacks in manufacturing and material processing in various industrial branches, in particular in mining industry, metallurgy and mechanical engineering. It also leads to reduction of areas used by the armed forces and railway companies. People leave residential districts, the amenities and surrounding environment of which do not meet the current housing requirements and, thus, the decrease in population results in cutting down the scope of services and production leading to a progressive economic decline and deterioration of these regions.

In case the vacated land remains fallow and the market is not able to arrange for any treatment of this land, a problem arises and must be solved. These lands can be in general summarized under the term "brownfields" (as opposite to "greenfields"). The lands, which are or may become brownfields in the future, include primarily warehouses, former gas stations, factories and premises of various industrial plants, bus terminals, waste dump sites, former quarries and many more.

On contrary to this issue, however, there is a constantly increasing demand for new building land nowadays which would be used both for housing and leisure time facilities as well as for industry, storage, business centers, transport etc. In these terms the discussions always concern development on lands unaffected by previous construction, i.e. without any environmental and other risks.

Since the development on greenfields, however, is currently becoming more and more demanding in terms of occupying open areas (in Germany, for instance, they talk about ca 120 ha of greenfields used up per day), the individual countries start to contemplate on a more extensive use of brownfields (e.g. Great Britain has set the objective of 60 percent of new development to be built on brownfields).

There are two options for using the land designated as brownfields:

1. Use the land for further development
2. Revegetation (so-called green-brownfields).

There are seven basic construction stages in the development on brownfields itself:

- Location identification
- Initial location assessment (1st survey stage)
- Economic, architectural and sociological appraisal
- Detailed location assessment (2nd survey stage)
- Development and financing project
- Remediation project and its implementation
- Construction implementation

Naturally, it is essential to develop a certain concept for further use in order to be able to attract the prospective investors to this land instead of continuous use of such lands only, which have not been deteriorated by anything. This is associated with the problem that at least the first 4 basic stages should be ready and prepared for the potential investors in every

place. This naturally implies funds not only from the local authorities, but also on part of the government.

However, the preparation is definitely worth it since then it is possible to offer to the potential new investors specific locations mapped down in detail, for which we already know the further steps to be taken. This is a way to achieve a lower number of newspaper articles saying that "the investor has decided for new investments on the greenfield".

Because I come from the city of Chomutov and these issues are highly familiar to me from the professional point of view, I naturally was interested in particular in the question of whether such a concept has been prepared in our region and I was taken by surprise in a very pleasant way. Not only that the individual cities themselves try to use such lands as much as possible, but they also cooperate in the restoration of places outside of the city localities, which many of us do not even take into account. This concerns for example the location of the former quarry near Most or the former army land in the municipal localities of Chomutov, Louny, Žatec and Most. It would not be difficult to find more such lands, at the same time we can also say that some places just lie fallow. So let us wait till the time comes; maybe in some 20 years we will be re-using previously used land in increasing extent and the greenfield lands will only be used by the nature.

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Innovative Lectures on Geology in the New Organization System of Study at the CTU

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Lectures on geology, mineralogy, petrography, hydrogeology and engineering geology have been a tradition at the Faculty of Civil Engineering for many years and they are an essential part of courses of study in all specializations and fields of study at this faculty. About 1,300 students are instructed in geological subjects every year, both in the Czech and the English languague.

These subjects as a natural science part of the related courses of study help students establish their relationship to the environment, find and discover connections between nature and technological growth and lead them to feel responsibility for consequences of civil engineering practice. Global ecological aspects of geological lectures cannot be substituted by any other specialized subject.

This year, the courses of study were divided into Bachelor and Master degree courses and together with this transformation the decision about the reduction of the number of lessons was accepted. The most problematic consequence of this alteration is a lack of classtime for mineralogy and petrography courses, the basis of other geological subjects.

To solve this problem, a new approach to petrography lectures was offered. The limited amount of time can be compensated by a supplementary on-line course of petrography. This course enables its users to study individually and check the level of mastering the new knowledge.Thus, the course can improve the examination results of students. This educational scheme requires computer equipment with a standard level both qualitative and quantitative.

One principal aim of the project was to improve the material basis for this format of lectures, ecpecially the equipment of the department computer room, which had also been used for teaching subjects concerned with geomechanics since October 1998. The computer hall used was equipped with 7 computers and a server, and it is enough for instruction in elective subjects, but not for regular work of hundreds of students of the first year of study.

In agreement with the planned non-investment expenses, the following items were bought as part of the project – 5 computers with appropriate monitors to serve larger student classes, graphic cards, IDE disks and computer memory for upgrading older computers, a film scanner for digitalisation of photos and slides, printer toners and other consumer material. The finances allocated to this project were efficiently utilised with the aim to augment the level and quality of the material equipment used at the Department of Geotechnics, both in this project and in the future.

As the project follows from the long term ideas of modernisation of instruction at the department, and as the material basis has been improved, the authors of the project together with other department members will continue in quality enhancing of lectures and in extending of possibilities of on-line interactive presentation of the taught material in the teaching process.

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Progressive Steel Thin-Walled Structures in Civil Engineering

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The research project covered period of 2001-2003 and the results described below dealt with progressive steel thin-walled structures of civil engineering in the following fields:

1. Stressed-skin design using trapezoidal sheeting and cassettes

Models simplifying and specifying stress-skin design in comparison with procedures given in Eurocodes and ECCS Recommendation No. 88 were found. Analytical model of a cassette industrial building side-wall loaded in shear was derived based on experimental investigations and numerical parametric studies. Stress-skin design of a purlin roof with trapezoidal sheeting was refined using own experimental data and non-linear analysis performed with LUSAS software. In general the importance of material non-linearity of joints or connections and introduction of contact elements in FEM modelling was emphasized. Recommendations and practical examples of the new design were published, see e.g. [1].

2. Thin-walled arched steel sheeting

Novel evolutionary structure was developed, using thin-walled arched sheeting as a permanent formwork suitable for large-span floors. Large experimental work (6 samples of 6 m span) provided data for geometrically non-linear analysis with imperfections (GMNIA). The arched sheeting TR 40, TR70 and TR 107 produced in Czechia (Vikam Ltd.) and light concrete of density 1700 kg/m^2 (Liapor) were proposed to use as suitable Czech-made products. Project proved the new element to be usable and economical for practical use in floors of spans up to 9 m, see e.g. [2].

3. Girders with undulating webs

The progressive element was investigated in fatigue behaviour for novel use as a crane girder. Two large groups of demanding tests were performed, the first one (10 samples) with loading predominantly in shear, the second one (another 10 tests) with predominant local loading. The investigation resulted into required parameters – fatigue categories in both shear and local loading. In addition a special testing rig was developed for tests of short girders loaded locally by moving loading. The reason for these tests was an investigation of the significance of local shear change under the moving loading. As a by-product of the numerical investigation the effective length of the undulating web was derived and an appropriate formula provided. The results may directly be used in practice, see e.g. [3].

Another use of girders with undulating webs was proposed in the area of composite steel and concrete beams. The laboratory girders were fastened with concrete slab by means of novel shear connectors Hilti Stripcon. The strength of these connectors was investigated by the Authors in a previous research, which resulted into certification of these connectors in Czechia as a first country in the world. Two composite girders were tested, first one with full, the second one with partial shear connection. The published results of the tests and theoretical analysis proved the applicability of the element in practice.

4. Thin-walled profiles Z and C

Real interaction of purlins or wall rails with sheeting was established. Based on extensive experimental results the data for calibration of FEM numerical analysis (ANSYS software) were obtained. Plastic reserves of thin-walled profiles under bending proved to be significant and recommendation for their use were provided. New design method for determination of rotational stiffness between sheeting and purlin was developed, see e.g. [4].

5. General problems of stability of thin-walled elements

Systematic investigation of new knowledge within conversion of current standards to European Standards and preparation of National Annex of Czech Republic concerning buckling of thin-walled structures was performed. The investigation was published and introduced into new standard procedures, as the workplace of the team is guarantee for this field in Czechia.

6. Thin-walled steel shells

Detailed linear and non-linear analyses of behaviour of long cylindrical shells (using Nexis 32 software) under transverse loading were provided. The behaviour of transverse stiffeners with respect to their mutual distance and rigidity was studied. Parametric study including various boundary conditions was performed and the results compared with simple strut analysis. The published results may be used for design of stiffeners of shell (chimney) structures in such a way that optimal distance and rigidity of the stiffeners are designed in accordance with proposed formulas and the following variant design may be done with use of simple strut analysis (instead as shell structure).

7. Crane runway girders

There was elaborated a detailed study of horizontal loading due to movement of overhead travelling cranes. Various approaches were analysed with respect to experimental results provided by literature and used in various standards including Eurocode. The results (provided in CTU research report) are very illustrative in large differences of results and the preferred ones will be used in following research on behaviour and design of overhead crane girders.

Results of the project were published in 34 publications, 2 PhD theses, 1 docent thesis, 2 PhD theses have been submitted in 2003 and another 2 are supposed to be submitted in 2004. The team collaborated with specialists from Heriot-Watt University (Edinburgh), KTH Stockholm, Lulea University of Technology and University of Loughborough. The results may directly be used in practice, some structural elements are of novel origin and all of the results lead to an economical design of steel structures and increase competitiveness of their users.

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Technical Tools for Long-term Monitoring of Structure Deformations

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Recent structural practice often requires long-term monitoring of strains or displacements on chosen points of the civil engineering structure. The reasons which leads to this effort consists in requirements of static reliability evaluation of this structure. This concerns both contemporary and also historical structures. Several methods applied in the Klokner Institute are presented.

Reasons for the monitoring of the structures are mainly evocated by requirements of objective investigations of a failure which occurred at any structure. The other reasons for the long term monitoring conducting is reliability assessment of the important structures or the structural elements.

Main improvements of technical tools have begun in connection with exploitation classical monitoring methods at single loading tests of structures and in connection with economic accessibility of laser technique. Properties checking the unbroken structure, i.e. the stiffness and amount of elastic and sustained deformations, demands higher level of differentiation and also demands diminishing of temporal requirements on repetition reading with comparison with long-term monitored structure.

Technical tools for monitoring of structural deformations depend mainly on:

- financial accessibility for the laboratory,
- installation and maintenance complexity,
- labor consumption of reading and data processing,
- accuracy of measuring.

Measuring devises are differed according to the level of resolution of displacement:

- less than 0,001 mm,
- higher than 0,001 mm; application of the acoustic strain gauges belongs to the optimal way.
- in the interval 0,001 ÷ 0,05 mm electrical devises, respectively surface deformeter are applied,
- in the interval 0,05 ÷ 1,0 mm application of sliding device with vernier,
- in the range 1,0 mm application of laser rangefinder.

The inclination from line of sight in vertical or horizontal plane belongs to other monitored values. The inclinations are generally measured by classical surveying engineering method. Surveying could be also executed by laser level. In certain cases the application of the laser level equipped by a pair of opposite laser flash has been proved. Laser level bedding down to fixed board in the point of minimal shifting (for example in middle of the bridge span within loading test) enables to determine the shape of deflection line in both planes. Simple laser level could be applied for measuring in the distance lesser than 30 meters. Reading of

inclination from line of sight is conducted by sliding device with vernier. This method of measuring is recently verified in the laboratory conditions. Uncertainty of leveling corresponds to 0,5 mm.
The application of transportable compensatory clinometer was verified in situ conditions. It was shown that combination of the clinometer and laser level is advantageous because both methods use the same stabilized points.

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Wall Jet of Cold Air Along a Vertical Surface

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Recently, computer simulations are becoming a more and more frequently used tool for various engineering problems including indoor air flow. The results obtained from computing fluid dynamics simulations are much dependent on boundary conditions. It is necessary to validate the CFD model possibly by comparing it with the results from physical experiments.

The behaviour of a non-isothermal (cold) wall jet of air along a vertical surface is not described in a form which could be useful for engineering applications. With the knowledge of the wall jet behaviour, it will be possible to create local microclimate, different from ambient environment, as presented in [1, 2].

This paper presents the CFD and experimental investigations of the mean velocity and temperature of three-dimensional wall jet with buoyancy forces.

In the first part of this project the commercially available software package FLUENT was used for the computational fluid dynamics simulations of air wall-jet flow. This software has been used in the Department of Environmental Engineering since 1996 in a number of research projects. The CFD model was made in a preprocessor called GAMBIT and mashed with more than 1 500 000 hexagonal cells. For better investigation of boundary layer near the vertical wall, it was necessary to refine current mash into smaller cells. Boundary conditions were following:

- velocity inlet $w_{in} = 0{,}2$ m/s
- inlet air temperature $t_{in} = 20°C$
- ambient temperature $t_{out} = 24°C$
- height of the model a = 4m
- lenght of the model b = 6m
- width of the model c = 2m
- width of the outlet element x = 0,1m
- lenght of the outlet element y = 4m

The k-ε RNG turbulence model was used for solution.

With the difference between inlet and ambient air wall jet flows faster to downwards. According to this results wall jet is contracting in the middle part of the model. Where the wall jet temperature balances the ambient temperature, the air flow slows down. The temperature difference at the inlet and the bottom of the model $\Delta t = 2{,}5K$

In the second part of this project the experimental wall was installed. The experimental wall was installed in a laboratory of the Department of Environmental Engineering. It is made out of wooden plates, the construct is made out of iron profiles. Height of this surface a = 4m and it is possible to increase this dimension. Lenght b = 6m. Distribution element is not installed yet, because of troubles with uniformity of outflow along all lenght. Lenght of the distribution element y = 4m.

The laboratory experiments will be performed with the usage of existing instrumentations that are possessed by the Department of Environmental Engineering. The system capable of data acquisition from 90 points at a time is available for temperature measurements as well as anemometers for low velocities (up to 1 m/s).

Finally, it will be possible to predict temperature and velocity field of wall jet in 3D along vertical surface according to inlet air temperature, inlet air velocity, distribution element dimension and ambient temperature.

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Effects of Channel Improvement Structures on Flood Routing in Upper Reaches of Minor Streams

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Placement of transversal nonsymmetrical in-stream structures is a frequently used technique of channel improvements of heavily engineered minor streams. Application of these techniques leads to increasing of stream course sinuosity during low flows, creation of flow shade behind particular structures and slowing down velocity of flow in channel during high flow conditions, which results partially in increasing of retention of channel, but in particular to enhancement of flood routing ability of channel. The main environmental effects can be seen in enhanced input air oxygen to water environment and recreation of suitable conditions promoting higher diversity of aquatic habitat. However, higher rate of macroturbulent flow is connected with higher flow resistance, in some cases responsible for dramatic reduction of conveyance capacity of channel. Drop in channel conveyance may not be necessarily presented as a fault of the channel improvement measures. Decrease in conveyance leads to precocious offbank flow and then the passage of a flood wave through a reach with channel improvements is retarded compare to the inbank flow. Longer time of flow wave travel and its higher diffusion is a positive feature within the flood defence scheme of settlements down the reach the channel improvements measures were applied. It gives to river managers some extra time more to organize preparedness of citizens or even to do fast flood defence measures. Also damages in channel of the river are considerably smaller compare to the situation when the peak discharge can not flow offbank during flood event [3].

River engineers are used to make in their flood analyses an assumption of constant flow resistance coefficient and they neglect its variation with depth of flow. It might be used with no effect for slow transient conditions. So called “flash flood”, which is a result of storm events over small upland watersheds, is characterized by short time duration of flood wave and extremely steep rise limb of discharge hydrograph. Flash flood is a transition between slowly and rapidly changing flows (for example dambreak flow wave) and there is no clear evidence that an assumption of flow resistance coefficient constant with depth has no effect for flow analyses.

It has been reported that in channels with added in-stream improvement structures the flow resistance coefficient changes considerably with depth. There is a strong similarity with flow in boulder bed rivers when the velocity profile is disrupted and becomes sigmoidal in its shape. For lower depths the flow is significantly obstacled with in-stream improvement structures, for depths higher than height of structures flow is relatively free.

Based on the laboratory observations a universal formula was derived to evaluate flow resistance with respect to the actual flow depth for particular geometry and dimensions of channel and in-stream improvement structures. Applying this formula for set of flow rates or depths one can obtain a characteristic rating curve of channel with improvements and after rearranging a vertical variation of resistance coefficient is obtained. This is can be used as an input for unsteady analyses.

This approach was adopted for a typical reach of minor stream with heavily engineered channel of trapezoidal cross section as an example. The reach was 3 km in length and span between transversal nonsymmetrical improvement structures (spurs) was 5 m, 7.5 m, 10 m and 15 m respectively. The numerical simulations were performed using 1D –unsteady computational package HEC –RAS v.3.1. A channel with improvement structures placed in it was substituted with a channel without in-stream structures, but with higher rate of macro-turbulence expressed by an increased flow resistance coefficient computed from suggested formula. Computations were simultaneously undertaken for variable and for constant vertical distribution of flow resistance coefficients. Results were examined looking for discrepancy between traditional and suggested method of analysis.

It was found that there is a distance between spur structures which is the most effective in routing of flood wave and higher density of spur structures applied, i.e. distance between spurs smaller than this, does not bring any extra effects. It means that for particular shape of spur structures and characteristics of channel the optimum distance between improvement structures can be designed. It was also found that improvement structures are more effective in flood routing if they contribute to precocious offbank flow. If the peak flow stays inbank of channel, the flood routing effect of improvement structures is less important. River engineer responsible for design of channel improvement structures may considerably enhance resultant flood routing of channel reach if a shape and dimensions of in-stream structures in design are taking into account the actual conveyance capacity of the channel.

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Section 14

ARCHITECTURE, TOWN PLANNING, GEODESY, CARTOGRAPHY

Methods of Digital Cartography and Their Implementation into the Course at the Faculty of Civil Engineering, CTU Prague

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The development of information technologies, methods of spatial data capture and software systems for their storage, processing, analysis and visualization – these phenomena increasingly contribute to substantial changes in cartographic methods and procedures for production of maps and atlases. Skills and knowledge of computer aided map design based on digital data visualization become a necessary part of university education in cartography and also in other disciplines dealing with spatial data presentation.

In the presented papers [1-2] it has been demonstrated that in recent years the curricula of university programmes in cartography have – more or less - started to reflect the development of digital methods in spatial data processing. Up to now, the traditional cartographic education at the Czech technical universities (Prague, Brno) has been replaced by digital methods only in a limited extent. At the CTU Prague, Faculty of Civil Engineering, the methods of digital cartography started to be implemented within the subjects of the study programme Geodesy and Cartography, especially within the subjects Map Production and Reprography (compulsory course) and Map Production seminar (elective course). During the academic year 2002/2003, the Adobe software systems were used within those subjects for construction of choropleth maps and cartodiagrams (Adobe Photoshop, Adobe Illustrator). Partly we started to use also the program OCAD for creation of city maps, thematic maps and topographic/geographic maps.

Within the grant project we planned to upgrade the software available in a new Laboratory of Digital Cartography at the Department of Mapping and Cartography. Using the grant resources we purchased upgrades of some software used for teaching digital methods in cartography: Adobe programmes (Illustrator 10, Photoshop 6), OCAD 8 Professional and Microsoft MapPoint 2002. The lab of Digital Cartography is at present very well prepared for teaching and for individual work of doctoral students or diploma students but due to the limited capacity it can be currently used only for voluntary subjects with max 12 students in one study group.

A compulsory course Topographic and Thematic Cartography (K153TT10) is supposed to be the necessary pre-requisite for a new elective course Digital Cartography which will be offered to the students of Geodesy and Cartography study programme beginning from the academic year 2004/2005. We propose to run this new subject in both winter and spring terms in order to enable more students to attend it in the limited groups. The course will be concluded with a classified credit. The idea is rather to promote and learn principles of digital methods in cartography using a simple software tools than to embrace all the possibilities and potential functions of complicated programme packages.

The subject Digital Cartography will be focused on implementation of digital cartographic methods for creation of small and middle scale maps of various types as for example topographic and touristic maps, road maps, city plans etc. Following the analysis of suitable software systems for teaching digital cartographic methods we prefer to start the lessons with the software OCAD which is effective, user-friendly and quite simple for „getting started" with digital cartography in a limited number of teaching hours. OCAD has been originally developed for orienteering maps nevertheless the current version is used for commercial production of digital maps of various types in a number of private cartographic companies in the Czech Republic. Adobe programmes (Photoshop, Illustrator) we plan to use more in the current (elective) course of Map Production seminar where professional possibilities of DTP (desktop publishing) methods can be fully implemented, especially advanced functions for colour models definitions usable for creation of choropleth maps and cartodiagrams. Another software tool for simple presentation of statistical spatially referenced data is Microsoft MapPoint based on MS Excel. For next years we plan to involve also cartographic applications based on MicroStation because this software modul and its applications for digital cadastral map has been offered as an elective course for several years at our university. The system itself enables to create a topological structure in layers suitable for implementation in GIS. A close connection of GIS and digital cartography can be well demonstrated on ESRI software (ArcInfo and related programs) of Intergraph applications (Geomedia, etc.) in GIS/cartography education.

The theoretical part of the syllabus of the proposed subject Digital Cartography at the branch Geodesy and Cartography, FCE - CTU Prague, will involve an overview of available resources of background data for creating digital maps (vector and raster data files of state map series, conditions for their use, copyright issues), general principles of map design using the OCAD programme (main graphic functions, defining colours and their use for map elements, defining new map symbols, map labeling, new options of the OCAD 8 Professional version, transformations of background maps, automatic generation of map index, output layout). Practical training will be focused on creation of a city plan, touristic map, road map and geographic (atlas) map using the OCAD software, including map legend design and preparation of printed output (plotter/printer).

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Optimum Laser Systems in Industrial Metrology (part 5)

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In order to observe atmosphere influence on geodetic measurement, experimental measurement in the scientific-research network "Stare mesto pod Sneznikem" continued in the year 2003. The time development of a measured vertical angle, a determined refraction coefficient and a height-difference was monitored repeatly from two independent methods of measurement: the precise levelling ant the GPS method. Coordinates and an altitude of a new-stabilized ground point "Tetrevi hora" (1235 m. a. s.) were determined to application of Sanchez's method, where the height-difference is at least 600 meters and terrestrial and independent GPS measurement are used.

In the previous run of the project there was designed, created and calibrated the apparatus for determination of the position of the laser spot on the screen of the camera's box. It is based on simple digital camera originally designed for web presentations.

In the paper [2] there is described the method of the testing and evaluating of the practical check of the precision of the position of the laser spot on the screen in the vertical direction (analogy to the vertical shifts measurement).

Practical verification of the precision of the monitoring of the deformations was made at the roof extension of the building B of the Faculty of Civil Engineering, Czech Technical University in Prague. As a source of the laser beam there was used helium-neon (He-Ne) laser Tesla TKG 205 together with specially designed stand. Laser was placed on the concrete pillar. Camera's box was placed on another pillar at the distance 23,5 m. There were also measured values characterizing the current state of the atmosphere during the measurement to suppress it's influence.

Both tests confirmed supposed precision of 0,2 mm.

Two papers were published in workshop proceedings in foreign languages during year 2003. Mostly activities of previous year are mentioned in these papers because of time necessary for preparation of publications. Laser technologies which are used for geodetical and building applications and systems of geodetical measurement for industry were main parts of our research.

Research was focused on monitoring of stability and shifts of building constructions during year 2003. Precise local level network - an evaluation of its figure, measurement and possibilities of calculation (adjustment) were investigated. It is also topic of the diploma thesis of J. Kotouč. The conclusions are available for practice of vertical shifts measurement [3].

The instrument AS 145 ARCS is durable and accurate measuring device with fully electronic dual grade lasers and integrated ARCS (Automatical Reflection Control System). This instrument can be used for levelling works, construction equipment control, working treatment and area creation. Several functions of this instrument were tested in our research - self-levelling range of instrument (it was ±4,7% in both axes X and Y), determination of horizontal and tilted levels (standard deviation 3,7 mm for horizontal level and 8,0 mm for tilted level), setting out of horizontal directions (standard deviation 13 mgon for distance 30

m) and determination of dead zone of detector. The dead zone of detector depends on sensitivity of the detector, rotating speed of laser beam and distance between instrument and detector[4].

Laser scanning system Cyrax 2500 [1] testing took place in October and November 2003 in the firm Stavební geodézie a geotechnika (Building Geology and Geotechnique). Four experiments were performed: Influence of distance on the object modelling, space distance accuracy, reflection quality of various types of materials and reverse border measuring accuracy. The performed experiments confirmed our expectations. The results of this testing will be published partly in the dissertation of Jan Vitáček and partly in the report of Ing. Křemen at the Juniorstav conference in Brno in February 2004.

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Research of Historical and Contemporary Architecture - 5th Phase (Year 2003)

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The comprehensive subject of the research project comprises 9 parts focusing on either historiography or the study of historical, functional, spatial and building structure of buildings. Twelve staff members of the Institute of the History of Architecture participate in its solution. The topics chosen are in harmony with the specializations of individual research workers and aim at important research trends in the history of architecture and the possibilities of the applications of the results in undergraduate and postgraduate studies.

Research continued in the line adumbrated in the preceding phases. In the course of its solution an application for prolongation of the deadline was allowed for another year. This change had a positive impact. The character of themes being solved, which represents either a part of the extensive up to now non-adequately treated areas, or themes to the elucidation of which a more profound elaboration of the context of the studied phenomenon required more time and space which due to the prolongation was turned to good account.

Complications which emerged as a result of damage of part of the archives containing architectural drawing are being made up for by postponing the time limit of the research to the half of the 19th. century (E. and B. Fanta).

P. Kalina studied the historical transformation within the profession of an architect and also his relations with customers who order his works.

An attempt to integrate themes of similar contents from the area of urban and feudal housing in the Middle Ages (M. Hauserová, M. Rykl) continued in close collaboration during work on the theme itself as well as in elaboration of analogous methods of building archaeology. This theme serves as an example of research, the extent of which exceeds the time limit allotted to the task, and which is more or less of a long term perspective research project character. Within the framework of the research project there exists an experiment the aim of which is to form a more extensive research base and to elaborate research methods. The purport is to establish a basis for activities which go beyond the time set for this research. Research workers dealing with tasks of similar volume centred on historical construction (J. Škabrada, M. Ebel) are adopting a similar policy.

The author´s profile of J. Joendl (P. Vlček) and a retrospective view of Czech rondocubism (P. Škranc) in the result of teamwork focused on Czech architecture of the 60ties (Urlich and team). They represent those of the themes which due to the prolonged time limit made possible an increase of documentation and further context of the phenomenon was worked out to a greater depth.

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Easy Access Buildings and Architects´Responsibility for their Design

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In partnership with the Prague Organization of Wheelchair-bound People we have prepared an event named "Let us overcome the barriers – future designers, think of us", aimed at students of Construction and architectural faculties of Czech Polytechnics. The event lasted the whole day and consisted of three parts:

A) In the courtyard of the school an exhibition of photographs was installed. These were taken by the students and documented both good and bad solutions of the pits, entrances to buildings, drives and public transport in the centre of Prague.

B) There was an obstacle course placed directly in front of the college building where everybody could try for themselves a ride on a mechanical or electric wheelchair or to walk with a white stick. The students first hesitated before they dared to try a wheelchair or a stick. After they managed to drive over several ramps with variable slopes and to drive the wheelchair into a small cabin simulating – by its measures – the toilet for the disabled, they quickly understood what every per cent of slope and every centimetre of space means for the disabled people.

C) In the afternoon, there was a discussion, during which the students had an opportunity to compare the opinions of those, who are responsible for the norms with the opinions and insight of their coevals, bound to wheelchairs. Among the participants of the discussion were:
   - Ing. Jan Skopec from the Ministry of Local Development, the author of the Directive 369/2001 concerning the general and technical requirements ensuring good accessibility and using of the buildings by disabled people
   - Ing. František Baroš, consultant of the Association for the Environment of Disabled People in the Czech Republic and a member of the commission for buildings and transports at the National Board of Disabled People in the Czech Republic
   - Dr. Josef Vanický and Mgr Zdeněk Pejčoch from the Association of Disabled People in the Czech Republic
   - Mgr. Viktor Dudr from the Unified Organization of the Visually Impaired People in the Czech Republic
   - Kateřina Kolářová, Romana Hrozná, Jarmila Onderková from Prague Organization of the Wheelchair-bound People

The event became a step to a better understanding of the needs of the disabled and handicapped people.

Within the framework of my course Design of buildings IV in the summer semester I built upon the personal experiences of the students and focused my teaching on particular solutions of real life situations in cooperation with the representatives of the Prague Organization of Wheelchair-bound People. Together, we have selected some inaccessible public buildings or places, discussed the entrances to the cinemas, swimming pools, cemetery

halls, living at the college dormitories, paths at the interesting places in Prague and mapped the accessibility of particular stations of low-floor buses and the underground.

The students – accompanied by a disabled representative of Prague Organization of Wheelchair bound People - first had a look at a good solution of non-barrier building and then visited the actual place. Also they got hold of the plans of individual buildings and after consultations they handed in their own works which clearly map the solution of building or a place with regard to non-barrier access and suggest the optimal solution for the remotion of the barriers.

The results of the students' work were then given to the representatives of the Prague Organization of Wheelchair-bound People who will use it in solving the concrete problems.

Within the accompanying programme "Post-hospital care as an important part of the return to complex life" the exhibition of photographs from the event "Let us overcome the barriers – future designers, think of us" was shown here. The identical exhibition was then a part of the international exhibition "Non-barrier Environment for Everybody", organized under the patronage of the Ministry for Local Development in Nové Město na Moravě in September 16 – 18, 2003.

In the winter semester of this academic year we started working with the Technical University of Dresden, the faculty of architecture, with the department led by the professor dr. Ing. Heinzpeter Schmieg. In the studio of Ing. arch. Šestáková and Doc. Ing. arch Fořtl a solution for the integration of the people with physical disabilities is being search for within the framework of the project "Dresden – Prague, One Task for Two Cities".

After the visit of our students and teachers in Dresden, during which we had a look at the place that was the focus of the solution, the students and teachers from the Technical University of Dresden came to Prague. From Prague, the whole group of Czech and German students, including their teachers, moved to the training centre of the Faculty of Architecture in Kruh near Jilemnice, where a three-day introductory workshop took place.

The projects will be presented together and different solutions of the topic will be compared and discussed, as well as differences in the directives of the law in the two countries and different opportunities of the handicapped people in Germany and the Czech Republic.

We are currently planning to organize exhibitions on both universities and to issue a small booklet. This project has been also supported by the Czech-German Fund of Future.

As a consequence of those activities I have established contacts with many organizations and was named by the dean of the Faculty of Architecture the responsible person for the participation of our faculty at the all European project AUTONOME. This project rounds together the experts in all fields and its aim is to set certain rules for the construction of non-barrier building. The first, preliminary phase will take place from March to August 2004. Our task will be to test the accessibility of public buildings in the Czech Republic. This study will then serve as fundamental material for the further phase of the project.

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Innovation and the Development of the Laboratories for Practical Teaching of the Engineering Geodesy

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Introduction

Students of the civil engineering and architectural studying programmes carried out at the Faculty of Civil Engineering attend compulsory subject Engineering Geodesy. Quality of the teaching depends on the equipment used for pedagogic purposes as well, its grade is important in the laboratory lessons and in the field work above all. Teaching of this subject is fully provided by Department of Special Geodesy and thus its equipment is crucial for quality of the practical teaching.

State of the equipment used for teaching of the Engineering geodesy at the end of the year 2002 can be characterized by a few data. There were used mechanical theodolites only, 65 % of them is older than 25 years and 93 % older than 15 years. These instruments were also so old, that if we compare them with present instruments used in praxis by private commercial companies, students were learning to work with instruments and studying technologies of the measurement more than 15 years old.

For that reason there was designed project "Innovation and the development of the laboratories for practical teaching of the engineering geodesy", which was supported by a grant of Fond rozvoje vysokých škol MŠMT (The Fond of the Development of the Higher Education of the Ministry of Education, Youth and Sport).

The aim of the project

As arise from the introduction, complex innovation of the equipment used for teaching of practical lessons and field work of engineering geodesy was the aim of the project. It has been designed to acquire equipment at least comparable to the one used usually in praxis, it means replace the old mechanic theodolites and rangefinders by so-called total stations, which can be used in basic field works as for example special-purpose plans making or setting out.

Graduates of the Faculty of Civil Engineering should be than more competitive not only in economic conditions of European Union.

Implementation of the project

Teaching of the engineering geodesy takes place in two laboratories (B967 and B969) simultaneously and then both must be equipped identically. Number of students in studying group is no more than 24, it means no more than 12 students in one laboratory. From pedagogical point of view 1 total station is sufficient for two students and so 12 total stations is needed altogether. For some tasks an external controller is not needed and to save funds the number of external controllers can be decreased to 8. For field works the number of total stations and external controllers is sufficient too.

On the base of internal selection procedure there was chosen an offer of Topcon GPT-2006 total stations and external controllers by the firm Geodis Brno. Main criteria were technical parameters, included accessory and of course the price.

Listed equipment, it means 12 total stations and 8 external controllers, allows complex innovation of the laboratory and practical teaching of the subject Engineering Geodesy.

Conclusion

After the purchase of the equipment described above the contents of the laboratory lessons and field works was modernised. Students familiarise themselves with basic principles of the measurement and learn to solve the basic tasks of the engineering geodesy common in the civil engineering as topographic mapping, setting up etc with modern instruments.

Equipment was put to use in winter semester 2003 – 2004 with the support of "Fond ČVUT na podporu celoškolských aktivit ".

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Issue of Brownfields in Small Towns

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Birth and Life of Brownfields

One of the most important impacts on city planning, that happened after social-political changes in 1989 at the Czech Republik, was produced by transfer of real estate ownership from State to private property. It brought a.o. bankrupt and disappearance of some companies. Lands – first used by those companies – were left and not used – gave birth to underdeveloped areas = brownfields.

Those areas are very problematic from town planner´s look, town concil´s look and cityzen´s look – they are bringing loss of jobs (winding-up companies), they are aesthetically in bad condition and they attract problematic social groups (squaters, drug consumers, criminals, …). If brownfield is unsolved for a long time, population from neighbourhood move out from its proximity and thus successive growth of brownfields goes on. Affected area is unhabitable for middle and high ranks past the time, only socially low families and problematic ranks are staying here – locality progressively deteriorates and collapses.

Return to normal live in affected areas are very time-consuming and capital-demanding. Problems of brownfields in small towns is even more important, because it must be identified from the very beginning and faced in starting process of dilapidation, already.

One of the most important prerequisite of a good solution of brownfields-problems are multidisciplinary educated communal officials and town council-members, who will identify problems in time, properly analyze it and hand it over to expert´s hands. This approache would possibly create ideal condition – no brownfields will born any more.

Examples of redeveloped brownfields

Evidence of successful of redevelopment of brownfields may be documented by examples of improved areas of former brownfields. The ecological stress in these cases is taken away as their clearance is not the most necessary condition for new use of these areas.

The redevelopment of print works at Václavské náměstí no. 15 is one of good examples. This print works, from totalitarian time, is known like “Gallery Art Factory” now. There are shown works of art by nowadays authors on the area 500 m^2 approximately . The industrial places, where were conserved parts of printing machines, perfectely complete the show of nowadays art pictures and sculptures. All place was reconstructed during only one month and was getting a high esteem of a part of modern american galeries.

Another often quoted example is transformation of industrial place of ČKD Dukla Factory in Karlín. This ground gradually developed during approx.160 years – in break of 19. a 20. century. During nineties of the 20.century development was suddenly broken as a result of bankruptcy of factory. Buildings was partly sold out and used as deposits or left only to decline. The change of owner represented a new chance to redevelop groungs according to new conceptional solution. After realising urbanistic and building-historical research and evaluation of environmental characteristics the new land-use plan was made. The land – use

plan, however, was not compatible with approved city plan from autumn of 1999, what meant, that the correlation of land-use plan and and the city development plan actally in force was rather dificult. That´s why a modified approach to redevelopment of specific buildings was implemented.

For another example, the nowadays complex of Corso Karlín was rebuilt from single-aisle industrial building to five-tract administrative building with a land - officies in overground and parking places in underground. The massive brick base accentuated by vaults and ledges made good contrast with newly- built glass cube, which is maximally lit across the main structure and used building elements and materials.

On the other hand Pernerova Project of redevelopment required the total clearence of original deposit buildings. New multipurpose buildings are actally located in the area instead of the old ones. New buildings look very light and elegant because of the choice of building material and shape of subdominanted floors. The redevelopment completly closed the Perner´s street and extended into the park nearby with the small baroque chapel.

The other well known examples of successfully redeveloped brownfields are:

Ikano Building – Stará celnice (The old custom-house) in Prague 1 – rebuilding of custom-house into multifunctional building;

Arena centrum Praha (Arena centre Prague) in Holešovice – redevelopment of the First Prague Brewery into the complex of administrative multifunctional buildings;

Cement Plant "La fábrica" in Catalania – redevelopment of former cement producing plant into archives, apartments, studios and show areas;

Lime works in Hranice na Moravě – redevelopment of circular lime works to roadhouse with leisure activities.

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Ecological, Cultural and Humanistic Aspects in Education of Technologists in the Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic

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In 1999, as a reflection of a general „Agenda 21" (document of the UNO International Conference on Environment and Development, Rio de Janeiro 1992), the international organization CIB has published „Agenda 21 for sustainable construction" – document, that:

- defines fundamental goals and tasks of building in relation to secure sustainable development
- contains recommendations for preparation, design, construction and use of buildings
- sets up recommendations for strategy of human settlements´management, orientation of research and conception of designers´and civil engineers´education (see the motto above).

Education at the Faculty of Civil Engineering of C:T:U in Prague, first public Enginnering School in Central Europe (founded in 1707), is based on the same philosophy.

After fundamental change of social and economic establishement in the Czech Republic in 1990, key changes in study programs have been executed: deviation from the formation of highly specialized experts with narrow profesional profile to professionals in Civil Engineering, profiled also in connected subject areas and synthesizing general fields of knowledge, able to solve problems not only technically but in a complex way. This is especially important for those professionals who take share in the use of natural resources, design the environment and shape the landscape and existing settlements.

New Departments of Architecture, of Planning and Regional Development and two new branches of study (Environmental Engineering and Building and Architecture) had been established at the Faculty of Civil Engeneering, Czech Technical University in Prague, as a reflection of the new political, social and economical reality after 1990. The education in interdisciplinary professional modules was considerably extended. One of such modules is „Planning of settlements and regions" and is fully practised by the Department of Planning and Regional Development with the aim to form Communal Engineers, Planners and Communal Politicians, who would promote the following rules of man´s behaving in the environment :

- to change the man´s behaving in environment from exploitation of natural resources towards careful cultivation and in conformity with biological cycle
- to optimize the economyof limited natural resources and environmental potential
- to suppress the sectorial approach in favour of the complex creation of environment
- to forecast the relations rather than target values in different time – horizonts
- to produce alternative proposals of problem – solutions, tools and means for development of settlements and regions
- to contribute to reinstallment of natural balance in areas
- to collect information on territory and develop methodology of data base treatment as means for realistic prognosis, long-bearing plans and development programs.

It is obvious, that these newly profiled Professionals need not only the technical information, but also the basic knowledge of humanities (philosophy, politology, sociology), of planning

and architecture and also be sufficiently informed about economical, legal aspects of building and construction, financing and management of territory and settlements.

The goal of pedagogic activities of the Department of Planning and Regional Development is to equip students by professional knowledge and skills required by their future jobs in Local Authorities, Municipal Administration and Management and emerging Agencies of different profile (design, consultancy, expertise), private business and International Organizations.

Conception of education (lectures, seminars, projects) and composition of subjects in the module of „Planning of Settlements and Regions", that the Department warrants, is based on the following philosophical background:

- united basis of science, research and education practically implemented in individual conditions of really existing areas
- teach students to learn complex approach to problems, to search for connections and relationships
- improve students´ knowledge in other than technical and technological disciplines and show practical implementation of non/technical subjects (sociology, ecology, economy, law]
- orientate students to individual creative work and team cooperation with respect to individualities
- point education on progressive forms of management in engineering practice as required by current demand of not only well educated Civil Engineer but organizer and businessman as well

Ecological, cultural and humane aspects are integrated in teaching program of the Department of Planning and Regional Development not only in individual subjects (compulsory or optional), ensured for students of our module by the Department of Social Science (Social Ecology, Economy and Organization of Self-ruled Territorial Units), but in technical subjets as well (Basic Townplanning, Planning Techniques, Social and Economical Infrastructure of Settlements, Strategy of Urban and Regional Development, Planning of Rural Areas, Urban and Physical Planning) ensured by the Department of Planning and Development.

Our goal is to form not only professionally well educated young experts, but well educated people generally, open to all three categories of knowledge: technical, social and spiritual. People able to take share in creation of cultural environment of our civilisation – high cultural standards as a quality of life, as a life-style, value orientation and relation to nature…, people able to perceive and create „beauty".

„Esthetical and ethical feelings are closely connected. Both, the beauty of nature and beauty of surrounding cultural environment created by man are necessary for psychical and spiritual man-health. Total blindness of Soul to whatever is beautiful, which is expanding so rapidly, is a mental disease, that we have to take seriously, because it is followed by unsensibility to what is ethically condemnable"

Konrad Lorenz: "Eight lethal sins of a civilized man", Munich, 1973

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Current Demands on Planning of Sustainable Urban Renewal and Regional Development

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To learn complex and not only technical and technological problem – solutions is especially important for those, who shape man-made environment through design, building and development. They decide about the use of non-renewable resources (as the land, for example), locate the results of their professional activity into landscape or existing settlements and thus cultivate or deteriorate the environment. Multidisciplinary character of design and management of human settlements´and regional development ask for conceptual professionals based on multidisciplinary profile.

1. Educational basis and contextual sensibility

The starting point of the planning reform was marked by two questions of major importance:
1.”Do our technical universities and schools make their graduates think sufficiently of the influences of projected technological and technical developments on the quality of the environment and of their social and cultural impacts?”
2.”Is the technical education proportionally completed with a complex knowledge of applied social and natural sciences?”
Needless to say, that the answer of a considerable part of public and professionals is still negative. However, the current educational concept of future planners is based on the fact that the interdisciplinary character of development and management of human settlements and regions requires conceptual specialists with interdisciplinary professional orientation, who will be able to design and make qualified decisions both on the basic level of state administration, that is in Local Authorities´councils, as well as on higher levels of state administration, and who will be able to set and process the planning documentation of the area. Moreover, they should be able to identify and assess cultural values of environment, needs of preservation of nature and cultural monuments, integrate proposed new developments into existing environment and last, but not least to make distinction between the real needs of citizens on one hand and particular interests of lobbying groups and corporations.

2. Last century´s experience

Throughout the post-war era the aim of education and teaching has been to produce clearly and explicitly profiled specialists with a detailed and specific knowledge of their field of study, but unfortunately missing outlook and orientation in connected or synthetizing subjects. Under the pressure of more and more specialized advanced building technologies, Civil Engineering itself fragmented into a number of rather independent professions and lost its´original close and integrating relation to Architecture and (Town)planning. Decomposition of Civil Engineering was obviously reflected in education and research.

3. Project – problem based education of Planners and Civil Engineers?

Since the very beginning of the reformed study of Urban Planning and Regional Development at the Faculty of Civil Engineering in C.T.U., Prague, the programs are project – problem oriented. Every student willing to pass, has to produce a series of designs and projects assigned on current tasks of development or redevelopment of selected Czech and Moravian cities and villages. Our answer to the challenge of problem-based education is generally

positive: “Yes, but in which sense?” The range of questions emerges again: “Is it a type of teaching methodology based on search for practical solutions of practical problems, that we need the most? Is it a “demand x supply” type of education in technologies, structures, networks and patterns? Or, should it be the opportunity how explain philosophies, approaches, policies and principles using the typical sets of problems of urban and regional developments?” I would incline towards the last understanding of project-problem based education.

4. What is a “problem” in Planners´ education?

The concept of project-problem based education leads me to some hesitations about what the “problem” means in Civil Engineering? Is the complexity of current world´s reality sufficiently reflected in Civil Engineers´ education? After all, even for two Civil Engineers of different profession the same specific task to design, let´s say a new motorway through the city may represent “problem” of two very different kinds: destruction of existing structure of the city for a Planner on one hand and squeezed space available for Transportation Engineer on the other. What Planner and Architect consider be a problem of major importance is not seen as a problem by Civil Engineers at all! So, relativity of “problem” in Civil Engineering is a real problem. I am convinced, that complex processing of “problem” in Civil Engineering: identification _ assessment _ structuring _ proposal of adequate means for solution _ choice of optimal solution _ evaluation of results is actually one of the most important issues of education.

5. From Project - problem based learning to Project- value oriented education

Implementation of „problem“ processing in Planners´ education programs requires the existence of certain value orientation of students. It means a system of personal attitudes, approaches and assessments for individual reflection of reality. It represents an individual behaviour basis to which the student relate and compare the reality, he currently faces. Development and cultivation of such a basis, I think, should also be a major task of education at all and of Civil Engineering education especially.

6. How the philosophy of sustainable development influences the planning of regions, settlements and buildings?

Ecological transformation of settlements has the key importance when solving the crisis of environment. Urban growth together with starting shortage of natural resources and affected environment represent the global threat to our living conditions. Deterioration of natural environment was firstly manifested by the air, water and soil pollutions, disappearing greenery, increasing noise-pollution and nuclear deposits. Then losses and general functional unsutability to satisfy the real needs of inhabitants were specified. Urbanization and consequently process of concentration of population in large-scale cities, housing problems, disappearance of cultural identity of settlements, result in uniformity, utilitarity of technical products and buildings, as well. Diversified and healthy environment represent a basic value for healthy development of society.Therefore, the new forms of ecologically balanced urban development on a highest scientific and technical level are needed – „development“ does not always mean „growth“.

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Sustainable Construction of Buildings and Sustainable Development of Urban Space

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The problem of sustainable development of built environment represents highly complex issue incorporating a large number of criterions from different areas of technical as well as non-technical sciences. On the global scale, the construction industry and its products, which form a built environment (buildings, bridges, dams, roads, etc.), consume a crucial amount of material and energy sources and are responsible for a very significant portion of pollution by harmful and damaging emissions and wastes. It is estimated that in the European Union the construction and operation of buildings are responsible for 30-40% of total energy consumption, CO_2 emissions and total waste production. Simultaneously the built environment (buildings, urban space) forms a necessary basis for the quality life of humans (security, safety, cultural function, healthy aspects, aesthetics, economy constraints etc.).

The construction sector responded to general requirements of sustainable development (specified in Rio Agenda 21 in 1992) in the CIB report Agenda 21 on Sustainable Construction published in 1999 [1] (Czech version 2001 [2]). New approach to design and construction of buildings and to development of urban space is more complex and covers several sets of criteria, which are based on general Agenda 21 sorted to three basic areas of sustainability:

- Environmental quality (outdoor and indoor environment)
- Economic efficiency and constraints
- Social equity and cultural issues

All essential aspects incorporated in these areas should be considered within the whole life cycle of particular elements of the built environment (design – construction – operation – modernization / reconstruction – demolition – reuse / recycling).

The main goal of the current doctoral project "Sustainable Construction of Buildings and Sustainable Development of Urban Space" supported by the Czech Grant Agency is to create a professional platform for communication of students in doctoral study programs and their supervisors, dealing in their research activities with different aspects of sustainable construction of buildings and sustainable development of urban space. This project started in October 2003 and is planned for 3 years duration.

Taking into account the multicriterion character of the problem of sustainable construction, the project is organized "across" different departments of CTU in Prague. The aim was to involve into the team students and supervisors working in different segments of the research in this specific field of investigation. Therefore 16 PhD students from 9 departments and from two CTU faculties are integrated in the established Doctoral Team. Ten students are studying at Faculty of Civil Engineering CTU, 6 students are studying at Faculty of Architecture CTU. All involved PhD students are dealing with different aspects of sustainable construction:

- 9 PhD students are oriented to technical aspects of construction and operation of buildings (low energy aspects, acoustics, timber construction, use of recycled materials, building services, solar design etc.)

- 5 PhD students are focused to social, sociological, functional, urban and architectural aspects of built environment (urban sprawl, brownfields, reuse of industrial historical buildings etc.)
- 2 PhD students are engaged in development of methods for assessment of environmental and social impacts, and economic efficiency (sustainable economy and management, LCA)

Supervising board of the Doctoral Team is formed by 6 selected teachers - supervisors of PhD students – three of them are from Faculty of Civil Engineering, three from Faculty of Architecture. Overall coordination of activities of Doctoral Team is controlled by Head of Doctoral Team and by one PhD student of combined doctoral studies.

The educational activities of Doctoral Team are planned and performed on three levels (1) Working Discussion Meetings, (2) Seminars and (3) Workshops. During the fall 2003 there were organized following actions:

- Three Working Discussion Meetings, two of them were focused to scientific topics: General Aspects of Sustainable Construction; Impact of Green on Microclimate of Urban Space.
- Seminar: Unburned Clay in Contemporary Construction (partially organized and supported by this grant)
- Seminar/Lecture: Overall Hygrothermal Performance and Related Computer Simulations given at CTU by Prof. Carsten Rode from DTU Lyngby, Denmark
- Exhibition: Wood in Contemporary Austrian Architecture – Corinthia
- Exhibition: Harmony, Ecology and Economy in Housing
- Participation of 3 students from Doctoral Team on the PhD course "Integrated Design of Sustainable Buildings" organized at DTU Lyngby, Denmark by Prof. S. Svendson.

The activities of Doctoral Team are presented on newly developed internet pages which are incorporated to existing web site www.substance.cz.

Additional education of PhD students involved in Doctoral Team is focused to technical problems connected with the design, construction and utilization of buildings, as well as social, economical and urban problems of the urban space. The transfer of information between supervisors and students from different faculties and departments can improve and speed up the progress in solution of research tasks within doctoral studies and it will help to extend possibilities for cooperation of researchers from different workplaces of the university, which are oriented to the research in the field of sustainable development of construction.

Current project will continue in the following three years.

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Constructional and Material Analysis of the Functionalistic Buildings

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Within the Czech Republic can be found a number of modern buildings of an international importance. Modern buildings can be characterized not only by their sophisticated architectural style, but also by the use of progressive constructional principles, materials and technologies. Reconstruction and renovation must approach the buildings so that the architectural, constructional and technological qualities are saved. It is needed to concern on those buildings due to their value as the cultural heritage.

The time between two world wars limits not only the existence of the Czechoslovakia, but also the era of the modern functionalistic style. In the year 1924 the architects published their opinions on the "new architecture" in the magazine "STAVBA" that is understood as a program of the new style. They demanded on a perfect fulfilling of function and use, improvement of the living and hygienical standards, precision and economy in the material and structural design and usage itself. New constructions, new materials, new technologies and newly formulated demands were to complete these ideas of the modern time.

The building of the interwar era offered the full range of constructional systems, e.g. constructions of brick masonry, reinforced concrete beam-and-support structural frames, combined systems and also prefabricated constructions started to appear. It was not earlier then in the beginning of the 30s of the last century when the masonry lost its position of the most traditional material for the construction of the foundation, external wall, inner load bearing and partition walls as well as for the ceiling. Since that time are for the modern style buildings typical the reinforced carcass construction with the bi-directional portal-frame arrangement or, more often, combined construction of brick masonry and reinforced concrete ceiling, sometimes completed by the inner carcass system.

The will to improve the building situation, the need to build up quickly on high functional, technological and constructional level led to exercise of a wide range of new building materials. It was for example the masonry from bricks with or without cavity or from blocks that were used due to their low weight. The blocks were made from terracotta, from siliceous earth, from the simple, foamed, breeze and slag concrete. Those were however mainly the concrete and reinforced concrete that were the materials of the 20th century. The reinforced concrete approached the buildings through the ceiling structure for which was more frequently used since the last quarter of the 19th century already (the first house made up of a reinforced cast concrete was designed and patented by a Frenchman Francois Coignet in 1854). The engineers of the end of the 19th century concentrated on the interaction of the concrete and reinforcement, as well as on the calculation methods (the principles of the reinforced concrete were for the first time understood by William Wilkinson in 1854 already), so by the beginning of the new century the knowledge was sufficiently advanced to evolve into an independent field. The architects of the modern movement then picked up the advantages of the concrete technology and introduced the cantilevered floors for projected balconies, landings, roof

overhangs or for the so called open corners, etc.

Next to the reinforced concrete played an important role the introduction of the curtain wall constructions. It was recognized three main types of the structural fillings for the carcass construction: a) *heavy:* that were a part of the load bearing system (bricks from the slag or pumice concrete, bricks with or without cavity, blocks etc.); b) *medium:* that were only partly used as a support for the load bearing structure (for example profilated bricks with the "*Isostone*" reinforcement); c) *light:* that were put between the load bearing elements (pressed products from the cork crush, sawdust, vegetable fiber –*Celotex* or made of combined wooden desks with a distance air cavity etc.). Another of the important new elements was the structural glass that was widely used during the 30s of the last century. The so called glazed bricks, "*luxferprismaten*", influented the architectural vision and became one of the building features for the horizontal, vertical as well as for vaulted constructions.

Within the range of new materials must be listed the waterproof and the heat insulating materials too. Both were, next to the other structural parts, mostly needed for one of the main features of the functionalistic buildings- the flat roofs that composed of the ceiling structure, heat insulating layer, downflow, leveling and protecting layer and the waterproof layer. The role of the waterproof material played mostly the asphalt itself or the asphalt boards and paints, such as *Ruberoid, Semptalin, Adurolit, Ocelit*, or the tinned roofing made of copper, lead or zinc. As the heat insulation were used different insulating paste, pressed desks, mats and pads made of siliceous earth, pumice, cork, wooden sawdust, peat, reed, straw or of lightweight concrete (porous, foamed, pumice concrete, wooden concrete etc.) or for the flat constructions fills from slag, breeze, siliceous earth, pumice or cork. Next to the listed materials, the engineers concentrated on creating new building elements that had better heat insulation characteristics, such as the "*insulating masonry*" (blocks mainly made of slag, pumice and siliceous earth) or the "*cavity brick masonry*" (masonry from tannins, slag, foamed, porous or pumice concrete).

In this contribution the constructional and material variations of some structural elements of the modern style buildings has briefly been introduced mainly from the material position. All together can be said the interwar era used elements based on natural materials: slag, breeze, pumice, siliceous breeze, terracotta, cork, peat, wood, reed, straw, paper or asphalt. In order to a better understanding of the functionalistic architecture it is important to understand and know this wide range of material, technological and constructional possibilities as well as the physical characteristics of the structure. The importance comes from the need of special conservation approach and methods so the loss of the original substance is minimized.

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Content of Regulatory Plans

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The aim of the diploma project is to create an unified methodology of graphic signs of the regulatory plans. This methodology is missing nowadays and present regulatory plans do not often contain basic information, are not clear enough and may lead to confusions. Missing unified legend in the planning documentation is also an issue to be deal with.

The work begun with collection of numerous regulatory plans from the past and the present time and continued with their detail analyses. This was followed by the research of the history of the town planning and particularly the survey of the graphic display of regulatory issues. It came out, that the basis of the graphic signs used in legends was established already in XIX century and in the first half of XX century. That was the time of dynamic growth of cities, the time of industrial revolution, the time, when the need to regulate the city development became necessary as a tool of protection of public interests. The first attempts to unify the graphic signs occurred in that time too. The Gubernial decrees about the permitted colours are dated from 1828 to 1837. The planning guidebook of Prague Building Code by Adolf Stafl contains also many remarks concerning graphic signs in regulatory instruments. The book „City and Regulatory Plan“, published by Masaryk Academy Publishers, dealt with the graphic signs as well. The book belongs to one of the most important publications about planning from the „first republic“ period. The most relevant document for the research work is the Norm Nr. 1134 – Regulatory Plans from the year 1934. It defined the content, scale and the type of the graphic signs. This norm was used not only for regulatory plans, but also for urban study, urban competitions entries etc. Other key document is the „Building Regulations for the City of Prague“ adopted by City Regulatory Committee in 1935 as an integral part of the land use plan in accordance with the Act 88/1920. These regulations unified the graphic symbols, colours for functions etc.

Generally, in the contrary to the technical drawing, which unification begun also in the early XX century and which keeps its system till to today, the graphic signs used in the planning varies and there is no single rule for their use till these days.

The above mentioned preparatory research work will be followed by the diploma work. All individual items of the legend will be summarised in one overview table including their graphic signs using both old and new symbology in black and white as well as in coloured form. The items will be categorised into groups. The symbols will be evaluated and a new synthetic table will contain recommended graphic signs including description.

The goal of the diploma work is to propose a system of graphic signs, which will be unified, understandable and which will correspond with present legislation. Finally, a new recommended set of graphic signs for different documentation scale will be suggested. Most likely there will be sets for new development sites, for existing city fabric (regeneration) and

finally for small settlements, where the land use plans and regulatory plans might be elaborated in one document (as proposed in new building code).

The recommended set of graphic signs will be divided into groups related to different phases of planning process and, most likely, related to individual drawings. Each regulatory item will be labelled as obligatory, compulsory and optional.

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Model Projection of Architectural Objects

The Physical Architectural Model and its Parallels in Fine Arts

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The following thoughts, opinions and notes come up from common views on architectural composition and from some basic principles of fine arts, mainly from sculpture – non figurative.

And so we are approaching basic problems: architecture, model and their art sources. Or, from the other side: fine arts and their architectural impulses.

Every piece of architecture tells the story, at least about its existence, doubtless, it is art. We can analogically understand the informative function of an architectural, urban model. Common terms: "model", "model creating" recalls associations: semiotics, semantics, and language of architecture. In this context we understand the architectural model (mainly physical, spatial – regular model) as a part of a way of communication: model as one of technological and artistic means interpreting fantasy and reality.

It is also necessary to remember the need to examine the essence of perception of the model, and to examine its psychological affects; like the affect of realized architecture.

Subjective factors of perception of architecture and its model are in connection with individual features and experience of a man, with his emotional conditions, with his individual interpretation of an architectural shape, volume and space. The same things we can declare about perception of fine arts, mainly non-figurative sculpture.

The physical architectural model creates informative background for the explanation of architectural ideas and their aerial, formal and volume able, spatial and functional description. The model becomes, with its simplification and conscious abstraction, a specific kind of expression of artistic quality of architecture. The architectural model becomes, or should become, the artistic object by its own. The architecture, in comparison with other human artistic activities, is specific. And art could have, in different times, places and social connections, different meanings in spite of those different, important and less important, relations do exist and did exist. It is also for that reason, that the field of art and artistic creation is included in a sphere of information.

Could the certain piece of art be a metaphor of architecture? Or could architecture be a metaphor of art? As Kenneth Frampton says, the architecture is not conceived as a primitive hovel, a cave…., before a man transformed a vertical support was to a column, a roof to a tympanum, before he laid a stone on a stone, there was a stone set on ground to mark the spot in the middle of an unknown universe to describe it, to change it… In other words, the art perhaps begins, when mere "usefulness" is enhanced by a certain "artistic"intention.

Basic and common points of architecture and fine arts result from these questions and contemplations. These are not incomparable, but evident. It is evident in realizations, but also in models of architecture. Just as a piece of art (mainly non-figurative sculpture) could be an inspiration of architecture, so could basic principles of architectural creations be part of the creative process and results of fine arts. Sculptural architecture or architectural sculpture?

Examining the frontier–points of architecture and visual arts, there is not only the visual arts, there is not only the visual – evident part, or similarity that matters, but the roots, outcomes, inspirations and ways of approach are important (the ways possibly parallel, crossing, non-crossing). One can observe their aims, asymptotes, parallels, as well as dialogue between architecture and visual arts – evident already since the model-sketches. If we watch (limited selection) examples of common points between architecture and visual arts, we can notice dialectical problem. Is the object architecture, sculpture, religious space, symbol, technical (astronomical) machine? Or, already mentioned, the centre of universe? All we mean are objects like menhires, dolmens, trilits, like Stonehenge area, as well as pyramids… The question of functionality seems to be responded, but how about the artistic architectural part of question. Coming over ages, we get to recent parallels: space defined by a number of menhires called "Discussion at the table" (by Magdalena Jetelova, 1985). Ales Vesely`s last projects, going over boarders of "classical" sculpture near to land – art and architecture ("desert-tower"-1997).

The beginning of the 20th century offers a couple of visual-art phenomenon and sound names: engineering, architectural synthesis of the Pevsner brothers´ sculpture. Some of Antoine Pevsner´s later works set very close to architecture - they are imaginary human dwellings. These and similar sculptures of other artist (Max Bill, Hans Arp) might be understood as models of latter architectures. It is necessary to mention the sculptural - architecture of the expressionism (e.g. Artist's house, 1929, H. Finsterlin; Einstein tower 1922, E. Mendelsohn), or Czech architectural cubism. The crossover from dynamics in painting to 3D models was examined by soviet supremacist (1913-23). It is often nicknamed "architectural paintings". The examples might be Kazimir S. Malevic`s "planity" and "suprematic architectons". Later El Lisickij`s "prouns" and J. Cernichov`s architectural fantasies. Le Corbusier`s chapel in Ronchamp (1955) disturbs with its sculptural forms, his idea "a house as a machine for living". Transformation of a sculptural object into architecture grows up of ideas about "house-sculpture", by A. Bloc (Residential garden-sculpture, 1964), as a opposition to L.C. ideas. There was a group of artists, whose artistic works were on the frontier between fine arts and architecture (K. Malich, Z. Sykora, S. Kolibal) in the 60`s in the 20$^{th}$ century, in our country. The example of exact synthesis of architecture and sculpture is the project on the Youth club by C. Parent (the 70`s the 20th century), which was created on the base of sculpture – model by G. Mannoni. The extreme example of the relationship between sculpture and architecture, nowadays, is a "back reverse" cast of an interior of London house (in scale 1:1), made by minimalist sculptor R. Whitereadone (the house was destroyed in 1994). In our country it is possible to see close connections and common basic points of architecture and sculpture also in these days. For example: works of F. O. Gehry and V. Milunic, or J. Stritecky and J. Krupauer.

The text above is presenting a problem for a discussion: Is the architecture identical with sculptural fine arts? Can they be internally identical?

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Architectural and Historical Field Research in Chateau's Park Veltrusy

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In the year 2003 were made complete field architectural and historical researches Of the buildings in areas of Františkovi Lázně a repeatedly in the chateau's park in Veltrusy near from Prague. There were as well made preliminary researches in Karlovy Vary and in Mariánské Lázně and there were prepared workground records from technical literature and as well from preliminary researches which are needed for working out complex researches in the next year.

There were finished historical studies and were produced compositional analysis for the building above František's Well and Glauber's Well I in Františkovy Lázně (M.Nesměrák, J.Tencar, D.Štětina, Klára Janotová).

There were finished historical studies and compositional analysis and displaying of buildings in chateau's park in Veltrusy (M.Nesměrák). As a next step there were undertaken, as a reaction on a rising damage of builings by flood, repeated field researches in park Veltrusy (M.Nesměrák, J. Tencar, D. Štětina, Klára Janotová, Ondřej Zemánek, Lucie Bednaříková). These researches were undertaken in spite of observing not only the development of technical failures but as well for finding out structural system of the building what was anabled by uncovering of certain parts of buildings in spite of large damage. The original aim of displaying the buildings in ideal original conditions could be completed by displaying the conditions before and after the flood.

This displaying cold be large contribution not only for studies of architecture, finding the methods of displaying but as well for saving these extraordinary significant buildings.

This english type park is extraordinary example of urban composition as well as from the point of architectural quality of particular buildings. The subject of our research were existing pavilions of antiquity character.

Laudon's Pavilion

The most damaged building caused by floods, by neglected building maitenance and by vandalism is so called Laudon's Pavilion (the bridge with water-gate) built in 1792 according to design of architect M. Hummel[1)]

The building is in lower part made by stone spanned bridge linking both banks of artificial river trench. The upper part is made in form of passing through amfiprostylos type temple (floor plan dimentions 4,9 x 5,4 m) The doric style front face is made by two columns and an entablature with a gable. Lengthwise walls are symetrically broken by two windows divided by arch above them. The lower part including bases and capitals of columns are made from stone. The rest of the building has the surface covered by stucco plaster. The ceiling of the interier is decorated by paintings.

The Pavilion of Marie Terezie

This pavilion was seriously damaged by flood and by neglected technical maintenace. It was built in 1810-1813 probably by architect M. Hummel[2)].

The building is designed in the form of tetrapylon (the floor plan dimensions 8,35x8,35 m) with two arches possible to pass through and with set forward stairs. The other

two arches are closed by balustrades. The three set forward corner columns (height 5,05 m) in tuskan style are placed on a plinth. The building is covered by a cupola. The inner space is formed by flat ceiling.

The Temple of Friends of a Countryside and Gardens

As best preserved building from outer look appears the Temple of Friends of a Countryside and Gardens built in 1792-1794 by architect M. Hummel.[3)]

The building is situated on a round platform. A set forward stair, sidings of the platform, bases and capitals are made from stone. Ten columns (height 6,7 m) are made as an individual variation of ionic style. An Entablature is also in ionic style and is rythmically articulated by rossetes. The building is covered by a cupola on a tambour. The core of the building is also round and is accessible by door and lighted by rythmically placed windows. The wall of the building is covered by stucco plaster. Inner space is covered by cupola decoraded with paintings.

Doric Temple

Surprisingly the most damaged building in consequence of negleted technical maitenance and vandalism is Doric temple built as a second building in this area before the second half of the 19th Century.

Pavilion is like the Temple of Friends of a Countryside and Gardens situated on a raised place of a relief.

The building in the form of monopteros lays on a platform (floor plan dimentions 5,46 x 4,77). Set forward steps and sidings of the platform are made from stone. Four columns (height 2,83 m) put on all sides are elaborated in unusual doric style. Doric entablature is crowned by gables above the longer frontages. The surface of columns, entablature and gables is covered by stucco plaster. Inner space copying the form of pitched roof is covered with wooden coffers and rossetes.

More detailed analysis of whole building, architectural details, used building structures and materials including detailed description of structural failures will be presented after the finishing the research task.

During the field research in 2003 there was realized co-operation with members from the Chemical Technology Preservations Department at the Chemical Technology University in Prague[4)]. The subject of co-operation is joint proceeding in field research and subsequent exchange of information important for understanding these extraordinary buildings as from the architectural, structural though material point of view.

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Transformation of Urbanisme

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Sustainable development principles and a new political context require changes in methods and instruments of spatial management.

The main goal of the research is to analyze existing principles and methods of urban design and planning, to search for new ones, as well as to define their linkage to the Building and Planning Act. On the base of the previous years' research, outputs are finalized on key topics of urban and planning practice. The outputs were externally reviewed and they have been published or they are prepared for publication namely:

- Regulation and regulatory plans (methodology, techniques and standardization
- GIS metadata and spatial planning in the context international integration of contents
- Transformation of countryside and sub urbanization

The research reports of below listed topics were presented during several conferences and seminars in the Czech Republic and abroad in 2003. The reports are available at the Department of Urban Design and Planning of CTU Prague. Special yearbook of the research is ready to be published: City , Countryside and Landscape IV.

The particular topics elaborated in 2003:

- Urban regulation in the history – Phase 4

Draft version of summary of preceding three phases was elaborated.

- Methodologies and techniques of urban space analyses

The focus was on those areas of urban planning that are currently underestimated in practice – namely conception and urban design.

- Functional aspects of transformation of public space- 2003.

Completion of missing cases from the receding stages. Definitions and specifications of conclusions.

- Transformation of countryside and sub urbanization - Phase 4

Completion, following the results of review. Improved methodology, text arrangement and certain viewpoint corrections.

- Character of landscape and its preservation (Prague-Pittsburgh - Landscape Character Protection).

The research was devoted to the methods of cave for landscape; focus was on the applications of landscape character preservation and maintenance of cultural landscape in real situations. Case study was elaborated for Prague and Pittsburgh.

- Transformation of leisure use of the territory

Summary and updating of selected phenomena of leisure use, based on survey and analyses.

- Methodology of GIS data management and registration for the use of spatial planning

Formats of metadata – community profile for spatial planning. Background for metadata information on GIS data relevant for the national/regional level of spatial planning in the neighboring states.

Additional topics elaborated in 2003

- Changes in the land use and development of urban agglomerations in the Czech Republic. Survey of changes in urban land use in particular Czech towns
- Analyses for regional and national level of planning instruments
- On the background of available GIS data relevant for spatial planning, several analyses were elaborated for the National spatial development policy (appending planning instrument in the bill for new Planning and Building Act.)
- Building for agriculture in villages and country
  The 2003 research focused on negative impacts of the buildings and their evaluation in planning.

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Architecture - Environment, City planning, Construction, Space Arrangement, Technology for Sustainable Development

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One of the most important topics in actual architecture creation is the design and production of low energy houses, but not only this. It specially depends on sustainable renewable energy development. Main point of energy claims in our conditions is in consumption of energy, especially the consumption of the thermal energy. This is complex problem and in architecture we could contribute in many ways. Saving the energy is possible in production of materials, transportation and space arrangement. Harmony can rise only from complexity.

General energy claims of buildings we can affect by its architectural design. Already at the beginning, in concept, we can markedly reduce energy losses and maximize energy profits.

At first, for realization of low energy architecture is very important optimal land utilization. It means evaluation of existing environment conditions in specific locality. For energy savings in urban planning is good, when the city planning is based on concentric construction, compact residential unit and suitable location of building. Very important is also topography, configuration of the land, orientation, atmospherical conditions and location of water areas. Combination of all these mentioned climatic factors enables to create suitable local climate. Basically is possible to say, that this is the cheapest and easier, if it is applied in high level of city planning. When the house is reasonably situated in environment, we can save up to 50% of the heat looses.

After space arrangement, the next important thing is orientation, space layout in environment and the shape of the building. Most compact shape is the bowl, but this shape is not very useful for internal spaces design. The best is, when the house is compact as possible. That means not flat or broken to small parts. Orientation of the building is best, when the main - lighting and open view façade is oriented to the south. Then is best to situate small windows on the north façade and its area could be between 15-25%. The main rule of low energy houses is situating of the warmest room to the center of the disposition. Other rooms gradually continue to coldest on the outer frame of the building and that means that the heat looses are only difference between coldest room and the exterior. For application of solar energy conservations is good to integrate green winter gardens or solar walls in south façade of building. Application of these winter gardens depends on location, for example in our location they could make looses of energy so it is necessary to take it into consideration and evaluate if its application is reasonable.

Architectural concept is affected also by many another non architectural- technical solutions. For example type and effect of heating system or passive and active solar devices.

They essentially force the design and outer look of building. They could not be used uncontrolled, they have to make building more aesthetic and more complete, not degrade it.

Another point of view is using particular materials, are used in construction. Example of ecological materials, nowadays celebrate revivals mainly in housing projects, are constructions from straw, or clay. One has to count advantages or disadvantages, but these materials sometimes could astonish us. The lower energy demands are evident. Construction made from straw parcels with clay plaster could have same, even higher fire resistance than brick wall. Clay is good material for making man friendly inner climate. Unburned clay could transport humidity very effectively. In houses made from this material is 40-60% humidity in air, ideal for human dwelling.

The all are determinants and inspirations for new and specific architectonic term. Architecture has great impact on our lives. Harmony is possible, when we know about all these aspects.

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Industrial Architecture of the Inter-war Period in Czechoslovakia and the Technological, Economic and Cultural Context

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The project takes a targeted look at an important period of industrial architecture, between the emergence of the independent Czechoslovak state in 1918 and the Second World War, though a period that from the perspective of the process of mapping industrial heritage has been neglected. Yet, it is the industrial architecture of the twentieth century and specifically that of the period between the 1920s and 1940s that represents such a substantial contribution, not only from the relatively smaller, regional perspective of this country, but also in a European and a worldwide context, and this is one of the significant aspects that the research project intends to emphasise.

In a European comparison the Czech heritage of industrial architectural work is among the examples representative of the exceptional cultural, technical and economic flourishing that occurred between the two world wars, and it can be directly traced back to the progressive tradition of the *Werkbund*, whose creativity no longer sees industrial production as such for its shortcomings, but focuses instead on its production under artistic scrutiny. The fusion of these two values – production and artistry – is the essential contribution of architecture that, though very fragile from the perspective of applied aesthetics (a frequently abstract form), today represents one of the basic milestones of the recognised values in the first half of the twentieth century.

The subject of the research is tied to the conception behind the newly founded Research Centre for Industrial Heritage at the Czech Technical University. The coordinating team is comprised not only of experts long engaged in the area of the research, conservation and popularisation of industrial heritage but owing to the inclusion of the new topic also involves experts in the field of the theory and history of modern architecture of the first half of the twentieth century in a European context. The direct ties in terms of personnel and organisational aspects to the technical university and especially to the Faculty of Architecture enable a full use of the potential offered by a broader group of contributing associates – teachers, students, and especially doctoral students – and the prompt verification, presentation and application of the results in the pedagogical process.

The project is designed to proceed in three interconnected stages:

A) The introductory first stage will focus on filling in gap areas in the collecting of documentation and on the **construction of the database** of valuable industrial and technical works dating from the inter-war period, a work process that is primarily to be based on field research, which will take into account the specifics of development in individual industrial branches, as well as the role of owners, investors and technology suppliers, and the creative interpretation of the architects, planning offices, and construction firms. The database will also provide an appraisal of the results of the bibliographic research and archival sources.

B) The consummation of work on the second phase, along with filling in the database on the basis of ongoing findings and information, will be a **scientific conference** of theorists in the field of architecture and technology historians which the Research Centre for Industrial Heritage will hold on **11-13 October 2004** with the aim of analysing and in a European context defining the more general aspects of technical development and modern architecture of the first half of the twentieth century. It will be possible then to make direct use of the papers presented at the conference, which will be published in a collected volume, for applying to the work in the next stage of the research, one of the purposes of which will be to contribute to formulating more generally applicable viewpoints enabling more precise classifications and unifying the criteria used to assess the historical, artistic and technological significance of buildings and sites to date assessed inconsistently. This will be possible once a sufficiently substantial sample of information and knowledge has been concentrated to allow for a genuine critical comparison to be made.

C) In the third stage, alongside the summarisation work that will be performed through the research on the collected information, attention will be focused on the **most significant representative** works **of industrial** architecture and technology of the inter-war period. Owing to the fact that this involves an evolving direction in industrial heritage research, the appraisal of industrial sites and structures of this period will only be feasible approached once more exact criteria for doing so have been formulated.

Therefore the work primarily involves making a clear listing of the most valuable sites, which will be recommended for declaration as cultural monuments in accordance with the law no. 20/87 on state heritage conservation. Separate data cards will be drawn up for these sites.
More extensive documentation work will focus on delimiting the number of selected industrial buildings and sites (in the registry of heritage conservation), which owing to their unquestionable historical and artistic qualities deserve to be given new uses, while restoring the original architecture and/or preserving the historical technology. The gathered materials will be used to prepare summary reports, but will also serve as basic resources in the ongoing publication of work in the professional press and in occasional publications issued by the VCPD.

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Section 15

TRANSPORTATION, LOGISTICS, ECONOMY, MANAGEMENT

Laboratory for Modern Educational Methods and Practical Training of Flight Planning Process

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Flight planning and preparation belongs to the most difficult processes in professional pilot education both from the point of view of understanding the theoretical part and from the point of view of practical application.

Because of this reason it is becoming more and more important to find an optimized educational method of flight planning that is closely connected to the practical flight planning process. This is one of the priorities in the education of professional pilots, which is provided by Department of Air Transport (Faculty of Transportation Sciences, CTU) according to European JAR-FCL (Flight Crew Licensing) requirements and approved by Civil Aviation Authority of the Czech Republic.

The quality of the theoretical training must be continuously monitored. Fulfilling of the requirements is a fundamental aspect for increasing the safety of the Czech civil aviation.

The basic aim of this project was to build up the "Flight Planning and Preparation Laboratory". The laboratory is a part of highly specialized workstations serving as the theoretical knowledge and ground training improvement of educational process of professional pilots. The heart of the laboratory is created by three computer workstations that allow:

- collection of meteorological data (METAR, TAF, SIGMET, CHMI information – forecasts, forecasted maps, satellite and radar data, etc.),
- flight planning and pre-flight preparation using a sophisticated software Jeppesen FliteStar,
- aircraft mass and balance computations, center of gravity assessment.

The building up of the laboratory was characterized by three main phases. During the preparation phase the laboratory was fully equipped and prepared for operation. The laboratory workers were educated about flight planning process during the educational phase. Finally, the experimental phase was featured by testing and verifying the designed flight planning and educational method.

The philosophy of the laboratory is to ensure a complete preparation of student pilots for the certain flight regarding all the aspects of flight planning and preparation. Then the prepared flight can be practically realized either in the real aircraft or on the flight simulator. What is very important is that the student pilot works in a real environment and with real data and is able to assess if his preparation for the flight was sufficient or not.

The "Flight Planning and Preparation Laboratory" creates together with the flight simulator laboratory and the radio-communication laboratory that were built in the recent past a very efficient tool for theoretical pilot training and ground preparation.

The laboratory also provides a perfect basis for additional research and modernisation. This issue is also to be solved through the doctor thesis and future projects at the Department of Air Transport.

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Strategy Making in Trance-National Enerprises

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In this times of market situation, when the market is under influence of many factors, among them the process of globalization and local and international integration as main factors. On market where many companys compete undertaking of diferent sizes and importans, and where exists a number of small and big companys having same program. Each one of this companys tries to have a part of the given market, in case of bigger company , it have to get a bigger part of the market, and as final result to have a bigger number of consumer for it products or services.

When choosing a suitable foreign market, each trance-national company must take in consider general factors, partly specific influence applied already on concrete choice sector, selection entrepreneurial aim, strategy and organizational design. Municipal macro-environment is created by political and law conditions, economical conditions, technical conditions, cultural and historical and social condition. Specific environment is given by the atractivity of the market, of competition position, supplier and cooperative companys.

From views of international enterprise is international management sight on human element in Company, whereas has also order meaningful contiguous surface. First is the region election of strategic aim, respectively strategic management. If we consider basic supply rate as not only the sources of material and financial, also sources of human and know-how, it can be found graet amount of continuity between the formulation of personal strategy and personal policy of the enterpricse. Substantial improvement is, that this refield of support fulfill fundamental prospectus, was with them in conformable. For this, is the question of formulation of strategic aims, like definite way, is impossible to bend in none of above-mentioned regionof international enterprise. From this view is then interesting to know the content of strategic decision making, which covers suit timely identification of future trends and occasions, election of strategic aims and reservation of needed sources (material, financial and human) to utilize these occasion. Strategic decision making then teak company policy and especially capital decision.

Content of business strategic aims with contain business political intention, research, development and production, also production manpower and incidence in developming areas of company values. Singel areas ofstrategic aims at the same time respectively infuence and undermine, that is why trance-national enterprises must considerwhen choosing the strategy, many internal and external influences and confront specific exigencies pertinent of foreign marketplace with inner business possibility.

Progress of creating of the strategy and analytical basis on whichis we creat the competitive strategy is possible on basis of structural analyses and competitor analyses. Progress of these analyses is:

1. structural analysis of a branch
2. identification of fundamental strategy
3. competitor analysis
4. strategy to customer and supplier

During the process of strategic decision making, gets to accumulate a big quantity of different data, which are necessary to be further classified, and use them properly to reach the best possiable decision.

Situation before decision making:

- create a new concept
- enhance the quality of strategic conversation
- obtain the attention of the organization
- try that the organization gain more from its environment, to be adaptable.
- motivate
- force people to think

Situation during decision making:

- take in consider organization force and its thoughts
- develop the ability and portfolio of possibility
- strategy development
- judgement
- decide

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Creating a Sustainable Manufacturing Strategy

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In the Czech Republic the most important reason for preparing and implementing any strategic plan is the ability to take control of the situation. Plenty of manufacturing companies have a manufacturing strategy, but for many it is not a formal plan. It is usually the result of numerous tactical decisions, each made independently, frequently starting over each time. Yet these decisions follow a certain logic because the same people make them. The result is an unstructured strategy, not fully thought through or communicated to the implementers. All too often, this strategy is inward-looking and focuses on improving efficiency, not effectiveness. Peter Drucker once remarked that it is more important to do the right thing (to be effective) than to do things right (to be efficient). Current strategic thinking sees a clear role for both efficiency and effectiveness. Balancing the two is particularly important for manufacturing:

- **Efficiency** *(inward-looking)*: Productivity measure, company scale of measurement, how well does the company perform its own operations? How does business compare to last year's?
- **Effectiveness** *(outward-looking)*: Value-added measure, industry scale of measurement. How well does the company serve customers? How does business compare to competitors'?

Manufacturing is susceptible to a diet of incremental changes, so it is very vulnerable to this form of planning.

Why do we need a manufacturing strategic plan? Principally, because manufacturing involves most of a company's assets and ties up most of its working capital, but also because it is manufacturing which translates the product ideas into tangible items to sell. Manufacturing is between a company's ideas and the customers' needs. Management's challenge is to ensure that manufacturing facilitates the process and is not a barrier to progress. Nevertheless, the manufacturing strategy is only a dependent functional strategy. A first-rate manufacturing strategy is valueless without a first-rate business strategy and other functional strategies. Czech management must determine what business the company is in and how it intends to serve our customers before defining the manufacturing plan closely. It must establish competitive differentiation and ways to maintain it, and it must identify our key success factors. The manufacturing strategic plan should be developed within this framework. After it the strategic plan establishes the decision criteria to be used. The strategic planning process makes sure that people are aware of the background to the criteria, and communicating the plan confirms the importance of the criteria to everyone. There are also significant benefits from establishing the discipline of strategic planning in a company beyond those which flow from the plan itself. In my opinion these benefits include:

- Improved day-to-day decisions, in particular focusing resources on key issues and encouraging the rejection of other opportunities which at first sight may appear attractive but which really tie up resources.
- Small changes in daily tasks that increase effectiveness considerably.
- Improved communication among executives, managers, and other staff of the requirements to achieve success.

- A form of insurance, the planning procedure, guaranteeing a company's ability to respond to competition, even if it has to develop a new strategy from first principles.

In my opinion an important issue for manufacturing strategies is: How to change strategies when the current one is showing signs of age. This is a common situation facing manufacturers who are experiencing declining fortunes. Often a company must change strategies under severe pressure in response to questions such as:

- How do we respond to actions by a major competitor?
- How do we reproduce the growth of the last few years now that our current strategies are losing effectiveness?
- How do we reinvest retained earnings and maintain our current rate of return?
- How do we implement a change in strategy?
- How do we turn our business around?

The procedure for preparing a manufacturing strategic plan has to be similar to the procedure for preparing any other functional strategic plan:

- Set objectives for manufacturing that support the business strategy.
- Compare them with the current situation.
- Develop an appropriate strategy with implementation programs that eliminates the gaps between today's situation and desired objectives.

The goal is to reposition manufacturing so that it is an effective competitive tool for the business. The major business objectives are developed during the business strategic planning cycle and communicated to manufacturing management. They include profits, growth, rate of return, shareholder value, cash flow, customer service, and product quality. Later in the planning process, these objectives should the decision criteria be used in the final selection of the strategy. The strategy focuses on what the company should do, not on what it should be.

Now, Czech management needs to convert the business objectives into manufacturing objectives. Products, in production and planned, are the most important tool in the conversion process to link the business objectives and strategy to the manufacturing objectives and strategy in the Czech Republic. Products are key to gaining and retaining customers, and they absorb corporate resources in their development, production, and delivery.

The quality of the completed plan depends on the tools used and the skill with which they are used. There is no automatic way to develop a manufacturing strategy. Each strategy and each revision succeeds or fails based on the skills and judgements of the people involved in preparing it.

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The Long-Term Forecast of the Electricity Consumption and the Electricity Prices in Europe

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Economy of each state needs enough energy for producing its outputs. In this time still exists data correlation between the growth of Energy consumption (including Electricity consumption) and the growth of economy output – Gross Domestic Product. Electricity has privileged status, because present-day information community is based on it.

This is a one of the reasons why Energy consumption is under review. This branch needs long-term forecasts, because plant construction or electricity supply system building is very expensive and time-consuming. It is not feasible to make forecasts for the whole Europe, because there are so many disparate states with difference in their economy and Energy sources. This is a reason why there was used state allocation in the analysis only on the European Union and the Czech Republic without other European states. There was used separation of the electricity consumers into three main sectors. Namely:

- industry
- tertiary-domestic
- transport

Each of these sectors shows different Electricity consumption and trends. But consumption habits are moving and Electricity consumption brings increasing trend to the detriment of other energies. The prognoses have to also consider decrease of Energy intensity and growth of Energy efficiency. One of the helpful indicators is Energy intensity which shows the ratio between consumption of energy and Gross Domestic Product. But there are still marked differences between the Czech Republic and states of the present European Union.

The long-term prognoses were made for a period until year 2020 using available statistic data separately for the EU 15 and the Czech Republic. It is evident, that Electricity consumption is going to the growth. The growth can be expected by 1.5% per year for the reference scenario, approximately 1% for the low scenario and 2% for the high scenario.

Nowadays, the Czech Republic has multiple Energy intensity against the EU. But there can be expected, that in the future will be slow growth of the Electricity consumption, because Energy intensity will be decreasing.

There can be expected growth of Electricity consumption about 1% per year. The Czech Republic has got hidden reserves in improvement mainly Energy intensity.

Creations of the price prognoses are very difficult, because energy prices are influenced by many factors including the progress on the world energy markets and its character in the

single states. Although average prices in the EU in the last years instead decreases, in the near future will increase.

The same situation can be expected in the Czech Republic where market liberalization can decrease prices only for transition period for some groups of customers.

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Relation between Technology Investments and EVA

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Old technology equipment, this is contemporary situation in many of Czech industrial companies. High level of quality and speed of producing requested by the market is quite problematic to achieve for industrial companies with old technology equipment. Whether these companies want to be in according with the market request, that is condition for its economic development, afterward management is going to consider investments in new producing technology.

High costs of new industry producing technology have huge impact at basic economical indicators like profit or economic value added of industrial company. In first months or time of new producing technology implementation costs are mostly dominated. Positive impact of new technology at industrial company revenue is usually shown with time latency, when is new technology completely implemented and integrated in company processes.

To assess economical results or quality of management of the industrial company by mentioned traditional indicators can bring in specific cases distorted information. Whether the industrial company invests high financial resources in technology renewal, than are traditional indicators like profit going down in short term time.

For that reason can economical assessment of industrial company, based just at traditional indicators, create negative management attitude towards technology renewal. Because managers would not be able to risk lost of shareholders trust and afterwards is not assured optimal technology renewal.

Solution of this problem would be measuring of economical results as well as by indicators that comprehensive company market value growth.

Economic value added is based at net operation profit and cost of capital opportunity. Rapid growth of depreciation is usually connected with high technology investments. Because revenue improvement, created by technology innovation, is shown with time backwardness, in first months of technology implementation will have new investment negative impact at net operation profit and as well as EVA indicator.

Economical environment of Czech industrial companies does not allow using own financial resources for technology investments. The most used way of financing is loan capital that brings higher costs of capital that has impact at EVA indicator.

Value of new producing technology is usually higher than old technology value and therefore is value of capital bounded in company assets. This is another factor that negatively involves value of EVA indicator.

Suitable solution of described problematic is using of indicators that is based at free cash flow instead of net operation profit as in EVA indicator. Construction of indicator based at cost of core and loan capital as well as in EVA indicator would be at similar principle. Advantage of this solution is that free cash flow contains depreciation of new technology investment and new investment and more effectively express change in economical value of company.

Second suitable indicator could have similar construction as EVA, but instead of net operational profit is used market value of the company. Market value is in this case calculated

by two basic methods. First is discounted free cash flow, when value of company is based at future discounted cash flow, that is predicted by management or independent economical expert.

Second method is substantial value, when company value calculation is based at producing assets market prices.

To use just above mentioned indicators instead traditional profit or EVA could not be the optimal solution, but they can be suitable additional indicators that could explain some trends in value of traditional indicators.

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Information Support of Development of Product Strategies of Small and Medium-sized Industrial Enterprises

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Developing an effective product strategy of a small or a medium-sized industrial enterprise requires a firm understanding of a company's existing whole products, related assets and market approach. When a company works with companies pursuing early market opportunities, we focus on the:

- viability of their product category,
- potential value chain disruptions of their technology and products,
- uniqueness of their technology and products and related intellectual property (i.e., patents),
- professional service methodologies,
- technology and distribution channel partnerships,
- business model,
- management team, business and technical processes and ability to execute,
- industry and financial analyst insights about the company,
- market strategy in terms of current markets and positions and strategic potential of early market prospects and customers.

In addition, for companies entrenched in existing markets, we also must focus on the:

- completeness of their whole products,
- strength of their partnerships,
- strength of the value chains the company and its whole product are associated with,
- installed customer base to evaluate market share, target market and adjacent market segment growth potential and
- position within such target market segments and plans for expansion relative to competition.

The output from this engagement is a SWOT (strength, weakness, opportunity, threat) analysis of the company's market strategy, including the whole product and positioning.

With the background information established, a company builds market strategy models to facilitate the definition of a market strategy tailored to the needs of the company. The definition of a market strategy begins with category definition and the placement of your company and its category in the technology adoption life cycle (TALC).

It is possible to show that technology adoption follows a well-defined life-cycle, the technology adoption life cycle (TALC). Companies, products, and categories are at some stage in the technology adoption life cycle. Placement is key because it drives what you build, what you sell, who you sell it to, and how you sell to them. Once a company has defined their product's category and placed it on the TALC, than they have to define the following elements of company's market strategy:

- Definition of Target Customer Strategy.
- Definition of Compelling Business Reason to Buy.
- Definition of Whole Product Strategy.
- Definition of Partner Strategy.

- Definition of Distribution Channels Strategy.
- Definition of Pricing Strategy.
- Definition of Competitive Strategy.
- Definition of Market Expansion Strategy.
- Definition of Positioning and Messaging Strategy.

Re-positioning and Market Strategy

A small or medium-sized industrial enterprise has to engage some aggressive interventions for product lines and market strategies that have reached the point of diminishing return. The more distressed the situation, the bolder the actions necessary to turn things around. Such actions often require rapid decisions that involve significant risk and have difficult near-term consequences. In experience in such situations is that companies often reach a point of diminishing return due to:

- lack of product and technology renewal,
- incomplete whole products,
- lack of focus on target markets and
- poor execution that does not scale well.

Development of Market Maps and Market Research

A basic tenet of effective market strategy is a firm understanding of the market landscape. The rapid growth and broad reach of certain technologies and markets often preempt the emergence of market maps that identify market segments and relationships among them. As a result, many technology companies have difficulty in:

- defining their market position,
- communicating to others about their technologies, products and other assets,
- understanding the technologies, products and assets of other companies,
- identifying gaps and opportunities for growth, and
- completing partnerships of significant value.

With the product and service categories defined, we can identify the major and emerging suppliers of products and services for each category. The company must validate the completeness and vision of the market maps with the company and leading industry experts. Finally, a company applyes the market maps to meet their goals. This may include:

- refinement of the company's category,
- definition of adjacent market segments.

Than comes an Analysis of Competition

- target customers, market segments and emerging market segments,
- value proposition,
- whole product offering and related intellectual property,
- partnerships,
- distribution channels,
- pricing and business model.

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Investing to Managers

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Basic Conditions of success investment to manager

1. Motivation
2. Personnel abilities
3. Type of investment
4. Checking

Conditions for investing to managers

Many companies thing if give for managers same investments they have to be hay and glad of this, because company give them same thing what can spent "better" to buy new machine or car. This is big mistake of lot of companies. Every body is different. We have to faint they conditions for investment.

1. Motivations

We have to fiend what is motivation factor for same managers. For same bodies can de carrier its mean job advance. Money or bonus is very good motivation for short time. For young manger is many tames important knowledge – job knowledge advance. Prestige is important for manager how have to direct maybe discover team, every body know he did same thing good for they prestige to as team. If for young managers is motivation of this training program joust, because have vision to faint same good job after one year and because company haven't excise for new skills of them, this training was very unprofitable.

2. Personal abilities

We have to identify personal and managers skills from Diagnostic.
Structure of diagnostic:
1. Intellectual capacity
2. Management Qualities
3. Characteristic Personality Traits
4. Conclusion

Presuming, that v populace is 5 % heat manager and 20% manager + able specialist, remainder with divide by on worker ingressive and char ends.

3. Type of investment

This can be:
Salary
Curses – language, special skills, manager skills…
Special courses – technical
Internship, conference

Employee facilities

4. Checking

Every strategy and every investment have to be checking.
For this we have:
Reports about work what has been done
Exams
Questioners
Work meetings
Effectiveness for the company

Investing to managers is profitable?

This questions heard everyone how are in top management of big or small company. The question is important for management. Every body want knows that profit. Investing to managers as to as you invest in new machines or you build new companies. Firm have to make good choice.

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Manager - Personal abilities

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We have to identify personal and managers skills from Diagnostic.

Structure of diagnostic:

1. Intellectual capacity
2. Management Qualities
3. Characteristic Personality Traits
4. Conclusion

1. Intellectual capacity

Intellectual capacity is not IQ it is something different. IQ is overall intellect.
Intellectual capacity has this structure,
We have subtests with time limited:
of which: practical logic, ability to generalize learns quickly, combination abilities, constructor and designer abilities work speed

For example:
In the test examination, Mgr. Š… demonstrated that she has an above-average intellectual capacity with an overall balanced structure. She achieved above-average results in the subtests for combination skills, practical logic and optical conception of constructer or designer type. Average results in subtests for powers of generalization. She works quickly, and is not afraid to adopt approximate solutions by guesswork in time pressure situations. She showed that she is able to work intensively without a break for about 2 hours. After this time her performance begins to fluctuate.

2. Management Qualities

It is from England. They company did not wont to invest in wrong manager and star to jus this tests.
Makes logically correct decisions on the basis of incomplete information
Solves new problems effectively and directly, innovative

For example:
In the tests for management qualities, she achieved above-average results in the test that measured the ability to solve new problems effectively and directly, and average results in the test measuring the ability to decide correctly on the basis of incomplete information.
The strong points of Mgr. Š…'s intellect are logical structures of intellect and combination abilities. A relatively weak point consist of average verbal structures.

3 Characteristic Personality Traits

Characteristic
adaptability, friendly openness
calm, stability, inner serenity, resistance to stress
dominance, competitiveness, assertiveness, ability to assert oneself

optimism, tendency towards enthusiasm, relies on luck and has it
social courage, ability to take risks
stubbornness, realism, pragmatism, self-sufficiency
tolerance, conciliatory, quickly forgets inconveniencies
social adeptness and discipline, diplomatic talent
self-confidence, self-assurance, resilience
independence in decision-making
enterprise, ability to take advantage of opportunities
neuro-psychological stability, relaxed calm, easy-going

For example:
Mr. B… is a very positive, friendly and sociable person. He is willing to co-operate, and is able to adapt easily to new conditions and new people. He is moderate, attentive to people, trusting on the whole and kind. He has very good judgement and learns quickly. He is tireless and endures well. ……
He is dominant, self-aware, competitive and knows how to assert himself. He has no tendency towards aggressiveness …….
He has a tendency towards enthusiasm over what interests him. In these situations he is talkative, he expresses his …….
He has a marked tendency towards activities that demand personal courage of social type. He can occasionally act impulsively, or at least have an inclination to do so. Probably his disciplinedness holds him back in this respect. He is not afraid…….
He is sensitive, but not over-sensitive. He expects love and attention, and is himself loving and considerate and is able to act on the basis ……..
He gives precedence to simple and honest expressions of relationships. He acts spontaneously and naturally. The analysis of other people's motives is not one of his strong points. …….
He has a rich imagination and probably some type of artistic or generally creative talent.
He lives in a state of optimistic self-confidence and calm self-assurance…….
He thinks liberally on the whole, he is not afraid to doubt, and has his own standpoints. ……
He is not frustrated, and lives in a state of calm. He has a robust and resistant neuro-psychological constitution, and is capable of concentration and long hours of demanding work.

4. Conclusion

For example:
Mr. B…. has very good intellectual and personal prerequisites to being a successful manager. I recommend developing special managerial abilities – functional literacy and inductive thought. He has the potential of becoming a top manager.

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Structure of Budget for E-learning Education

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The objectives of this contribution are to abstract basic aspects for budgets creation, including creation method of budget items. At the first time for the regular budget is necessary to define the activities, which are underlying of the budget. After this definition, it is possible to generate the numeric values of the budget items.

This contribution is too short to by able to describe defining the activities. Therefore, we expect that the activities are defined and we can come up to budget creation.

For the each other course, which make filling of institutions activities, is necessary to generate an individual budget. Including of defining activities is important to define other resources, which are necessary for "fluently running" of the particular course.

The size of budgeted items determines the way in which the activities in the course are provided and influence the education process within the course. The size of budget depends strongly on the scope of course, on the scope of evaluation that to be made for each student, on the scope of the instructor's time offered for consultation with the students, on the expected or limited number of students.

Amount and requirements of the course influence the all associated organization and administrative activities. It has to be stated who will provide these activities: internal or external employees, the number of hours and used hour's tariff.

The list of these supported activities (communication with students and lectures, controlling and evaluating of students works, certification preparation, etc.), which are necessary to be done, has to be developed. Without that specification, the hour's calculation and budget items size could not be completed.

Budget of education course is continuations real specification of the course content, which include especially:

Topic and its particular specification and relationships
Kind of education
Amount of education and related activities
Special securing requirements

The budget of e-learning course is usual consist of costs and returns items. The costs items are both: Fixed and variable.

In the budget is necessary to enumerate the costs specification items together with using requirements on the common equipment of the whole institution (for the allocation of using this equipment or for calculation). This problem is applied to institution technical equipment (software, hardware, internet…), demand on internal or external employees (employees, which work on project of the courses, boss, secretary, accountant…), travel costs or promotion costs. These costs are called fixed therefore their size is not changing by the number of courses until it get not over some number of them. The costs are allocated to the course during the cover contribution of the common costs of institution.

The second part of costs constitutes variable costs. The size of these items is changing by the number of courses, therefore we are calling these items variable. Among these items belong:

Employee's costs – they include wages and costs on aids for the employees (notebooks, mobile phones, technical literature,).
Small-sized material costs – it is costs sum on small-sized material exhausted for the course (cartridge, papers, writing tools,).
Communication costs – they include costs sum bear on running course on the part of students (letters, telephones,).
Others costs – they include sum of others costs belonging the course (certification costs, propagation costs of certain course …).

Major revenue items of the budget are:

Fees of applicants
Project contract
Different kind of donations, grants, sponsoring, advertisements, etc. linked directly to the particular project.

The summarizing of the cost and revenue items determines the profitability of each course. If no targeted profitability is reached, the changes in the content or scope or linked activities of the course has to be done or number of students has to be changed. In addition, the marketing activities may be supported.

Make regular evaluation of the budgeted items size has, to assure that the planned profitability is fulfilled.

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Work Opportunities of the Graduates of the Czech Technical University on a Labour Market

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Lately, there is a growing number of discussions about further development directions of the Czech Technical Faculty and its component faculties in the context of the transformations under way in the Czech society and with regard to the accession of the Czech Republic into the European Union. One of the sources of information is also the knowledge about the chances of the graduates from component faculties of the Czech Technical University on a labour market. In 2003, for that reason, a survey gathering information about graduates from 1994 to 2001 of all the six faculties of the Czech Technical University was realized.

The subject of this survey is connected to three representative surveys realized within the Czech Technical Faculty, namely, the survey of students in the 2nd to 5th year of their program in 2001, students in the 1st year of their program (2001) and students who did not enrol after they had been accepted in 2002. In these surveys, the opinions of existing students as regards the instruction, motivation to study, and identification with a selected course of studying, etc., are being uncovered.

The survey information about the graduates describes their chances on a labour market, for example, what kind of work they prefer after graduation, how many of them work in leading posts, or work independently, in what kind of companies they are mainly employed, etc. What is very important is the feedback information about the instruction, assessment of the relevance of completed courses for the practice, and simultaneously finding out required knowledge and skills, which the students are missing in the instruction.

The target of the university is to pass on the theoretical foundations of their disciplines to the students and inform them about the future development directions of their chosen specialty. In spite of this, it has to response to modified conditions within society, of course, with the aim to secure as good as possible chances of its graduates on a labour market.

The Position of the Graduates of the Czech Technical University on a Labour Market. Three quarters of the graduates are employees, and almost two fifths are entrepreneurs. At present, 7 per cent of the respondents are without any working position (on a maternal leave or in a compulsory military service). 3 respondents are unemployed, however, 21 per cent of the graduates state that they had been unemployed for a certain period. In terms of the company's size, one third of the respondents work in a small company up to 25 employees. Two fifths of the respondents work in the middle sized companies and almost one third of the respondents work in large companies.

In companies according to the type of ownership, one third of the graduates work in the Czech private company, another one third in a foreign company, one tenth of the respondents have their own firm, and also one tenth of them work abroad. The graduates hold very different positions. Most of them perform organisational and managemental work (one fifth of them) and projection work (one fifth of the respondents). 36 per cent of the respondents hold leading positions. More than two thirds of the graduates of the Czech Technical University work in the same or related field, which they studied.

In terms of the type of working position, two fifths of the graduates changed an employer after they had finished their studies: one half of them once, one quarter of them twice and one fifth of them more than twice. For a part of the graduates, the main reason for their finding a new employer were the organisation changes in their company, the need of a higher salary, and a lack of good prospects in the company. 84 per cent of the respondents are satisfied with their current job. Three quarters of the respondents renewed their qualification after the end of their studies, more than one half of them in firm seminars.

The Evaluation of the Instruction in the Czech Technical University in Terms of the practice. The graduates show relatively high identification with a faculty and a field of study. 69 per cent of the graduates of the Czech Technical Faculty would study the same faculty and the same specialty, 11 per cent would study a different specialty; that means that 80 per cent of the respondents would study the Czech Technical Faculty. Next, the respondents evaluated, according to their experience with the practice. 81 per cent of the graduates value most the acquired ability of technical thinking. Three quarters of the respondents assess the theoretical preparedness as very good. 70 per cent of the respondents evaluate positively the orientation in a chosen field, and 56 per cent conception abilities. Practical knowledge from the field got a lower positive assessment only from one fifth of the respondents. In terms of the knowledge of foreign languages, the knowledge from the area of work organisation and management, only one tenth of the respondents gave a positive assessment. In terms of the practice and preparation for a future profession, the graduates assess as best those forms of instruction in case of which they can actively participate; that means the projects – diploma and complex projects and exercise. Excursions and professional practice got the worst assessment.The majority of the respondents (30 per cent) had to complement their language skills after finishing their studies, 19 per cent had to improve the knowledge from the area of management and organisation of work, 10 per cent the knowledge from the area of computer technology, and then the knowledge from economy, law and legislation. This is the reason why the graduates do not assess positively the knowledge acquired at the faculties from the area of management, work with people and the knowledge about a today's society, which are important for a good performance in practice.

The analysis of this sociological survey results brought a large set of valuable information about the position of the graduates of the Czech Technical Faculty on a labour market. In the first place, considering the needs of the Czech Technical University, relatively detailed evaluation of the instruction in terms of the knowledge utilisation in the practice is specifically important. The knowledge acquired in the survey reveals that the students go to study the Czech Technical University for the reason that they want to study in a university with a professional technical specialization. The graduates are satisfied with their original choice of the field of study. In terms of their future work, the graduates acquire a very good theoretical and a good professional training within their specialty. They miss practical experience and professional practice in companies, however, this is insoluble for the time being. For above stated reasons, it would be good to concentrate more on the independent work of the students, on their skills to present and justify their work and on team work.

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Analysis of Social and Legal Aspects of Building Environment Impact

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In the Department of Social Sciences of the Faculty of Civil Engineering of the Czech Technical University and within the research objects No. 5 The Environmental Aspects in Civil Engineering and No. 6 The Management of the Sustainable Development of Buildings, we deal with the topics of social, philosophical, legal and economic aspects of civil engineering impacts on the environment and the problems of social conditions of technological innovations, which belong to the necessary targets of the program of sustainable development in the European Union. In 2003, we concentrated on the problems of sustainable developments in terms of philosophical, legal, social, ethical and economic aspects, on the conception of risks, communication with the general public and on the knowledge of the graduate of the Faculty of Civil Engineering in terms of the sustainable development. At the same time, we were facing the problems of brownfields. In our approach to the questions of sustainable development we draw on the conclusions of the documents of the UN international summits, namely Agenda 21 (accepted on a summit in Rio de Janeiro in 1992) and of the 16th summit in Johannesburg (2002) "People, Country, Prosperity", which define 3 pillars of sustainable development: social, ecological and economic. The goal of the social sciences is to study these individual areas and their mutual relations on a global and national level.In accordance with these initiatives, a set of partial studies (with regard to the research objects No. 5 and 6. were elaborated and some of them are still being processed.

In the area of philosophical, ethical and cultural studies, the topics of the ethics and aesthetics of the environment have been discussed for a long time (in the context of the questions of human ecology and social ecology). The study ‚The Concept of Culture in the European Context' belongs to this field. Prospectively, further activities will be also concentrating on the issues of the cultural landscape preservation. Within philosophy of education, considerable attention is also paid to the issues of educating with respect to sustainable development.

In the social and sociological context, the approaches which are related to the knowledge of the graduate of the Faculty of Civil Engineering of the Czech Technical University about the issue of sustainable development, are being elaborated. The student should, for example, know the characterization of individual social strata and their needs, e.g. in the area of habitation. Other questions are related to the awareness about the continuity of building-up the space, with the long-term existence of buildings, both in terms of the historical retrospective, and in terms of the future (social and cultural approach). The continuity of the urban space utilisation is very important as regards the changes in building, reconstruction, and, especially, as regards the new ways of the space utilisation, such as so called brownfields and with a view to the E.I.A. procedure and the law about the environment. In terms of the legal issues, the analysis of social and psychological aspects proceeds from estimating the impacts on the population and effects on the environment, among which we can find also the impacts on the material property of the population and, for example, on the cultural sights, etc.

Within the discussions about the sustainable development in civil engineering, we are facing the problems related to the E.I.A. procedure, which follows the Law on Estimating the Impacts on the Environment 100/2001 (statues at large). Legal issues also address a very important topic of the interests of the general public, the bearers of which are unspecified, nonetheless at least broadly defined units, or communities of people, such as the general public, etc. The interests must not be in conflict with the accepted legal instructions and must be authorized by the bodies of general authorities and their performance must be correct in the relation to the general public, or to the society as a whole.

Economic approaches to these issues are connected with the area dealing with the crisis solution from the economic and social perspective, and with the issues of transactional costs of the firm; in our context with the specification of a construction firm. An important role in these approaches is played by the conception of institutional economy, which integrates economic and human (social) approaches.

At present, all the above stated approaches can be applied the current topics of construction in already utilised space, that means the so-called brownfields. The civil engineers and architects are considering the utilisation of this space in terms of its reconstruction or a completely new construction as a prerequisite of new investments. A sociologist and a psychologist see in this space its social, psychological and cultural aspects. Newly built-up space will bring (from a perspective of an economist) the possibilities of new production and distribution, as well as the employment. New housing space, the space for cultural life of the people in different age, space for administration, etc. is being created, as well as the new identity of space.

The participation of the Department in the research objects is interdisciplinary; the results bring contributions to the development of philosophy, sociology, ethics, aesthetics, psychology, law and economy. We consider the interconnection of these human sciences and their methodology for studying social phenomena and the technically oriented disciplines to be the most important aspect of such studies. The construction outputs and the construction as such influence deeply the environment in which we live, and therefore the interconnection of both approaches and perspectives is highly beneficial. The study is related with internationally observed topics of connecting social aspects with technology (science, technology, society). The outputs are connected with the future realisation of the environment and with the EIA procedure.

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How Could Be Carpool Lanes Used in Czech Republic?

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„… would it be faster by foot?". I can not imagine spending another morning in a traffic jam. The question appears suddenly. How long will we be willing to spend tens of minutes in traffic jams? The drivers should ask themselves: "Is it really so comfortable to drive my car every morning to get to work? Why do I have to wake up earlier just so I can sit through a traffic jam? The drivers would not ever do the first step. The solution to this problem has to be found as soon as possible if we do not want to undergo this situation. The young manager has just finished his work. Usually he goes home to see his family, but not these days. He has to integrate his car at the back of the line, if he does not want to risk loosing his job because he did not get to work at time.

The substance of this problem is to find an efficient instrument to calm traffic down. During my own traveling in different countries I found one solution from USA (California) very interesting – setting up carpool lanes. Unfortunately, as I am going to explain later, it did not work as they expected.

In early 70^{s} there was a dangerous political situation in the Near East, which elicited an economic crisis in the western world. The USA and Netherlands had to face a total oil boycott. Generally it was at thought that energy supplies were almost bottomless (until this economic crisis). A decrease in oil usage was more than necessary. In 1973 the price of one barrel of oil increased four times. Car usage decreased, and the first carpool lane was set up as a result of this crisis.

The El Monte Busway, the first carpool lane, opened in Southern California in 1973 along Interstate 10. It was first available for buses and then later opened to carpools with three or more people.

Carpool lane, also known as *diamond lane*, is a special traffic lane. This lane is reserved in rush hours for cars carrying two or more passengers. This is the only rule we have to obey. If you decided not to obey this rule police ticket you. The fee for the ticket is up to 270 USD. That is a very strong argument.

In 1980 when there were no carpool lanes, 16.3% carpooled compared with 14.3% in 1998. This was despite constructing 266 miles of carpool lanes, beginning in 1982. A study by RIDES found carpooling has decreased from 16.7% to 14.3% of commuters (1993-1998). From census data, carpooling decreased between 1980 and 1990 in the Bay Area, from 20.5% to 15.9% of motor vehicles. As percent of commuters (including mass transit, bicycles, walkers), carpooling decreased from 16.3% to 12.9% in the same period. In Santa Clara County carpooling fell from 17% of commute trips to 12.5%[15] despite constructing 115 miles of HOV lanes in that period (1982-1990), more than all other Bay Area counties combined. 71% of car commuters drive alone to their jobs. The figure was 65% in 1996. The drop in market share of HOVs despite spending millions on HOV lanes shows the concept is a boondoggle. No business would spend money on something that results in a drop in market share.

The definition of carpool is a distortion of the concept:

From a Rt. 237 questionnaire, 51% of carpoolers commute with a family member. Designating one passenger in a vehicle as a "High Occupancy Vehicle" is a distortion of the concept. This is Low Occupancy. Many metropolitan areas locations only allow buses and approved vans. [The I-80 freeway is 3 person, all other Bay Area carpool lanes are 2 persons.] The logic behind HOV lanes is to give preferential treatment to encourage commuters to change from solodriving to carpooling. Chauffeuring the spouse to work (thus doubling the commute trip by doing two round trips daily) or the kids to school is not a logical criteria for preferential treatment.

Carpool lanes greatly increase solo drivers:

Solodrivers accounted for 79% of 5769 vehicles added to Montague Expressway six years after constructing the HOV lane. Thousands of solo drivers are pouring onto our freeways and filling spaces vacated by carpoolers when constructing a carpool lane.

Carpool lanes increase air pollution:

Frankly, there is no reduction in auto emissions by constructing carpool lanes. HOV lane construction has never reduced automobiles, it has always increased them. Even worse, it has ALWAYS increased solodrivers and Vehicles Miles Traveled (VMT). A likely reason for this loss in market share is that HOV lane construction decreases travel time in other lanes, making solodriving more attractive.

As seen from the government`s data, setting up carpool lanes in the USA did not work. There is very important point to this problem. To decrease quantity of cars on highways is necessary to set up carpool lanes from existing lanes to decrease quantity of cars on highways. Doing this will solve this problem.

Would setting up carpool lanes in the Czech Republic solve the problem with heavy traffic?

It has already been said that it is important to solve the heavy traffic problem in Prague. Prague traffic is shown in numbers just to visualize how big the problem really is. From 1991 number of cars and intensity of motor transportation increased significantly. This situation has not analogy in Europe expect cities in former East Germany. This trend was still continuing in 2001, but outside of Prague center. Accumulation in the last three years decreased in comparison with the first period of the 90^{s}. In Prague, there were 1.9 passengers per car at the end of 2001. This means Prague has been surpassing most motorized western cities in Europe for several years. The level of motoring is usually 1 car per 2.1 to 2.3 residents. Motor traffic in the city increased. This means there are more cars and we ride them more. Automobile transport, in general, increased in the area around the capital city in 2001 – based on volume of transport in communication network – on average of about 2.9 % in comparison to last year. If we think about the data shown, especially about the average amount of passengers in cars, and the most encumbered stages on Prague`s communication network, then we have to ask a question: Why not to use the carpool lane idea as a traffic solution
(of course with modifications based on Czech demography) in the Czech Republic?

The Evaluation of R&D Effectiveness in Industrial Enterprise

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Innovation is crucial for the companies if they want to improve the competitiveness of products, labour productivity, and consequently economic results. A rising importance of research and development in the industrial enterprise is a result of this run for new technologies or innovated products. However, the more money is put to R&D, the more effort must be made on monitoring and controlling the effectiveness of the R&D investments.
The effectiveness of R&D can be expressed as a ratio of effects, which come from implementation of research outcomes, and costs on R&D.

Assuming:
e … effectiveness of R&D,
U … effects of R&D,
N … costs on R&D,

we can count the effectiveness:
$e = U/N$.

The evaluation of R&D effectiveness is dependent first on determination of costs on R&D and implementation of its results and second on assessment of effects which come from R&D results. The costs and effects of R&D are usually not monitored in the Czech industrial enterprises, because especially measuring and assessment of the effects is very difficult and some of effects are even impossible to be quantified. Further, I will deal with the specification of effects and costs as well as with the methods of effectiveness evaluation.

Assessment of costs on R&D

The costs on R&D are usually not examined and they are taken as a part of overhead costs. From the research effectiveness point of view, it is necessary to assign these costs as precisely as possible to individual technologies or products. Especially these cost items are necessary to enumerate and examine during the innovation process:
Direct costs, i.e. costs on marketing survey relating to applicability of new technologies or products, materials, energy and transport costs, costs on sub-deliveries, costs on devices and equipment, wages, health and social insurance of researchers, administrative and other staff.
Part of overhead costs, i.e. proportional depreciation on machines and devices, proportional materials and energy costs and proportional wages, health and social insurance of administrative and other staff.
Determination of direct costs should be quite easily achievable. On the base of standard bookkeeping data it is possible to enumerate these items. Assessment of overhead costs is in comparison with direct costs much more complicated. Overheads can be enumerated e.g. by the share of time consumption (depreciations, energy costs), or share of labour expenses. Costs on R&D are not dependent on the volume of production; therefore they have a character of fixed cost. These costs are limited only by time and related to a new technology or a new product.

Assessment of effects evolving from R&D

First, I have to mention that it is possible to assess the effects evolving from R&D only in case of realising the outcomes of research. The research outcomes need not to be always implemented, thus we have to take the risk into account (e. g. 20 % of projects are not really realized). These risks have to be considered as increased fixed costs (e.g. by 20 %).
Assessment and enumeration of the effects is a very complex and challenging task. The effects of R&D projects can be examined both by makers (producers) and users (customers). The effects are possible to be monitored and assessed in the areas such as material and energy reduction, labour cuts, quality improvements, utility value enhancement, and increase in production volume. Then it is necessary to enumerate these effects and to determine, how much they participate in increasing profit of research initiator. On the base of calculated reductions, it is doable to assess annual increases in profit evolving from application of research outcomes.
The effects which will appear as results of R&D by customers have to be evaluated indirectly, using experts and combination of qualitative and quantitative indicators. An increased quality and utility value of new or innovated products, material, energy, and labour reductions by customers can be then counted into annual profit of research financier.

The evaluation methods

There are lots of indicators which can be used to assess the effectiveness of research. These indicators can be applied to create a suitable method of effectiveness evaluation. This is just one example:

Profitability of R&D costs

$z=Z/N$

Return on R&D investment

$r=N/Z$
Z … average discounted annual profit increase caused by implentation of R&D results (calculated e.g. for the period of production using the discount rate of 3 %)
N … R&D costs

Increase in labour productivity

$\Delta p=Vn/Pn-Vo/Po$

Vo … original volume of production
Vn … new volume of production, increased due to research outcomes
Po … original amount of labour force
Pn … new amount of labour force, decreased due to research outcomes

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The Evaluation of Regions and Structures in Relation to Sustainable Development

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The research objective focuses on strengthening decision making on long term values (investment, infrastructure, living environment) from the point of view of the acceptability and implementation of a particular concept namely sustainable development. The task for a long time has been to create prerequisites for a change of attitudes towards the status of building and land which has been up till now concerned with only a short term economic orientation. Building is understood as a space for the realization of the project proposal of a designer, its organization and production technology. Land is understood as a space for urbanization, investment and productive yield. The life-cycle (LC) of the financial implications of the economics is short-term (only a few years). A long-term life-cycle (LC) requires a change of approach, evaluation and methods. The classical interpretation of economic regularities in the economics of a design proposal (D), production (P), sales (S), financing (F) produces the core scientific content of the subject. The replacement of economics by another relevant discipline has not been successful in the past (planning, systems management, project management). More successful perhaps can be the reconstruction of a combination of those parts of economics, design, production, sales and finance which were insufficiently theoretical or wrongly negotiated or elaborated in theoretical terms. Essential in the given situations are the evaluation criteria. Sustainable development in its linkage to the life-cycle LC involves a change of criteria and a change of evaluation D/P/S/F. The main contribution is therefore the change in evaluation methods, a move away from the economics of short money, (values, ST/LCC), and a transition to the economics of long money (values, LT/LCC).

The working group accepted a number of new working hypotheses and introduced a number of new terms. The term sustainable construction, which highlights a new perspective on technical problems, belongs among them. It works with wider linkages. In addition to a technical solution it is necessary to judge even wider impacts. One of them is a perspective taken from the protection of the living environment.

The researchers continued with the results elaborated and published in the last years. When solving the given problems they drew on the analysis of the present condition of the building industry in the Czech Republic and the EU countries taking account of prognoses of their future development. Requirements and conditions of Czech building firms on the Czech Republic entry to the EU were analyzed. The need for an integrated database of the EU countries is considered for the evaluation of building firms and from it emerging quality economic information on the effectiveness of the management of building firms on their entry to the EU building market. A stress is also put on exploiting a quality information system in connection with information technologies so that sustainable growth of building capacities is ensured. At the same time the problems of using the Internet in the building industry were

analyzed, with its possibilities and contributions for further sustainable development of this sector.

Achieved results proceed with the activities in 2002. Aims were focused on the application of the new decision making processes. Evaluation criteria are being gradually elaborated and quantifying procedures are being explored. During 2002-2003 the linkage to the program COST has been managed to widen forms of participation through action A17 (Small and medium-sized businesses and land development). Program COST is a part of the general program 6.FP EU.

In connection with the fulfillment of organizational and technological aspects there was successfully created a working group of PhD students supported by a grant agency GACR. Its focus attends to the problems of sustainable constructing, the lowering of energy demand, the improving of internal quality of flats and civic buildings environment by substituting wood material for existing chemically treated materials and surfaces.

Two doctoral theses were successfully defended in connection with the given research objective.

It will be useful to further update and elaborate new trends, augmenting our methodical tools. In this connection it is necessary to identify shifts of priorities in technical practice, constantly monitoring evaluation objectives within the general program of the EU.

From a long term perspective the reconstruction of the idea of the specialist subject economics of the building industry within structured studies there were updated curricula content of some subjects in which the results of the research objective were included, dealing with sustainable development, taking account of risks and uncertainties implemented within economic realities. The concern is with the economics of sustainable development, with special reference to environmental management.

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Determining the Factors for the Optimization of the Construction of a High-Capacity Highway Network

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A significant part of the road optimization process consists in gradual modernization of road network and construction of high-capacity highways. The decision making practice concerning potential implementation procedures requires the use the economic criteria of benefits both for the users of the respective road network section and for the inhabitants of the territory affected by the respective highway.

Research in 2003 was focused on solving the problems of indirect benefits of newly-built transport infrastructure, and the major part of background materials for the calculation of indirect benefits was fulfilled by setting out four factors for assessing the territory affected by the construction of a new road. This resulted from numerous analyses and verification of various databases of mostly regional and geographic character.

In order to facilitate the assessment, it is beneficial to divide the territory presumed to be affected by the construction of a high-capacity highway into certain territorial units. The best practice to-date seems to be its subdivision according to individual exits served by the future highway with hinterlands identified by their accessibility within 15 minutes of travel by a motor vehicle.

The territory of each exit is assessed with regard to the differences in the monitored factors of benefits generated by the route in relation to the respective catchment area. The assessment with regard to the difference (growth or decline) between the situation without implementation and the new situation (after the construction is completed) is carried out within a time perspective of twenty years split into five-year intervals.

The following effects were applied as assessment factors describing differential consequences, the differences between the original situation and the new situation after implementation:

F_1 - job opportunities,
F_2 - personal mobility in relation to salaries,
F_3 - assessment of affected territory

Individual factors F_1 to F_3 represent indirect benefits expressed by the changes in the territory along the route of the new road construction. These are effects which cannot be directly quantified at the level of immediate partial users of the highway network. They represent an appreciable contribution (or loss) arising in relation to the territory of interest across which the route is led.

The factor F_4, which includes environmental effects, should be expressed, due to its aggregated nature, for the entire assessed route in question, and, therefore, it is not subject to assessment within individual road exits.

Characteristics of individual assessment factors:

F_1 - job opportunities

Newly arising jobs within the catchment area of an exit demarcated by accessibility of up to 15 minutes of travel are all emerging jobs in newly established companies as well as the

jobs arising by the expansion of existing work places of existing companies. Individual exits are, therefore, efficient only if they give birth to a sufficiently large area within potential catchment territories deriving their economic profit from the highway route. An exit leading into economically attractive areas with a higher density of jobs is better assessed than an exit into a territory with low productivity and no job opportunities available.

In the practical solution, therefore, newly arising job opportunities are related to the companies, commercial projects, which are based in the territory and generate immediate effects for the affected territory. The job opportunities arising outside the borders of the catchment area and profiting from the improved transport accessibility at longer distances are not included in this assessment factor. In this respect, the assessment of job opportunities within the immediate catchment area of the exit is at the bottom limit of the assessed effect.

F_2 - personal mobility in relation to salaries

The basis hypothesis says that mobility (i.e. implemented transportation performance) is an elementary factor affecting the productivity of labour in the national economy. Productivity of labour is defined as the ratio of value production within the whole economy to labour consumption. The higher the productivity of labour, the higher the potential of value production reached within the given national economy. Thus, productivity of labour becomes a key and driving force of economic development and rising incomes of the inhabitants.

By the construction of a new transportation route, the mobility of economically active inhabitants of the affected zone allows for the manpower to get to the job sites and workplaces corresponding to their qualifications and efficiency. Effective allocation of wage-earners guarantees high productivity.

This fact, at the same time, creates conditions for increasing the incomes of economically active inhabitants. The expression of salary growth is a parallel quantifiable additional factor depending on the number of newly created jobs and, further on, on the increase in the income of wage-earners due to their implementation of higher qualifications and performance.

F_3 - assessment of affected territory

Together with a higher rating of the affected catchment territory in terms of labour remuneration (F_2) due to increased demand for labour (F_1), the catchment territory will grow in value on its own. This effect will be evident from the growth in land prices within the entire catchment territory. Here again, the assessment will be performed in the form of differential (comparative) comparison. Comparison of the situation before and after the construction of the highway indicates the degree in which the highway route running across the catchment area participates in the generation of economic effects.

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Strategic Plan of Development - Feasibility Study in the Company Kolas

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The essence of enterprise is to reach the vision ,which was determined at the beginning, and make a profit as high as possible. It means the value must be in excess of its cost. The shareholders expect dividends and capital growth. The company itself needs the profit for another development. In these days – in information age the role of strategic management is more significant then it was in industrial age. The companies are mergered, competitive environment is getting harder every year. Nowadays it is insufficient to provide a quality product to the customers, the prominence have marketing, the image of the producer, service to customers, the price of the product. It depends on the decisions of the establishment of the company which markets are suitable to be occupied, which segments of the customers are able to provide maximum profit and which products are the most appropriate for that. All these decisions taken at managerial level belong to strategic management. If these decisions are correct the company will achieve its goals.

There are many methods how to manage the company in the right direction and which support the strategic management. One of them is the Balanced Scorecard. The Balanced Scorecard was developed in the early 1990's by Drs. Robert Kaplan and David Norton. The Balanced Scorecard is a conceptual framework for translating an organization's strategic objectives into a set of performance parameters distributed among four perspectives – financial, customer, internal business processes and learning and growth. Financial performance measures indicate if a strategy of the company and execution are contributing to improvement of the profit. Financial objectives are, for example, return on investment, return on assets, economic value added and many others. The customer perspective captures the ability of the organization to provide quality goods and services, effective delivery, and overall customer satisfaction. The measures in this perspective also include market share, customer retention and customer acquisition. The perspective of internal business processes provides data regarding the internal business results against measures that lead to financial success and satisfied customers. It is necessary to identify the key business processes at which the companies must excel. The perspective of learning and growth captures the ability of employees, information systems, and organizational alignment to manage the business and adapt to change. Processes will only succeed if skilled and motivated employees are driving them. It is important to say that the Balanced Scorecard includes financial and non-financial parameters as well. Very often there is a problem in companies how to recognize in organizational balance sheet the assets like employee skills, customer loyalty, motivation of the employees. But these assets are necessary for success in competitive environment and the Balanced Scorecard enables to measure, manage and communicate the non-financial values of the company.

In this contribution I present the feasibility study of the strategic development in the company Kolas for which we have used the Balanced Scorecard. The company Kolas is

fictitious company, which has been made up only for the purpose of the feasibility study. This company originated in the 1992 in the Czech Republic and turns out the mountain bicycles and tracking bicycles. The company was very successful especially in the beginning because the market with the bicycles was not filled. Apart from the Czech Republic the bicycles were distributed to Slovakia, Poland and Lithuania. From its origin owners have been leading the company. But during the last three years the income was constant and the profit was decreasing. It is clear if the company continues with these results it will sooner or later perish. So that there was decided to change management and now the owners are only in advisory board. Professional management leads the company. The new management has to create a strategic plan of development of the company which would be acceptable by owners. The expansions to the new markets, using the new distribution channel and particularly creating of a new type of bicycle are included in the strategic plan.

First was assessed the existing state of the organisation and the environment in which it operates and also in which the organization will have to operate in the future. The outcome of this stage was S.W.O.T. analysis. This analysis includes the organization's strengths, weaknesses and opportunities and threats of the environment. The key impacts were judged. This analysis enabled to create organization's future strategy that is assume to be right. The important conclusion of the S.W.O.T analysis was to enhance a number of distributors on current markets, introduce a new product called Citybike, make an acquisition of the competitor in Lithuania and a decrease in the costs.

The second stage was to implement this strategy into the organization. For this purpose was used the Balanced Scorecard. There have been created a strategy map of the organization's objectives, a set of measures and targets and initiatives. For example, the objectives in the customer perspective were to increase loyalty of the customers, increase awareness of the trademark Kolas, growing distribution of products and so on. All the objectives and measures are supported by initiatives. As the particular initiatives of the objective – to increase awareness of the trademark Kolas, it is possible to abduce an advertising campaign, giving free bicycles to the sellers as the test pieces, the support of building new ways for bicycles and many others. It means, if the company wants to sale more bicycles what should be done to reach it.

The third stage was to link calculated costs with revenues in order to find out the profit. Eventually the profit and loss statement was created.

The feasibility study, which have been made up, points to opportunities how to use the Balanced Scorecard for strategic management, which information is possible to gain by using the Balanced Scorecard, what are the strengths of this method. The feasibility study includes a comprehensive process of strategic management from the creating the strategy, implementation of the strategy to verification of the strategy.

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Different Probability Distributions in Risk Analysis Using Monte Carlo Method

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In papers [1] and [2] there was introduced the problem of usage Monte Carlo method in risk analysis and their applications, especially in computing of Net Present Value (NPV) and in profit planning of bulding corporation.

In further papers, especially in [4], were described further developments of the topic mentioned.

The program package, that was developed by the author, was used for different analysis, comparison etc. with the aim to make the risk analysis using Monte Carlo method more user friendly for managers of building corporations.

The investigation in present stage of research was focused on usage of some different, but in some sense similar, probability distributions.

- The first possibility – returns and costs are specified by the manager as independent risk factors (random variables) with discreet distribution.

Although this possibility seems to be very easy and very acceptable for the managers, the results – the probability distribution of the total profit of a corporation – are not satisfactory. It is due to the fact, that there are generated (by Monte Carlo method) combinations of returns and costs, that can in reality arise with different probability than the product of specified probabilities, many times even with zero probability! In consequence of that fact the results of simulation (such as expected value and variance of the total profit of a corporation, or especially the probability of an event that the total profit of a corporation would be negative) are not too helpful for managers as a base for a decision making. For more details see [4].

- The second possibility – the probabilities of all combinations of returns and costs are explicitly specified by the manager (discreet distribution).

Although this possibility seems to be a little bit more complicated for the manager, because he has explicitly to evaluate and specify the probability of every combination of returns and costs (in our case 9 combinations, it means 9 probabilities for each construction), the results of simulation (again e.g. expected value and variance of the total profit of a corporation, the probability of negative total profit of a corporation) shows to be much more useful for managers as a base for a decision making. It is especially due to the fact, that the resulting random variable - the total profit of a corporation – has a distribution

with smaller variance. For more details and comparison see again [4]. Of course, only different distributions with some strictly identical parameters can be compared.

- The third possibility – the risk factors of returns and costs are specified by the manager as independent random variables with normal distribution.

In this case has the manager to specify the expected value as well as variance both of returns and costs for each construction, so that only 4 values are needed for each construction. This is for manager very convenient, but has another disadvantages. The comparison of results in this case (with these ones given by first or second possibility – see above) can be of course made only for distributions with identical expected value as well as variance both of returns and costs for each construction. For more details and comparison see again [4].

Usage of further probability distributions are investigated at present.

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Monitoring of Tested Sections with Noise Protected Elements in Cernokostelecka Street in Prague

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With the development of city rail transport, which brings many advantages for the environment, big problems with the noise of trams appear mainly in town and city centres with narrow streets and a high population density. In such conditions, no additional protecting constructions are possible, and so the noise must be reduced at its source. Contemporary trend of organization and traffic control in town more and more prefer public mass city transport, especially tram transport, to individual automobile transport. Parallel to increasing intensity of tramway transport it is more and more required also expressive decreasing of its noisiness. Measurements of noise pressure levels taken in CR and abroad demonstrate, that lowest noise pressure levels are round tram track with open trackbed. However, this type of tram track construction is on many places in town unusable and some pavement must cover track. In this paper results and comparison of measurements on tested tram track with grass cover and different noise absorbing elements are given.

The noise of moving tram consists of many particular noises emitted both by the tram and the track. Some of them depend only on the vehicle and its technical equipment, but the "rolling noise", which represents an essential part of transport noise at relatively slow speeds of trams in city centres (to 40 $km.h^{-1}$), is emitted by all moving or oscillating components of the bogie and the track and depends on the interaction between the wheel and the rail. So it is useless to separate the noise emitted by the vehicle and the track if we can evaluate the influence of the tram track structure on the noise emission from the tram traffic.

All measurements were taken during night and carefully care was paid to exclude any other disturbing noise, mainly from another tram, cars, moving people etc. The noise of passing trams was scanned by a Brüel & Kjaer sound level meter Type 2231 and stored on Sony DAT recorder. This signal was subsequently analysed by Ono-Sokki CF-930 analyser. Excel processor then worked out obtained data from analysis to needed spectra.

Monitored tram track is in Cernostelecka street between tram stops „Vinice“ and „Nové Strašnice“. It is situated in straight line on segregated track surrounded along both sides by street. To the June 2002 consisted tram permanent way of grooved rails on concrete sleepers with rigid fastening of rails with hard clamps. Tram track was covered by asphalt wearing course. Then was tram track completely reconstructed and six tested sections.was founded. Their construction consists of grooved rails NT1, concrete sleepers TB93 with direct fixation of rails, in sections 1 – 5 with elastic clip fastening SKL 14, in section 6 with special hard clamps by Ortec. Except of section 3 they are used different types of sub-ballast mats. In the end of year 2002 was construction of permanent way completed with different types of rubber filler blocks and track was covered by grass course.

First round of measurements was taken in July 2002 on old construction of tram track; second round in September 2002 on reconstructed tram track but still with open trackbed and third round in January 2003 on completed tram track. Measured equivalent sound pressure levels are shown in following table.

	Tested sections Černokostelecká					
	1	**2**	**3**	**4**	**5**	**6**
Period	**06/2002**					
L_{eq} [dB]	**85,9**	**86,2**	**82,7**	**84,0**	**83,3**	**82,8**
L_{Aeq} [dB]	**79,7**	**80,0**	**76,7**	**78,3**	**77,9**	**76,2**
Period	**09/2002**					
L_{eq} [dB]	**86,7**	**85,2**	**83,2**	**82,8**	**83,7**	**85,3**
L_{Aeq} [dB]	**81,4**	**80,3**	**77,9**	**78,2**	**77,8**	**76,3**
Period	**01/2003**					
L_{eq} [dB]	**84,8**	**85,6**	**83,3**	**83,5**	**84,8**	**85,5**
L_{Aeq} [dB]	**78,3**	**78,1**	**76,2**	**75,7**	**78,4**	**77,1**

This results of measurements are surprising and don't allowed to give final conclusions. One of possible reasons is that due to sub-ballast mats the layers of trackbed cannot be tamped enough from the acoustic aspect. Therefore measurement will be continued after approximately one year of consolidation of tram track by regular operation.

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Multistage Evaluation of Scenarios Probabilities

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Scenarios writing is an important technique used in decision making under risk, especially in the field of strategic planning. It makes possible to respect various risk factors influencing the outcome of the selected decision alternative.

The specialized literature devoted to scenarios writing gives mostly account of particular scenarios combining the risk factors as binary random events, i.e. events which may or not occur. Such a procedure is not free of difficultes arising from:

- estimating the probability of each risk factor occurrence conditioned / unconditioned on the occurrence of another risk factor, these estimates being obviously subjective probabilities expressing the degree of confidence in certain events happenning,
- assessing the probabilities of scenarios as intersections of random events by means of complicated mathematical models.

That is why a different approach to scenario writing is worth to be suggested. Its advantage over the cited procedure consists in:

- the possibility of considering more than two levels of each risk factor (e.g. a macro-economic scenario combining each of three rates of inflation - moderate inflation, galopping inflation, hyperinflation – with some rate of unemployment),
- the relatively simple way of assessing the scenarios probabilities.

A group of experts performs a pairwise comparison of each couple of scenarios quantifying either the preference of one scenario to another scenario or the indifference of both scenarios. The ordinal measurement of scenarios probabilities enables the assessment of the order of scenarios according to their probabilities, not the assessment of their numerical values. It also comes into question to take into account the different competence of experts through a convergent iterative process, take initial iteration being the equal competence of all experts.

Even the incomplete information involved in the ordinal probabilities of scenarios does not prevent the decision maker from evaluating the decision alternatives under risk.

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Motivations behind R&D Outsourcing

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Globalisation has systemically influenced the way all firms carry out innovation. As companies are challenging their R&D departments to do more work with fewer resources, there has been a growing use of non-internal technology development, both by outsourcing and strategic alliances. There is a great variety of organisational modes that can be used to access external sources of technology. Firms depend on universities to gain scientific knowledge, outsource some of their R&D works, buy patented technologies, commission research, and take part in consortia. Hence, the modes include both external activities (R&D outsourcing based on contracts and other customer-supplier relationships) and quasi-external activity (such as strategic alliances, acquisitions and joint ventures).

The outsourcing of R&D has become more important principally over the last decade. The most often mentioned push factors of R&D outsourcing are increasing complexity and fast changing character of the research process of R&D. Many companies simply do not have all the necessary scientific resources to cope with these problems. The limitation of resources and the need to retain the firm's position on the technological frontier are the most important reasons for the growth in the use of non internal R&D activities in both large and small firms. Furthermore, by outsourcing firms can gain access to a much bigger technology resource collection, specialist techniques or equipment. Significant factor is also the ability to gain tight control of R&D timescales and budgets. Another aspect increasing use of outsourcing is automation of certain research. The main area here has been in the screening, testing and analysis of samples and or areas where repetitive actions can be undertaken by automated devices.

Generally, the nature of innovation and the risks connected with loss of technological competitiveness still discourage a high level of external R&D activity. Ceteris paribus, firms would take on innovative activities in their characteristic competences through own R&D. The transaction-cost theory is usually used to explore the boundary between internal and external R&D projects and the governance mechanisms of external R&D projects. According to transaction-cost theory, outsourcing can be structured as a make-versus-buy decision facing a firm. Technology sourcing leads to time savings and lower innovation costs to the extent of economies of scale in R&D. Transaction-cost theory proposes that managers need to consider the both production and transaction co-ordination costs, for example, the costs of monitoring, controlling, and managing transactions when making decisions about outsourcing. Because of high degree of complexity and uncertainty associated with R&D it can make contractual relationships difficult or sometimes even impossible to negotiate. Therefore, the transaction-cost model foresees that R&D would not be undertaken in a market-mediated system but rather carried out under conditions of internal organization within the hierarchy of the firm. The core-competency approach suggests that firms have key assets or competencies that have resulted from previous investments and from learning-by-doing. These core competences can be seen as resources as well as capabilities which are accumulated over the long term to gain competitive advantage. The approach suggests that firms decentralising and outsourcing their

R&D portfolios can weaken their core technological competences. The decision to acquire technology externally is then determined by the effectiveness of different mechanisms of protection of technology.

In other words, R&D outsourcing is only undertaken where doing so is cost-effective and does not endanger the competitive advantages of the company. On the other hand, cooperation and joining resources could help increase the competitive advantages of all companies in the network. And also the practice of outsourcing technology itself is playing an increasingly important role in achieving competitive advantage, because the core competencies changes from technical capabilities to managerial know-how in system integration. The manner in which firms choose external and internal R&D is associated with the importance of the technological competence to the firms' activities. For smaller firms outsourcing is a tool to obtain specialist technical and engineering skills which they lack, whereas large firms take it for utilising external capability as part of the corporate research.

Movement to a strategic role of outsourcing technology is the way how to achieve a competitive advantage by technology sourcing. The mentioned facts imply that outsourcing should be found as a part of long-term business strategy. The company has to identify the most adequate organisational form for a definite technological collaboration. In case of outsourcing, the company has to try to decrease the management costs of technology outsourcing, e. g. by providing a corporate technology monitoring rather than within each business unit. Another factor is managing the relationship with external vendors in a right manner, because trust and reciprocity help to increase certainty, and thus to make the transaction costs lower. Appropriate governance structures, including management control systems and the development of trust, may work to reduce risk and decrease failure. And finally, it is necessary to have enough internal technical expertise for governing outsourcing transactions. Fulfilling all these suggestions, it is possible to leverage the supplier`s greater skills, knowledge bases, investments, and processes.

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Evaluation of Research Economic Effectivity (R&S)

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The aim of this work is evaluation and specification of optimal method for evaluation of research economic effectivity. In the first part we investigate the main points and the basic strategy for acquisition of basic information.

Evaluation of research activities appeared as „rapid developing industry". In the most OECD countries the main emphasis is placed in increasing of responsibility and effectivity of government supported research and also in other categories of government expenses. Mainly from the point of view of optimization of financial support. During university seminars we specified several criterions for evaluation of research systems. The first level can evaluate work of individual researchers. The second level can evaluate research activities of scientific teams, laboratories and institutes (e.g. universities). The third level can overview and evaluate the whole specific research areas. The forth level evaluates government programs and agency providing financial support of research. Finally the fifth level summarizes the previous four levels and evaluates research in connection with other areas.

During research evaluation it is necessary to use international criterions. The emphasis is placed on transition from „pure academic" research to research with social benefits of scientific work. Two different approaches to research are point out: competition and cooperation. The decision depends on the financing institutions and abilities and possibilities of getting support for basic research. The amount of money for research depends also on economic situation of specific country.

We summarize the described problem in four points and reasons for evaluation of research activities:

- Quantitative and qualitative evaluation of research may be used as basic part of development of research activities
- Evaluation may be used as a tool for scientific-political decision making and defining research and scientific priorities
- Evaluation may be pointed for strengthening of administrative and government legitimacy of a research system or part o fit, pointing out its effectivity also to responsible agencies
- Evaluation may be used as a tool in intramural (inner) competition in between research fields (dominant research fields may influence the criterion and therefore to get some advantage with respect to the others)

The goal is to find out and effectively use the previous points in the set of rules, i.e. not to consider only research need but also the problem connected with research evaluation. It is clear that the evaluation is not only a technical or practical problem, but needs to be considered in broad (complex) dimensions.

Basic point could be stated as follows:

- Basic scientific-political needs and goal of evaluation

- Effects - explicit and implicit, direct and indirect – of this evaluation
- Taking into account variety and qualitative differences of different research areas
- Determining of real "responsibility". Determination of agency making the final evaluation
- Maximalization of advantages of evaluation and minimalization of negative effects
- Financial and time consumptions and evidence of evaluation

Recently the evaluation has become a significant and important part of university management. It helps in getting restricted financial resources in competitive environment. But also there is a Langer in growing administration and weakening of main reasons for evaluation.

Therefore it is necessary to consider the question if this method will not stimulate only „hunting for points“, and if there will remain enough space for seeking of new ideas and inventions. In results the cooperation of different researchers and various research teams is necessary for elimination of errors and mistakes.

Further it is necessary to take into account the different approaches to qualitative and quantitative indicators in different research areas. The only interconnection is the ambition of researches for discoveries and inventions.

The penetration of market economy into these activities induces decentralization and stresses need of creation of a system for research economic activity evaluation.

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Long Memory Decision Making and Regional Development

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The paper is an attempt about generalization. The authors consider as a *process* every technical-economic presentation of reality. They declare as *steering models* every abstract description of reality employable for elaboration of management interventions (1). In this sense they certainly associate themselves with the management school that exploits modeling as a certain instrument for generation of steering proposals. *Assumption of homogenous application fields providing production resources and application of continuous space and time can be important practical information for decision making.*

Decision process $\mathbf{D} = \langle \mathbf{F}, \mathrm{d}(\mathbf{h}) \rangle$ or $\mathbf{D}^{\sim} = \langle \mathbf{F}^{\sim}, \mathrm{d}(\mathbf{h}) \rangle$ in the course of **L** applications for steering processes requires completion of concerning area homogeneity within which can be the solution, created and implemented.

There will be argued that decision is not only dependent on homogeneity, but also on memory (**Mem**). Relevant decisions made in the *past,* influences decision in the *time being*.

It will not be, however, correct created impression that is feasible to break away from the existing mathematical theoretic rudiment. Even in modeling of **P** (real processes) and **L** (leading processes), the main model streams practiced are simplified models. However, implementation and propagation of decisions (implementation of decision interventions) might be done more careful, if we are aware of the complicated **Mem** space.

Fixed decision rule D˜ and long memory dependent decision space

The memory dependent decision space ($\mathbf{D}^{\sim}|\,\mathbf{Mem}$) is written as

$$[(\mathbf{D}^{\sim}|\,\mathbf{Mem}) \;,\; \mathbf{Mem} = (dBase,\ time\ series,\ ..)] \qquad (1)$$

It is worthy of note that any decision rule influences the structure (location in time and placement of implementation) of **P.** We speak about

- dispersion in time,
- value change of implemented action (activities) in time,
- present value change according to profit rate (discounted value),
- changed value in time according to construction of decision rule,
- changed value in time according to stick to memory of input data.

So the investments, whose purposes are to make use of demand in an economic area, for example, dwellings in time periods $t = 1, 2,\ldots$ and separate areas *A, B, C,…* .

Existing demand for goods in time t_0 is filled by volumes of initial investment (houses and lands) in *A, B*, *C*,.. . However, the filling in (implementation) is limited by resources (capital) that will be available. For simplicity we can suppose that the market space can be from the voluminous point of view (**Q**) filled and will have value 1, or unfilled and will have value 0. We can write that management decision will be for example $A^{Q} = 1$, or $A^{Q} = 0$, further $B^{Q} = 1$, or $B^{Q} = 0$. In that situation we can write down the vector of the starting action state for $\boldsymbol{P}_{t=0}$ (*A, B, C,*…) like vector (1, 1, 1, 1, 1, 1, 1,…), when it denotes fully *filled-out space of potential needs*. The vector initializing state processes $\boldsymbol{P}_{t=0}$ =(0, 0, 0, 0, 0, 0, 0,…) expresses

an *empty space of possible needs* (for example of housing in the initial time period and sites *A, B*, *C*,… . Supposed that the steering process is sketched in such a way that evaluate a positive situation of the state and given time period *t* by 1 (indicate for example realization of new capital assets or innovations) into industrial areas *A, B*, *C*,… . Implementation areas are reordered (sorted) in the chain of reflective importance for the decision-maker (for example according to his investment interests). New ordered areas are *M, N, O* (reveal *M* as neighborhood left, *N* is position of the decision maker, *O* neighborhood right).
The decision rules $\mathbf{D}^{\sim}$ might be constructed on the basis of much diversified classes of comparisons.
The practicing economy uses mainly criteria on the basis of *summation* or on *maximisation* of advantages (max of interest, max rate of return (ROI), etc.). We might speak about $\mathbf{D}_{sum}$, $\mathbf{D}_{max}$, $\mathbf{D}_{min}$, but also about decision conditioned by risk, uncertainty or long memory[1] ($\mathbf{D}_{sum}|risk$), ($\mathbf{D}_{sum}|LMem$). However there are other approaches in many applications available. There are criteria as security, ecology, ethics, aesthetic, prestige, domination, long duration, sustainability, robustness, etc. If we apply different criteria, there are obtained different results. Illustrative examples are given by fractals. Fractal simulation is based on criterion that might by create as follows:

if for actual sector *N* in given time t_n holds that
in t_{n-1} was free *space* for expansion in sector (*N* -1) or in sector (*N* +1)
and
in t_{n-1} was positive *experience* for expansion in (*N* -1) or in (*N* +1)
(read innovation or investment opportunity exist)
then further investment (innovation dispersion) is obtainable.

We will write this criterion as $\boldsymbol{D}^{\sim}_{sum>\alpha}$ **= (F,** d(**h**)**).** Graphical trace (simulation) of this criterion has graphic descriptions in many fractals. This and all further mentioned criterion simulations start expansion processes from single cornel cell $\boldsymbol{P}_{t=0}$ =(0, 0, 0, …0, 1, 0,…). The construction of criteria means to develop formulas, controlling volume of gains that were available in the past and anticipate future implementation development.

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[1] Memory aspects are very frequently in economic applications substituted by uncertainty (discount, decay multiplier, etc).

The Regional Development Evaluation

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The regional policy – a part of the structural policy – is a strategic EU-program for the regional supporting and development. Reducing differences among the regions in European Union and forming economic and social balance are the main aims of this policy .

The regional policy doesn't rank among common policies, all decisions are retained on national government, the European Union makes only a coordination and provides financial resources. For this purpose structural founds has been created. These founds are composed of four financial instruments – European Regional Development Fund (ERDF), European Social Fund (ESF), European Agricultural Guidance and Guarantee Fund (EAGGF), Financial Instrument for Fisheries Guidance (FIFG) – and an independent financial instrument Cohesion Fund (CF). In the period 2000 – 2006 cost Euro 195 thousand million are supposed. Structural policy projects have to meet prescribed conditions for the sake of financial supporting from EU-financial instruments Drawing up an analysis of the regional development evaluating is one of mentioned conditions.

The aim of this contribution is to evaluate and to describe a regional development of district Česká Lípa (a part of Euroregion Nisa). The evaluation consists of five parts – Economic Development, Agriculture, Human Resources, Environment and Tourism.

The different methods can be used for the evaluation. Here (like in Regional Development Plan) SWOT analysis was applied. In this method Strengths, Weaknesses, Opportunities and Threats are described. SWOT analysis is an open, very useful and prompt instrument because it includes internal and external factors and conditions that determinate the regional development. The deductions that will be used for the future development have to be formulated in every part.

Euroregion Nisa was established in 1991 as an alliance of three states – Germany, the Czech Republic and Poland. The Czech part of Euroregion consists of districts Česká Lípa, Liberec, Jablonec nad Nisou and Semily – it means 4,5 per cent area of the Czech Republic.
Among positive factors that determinate economic development rank activities of foreign investors from USA, Germany and Canada first of all in Česká Lípa, qualified workforce of glass industry especially in surrounding of Nový Bor, high level of economically active population (due to the atypical age structure of population) and traditional world-known glass industry with the biggest glass factory in the Czech Republic – joint-stock company Crystalex Nový Bor. These possibilities were founded for future development: 1. the establishment or enlargement of industry zones, 2. the infrastructure improvement in the countryside, 3. the support of small and medium manufacturer, 4. the economic structure innovation, 5. the exploitation of ex-military area Ralsko as a new industrial area.
It was found that the insufficient exploitation of agriculture land and a weak cooperation with finishing industry (in the mentioned district doesn't exist any dairy and slaughterhouse) are the main problems of agriculture. The alternative agriculture method as ecological

agriculture was identified as one of the most important possibilities. The ecological agriculture has an export potential for bio-products to Germany where exists higher demand for this kind of products than in the Czech Republic. The development of different kinds of country tourism (eg. Eco Agro tourism) would help to increase an income for farmers and to support tourism in the countryside. ECEAT CZ is an independent organisation of an international project of European Centre for Eco Agro Tourism and guarantees an official tourism project for the Czech Republic – "Holiday in the country", that would be used for presentation, promotion, certification and knowledge exchange.

District Česká Lípa has at one's disposal atipycal age structure of population – lower average age in favour of high level of economicaly active population. The total district unemployment rate is on the level of average rate of the Czech Republic. But local differencies exist between microregions. With respect to this situation a young population decreases in the countryside.

Due to the environment investment, biosphere balance, protection of natural resources in reservations, high level of forest area and acceptable air polution the environment has a good level. On the other hand ecological consequences exist eg. an uranium's output in area Stráž pod Ralskem and ground water polution in ex-military area Ralsko. Besides removal of the old ecological problems the development of ecological education and a protection of surface and ground water again the industrial and agriculture polution is very important.

Very good development conditions of tourism were identified: 1. a lot of natur beauties, 2. a proximity of frontier, 3. plenty of accomodation capacity, 4. the well known tourism locality Máchovo jezero. The tourism season extension, the global information system formation in the region, the improvement of cooperation with Germany and Poland in the organization Euroregion Nisa and Ralsko area used for cycletourism are necessary for future development.

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The Machinery Company and Process Costing

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Except of investments and projects came to the fore of interests in practice running operations (processes), which are sight always on a certain activity. Process planning and control generate needed transparency in the area of indirect outputs and give that way base for the run-down of their complication. Process planning and control then lead to procedural or also activity costing.

Methods of procedural costing

Problems of variable costing lead to the tendency to find a method that would result in the right (or rather to more precise) solution of the calculating problem. That method would be procedural costing or costing with using partial activity (Activity Based Costing, ABC). The base of this type of calculation is the first focusing on non-productive sphere in a company and farther on searching processes, which go through more centres and allow that way to find meanwhile unknown factors causing costs (cost drivers).

Subject of investigation

The subject of the investigation of procedural or activity costing is the area of common costs, possibly areas of indirect costs. To the area of common costs belong, among other things, supply, logistics, etc. and also production control (its planning and control). For procedural costing production is not relevant, in the sense of straight realisation of production activities, for that this area is right solved by straight relative quantities of the variable costing method.

Procedural control except for centre control

At attempt to reach transparency in indirect production areas forms the question, which are the factors, causing costs. Like causing factors (cost drivers) are indicated relational quantities in indirect production areas. While in the production centres there are big parts of costs caused by working or machine hours, in supply centres it is for instance the number of orders or the number of pieces of raw materials or good pieces. These reasons of the cost origin cannot be in indirect areas controlled separately only in the given centre because the origin of costs is in other centres. Production management may, for instance control number of commodities, as a cost cause for supplying area. To prevent egoism of centres the control of indirect areas must be carried out that way to exceed the area of the centre and must be procedurally focused. Only on the process focused procedure may the expenses per good order be identified and controlled.

The aim of this procedure is the optimisation of the economic processes in companies.

Main processes

The main process is aggregating matter of different partial processes, which objectively belong together, which exceed the range of individual centres. As already has been stated, the main processes cannot be assumed individually only on the level of the cost or process centre.

To open up costs of indirect areas for their control, these costs must be joined together to the main process. The main process is key-object in procedural costing and only in necessary cases we came back to partial process, in the main process included. For the procedural costing remained manageable process tool, the number of main processes would not usually be larger than 15 till 20. These complex processes serve like a base for the optimisation of processes, possibly for complex oriented costing (creation per cent additional fee for process costs).

Relative (specific) quantities and cost drivers

Like a relative (specific) quantities the relative quantities (sorts of outputs) on the level of procedural places are indicated. The relative quantities on the level of main processes as cost drivers are indicated or cost initiators. Differentiation of relative quantities is usually very large. Which relative quantities may be joined together into the cost drivers must be resolved in each company extra. The aim must be the smallest number of cost drivers (and thereby also the number of main processes), but at the same time the transparency of the content (cost drivers) from the point of view of individual relative quantities must be preserved. Demand on ideal relative quantities or on cost drivers: easy roundness, computability, and easy obtaining data from calculation technology, and proportionality to output.

Main processes joining

The change of the main processes is realised, if no-proper cost driver cannot be found for the given main process, if the cost volume related to the main process is very low, if the larger differentiation of the main processes is necessary to carry on (division of the main process, "raw materials order" according to the different sorts of raw materials).

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Today´s Situation, Problems and Development Trends of Machine Industry in the Czech Republic

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Machine industry as term is very often used, but it is not easy to define or to determine this term. We can define him for example by using categories of industrial products and services. In my research I describe position of machine industry in our state. Next I show production in these categories of machine facilities. Development trends of import and export in selected groups of products follow.

This chapter shows definition of machine industry in the Czech Republic. We have a few categories, which contain machine products. These categories are following divided:

- Practice in foundry (code 27)
- Metalworking products and repairs(code 28)
- Machines, equipments, facilities and repairs (code 29)
- Two-track vehicles, trailers and semi trailers (code 34)
- Other transport machines (code 35)

For near concept I describe main categories of machine products, which can be divided in several subgroups. In first category with code 27 are following products – casting of iron, casting of steel, casting of light metals and casting of non-ferrous metals .

Second part of products (code 28) contains – metal constructions and prefab unit for building industry, tanks cisterns, holders, radiators and furnaces, boilers, press forging, cold forging, closed die forging, stamping, cold extrusion, metal ceramics, heat treatment, metal finishing, cutlery, iron goods and other metal products.

Third group (code 29) includes machines for production and usage mechanical energy, machines and facilities for general purposes, machines for agriculture and forestry, machine tools, pressing machines, similar machinery, components, installations, mountings, services, machines for specific branch of industry, weapons and munitions, parts, installations, mountings, services, equipments for household.

Next (code 34) are two-track vehicles and engines, auto bodies, trailers and semi trailers.

A last group (code 35) is composed by crafts and small crafts, services, rail locomotives, car for tram, metro, rail traffic, parts, services, airplanes and spaceships with satellites, parts, services, motorbikes and bicycles, wheelchairs, parts, other transport machines.

In my paper I analyze development trends of these facilities production and their components. For such work I obtained data from Czech Statistical Office. Besides the

production values I also have data about import and export of these facilities. In the end of my report I mention time series of these data, which are in next table.

Zdar	1996	1997	1998	1999	2000	2001	2002
Import (mil. CZK)	218685,9	287767,6	309653,9	325712,6	404581,7	459267,4	439884,0
Export (mil. CZK)	238897,3	299945,9	369610,5	393693,0	476402,1	539700,9	523120,2

To summarise my paper: machine industry in our country is very complicated. This term does not exist and must be define by various categories of products. Practice in foundry, metalworking products and repairs, machines, equipments, facilities and repairs, two-track vehicles, trailers and semi trailers and other transport machines compose main groups. These groups contain next several subgroups of products, which description is changing in time, because the production is changing.

For illustration are mentioned values about import and export in these groups of products. Comparing import and export we can see that the export is larger than import. Time series demonstrates development of import and export, which is increasing during the years.

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Using Competitive Intelligence in Engineering Strategy Process

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In the present age, which is marked by a strong competitive and global effect, it is necessary to have enough correct information. If we divide information acquisition by sources, we gather information from the inside of firms through Business Intelligence methods and from the outside of firms through Competitive Intelligence methods. It stands to reason, that the question of Business Intelligence seems like a simple question, largely because of information availability. The subjects of our concern are the problems of Competitive Intelligence, which have become a pivotal area of our research within our postgraduate studies.

Intelligence competitive information may originate from many heterogeneous sources, which are most often the economic news results, the action of competitor's managers, trade press, workers of distribution, joint customers, suppliers and competitive product analysis. Is very unlikely, that one should manage to gather all the necessary data for the analyses of competition during a single action, which is why serious research should be devoted to this issue.

In the area of Competitive Intelligence world literature is not quite uniform. We attach ourselves to the definitions that give us intelligence about our **competitive position**, not only intelligence about our **competitors**.

In this area there are some defined subgroups: Competitor Intelligence, Customer Intelligence, Market Intelligence, Partner Intelligence and Technical Intelligence. These subgroups could be briefly categorized as follows. Competitor Intelligence is the compilation of information on our direct competitors. Market Intelligence involves data about marketplace development and changes. Customer Intelligence relates directly to our knowledge of the customer. Partner Intelligence involves obtaining information about suppliers and any other partners.

At the front of our goals of interest is the exploitation of Technical Intelligence in the engineering strategy process. Technical Intelligence is in fact a collection of instructions about where and how to search for information about cracks in technology development. Good sources of information are technical periodicals, which in most cases are published in electronic form making facilitated searching easier. Other sources of information are databases, manuals, handbooks, textbooks, technical papers, conference proceedings, sales brochures, catalogues etc. In principle the least researched area is searching for information about patents. It is known, that 80 % of patent information is never disclosed or published elsewhere [2], and patent applications are often published earlier than academic papers. Searching for patents allows not only the monitoring of prior techniques in your technology, but also the awareness of competitor patent portfolios. It is also useful to assess relevant

market trends and to avoid infringement of patent law. Technical Intelligence has an important benefit in engineering strategy processes. Only enough relevant information allows the evolution of the correct products and offers it to the right customers and also allows us to learn from the mistakes of others.

From our present experience it is clear that concurrent information usage from the outside of a company is in most cases a random process. Too often today in resident companies we find that there is nobody responsible for the analyses of the competitive position. Also there is no single correct way of gathering data about the competitive position, this means that it is necessary to devote attention to these problems, or there is a risk of losses of very useful and important information. Generally it is possible for competition intelligence systems to be divided into several functions. The bases of these functions are data acquisition, firstly from experience, most often from the sources, which are for example sales forces, engineers, channels of distribution, suppliers, advertising agencies, staff or counselling agencies. Secondly data can be acquired from the congregation of published data, most often from the source, which includes; articles, papers, advertisements, news analysis, Yellow Pages and commentary about patents. The sorting of gained data follows, helped by computer techniques, the next stage is plotting analyses, at which time data are summarized and ranked according to the credibility of the sources, transaction for example of abstracts from annual competitor news, comparative financial analyses, product analyses of competitor orders and estimates of competitor's waveform load. Pursuit of these activities results in a full analysis of competitors for the formulation of further strategies.

Our mission is to standardize this process to the measure of effectiveness, so that it could be implemented with success and its effects maximized. Creating a standardized system of obtaining and processing information allows company enforcement in the present strong competitive environment.

Competitor analysis is an incredibly important business in the modern business environment, and so it is essential that it is not approached in a haphazard way.

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Business Intelligence in Manufacturing

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As defined in [1], Business intelligence (BI) involves the integration of the core data, information, and knowledge with relevant contextual facts to detect significant events and illuminate forthcoming problems and promising opportunities. BI includes the ability to monitor business trends, to evolve and adapt quickly as situations change, and to make intelligent business decisions based on certain judgments and contradictory facts. It relies on exploration and analysis of related and unrelated data, information, and knowledge to provide relevant insights, identify trends and discover opportunities. BI requires high quality inputs, the organizations therefore, must understand the need for and value of a high quality data resource, the starting point of BI analysis. The real challenge to the companies is how to clean the up the raw data to produce a high quality data resource that truly supports business intelligence. BI can be looked at from three different points of view [1], namely; strategic, tactical and operational intelligence. However, they are all tied in with financial intelligence about organizations' operations. In this contribution, I will be considering, the strategic and operational intelligence and some of their applications in manufacturing.

Strategic intelligence occurs at the highest level and it is oriented towards many sources that are based outside the organization. These outside factors are helpful in assisting the top management and the corporate planning staffs determine what strategic direction the company should take today and, more importantly, in the future. As a helping hand to the development of appropriate strategic intelligence, the BI system software packages play a big role in assisting the managers in taking effective decisions. These software packages are extremely helpful in assisting the top management and corporate planning staff in getting a handle on the patterns of the immediate past, present and future operations. Analysis allows these high-level managers to spot and understand significant trends that impact the entire organization.

The operational intelligence in manufacturing and the ties to strategic intelligence: Manufacturing can be made more efficient and effective by utilizing a BI system operational mode. The starting point of operational intelligence is strategic planning at the corporate level. The focus at these higher levels is to establish periodic or annual manufacturing goals of the organization and its various manufacturing facilities (both owned and non-owned); the operational plans can therefore, be developed in manner that sets down specific periodic production goals which can be linked directly to key performance indicators of the organization. In turn, these plans can be employed for loading the company's manufacturing facilities on a day-to-day basis. Hence, the operational plans not only look back to strategic planning for their overall direction, but also provide the necessary input for daily production planning and execution.

Utilization of a learning organization in a manufacturing environment: Learning organization (LO) method is suitable when problem recognition, definition, and solutions are likely to differ for most situations.

The LO method centers on organizing employee to expand their capacity to create the results they truly desire over time. With LO, new and expansive pattern of thinking are encouraged, and employees are continually learning how to learn and work together better. Essentially, LO centers on knowing what the organization and the organization members do well, learning from that to do it better the next time and continually looking for improvement. The net result being that, the LO is able to maintain a competitive advantage in a fast changing world. To implement LO the organizations need to introduce new equipment, new learning skills, and knowledge-creating and operational intelligence management systems.

The internet has brought a drastic change in the normal way in which manufacturing plans used to be carried out. As a result of customer centricity, which represents a real shift in the established order of doing business, where a manufacturer has to produce based on the real and actual specification of the customer, manufacturing plans have to be revised quite frequently to meet customer specifications. It is the customer's choice that is dictating fundamentals to manufacturing, including what goods are produced and how they are marketed, priced, distributed and serviced.
Advance Schedule Planning (ASP) tools or applications are one of BI tools that can enable manufactures to dynamically schedule and reschedule their production on demand. The important fact here is that, the manufactures know how updated (current or fresh) the input information upon which they are acting to produce a given product. Getting better control of the data that is stored on the servers and using the web technology as delivery mechanism is essential to manufacturing. As such, customer driven manufacturing trend is creating an ever growing need for information and knowledge up and down the supply chain. To meet the competition, organizations need to create information about their customers' preferences and turn it into a rapid new product development. In other words, customer-centric (customer-centered) manufacturing requires dynamic business intelligence, and creation of such intelligence is necessary for effective daily operations.

The manufacturing applications related to BI systems include purchasing and supply chain management, and production planning and execution. In the BI system operating mode, we can see functions like engineering, manufacturing analysis, quality control and inventory control. BI system operating mode can assist manufacturing managers in analyzing manufacturing operations and quality control problems as well as those related to inventories, from raw materials stage to the finished goods stage.
In general, BI systems are useful to most manufacturing managers, not only for overseeing and evaluating factory operations, but also in the physical distribution activities that start with incoming materials from suppliers and ends with those activities that take place after the manufacturing processes involving the wholesalers and retailers.

Manufacturing software useful for operational intelligence in BI includes MRP (Material Requirement Planning), MRP II (Material Resource Planning), ERP (Enterprise Resource Planning), SAP.

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ISO 14040 (LCA) Application in the Building Industry

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A product's life cycle starts when raw materials are extracted from the earth, followed by manufacturing, packaging, marketing, transport and use, and ends with waste management including recycling and final disposal. At every stage of the life cycle there are emissions and consumption of resources. Therefore, the environmental impacts from the entire cycle of products and services need to be addressed. One of the environmental management tools is a Life Cycle Assessment (LCA). Life Cycle Assessment is a quantitative tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. LCA provides an adequate instrument for environmental decision support. Life cycle assessment has proven to be a valuable tool to document the environmental considerations that need to be a part of the decision-making towards sustainability. A reliable LCA performance is crucial to achieve a life-cycle economy. The International Organization for Standardization (ISO), a worldwide federation of national standard bodies, has standardized this framework within the ISO 14040 series on LCA.

ISO 14040 standard provides the general principals, framework and methodological requirements for the LCA of products and services. ISO 14040 series includes the following standards: ISO 14041 providing guidance for determining the goal and scope of an LCA study, and for conducting a life cycle inventory; ISO 14042 providing guidance for conducting the life cycle impact assessment phase of an LCA study; ISO 14043 providing guidance for the interpretation of results from an LCA study; ISO 14048 providing information regarding the formatting data to support life cycle assessment; ISO 14049 providing examples illustrating how to apply the guidance in ISO 14041.

Life cycle assessment is an iterative process in which the assessment is repeated several times, each time in details. It is much more complex than other environmental management tools and relies on scientific data. There are four general steps in life cycle assessment framework:

- Goal and scope definition involves drawing up a specification of the study, exact formulation of what is to be investigated and how the investigation is to be carried out. Besides, a functional basis for comparison is chosen and the required level of detail is defined.
- Inventory analysis specifies the processes involved in the manufacture, then combines them in the process flow chart and relates to the functional basis. Further the analysis collects data on each process and defines system boundaries, e.g. fish from sea and from farm pond. The inputs and outputs from each process must be adjusted and processed.
- Impact assessment represents classification of all environmental burdens according to the environmental problem to which they contribute. Among these impact categories we can recognized: resource depletion; energy depletion; global warming; photochemical oxidation; soil and lake acidification; human toxicity; aquatic and terrestrial ecotoxicity; and ozone depletion. These impact categories may be weighed for importance.

- Interpretation, the results are reported in the most informative way possible and the need and opportunities to reduce the impact of the product(s) or service(s) on the environment are systematically evaluated.

LCA was developed primarily as a simple tool for studying process changes in industry, but now it has a wide range of uses. LCA researchers quantify and characterize the inputs and outputs of every stage in a product's life to assess its environmental performance. If we want to understand the environmental impacts associated with any product, we must analyze the entire life of that product and consider the environmental burdens of each step along the way. Going into details of LCA, however, it gets complicate very quickly, e.g. quantifying energy and resource flows at each step in the life of a product. Architects and building professionals, who are interested in the environmental impacts on their projects, seek out or encounter LCA base-information. Life cycle assessment for building materials differs from those for disposable items packaging, because building materials have long service life ("use phase") and also their service life is highly variable, as even durable products may be replaced by other ones for aesthetic and economic reasons. Estimating the useful service life of a product or a building is very problematic for LCA putting a high level of uncertainty on the results of any LCA study conducted on building material. It requires creating the software with enormous amount of data for each step along the product's life cycle. Software that has been developed so far, e.g. TRACI or BEES is based on applying weighting factors to environmental and economic impacts, establishing a user-selected weighing system over twelve categories. Software developed in Canada called Athena is rather different. It measures six categories with absolute value and leaves the weighing up to the user, because as authors say "the weighing is subjective".

While it is quite simple to label food bought in supermarket and follow its life cycle, following building materials life cycle is not as simple as that. Someday in future construction materials may also have label or rate system, listing each product's contribution to global warming, ozone depletion, acid rain, habitat loss, and other significant environmental indicators as the result of life cycle assessment.

Life cycle assessment is a holistic analytical technique for assessing the environmental effects associated with a product, process, or activity. However, its use in the building industry requires a detailed research on environmental impacts of all building materials used in construction as well as considering environmental burdens of the whole building.

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Techniques for Effective Decision-Making

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Effective decision-making needs not only to use exact multicriterial decision-making techniques. It's worth to use more techniques at once. In this essay I will concentre on subsidiary techniques for decision-making and exact multicriterial decision-making techniques I will place aside [3].

It's impossible to mention all facultative methods, so I will choose three of them: Paired Comparison Analysis, Six Thinking Hats and Pareto Analysis.

Paired Comparison Analysis is useful where you do not have enough of objective data to exact decision talking.

We create a decision-making matrix – each option has own row and column. Then we compare each option with each option, take decision which of this two options is more important, then we assign a rating which shows how more important it is. We use the three steps scoring from 0 (there is no difference) to 3 (there is the major difference). We count grand total for each one from the options. These total values we can convert into a percentage of significance.

For continuing of decision-making process we can use quantifiers, we have created – percentage of significance.

Six Thinking Hats is a special technique that looks at the main decision point from all possible points of view. By using this technique you use the points of view of different type of people and as well as professionals. Different point of views could anticipate variant customers reactions.

Each person uses different methods of thinking, some favour strict rational point of view, some favour pessimistic defensive point of view, the others favour emotional and intuitive point of view. By using Six Thinking Hats methods we can mix all of these approaches. Each Thinking Hat presents different point of view, different way of thinking.

White Thinking Hat – exact rational way of thinking based mainly on the exact data; you use past data, trend analyses with their extrapolation and account data.

Red Thinking Hat – intuitive emotional way of thinking; we try to use our own intuition and emotions; we try to think – how the other people will use their emotions. Think about emotional reactions the others, what it could bring.

Black Thinking Hat – fixation on bad break points; we look on the decision from the defensive line – what all can go wrong, what might not wrong. You highlight the weak point

of the decision-making. By knowing these weak points you are able to eliminate some of these weak points, and with the others we can count in our plan by preparing emergency plans for countering them (the plan goes more resilient).

Yellow Thinking Hat – this hat represents positive and optimistic thinking; you see all possible advantages and benefits with their value. This hat could help you in case of dumpish going on, it could reinforce the team in carrying on.

Green Thinking Hat – mirror the creative art of thinking; it is "free-wheeling" way to new unsuspected creative solutions. There are a lot of special tools to use, such as brainstorming. In this hat is only a little possibility for criticism.

Blue Thinking Hat – is prepared for the control of team process dynamic. The hat is used by team leader in case the team dynamic in one hat sink like a brick – the leader by using this hat could change the theme or the hat.

Pareto Analysis is simple technique that uses well-known Pareto principle. The main idea is to separate twenty percent of your work which create eighty percent of the results (job, sales, etc.)

The first step is to identify twenty percent of tasks generating eighty percent of the outcomes. Afterwards you concentrate your interest and effort on these twenty percent. The rest, eighty percent of tasks are not worth for your attention greater than twenty percent of your disposition, because, they create only twenty percent of the outcomes. This tool helps you concentrate your expenditure on weighty - moneymaking tasks.

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Several Concepts of Management Accounting

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All information financial and cost character, which accounting personnel offer, go in for manager interesting and important, doesn't go about data, but above all about information. Difference among financial and management accounting entails stress, do you management accounting lay stress on purpose, rather than on techniques. Application engineer had to personnel ensure modification information for all level of management- for single parts of the process drive (above all for scheduling, decision making and verification activity in organization). Suit management accounting presents forms presentation, respective definite stage of management so, to information became tool, which helping topping purposes and policy firm day by day. Profile of specialist, who forms above-mentioned region information, isn't clean economic, nor clean accounting. Effort and save presents understanding of technical problem, subsequently economic fall, to information generation companion activity and policy whole firm. Express next proportion management accounting entails, we do not speak about an information system in known conception, but talk of an architecture, which with reference to organization like thing these systems cascading. Especially about a decomposition outputs of management accounting for purposes:periodic return (earlier EA), information clean load-yield (cost estimate and revenue pair with definite concrete activity), region check information, coadjutant management to check activity (plan and his verification, frequently budget like verification) talk of role communications, presents break down of the basic fission.

American Accounting Association (AAA) enlistment to the legitimate definition book-keeping too a role communications, communication among shapes inside of a company, communication among levels of and communication among informative subsystem. Exit from book-keeping managerial support and form decision-making activities, must be precarious prepare and provide with authority factor- human capital. How cover up influence hereof factor to the areas politics profession, providing outputs? Structure of a conception start from penetration among undermentioned systems:1.system economic, 2.system technical,3.System Psycho-social. Point No.2 follow on marketing activities, first from plan is plan market, resulting from analyses needs. Point 2 presents implicit competitive advantage (conversing if about forwardness produce and especially about innovation). Point No.3 covers behavioural factor. Is concerned interference behavioural factor outer with behavioural factor inner. Orbit development direction to goalsetting is eliminant two partial orbit.

$$\pm T_i^{(t)} \pm T_E^{(t)} \tag{1}$$

Author assume, do you first orbit is eliminant synergistic. Alternative orbit is interaction of a company with substantial surroundings.

$$\int_{t_1}^{t_2} F(S)ds + \int_{t_1}^{t^2} F(E)d_E = T \tag{2}$$

$$t_2 - t_1 = \Delta t = \Delta F_t \tag{3}$$

$$T = T_1 + T_2 \tag{4}$$

T1< 0 for organizational inconsonance,T1 = 0 for production organizational behaviour,
T1>0 incidence desirable direction, T2<0 dishonour exit, T2 = 0 decision making about exit,

T2>0 accept exit. Relation Nos. 2 it is possible interpret like definition interval balance-sheet synergistic, e.g . . $\Delta t = 1.c$.

c ∈ <6; 360>

For application cross over relation Nos . (2) to the shape

$$\sum_{t_1=1}^{t_2=30} R_S + \sum_{t_1=1}^{t_2=30} R_E = I \tag{5}$$

Terms model situation, quantitative terms are classification by quantities, make-up is at that time, will-if achievement measurement and aggregation. Practical page is given to analysis, based on outputs from balance-sheet. Interval duration of a cycle depend upon financial period. Time period of outputs for purposes management accounting would 'd move round one's for weeks (e.g. short-term final accounts).Communications and inter-disciplinary role of management accounting characterize this way: Wide a knowledge base of managerial accounting system, conception economies show managerial accounting like managerial in this sense

Information generation for decision-making activities classification just managerial economies, lay in her context, managerial accounting should be familiarization with operative research, quantitative method and know demand on outputs from areas statistics. Every day communicate specialist from areas information technology, has work even implementation these system. From practice know, do you considerable rock makes in the event of external acquisition information technology, programmatic safeguard, already formulation of a demand letter provider. An Implementation would lead off above all to integration. Decision-making role managerial accounting is high dependent just on integration. Decision-making activities are ad hoc and evaluative economy of intermediate source. Has-if at regular intervals happen to collation bottoms up anta, then confront with definite standards, must be resolution: Way tent standard,a ssesment period classification, functionality backward bindings. Mentioned factors generation companion development classification of a firm. Region of managerial economies look on accounting from a decision making position, less from a look check. Downtown politics will appraisement ,marketing and capital decision making. Operational research and his personnel collect on classification decision making, proposal decision-making system. Next insider are people, conversant behaviour inside firm generally. Here there has been connection between cost and management accounting e.g. motivational aspect standard funds and budget, subsequently reporting, shows comparison and differences in tracked region. e.c is perceptible a strong structure among personal drive and planning and controlling system. Before suit classification plan, budget and decision-making exercise, is necessary, know differences and differentiate among conception load in managerial book-keeping and load book-keeping. Happen to specific flow information of the cost accounting to the system of management accounting. In fine show in characteristic areas load type: 1. classification of cost, 2.allocation overhead costs, 3.production costing progress in systems,4.Interaction among preliminary and resulting calculation, 5.classification limitation costing access in terms of calculation absorbing and no-absorbing 6.critique and using break- even analysis, 7.whole check suit in terms of comparation information ex post and ex ante. Growing up controlling system, dependent up ex ante system, it is possible describe this way: analysis historical estimation, classification environment, whereof firm will move, tent long-term aim, comprehensive financial purposes, formulation policy to run to aim, survey policy to the levels of operational plan on period shorter, elaboration of detailed activities and budget according to responsibility manager. Motivation people to run to rated funds in plan, budget, collation contemporary record with value planned, forecast. Embody and production of reporting news for given to levels of responsibility. Purposes would have be all the time amelioration efficiency and economy.

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Principles and Benefits of Michadlo Cost Model

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In the first phase of the research, Michadlo Cost Model has been developed in two costing alternatives: Hour overhead tariffs method and fixed overhead rates. The major reason for the development of two alternative models was to offer a possibility of a comparison between both costing approaches. Fixed overhead rates is still the most commonly used method, despite the fact that the hour overhead tariffs method is a more suitable costing procedure. In this model the hour overhead tariffs method is applied in a vertical version. That means individual hour overhead tariff (HOT) for each workplace (machine) and the HOT for the remaining overhead costs of the center are stated and evaluated. In the recent phase of our research, which focuses not only on the single pieces of the product, but on the product line with many members in the line as well, only the hour overhead tariff method is applied.

Cost model has been developed primarily with respect to these interdependent principles:

- Integration of the utility, technical and cost points of view
- Target costing line
- Process approach application
- Period (time) dependent costs domination in the cost structure of the processes

Integration of the utility, technical and cost points of view has been applied partly up to now only as an interaction between technical (design, manufacturing technology) and cost points of view. The cost model is sensitive to each change in the product design (used materials, structure of product, or manufacturing technology procedures). The direct interaction with the utility characteristics of the customer segment is the task for the next phase of our research.

Taking in account the *target costing line* means that the model has been developed and is expected to be further developed in order to be able to include cost data from all the steps of the product development process. Current version of the cost model focuses on the product costing as the consequence of the pre-manufacturing and manufacturing product development steps.

Process approach application in costing means, that the effort not to surpass the cost target limit focuses rather on the changes in the product design, on the used manufacture technology and on the product manufacture processes and their conditions then on the autonomous cuts in costs. It also includes all traditional means such as negotiations with the suppliers about the price of the delivered components and services, looking after the outsourcing solutions resulting in cost cuts, assessment of the level of the productivity, etc. The recent version of the cost model enables to summarize product cost after each change in any process, in any used tool or in any used component or of course its price.

To maintain the product cost target limit *does not depend* only on the attributes of the given product and on the number of pieces to be produced but it depends *even more on the productive and economical attributes of the manufacture centers and the workplaces*. Their costs and their degree of utilization are more and more essential in the cost calculation. The continuously rising costs and productivity of the equipment underline the necessity of the high degree utilization of the equipment. The time dependent cost - machine (leasing payments, depreciation, overhead wages, cost of machine servicing, etc.) and personnel (not only wages and insurance but also other employee benefits) dominates in the cost structure. That leads to the application of the hour overhead tariffs method; because *time consumption is the major factor*, *which determines the size of the costs.* The size of HOTs is in thousands of crowns, not only some hundreds or tens of crowns as it was a few years ago.

Benefits of this cost model construction are the consequences of the used principles and of the application of the vertical version of hour overhead tariffs method. The main benefits are in:

- Integration of used approaches: Target costing, Process approach and Utility, technical and cost point of view link.
- Control of the product cost limit through process control - the selection of activities and the conditions under which they are running.
- Control of the product cost limit through workplace selection and its capacity utilization.
- Calculation with period (time dependent) overhead cost in an adequate way for the product costing.
- Product cost calculation with joint respect to different behavior of the product and equipment cost items and with respect to the degree of the capacity employed.
- Integration of technical staff into product utility and cost calculation (taking economical point of view in account) due to the application process approach (technical staff determines the processes, their conditions and their duration) and understandable measure of overhead cost (hour overhead tariffs).
- Application of the principles and cost model in teaching process.

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Strategy of Marketing Research

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There are no doubts that we are witnesses of an impressive coming of marketing in the theory and practice in the last years. More and more enterprising subjects, who are trying hard to go through in contemporary dynamically expanding market world, are realizing the necessity of the marketing orientation in their strategy. In the enterprises and firms which are let by the endeavour to win in their branch a competition advantage, and to earn from this advantage maximum, becomes the marketing and integral part of the culture of the firm and its system of together shared values. Marketing is therefore becoming an important implement of every firm in the competition fight for keeping and improving of the position the enterprise in the market. It is necessary to have a lot of information concerning the specified problem for any responsible decision, not only in the enterprise practice. The collection of evaluating and application of this information naturally have to precede this final decision. In the marketing practice is this logical progress twice accepted. The consequences of bad marketing decisions and strategies, which are made on the basis of incorrect or badly used information, have a result in the considerable economical losses, which often outgrow in the existential problems, which are in the contemporary "violent" competition only difficult to solve. Therefore is getting of primary data one of the basic pillars of the marketing draft.

Primary data are concentrated entirely in close relationship to the solution of concrete issue of wide economical connections in the market, the changes of customer's reactions to the product and acquiring of useful company intelligence. The source of the primary data is the searched unit that can be an individual person, household, firm, etc. First it is necessary to decide, who will substitute the selected unit and at whom the necessary data can we get. The selection of the suitable technique for the collection of primary data goes out of the aim of research, defined research problem and reaching of data of the secondary character that means the data which are generally to disposal, regardless on the concrete researched relevant questions. The aim of the marketing research is not purposeless gathering of information but mediation of the data about that spheres where this knowledge can influence up the dialing and behaviour of those who use results of marketing research.

By the help of marketing research the compatibility of the product can be determinate, is possible to analyze of the size of the market for specific products, to determinate the demand for new products, to set the possibilities of the sale. The marketing research can also analyze the sizes of the markets, prognosticate the general business atmosphere, study the relative profitability of various markets, study the economical factors which have the influence up the size of the market, the changes in customer's characteristics and so on.

Among the most frequently used methods belong the inquiring and observing which are often used in the combination. Whereas the observing is only reduced on the conditions, situations and events, it is possible by asking to gather the information, with which we can gather the relations and connections. For gathering of data in the quantitative research, with which is my work first engaged, has the inquiring -personally, by phone and in written form the greatest meaning.

Unfortunately we met nowadays more often with the unwillingness of the respondents to give demanded information to the questioner. The influence on this trend has fear of the

respondents before the misusing of the data (of personal character above all), and the whole hurrying in this time. The aim my work is therefore above all the proposal of new method or modification of the present method of the quantitative marketing research in order to increase the exploitation of research and to minimize the costs on marketing research. In case we were successful in finding answers on questions, which are mentioned below, and at the same time we will the acquired information correctly implement into practice, I am sure that the productivity of the marketing research, as well as the telling ability of the researched data will increase. For increasing of exploitation of qualitative marketing research is necessary to solve especially these questions:

- How it is possible to remove the prejudice to the marketing research to the respondent?
- How should we motivate the respondent to the cooperation?
- Till which certain extent it is possible to affect the respondent to conserve the objectivity of acquired data?
- How it is possible to apply the pieces of knowledge of the experimental psychology and the human psychology in the quantitative marketing research works?
- What an influence would have a harmonizing of respondents on the results of the marketing research on the same perceiving of values by help of first prepared interview, at which we would be able to affect the respondents so that they could take the individual attributes in accordance with our ideas?
- Till which certain extent is possible to use the marketing research as well as an advertising action at the contemporary keeping the impartiality of respondent?
- How the report should be mode to be the most intelligible to respondents?

The effectiveness of marketing is tightly connected with the quality and impartiality of the information with which we work. First the ability of the firm to win sufficient number of reliable information, in the time of creation of important decision, divides the firms into two categories: the firm who are successful for a long time, and the firms who are unsuccessful.

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Public Investment to the Inland Port Infrastructure

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An infrastructure of the inland ports and transshipment terminals is one of the most important subjects of waterways, because it directly allowed its effective utilisation. The infrastructure consists of basins, port walls, quay, railway and road systems, transshipment equipment and other support services. Main operation is oriented to transshipment of cargo between road, rail and ships, but the effort to more effective transport chain leads to development of enterprise, industry and stores, which are situated directly to port areas or to its neighbourhood.

The importance of development of waterborne transport is emphasised either in the "Transport Policy of the Czech Republic" and in the White Paper of European Communities "European transport policy for 2010: time to decide", because the present growth of road transport is not sustainable. This document declares that it is necessary to improve an utilisation of railways and inland waterways. For the Czech Republic it is important, that due the enlarged single market a significant growth of transport volumes is expected between new and old members of EC. Present experiences from Germany, Belgium and other countries demonstrate that inland navigation can support also a sector of utilities due combined transport chain.

Port infrastructure is more specific than other transport equipment. Firstly the port situation is limited because it needs direct link to waterway and there are not many suitable places along rivers and canals. Investment costs of transshipment infrastructure in ports are higher then in terminals for road and rail. It means not only building structure, but also cranes and other equipment. Effective operation of the terminals needs a good connection with road and rail network. These factors reduce possibilities for competition between transshipment terminals and ports and they behave as a natural monopoly.

Financing of the new or renew port infrastructure needs combination of public and private financial sources, because particularly in inland waterways it is not possible to use only private or public budget. The combination of financial sources must respect importance of a relation between enterprise activities and public interests.

Present situation in the Czech Republic

Transshipment infrastructure in the Czech Republic is divided by law either to public and industrial ports. Operation body of public port has to allow to all potential users transshipment theirs cargo and provide other port services.

The ownership of public ports was completely changed in 1990th, when were privatised all public ports. The privatisation consists of the whole infrastructure, technology and land except port walls and basins. There were established two private companies, one port operator and one shipper with two ports. Public interest is guaranteed in the company of port operator by a "gold stock" that blocks changes in utilisation and ownership of properties in long term.

Investment into ports is disturbed by problems with navigation possibilities on the river Labe between Ústí n.L. and Czech borders, when the efficiency of navigation is too low. Hand in hand with it is a lack of capital. The result is that private investment is low and is limited only to small repair work and maintenance.

In some examples government has invested through the Ministry of Transport into renewing of port walls, which are owned by state. In some examples the Ministry of Transport provided a limited special subsidy to port operators to modification or new transshipment equipment. That kind of subsidy is now not usable, because the budget chapter was abolished.
Implementation of public subsidy is difficult, because there is a problem with competition. The ownership of ports is private and then the public financial intervention supports only one private subject. This aid could distort free competition and so it is incompatible with common market according to Art. 87(1) of the EC-Treaty. The previous practice with grants and subsidies hasn't been systematic and it was used case-by-case.
Present situation in waterborne transport needs application of efficient and transparent grant schemes, which will help to essential modernisation of transshipment facilities as the one way to improve utilisation of inland waterways. The support system has to guarantee public interest and free competition hand-in-hand with application of subsidiarity principle with private sector. It is also an essential precondition for implementation of Structural Policy of the EC through the Operation Program "Infrastructure".

Application of PPP (Public Private Partnership)

One of the most efficient ways to improve quality of public subsidy of port development is an application of PPP principle, which consists of transparent partnership between public and private sector. Project developed by PPP utilises an optimal combination of public and private financial resources when both sides share profits and risks.
Using of ports is always charged by the operator and then the investment subsidy improves efficiency of private equity and could reduce the level of charges. The result is a better competitive position of waterborne transport.
There are several PPP models, which are applicable for development of transshipment terminals. Firstly it could be a model BFOT (build-finance-operate-transfer) which is based on a time limited concession. After the end of the concession the ownership of all facilities is transferred to State and there will be a new tender for operator. Second useful model is BOO (build-own-operate), when the ownership remains in a private body. This model often uses a principle of join-venture companies, when the public shareholder has strong power to protect public interest.
Public subsidy needs a guarantee of free competition, which is provided in some countries by a limited time of concessions (15-20 years), and transparent grant schemes. The beneficiary must guarantee that it will utilise the infrastructure for expected aim (transshipment of goods) for a specific time. The subsidy level is inferred from the whole eligible construction costs (up to 50 %) and the subsidy is paid after realisation of private share. In the case of higher subsidies of public terminals (more then 30 %) the port operator has to be found by an open tender and can't use the terminal to transship its own cargo. This requirement ensures that the terminals will grant open access to all potential users at non-discriminatory conditions.
Writer's research is oriented to optimisation of organisational and financial PPP models for the development of transshipment terminals with using subsidies from the public budget. Special emphasise is put on contribution of ports to local economic development and SME's.

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Definition of Road Safety Degrees on the Basis of Automatic Measurments in a Transversal Section (Profile)

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This project is focused on the issue of increasing the traffic safety. This issue is very up-to-date in this time and that is why it is also one of the priorities of the Traffic policy of The Czech republic. And there is no wonder, because in last ten years (1993 – 2002) more than 13.000 people died on Czech roads (it is equal to the number of inhabitants of Poděbrady city), over 60.000 people were heavily injured (number of inhabitants of Opava city) and approximately 291.000 people were slightly injured (number of inhabitants of Ostrava city). Estimation of the cost of material damages is more than 62 billions of Czech crowns.

Traffic engineering can be defined as a study of the interactions between drivers, cars and roads. Accident appears if there is a conflict at least between two of these three elements. Therefore if we would like to reduce the probability of an accident, we need to understand all of the interactions between them.

One of the topics of the increasing of the traffic safety, which is still passed by is the issue of Definition of the road safety degrees. These degrees should be determined on the basis of automatic measurments in a transversal section and farther automatically signalized to the drivers, by analogy to signalization of the information about the traffic fluency. The degree should be signalized directly to the driver by a variable traffic sign or by mass media (radio). This information should inform the driver that he or she is now driving through location which is in that time dangerous in some way. And the driver should respond to it with increasing of his or her attention, if this will be needed.

For closer study of this issue was first of all needed to become acquainted with the measuring devices which are available at CTU (Golden River – Marksman 400+, which is in ownership of the Faculty of civil engineering; hardware, software Trafficon + camera, in the ownership of the Faculty of transportation sciences; and laser speed measurment device Riegel LR 90, which was also available at the Faculty of transportation sciences) and discover possibilies of their usage. After recognition of all their possibilities was determined to use only the Marksman 400+ device, because Trafficon device + camer is not suitable for measuring of gap between vehicles, and laser speed measurment device is suitable only for speed measurments.

Golden River – Marksmann 400+ is a device , which use two rubber hoses fitted with nails to the pavement to scan and classify impulses which are created when vehicle axle cross these rubber hoses. These information are stored about each vehicle: time of the cross, spacing between vehicles (gap), speed, vehicle class, number of axles and wheel base. It is possible to store specifications about nearly 10.000 vehicles in the device inner memory. Measuring is limited only to two lane, two way roads.

With help of Marksman 400+ were made measurments in 6 localities (4 of them in Praha, one in Plzeň and the last one in České Budějovice). Measurment data were, and still are (there are nearly 50.000 vehicles counted) afterwards processed. By this processing is first of all needed to transfer them from the inner measurment device memory into computer, than transform them into text version, and with that transformed them into Excel or 602Tab editor. There we

could carry on with the processing: partition data according to the direction of way, than fragmentation into 15 minutes intervals (by reason of bigger number of data for statistical processing), than we need to remove "hums" (this usually occurs when the profile is simultaneuosly passed in opposite directions) and finally we could find out characteristics of the traffic flow (intensity, average speed and number of drivers accepting shorter than safe gap).

For definition of the road safety degrees appears as a critical quantity exactly the relation between intensity, speed and part of the vehicles going in shorter than safe gap. Safe gap depends on reaction time of the driver. Total reaction time is for 98 % of drivers minimally 0,99 s, if the driver fixes the object with eyes beforehand, but could be up to 1,48 s if the driver doesn't fix the leading vehicle. If we take account that brake delay and build-up time is similar for all vehicles and that driver of the following vehicle could start react at the moment of lightning up of the brake lights (those should light up at the beginning of pressing the brake), we don't have to these times in safe gap include. And the minimal safe gap between the vehicles is for 98 % of the drivers equal to 0,79 s (if the driver fixes the leading vehicle beforehand). During the processing was focused number of drivers who were driving in less than safe gap (and that in intervals 0 – 0,79 s, 0,8 – 0,99 s and 1,0 – 1,5 s).

During these traffic researches has been measured very wide spectrum of intensities from 9 vehicles / 1 lane / 15 minutes (during the measurment in Italska street during weekend) to 292 vehicles / 1 lane / 15 minut (in Holeckova street during the morning traffic jam). That means it was received extensive spectrum of datas for statistical processing. During the measurment the measure device Marksman 400+ was well approved but the limiting factor is the intensity of traffic in both directions: the higher the sum of the intensities of the vehicles going in opposite directions is, the higher the error rate of the measure device is. During low intensities the datas were measured without errors. During high intensities the datas are measured without errors only if the intensity of the vehicles in the opposite direction is very low.

In conclusion was from the measured datas evaluated the safety of each measured profile and their comparison was made. In next weeks will be searching the depandance of part of the drivers going in less than safe gap on intensity and speed of traffic flow, and then will be defined the criteria for five degrees of the traffic safety (a – e), which could be signalized together with the information about the traffic density (for example: 1a or 2c).

The results of the research confirm presumption that the higher the intensity of vehicle is, the more often hazardous drivers appear, that means the number of drivers breaking the rules of safe driving increases.

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Process Control of Nozzles Manufacturing

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Injection nozzles are manufactured in Motorpal a. s. Whole realization of injection nozzles is called PROCESS "NOZZLE".

MOTORPAL injection nozzles are called closed nozzles, consisting of a body and a needle, which form an individually, with a tolerance of thousandths of a millimetre exactly manufactured unit, the parts of which can therefore not be arbitrarily substituted.

There are two basic types of injection nozzles, which are manufactured in Motorpal:
Pin nozzles - designated DC, mostly used in engines with an indirect fuel injection (engines with precombustion chamber)
Hole nozzles - designated DO, used in engines with a direct fuel injection (currently the most used type).

Process "Nozzle":

- process "Nozzle" concern process realization from customer demand over production to shipping of finished products
- nozzles are very important products for this company
- define of process is prototype approach in this company
- whole process "Nozzle" is split into thirteen phases:

Phase P1 – Customer demand
Phase P1 a - New type of nozzle
- development and production of fuel injection devices
- development and production of injectors
- development and production of nozzle

Phase P1 b – Known (catalogue) type of nozzle
Phase P2 – Preliminary price supply
- quantity
- price

Phase P3 – Dealing with customer
Phase P4 – New order
- committee for new orders

Phase P5 – Quality planning
Phase P6 – Proposal of construction documentation
Phase P7 – Construction and technological screening (check – up)
Phase P8 – Introduction of new products
- committee for introduction of new products

Phase P9 – Technical preparation of production
- serial construction documentation
- serial technological documentation
- resulting costing

- tools, special tools,

Phase P10 – Serial documentation and planning data
Phase P11 – Planning of production orders
- production and inventory orders

Phase P12 – Products realization
- function check-up
- confirmation of planning data after the first series
- prepare for expedition – kind of packing,

Phase P13 - Products to the customer
- expedition from finished products inventory

For right costing is necessary to record costs separately for each order.

For control of nozzles manufacturing is necessary:
- process approach
- define process “Nozzle”
- split up process “Nozzle” into phases
- budgeting and filing cost in phases

Process “Nozzle” is only one of processes, which are in progress in company. Define all of them is very advantageous for decision, which activities are important.

Target Costing and Absorption Cost Calulation in Product Cost Models

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Under absorption cost calculation (full costing) the most often used approach of product cost determination a priori and a posteriori is understood. This means that all cost items are incorporated in a product, in other words all the cost items are allocated to a product. It is a quite obvious statement unless the various product cost structures items are no taken into account. Here particularly the *direct cost – overhead* structure and the *variable - fixed cost* structure should be mentioned. To complete the brief remark to cost structures it is reasonable to notice that there exist also costing procedures using only an incomplete schedule of cost items as e. g. the variable costing method leading to the contribution margin concept.

The market price is set at a level that will permit the company to achieve a desired market share and sales volume. A desired profit margin is then deducted to determine the target maximum allowable product costs. What is understood by allowable product costs? Are they production costs or full costs including non-manufacturing costs? Keeping to the definition of target costs given by the formula *target costs = market price - profit margin*, two possibilities of deriving the target cost concept are introduced provided that non-manufacturing costs are a part of the market price. The first of the concepts is that the non-manufacturing costs are included in the target costs, and the second one is that the profit margin contains the non-manufacturing costs. The second concept is based on the two-stage contribution margin not involving the fixed overhead production costs.

The following considerations are based on the concept of target costs including non-manufacturing costs. During the research period the problem of *causal cost* has been revealed. The causal costs are playing an important role as far as it concerns cost estimation of new designed products. Under causal cost are to be understood all those cost items, whether variable or fixed, that have a causal relation to a given product. This problem has already been discussed in previous contributions dealing with cost determination. By comparing production costs and causal cost of a certain product there still are some cost items left that need an explanation. Those costs refer as to variable indirect so to fixed production cost items, which don't have any relation to a given product. These cost items have to be allocated to each of the proposed new products with consideration to their foreseen manufactured volumes or sales. This can be managed by applying cost driver rates, as it is usual in activity-based product costing systems or by traditional overheads allocation rates.

To obtain a clear insight about the discussed cost problem an example will be introduced. Assume that the total costs (100 %) of a new designed product consist of casual costs (55 %) and unaffected costs (45 %). The casual costs split into variable cost items (35 %) and fixed cost items (20 %), the unaffected costs split also into variable cost items (19 %) and fixed cost items (26 %). 30 % of the variable casual costs represent the direct costs a the 5 % remaining variable casual costs joined together with the 20 % of fixed casual costs, unaffected variable (19 %) and fixed costs (26 %) create in the traditional costing concept the overhead and non-manufacturing costs (70 %). The outcome of this classification

procedure is a cost structure consisting of the variable fraction (54 %) and the fixed fraction (46 %) of total costs inevitably important for the creation of the input-output product cost model.

There was designed a method that makes it possible to use the input – output cost model. The main point of the paper concerning the research section related to cost determination of new designed products is a study of input-output models utilization. The problem consists in the definition of input-output models concentrated on linearity of variables towards the changes of product volumes.

Assume that an enterprise plans to produce n products and will use r-n production factors. The gross turnover for the jth product (j = 1, 2, ..., m) will be

$$X_j = \sum_{i=1}^{n} x_{ij} + \sum_{i=n+1}^{r} z_{ij}$$

where $x_{ij} = a_{ij}X_j$, i = 1, 2, ..., n are internal unit inputs-outputs, $a_{ij} \geq 0$, $z_{ij} = v_{ij} + f_{ij}$, $i = n+1, n+2, ..., r$ are variable ($v_{ij} = n_{ij}X$, $n_{ij} \geq 0$) and fixed (f_{ij}) unit inputs, which must be separated. The general input-output model equation $\mathbf{X = [E - A]^{-1}Y}$ ($\mathbf{Y}$ = expected market prices) adjusted for outputs $\mathbf{[Q]} = q_i$ gives $\mathbf{[XI_q] = [E - A]^{-}1[YQ]}$ that makes it possible to apply the input-output model.

The input-output model is generally divided into three quadrants: The first quadrant contains the internal input-output cost units x_{ij}, the second quadrant includes the outputs y_i and the third quadrant contains the primary inputs $z_{ij} = v_{ij} + f_{ij}$. There was designed a method of solving the problem of fixed cost appearing in the model. The procedure of building the model is divided into five phases. In the *first phase* all causal and unaffected cost items for a given product must be scheduled. In the *second phase* the input-output model for all conside-red products is set up. In the *third phase* before of solving the model for given product volume changes the fixed costs incorporated in the model must be excluded. In the *fourth phase* the model is solved only for variable costs realizing the sales volumes of all foreseen products. After solution the unchanged fixed costs are installed back to the model in *phase five*.

The advantage of using IO models is firstly the concurrent solution of target costs for a number of products and comparing the target costs with the standard or actual costs, secondly the chance to prepare several proposals with different sales volumes and analysing thereby the influence of capacity exploitation on enterprise economic development and lastly the application of indicators as the unit contribution margin, break even and profit analysis.

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Life Cycle Analysis of the Product

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1. Introduction

The investigation of analysis methods able to provide useful information for a concrete approach to environmental problems in the phases of production design and organization, leads to the need to complement classic design methods with new methodologies, as well as to develop and apply new instruments of analysis.

As a consequence, formulating the problem of design optimization requires the definition and evaluation of suitable environmental indicators (Green Indicators).

2. Life cycle and recovery levels

In the analysis of the life cycle of a product it is fundamental that a correct evaluation is made of the recyclability of parts of the structure at the end of its operating life. For this it is first necessary to distinguish between two different typologies of recycling process.

In internal recycling flows (closed loop), the material re-enters the cycle substituting virgin raw material at input. This can be accomplished either by re-using some components, or by manufacturing them from the suitably re-processed material of other components. From the energy and ecology points of view, there is a recovery of the overall energy consumption, and a decrease in the exploitation of resources in general, because the volume of virgin material required at input is reduced and the need to dispose of the recycled material is eliminated. In external recycling flows (open loop), at the end of the product's life some parts of the structure are recycled to provide material used either in the original production cycle or in the construction of different products unrelated to the original structure. In this way part of the energy content of the materials is conserved and, possibly, economic benefit is obtained from the sale of the recyclable materials.

3. Life cycle model

This represents the reference model for the life cycle of a green product, outlines the complex network of a product's recycling process. Three levels of recovery are evident.

1. Re-assembly of the parts: components, which have not suffered any kind of deterioration during the product's working life, can be recovered as assembly parts.

2. Re-manufacturing of parts: in some cases, possibly after being subjected to particular intermediate processes, the components which cannot be directly re-assembled can provide the material required in the production of the same parts. Or of parts with inferior mechanical characteristics.

3. Recycling materials: the materials of parts which cannot be re-used in re-assembly or re-manufacturing can be recycled through recovery cycles which are part of the life cycles of the materials themselves, or they can be treated and used to make products with inferior characteristics in the context of external production cycles (Open loop). The materials, which cannot be recovered even in this last phase, are consigned to processes of waste disposal.

4. Life-cycle analysis

Life Cycle Analysis (LCA) is one of the more effective techniques for the study and evaluation of strategies aimed at protecting the environment. The analysis is applied to the study of the entire life of a product, with the aim of conferring the property of compatibility on the product under examination. LCA is divided into three phases. Inventory analysis; the identification, quantification and allocation of the energies and resources used and of the various types of emission. Impact analysis; the quantitative and qualitative evaluation of the consequences for the environment. Improvement analysis; the evaluation of the opportunities available for improving the environmental performance. For these three stages to be an effective procedure of defining choices, the boundaries of the system under analysis must be accurately defined so that the control volume, in the context of which the energy, resource and emission flows are evaluated, can be identified.

5. Procedure of architecture optimization

An effective procedure resolving the problem of the overall optimization of the architecture can be represented schematically. First it is necessary to define a temporary architecture of the product, by traditional design procedures (analysis for structural safety) coupled with an effective procedure for the choice of materials. The next stages are the study of the optimal recovery plan for the architecture, and the evaluation of the most effective architecture modification. The optimal recovery plan identifies the parts to be sent to the various recoveries levels (re-use of components, re-manufacture of components and the recovery of materials) on the basis of the values assumed by an objective function. This function must express the environmental performance of the entire life cycle of the product, and therefore be able to quantify different aspects of the effect that the entire life cycle of the product has on the environment (consumption of resources, energy efficiency and emissions).

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Improved Load-Bearing Capacity of Subbase as One of Potential Alternatives Allowing Reducing the Thickness of Asphalt Pavements

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1. Introduction

The approval of a design method, described in TP 77 "Designing Road Pavements" and TP 78 "Road Pavement Catalogue", which is currently in force, meant, among other things, introduction of stricter requirements for the construction of subsoil and unconsolidated structural layers of pavements in practice. The required minimum values of the moduli of deformability $E_{def,2}$ (from the second loading branch of the loading test) for individual unbonded structural layers were set in relation to the design class of traffic load (hereafter TDZ) and the presumed design level of pavement failure (hereafter NÚP).

The existing situation in relation to subbase is somewhat different, where the required value of the modulus of deformability depends only on the type of subsoil, being:

- 45 MPa for fine-grained soils and
- 120 MPa for coarse-grained soils.

If, however, the actually reached value of $E_{def,2}$ on subgrade equals only 45 MPa, it becomes very difficult and often not feasible at all to reach the required value of 120 MPa or 100 MPa respectively on the protective layer. In order to solve this problem, there are two possible ways:

- increase the protective layer thickness, or in combination with replacement of this layer's material,
- improve the load-bearing capacity of subbase.

In trying to design cost-efficient pavement constructions, the second way must be taken as the corresponding modification (improvement) of subbase is usually economically less demanding.

2. Assessment of the effect of load-bearing capacity of subbase

As a follow up to the currently on-going revision of TP 78 Road Pavement Catalogue, the researchers' objective was to define strict, but, at the same time, realistic values of the required moduli of deformability on subgrade, graded (analogically to protective layers and base courses) in relation to TDZ or NÚP. In order to reach this objective, first it was necessary to make assessment of the effect of load-bearing capacity of subbase on the relative pavement failure value.

The assesment was carried out by calculations using the valid design method TP 77. In order to ensure the maximum possible objectivity and universality of achieved results, the calculations were made using a relatively extensive set of flexible pavement constructions verified by practice, included in TP 78. This set included:

- pavements for TDZ I to VI and combination of NÚP values from D 0 to D 3,

- pavements with base course bonded by asphalt, hydraulic binders and unbonded,
- 7 alternatives of subbase load-bearing capacity with the considered modulus of deformability $E_{def,2}$ = 30, 45, 60, 75, 90, 105 and 120 MPa.

The calculations took into account standard (and smooth) traffic load represented by the standard design 100 kN axle, traffic load intensity at the upper limit of the corresponding TDZ, the design period length of 20 years and a perfect contact at the interface of individual pavement layers.

3. Results of assessment

The results of above-mentioned calculations proved the already known fact that the design method TP 77 provides "reasonable" results basically only for pavements with unbonded base courses. The pavements with base (usually bottom) courses of bitumen-coated aggregates are generally underdesigned, contrary to pavements with cement-bonded base courses, which turn out to be significantly overdesigned. The protective layer material, as well, has an unrealistically great effect on the relative pavement failure value. The worst results were obtained for pavements with protective layers of gravel sand, while slightly better off were pavements with protective layers of mechanically compacted soil, and significantly better off pavements with protective layers of crushed gravel. It was further established that for subtler pavements, namely in combination with low subbase modulus values, it is the subbase that turns out to be critical, not the pavement.

With regard to the effect of the subbase modulus value on the value of relative pavement (or subbase) failure, the results of calculations proved the initial presumption that by reaching higher values of the modulus of deformability on subgrade, the relative failure value is reduced. This is most significantly shown, i.e. by the steepest growth in relative failure, namely between the subbase modulus values of 30 to 90 MPa. Additional increase in subbase modulus does not bring such significant improvement, i.e. financial means spent on it would not be so cost-efficient. In detailed investigation of the pavement construction behaviour under very different subbase conditions, we came to the conclusion that in some specific cases it is possible - by improving the subbase modulus value from 45 MPa to 90 MPa - to reduce the thickness of pavement base course by up to several centimetres – e.g. for NN 305 construction this makes 20, or up to 30 mm of base course of OK I.

4. Conclusion

Having evaluated the results of assessment and confronted them with practical experience gained in construction process, the required minimum values of moduli of deformability on subbase were formulated, grades in relation to TDZ or NÚP respectively. These designed values of moduli of deformability should be used in developing the modified version of TP 78 whose revision is currently going on.

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Behaviour of Systems in Case of Restricted Resources

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The research is based on the investigation of systems or decision-making in systems that work under condition of restricted resources. Systems can be economic (companies) or socio-economic systems.

Main method of the investigation is system dynamics [1,2]. This approach allows us to build large and complex systems that describe the problem situation that can occur in a reality. System dynamics games are good method for explanation of different problems to people in practice or to students [3]. Useful example is so called *Fish game* which makes possible to understand behaviour of complex system that works with renewable sources.

Players will manage fishing companies in some country. They will operate their fishing fleet during ten years. The main goal is to maximize their assets. It means that the criterion of success is to achieve the greatest possible assets in the end of the game = accumulated bank balance and the value of ships. All teams have in the beginning the same information, number of ships and adequate bank account. It this time the game looks like other "economic" game. Teams can manage the capacity of their companies (fleet size). Ships can be bought in auctions (ships are sold to the highest bidder and they can be used immediately), in trades with other teams (companies negotiate the purchase or sale) or ordered in a shipyard (ship are paid at the end of the year and it takes one year then teams can used them in their fleets).

There are two fishing areas. A large deep sea fishery and a smaller coastal fishery. Teams know estimated number of fishes in both fishing areas and they assume that the actual fish populations are near these upper limits. Fishing in deep sea ensures higher catch but also higher operating costs. The fish catch is influenced by the number of ships, the ship effectivness and the weather. Very important is the dependency between fish density and number of new fish per year – it is population dynamics. The population is increased by natural birth and decreased by natural deaths and by harvesting. Teams know general shape of this dependency but as it is typical in practice not exactly.

During the game teams do the decision about the fleet size and to allocate ships among fishing areas and also harbor – this is the most important decision in the game. Game operator gives the data to the computer program and distributes a computer printout.

Result of the game is very interesting. Presented evaluation is based on six years playing this game with different group of people:

To the end of the sixth year (often even the fifth year) all fishes are harvested and seas are empty. Last years they have to leave ships in a harbor and they spend the money for the maintenance. The final result is a bankruptcy of fishing industry.

The reason of this result:

The main reason is high capacity of companies (the sum of used ships). The result is the same even if *same* companies perform very caerful strategy. The number of ships is going up while number of fishes is going down. But it takes long time then companies realize this important fact.

The explanation is based on understanding of the dynamics of the system. It means to recognise main subsystems. There are:

1. Fish. This subsystem includes these connected elements:
   fish – density – fish regenaration + total catch from outside of the loop
2. Catch. This subsystem includes these connected elements:
   total catch – fish – density – catch per ship + number ships from outside of the loop
3. Economics. This subsystem includes these connected elements:
   a) loop: ships – operating costs – profit – investment + purchase and construction costs from outside of the loop
   b) loop: profit – desired growth – investment (conected with a. loop)
   c) loop: ships – total catch – income – profit (conected with a. loop) + fish price from outside of the loop

All subsystems are connected in one complex system. Next step of the solution is creating equations for describing processes in subsystems. Equations calculate important parameters (often called stocks).

The standard form of stock equation is

$$Lev(t) = Lev(t - dt) + (InRate - OutRate) \cdot dt$$

In this simple example *Lev* has a single inflow (*InRate*) and a single outflow (*OutRate*) [2]. Level is calculated in time t which is based on the inflow, the outflow and fixed time increment of dt.

After evaluation of the game, players are encouraged to developed *sustainable strategy* for fishing industry [4]. The main approach is based on the restriction (quotas) in catching fishes that eliminates the collapse. Other solutions can be: limit technology, fleets or use better assessment methods.

A depletion of sources concerns also: forests, groundwater, air, soil etc. System dynamics models allow us to develop suitable policy for usage these renewable sources.

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Total Quality management and EFQM – Excellence Model

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Total Quality Management (TQM) is periodically Lambasted by management gurus and the business media for its supposedly lacklustre impact on financial performance. This paper presents objective evidence on whether this criticism is indeed justified. The evidence is based on a study of nearly 600 quality award winners. Three critical issues are addressed in the paper. First, we discus the outgoing debate on TQM´s ability to significantly improve financial performance, the reasons for this debate, and the importance of resolving this debate one way the other. Second, we present evidence on the financial results that publicly traded organization have achieved from implementing TQM effectively.
Financial results are measured using variables such as stock returns, operating income, sales, and costs. Third, we discuss how the financial results vary by organizational characteristics such as size, capital intensity, extent of diversification, and the maturity of the TQM implementation. This evidence helps set realistic expectations of what different organizations can expect to get from TQM. The paper also offers a methodology, including various performances measures and data sources that organizations can use to link their quality initiatives to financial results.

Total Quality Management (TQM) – the management paradigm based on the principles of total customer satisfaction, employee involvement, continuous improvement, and Long-term partnerships with suppliers and customers – has recently been getting a bad rap in the popular business press regarding its ability to improve financial performance. The best way to resolve the controversy is to use objective and verifiable data to examine the strength of the relationship between TQM and financial performance.

For the last five years has been researched the financial impact of effective implementations TQM. This article reports key aspects or methodology and some of major findings.

The focus of the study was to examine the stock price performance of firms that have effectively implemented TQM. It makes sense to use stock performance as the primary performance measure for this study.

In the long-run stock prices are driven by profits (or net cash flows). The study examined profit performance by estimating the changes in operating income, defined as net sales less cost og goods sold and selling and administrative expenses. This measures the profits generated from operations before interest and taxes. Operating income is influences by changes in the growth rate and efficiency. The study measured growth by estimating the percent change in sales, total assets, and employees. The improvement was measured in efficiency by estimating the percent change in return on sales and return on assets. Return on sales in the ratio of operating income to sales and measures the profit per dollar of sales. Return on assets in the ratio of operating income to assets and measures the profit per dollar of assets.

Choosing a time period for examining the performance is important. Any attempt to establish the relationship between TQM and financial performance must examine performance over a long time period.

The performance was examined over two five-year periods. The first period – the implementation period – starts six years before and ends one year before the date the winners won their first quality award. It is during this time periods that winners are implementing TQM and incurring the associated implementation costs. To provide a balanced perspective on the net benefits of TQM, it is important to estimate the magnitude of these costs. The second period – the postimplementation period – starts one year before ends four years after the date the winners won their first quality award.

Results for the post-implementation period indicate that quality award winners outperformed the benchmark on almost every performance measure. Figure compares the stock price performance of award winners against the various benchmark portfolios using the following process.

Award Winners	…	114%
S&P 500	…	80%
Portfolio of All Stocks	…	76%
Industry Portfolio	…	88%
Size Portfolio	…	80%

Over this same time period an alternative strategy of investing a similar amount in SaP 500 Index and holding it over the same time period would have resulted in a 80% return. The difference of 34% is a statistically and economically significant level of outperformance.

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Methods and Techniques of Controlling

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Techniques analyses

Techniques analyses and supports decision making on strategic determination

Exercise strategic business planning consist in generating and upkeeping a high and certain potential of the success.

A point of departure is definition a factory model and main philosophy of the company. From that are generated an individual period of the strategic planning:

- Leading vision
- Segmentation
- Analysis (of competition, factory's neighborhood and market),
- Determination position
- Classification alternative (analyze diversification, title to sources, factors success).

Analysis competition

Analysis competition consist in the look into all data of competition company, which are for personal planning significant. Under a competing business regard the producers, who are bidding the goods on market.

This goods fill same or similar needs as ours produces. The analysis competition coming-out from processing information about of the number of competitor, their large-scale, places incidence, technological and innovational competence and qualities of organization. The analysis competition in practice are made by the help of questionnaire and working sheet to use a voice or by the help of scale give a values.

Market analysis

The factory market analysis is a part of environmental investigation . Analysis is for structure market or segment market.

Analysis wants define actual state in the market-place compared to pure observation market in time course. It orients to following elements:

- Market volute (potential)
- Average development during previous years
- Own share on market
- Price development in the future
- Use the marketing instrument
- Rate growth market

Analysis of potential strong and weak sites

Potential of the company indicate all factors, that are determined the efficiency system. It distinguishes on material potential (production factors), and nonmaterial potential

(research, know-how). Objective potential analyses is investigate and evaluate a factors, that have an influence to achievement.

Space analysis

A Schedule of all performance parameter the company discover a revenue variance and the profit. Namely between real and available value. Passive behavior turn thanks behavior of the competitions a decreasing tendency. Everyone steps will not be enough to the strategic revenue space will be enclosure. In the future critical situation would have anticipate. The company does an important mistakes and it have would precede.

Life cycle product

Life cycle product used to be defined by time period from rise new thoughts till definitive stricture the product from the market. But there have been other (marketing) definition, that are not so good for planning and control activities.

A typical partitions product life cycle:

Term origin:
- Search alternative solution.
- Classification and selection solution.
- Research and development.
- Preparation production and marketing.

Cycle in the market-place:

- implementation,
- growth,
- adulthood,
- saturation,
- degeneration.

On context of life-cycle product are offered these questions:

What is a new product? Is it going of a new product or is going just about product differentiation. When is suitable to introduce a new product. What are the synergetic effects of related product.

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The Utilization of the Forward Direction and Feed - Back to Strategic Management

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Strategic Forward Direction and Feed-Back

In business practice is process of a verification on body brightly delimitation by comparison reality - plan and secured by experience. Determination of the target plan and resulting detection attainment state is a common course verification, whereby are detection incident deviations. And from him has derived the necessary action.

This way in view is a process of control the biocybernetic with a negative feed- back. This negative feed- back may be defined by like repetition of the successful instruction in similar situation. The negative feed-back has been going to the stabilisation. It can be watching the deviation therefore, to by the help of fit steps for already directive or planned objectives achieving.

Strategic processes of forward-direction and feed-back are compared to positive feed-back , which include thinking about possible script and intensificate (often exponentially) a instant business processes. By contain positive feed-back of the possibilities script futures - it suit the strategic feed-back. It have to make for summary thereby to procuration to prevent the deviations, which are not occur yet. So originate needs in dynamic situation reticular put through company neighboured, it entails achieve optimalization of the deviations. There is a optimalization therefore, do you deviation there's no need to keep off, the deviations are necessarily urgency for suit development. In the process of manage it must be the trend of deviations to find out to could optimise success company.

A classical science about management differ in three strategic forward-direction:

1. strategic control of realisation,
2. strategic control of premise,
3. strategic supervision.

The strategic control of realisation matches collation plan - reality of realisation in principle .

Along a realisation of strategy it finds already out a incurred deviations from the strategic objectives. A direction of look is oriented into past and it has be stable strategically. At dynamic conditions contemporary economic events has be to seek a expansion in direction into the future (confrontation reality - future).

The strategic control of premise consist in select probable scenarios and then has be

taken for the base on definition the strategy. The scenarios witch are probable and the projection of the premise must be continuously verification, to strategy conformed changed the scenarios.

Strategic sight has against selectivity near verification transaction and premise. How verification transaction so verification premise issue from received strategic decision thereby are selective.

Management by deviation

The management by deviations is process that has clear time axes and action so it look at back either forward. Run a business by the help of deviation today has divided on three partitions. Once is accounting which determine a profit and forms the budget. An accounting has been oriented into past time. It follow them to a time axes by Controlling, that manage a profit and in which are know a real deviations. Further on time axes with look into the future is a strategic forward-direction and feed-back. That has to reserve a profit and recognise possible and probable deviations.

The deviation therefore has to define in terms of dynamic imaginings of objectives and it has to be investigated too, so that it can be do their optimalisation.

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Information Support for Strategic Decision

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We currently find ourselves in time of a great development of information technologies. In connection with this trend and the level of advanced society we can't doubt about the abilities of one of the most progressive trend – the use of internet and the future of such phenomenon like various types of electronic commerce.

As we focus on small and medium-sized industrial enterprises, that are the most suitable ones to use the electronic marketplaces, we took as an example a small-sized company that produces tailor-made systems of packaging, conveyors, dosing devices and electronic wages. The present-day status in gaining customers is reduced only on engineering fairs and the use of their own sales representatives.
The goal of this work was to find an information support for strategic decision in the company and gaining new customers.

First we have to take into account the importance of information, it's use for decision processes and their classification. Second there are some information barriers (e.g. orientation, technical, psychological, language, cognitive, political, financial etc.) and the ways to overcome them.

In the phase of collecting information it is needed to identify the demands of market and customers. After the comparison of available information channels we were assured, that internet is the most effective and at the same time the available source for our purposes. Then we started to find suitable electronic market places (especially business-to-business), which are of various types. As the best one for our use the bulletin board system occurred to be – it is an advanced information chart, where sellers as well as buyers can promote their offers to sell and buy goods or services. By connecting these offers a trade can come into existence. This mechanism asserts itself at market with non-standard and specialized products. The communication between sellers and buyers proceeds individually. This merchant model is in compliance of the branch of production and marketing of packaging machines, because of specifics of each order for individual clients.

For we were not able to find a specialized marketplace for the branch of packaging machines, we were forced to use the services of common search portals and specialized portals, that deal with the issue of internet electronic commerce and especially business-to-business. The result of our effort was a directory with the list of electronic marketplaces and the selection of potentially convenient ones.

In relation to previous steps we made a suggestion for a model of information database in the form of information table about internet marketplaces. The table contains essential information about each site, such as the name, internet address, commercial focus, type of the marketplace, main partners, terms of use, requirements for membership etc.

As an example, we chose one of the biggest marketplaces to show, how the principles and functions work there, lay stress on the main features and benefits mention the additional services explain the particular terms of use and determine the costs of use.

To complete the tutorial we showed also an exemplary of entering this particular electronic marketplace, beginning with the registration of a new member, getting to know the system of the marketplace, inserting a trade offer, searching through the trade leads, the use of search engine with filter criterion and other added value services. This was intended to help the integration of these actions in the work of trade department of the company and also to find a new business partner to deal with using other way than engineering fair.

We mentioned not only the importance of electronic marketplaces of its own, but also globally to increase the significance of company presentation and continuous process of searching business (and especially business-to-business) information with reference to other similar sources.

Finally came out the recommendations for the future development of information support in two ways. The short-term encouragement, that insists on a good promotion throughout the electronic sources (indexing services, internet portals, company directories) and active participation in electronic markets. The long term recommendations stress the need of quality training of involved employees in the issue of electronic commerce and information support. Not less important is also the processing of own information database because of never ending progress in the field of electronic marketplaces and the meaningful use of information gained from added value services, newsgroups and other sources to be able to forecast customers needs, situation on the market and their effective use in strategic decision.

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The Findings from the Research of Technically Educated Managers in CR

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A research I have conducted together with my colleagues from Masaryk Institute of Advanced Studies CTU since 1999 was focused on technically educated managers.

Through the past years we have conducted the following research activities:

1. A probe focusing on HR work in 10 industrial companies (1999)
2. A research focusing on applied methods and approaches to management among technically educated managers. (2000)
3. In-depth interviews with technically educated managers (TEMs)(2002)

Our activities in 2003 focused on evaluating TEMs' prerequisites for managerial work on the basis of competency models. To do that we combined observation of TEMs in assessment centres with application of psychodiagnostic questionnaires. When preparing the research probe, we presumed approximately 50 TEMs would cooperate on the project. We decided to split the sample group to three subgroups according to their results in different evaluating methods (assessment centre and psychodiagnostic questionnariers). The probe therefore compared individual TEMs with an ideal manager as defined by a competency manual and list of selected ideal personality traits. I considered this approach acceptable since our aim was not to find a perfect manager for any concrete position, situation or environment. Instead, we limited our findings to merely recommending, whether individual managers are suitable for managerial work of any level within industrial companies in Czech Republic.

To identify competences in which technically oriented managers show biggest weaknesses we interviewed experts working with the sample group, analysed information published in specialised literature and conducted in-depth interviews with TEMs. We have also applied observations and evaluation of selected competences in assessment centres and we have also used psychodiagnostic questionnaire method to analyse psychological traits of individual managers.

Most of general management competency models published to-date describe many various competences that are rather difficult to objectively evaluate in practice. There are also models that focus on just a few of the most important competences. However, I was concerned that these models are too limited to satisfactorily identify specific tendencies and problems associated with technically educated managers in Czech Republic. I have critically analysed the more widely used competency models, selected and modified one, which in my opinion, represents well the competency model suitable for mangers recruited from among Czech technical universities graduates. Hence I have chosen an approach of modification of existing competency models on the basis of field research results analysis.

Methods of emotional intelligence evaluation are still under development, which complicates research in this area. There are no generally accepted quantitative tools that could be used to measure and evaluate these competences. To solve the problem, we used a

combination of qualitative and quantitative research methods. Based on values of managerial potential according to Hogan Personal Inventory (HPI) and average evaluation of competences determined by evaluators in the Assessment centre, we have split the sample group in to three sub-groups: better-than-average, standard and substandard managers. We have then observed the differences between the two extreme groups. Interestingly, notable differences were identified only in some of the parameters. Afterwards we have compared results from HPI of both the extreme groups of TEMs with results of other tested managers in Czech Republic.

The most notable difference between the better-than-average and substandard groups as observed by the seven-factor Hogan model is a low level of ambition among the "weak" group members as opposed to high value within the "strong" group. The ambition factor includes self-confidence, competitiveness, vibrance and desire for success. This difference was further confirmed by another applied psychodiagnostic questionnaire VAPO. The scale of VAPO questionnaire reveals also other significantly different characteristics of both groups. Behaviour of the highly evaluated group shows higher social adaptability. Their environment due to their behaviour and abilities, better accepts these managers. Flexibility of the better-than-average group is comparable to flexibility of other university graduates, but flexibility of the sub-standard group is much lower. A Freiburg questionnaire showed, that better-than-average managers are more active in contact with people. There are other significant differences between the two groups, such as empathy and spontaneous orientation. However, its significance would be confirmed only if we had a bigger sample group. Although a sample of 47 technically educated managers is not fully representative of the selected group, it can be anticipated, that if we had a truly representative sample group, differences between the better-than-average and substandard groups would show in similar areas and magnitude as did in our research.

Our research confirmed, that models of American researchers Boaytzis, Spencers, Goleman and a five-factor model of work competences (Hogan) are applicable and useful for European conditions in Czech republic. The above-mentioned competency models have, until now, not been verified by any research and they are therefore doubted by some scientists in Czech Republic. The findings from our research confirm Dr. Goleman’s competency model is correct and fully applicable in Czech Republic in the first decade of the third millennium. This model defines basic characteristics of an ideal manager while stressing the importance of emotional competence. Our findings also identify what competences do Czech technically educated managers lack. On the basis of the conducted research activities I consider Goleman's competency model with specified supplement to be an appropriate basic model for evaluation and development of managers in Czech Republic.

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The Model of Technical Economic Analysis of Building Objects

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It is a lot of known or ascertainable information about technical and economic condition of the building objects. These inputs spring from more or less reliable sources, they have various significances, various exactness and they are variable at the time. Responsible decision about business financing (especially a maintenance and repair) based on this casual mixture of information is very difficult, as we did not know the inaccuracy rate of our decision.

It is possible to create the information system by the assembling and layout of all relevant and the certain date valid data about the technical and economic object condition to the uniform input data schema. This information system allows building object owners (managers) expertly and effectively take the control of object costs and revenues and its way of utilize.

The model of technical economic analysis of building objects is based on principle of fixed algorithm input data processing by means of building production reference database

The basic functions of input data schema are:

- guarantee the entirety of all inputs affecting the outputs quality,
- remove unreliable information and the information immaterial for analyse,
- enable the verification and individual correction of all input data during the whole analyse,
- enable comparison of various objects resulting values
- enable choose accuracy rate of analyse.

The submitter entering only the obligatory data obtain the basic analyse whose advantage is quick and cheep output information. The current technical contract documents and operating documents are sufficient for it. Whereby more accurately and more detailed information (input data ascertained by expert finding), thereby higher reliability rate.

The ascertained input data about building object and its structural elements are inserted in appropriate form according to defined protocol (fixed algorithm principle). The obligatory data must always be entered by the data producer, optional specifications necessary to the summarization, which are not entered, will be completed from the inside model databases. These values are ascertained by means of statistical methods pursuant to existing building objects analysis.

The sorts of input data:

- the identification and accounting data (the type of building object, the date of commencement, the address, the accounting information associated with object usage, the basic proportions, beginning and finish of period under consideration),
- the descriptive data (the construction structure, the condition of individual structural elements on the beginning date of monitoring and changes during period under consideration, technical data – proportions, quantity, life-cycle, economic data – the structural elements renewals, The accuracy of the descriptive data has direct influence on quality output information.

Data entry can be carry out in two ways: insert factual value to required quantity or choose item from offered options.

The model contains two inside databases.

- The characteristic representatives of building objects database,
- The typical structural elements database.

The existing building production is divided to 7 groups and than subdivided to 102 representatives. The construction elements are divided to groups according to function, life-cycle and unit costs.

The fundamental outputs are these packets of information about the building object:

- The economic balance sheet
- The profitability
- The investment, repairs and maintenance requirements
- The cost planning and optimisation

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New Trends in Design of Urban Roads

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1. Introduction

Road and square areas belong to the most important public spaces in towns and villages. It is these areas that, to a great extent, affect each settlement's unique character and the impression of the given environment. Such areas do not serve for traffic only, but they also provide a framework for various other manifestations and requirements of life which are reflected by various demands and functions. The creation of road space is, therefore, of primary importance in considering the problems of built-up environment; designing highways inside a built-up territory is closely linked to town planning and it cannot be dealt with separately, in the same way designing highway spaces always includes their architectural creation. Designing highways inside built-up territories (roads) therefore implies creating road spaces and it must be always treated as a complex designing activity.

A precondition of developing a working traffic system, both efficient for the highway user and friendly to the inhabitants with a maximum feasible level of environmental protection and maximum road traffic safety, consists in diverting all unnecessary traffic (i.e. traffic without its source or destination within the given territory, and therefore without a reason for entering this territory) outside its boundaries. Diverting transit traffic, however, does not imply a complete solution of the town traffic problems. Each individual part of town, in its turn, has to provide entrance for the traffic whose destination lies within its boundaries and thus it is necessary to realise that a certain part of traffic remains within the territory.

Traffic calming means elimination of superiority of car traffic in using the existing road network and in implementation of new urban roads (hereafter referred to as "UR"), creation of better conditions for pedestrians and cyclists, increased safety of road traffic and improved environment. The design of traffic calming is easier in planning new territorial units, than in its implementation within the existing, frequently historically built-up areas. There, the conflict between vehicles and pedestrians, vehicles and the surrounding environment is more frequent and more probable, as the existing development does not always allow radical solutions with traffic diversion outside the territory limits and service traffic removal from the district. In such cases we have to accept the fact that a certain part of traffic will always exist in the territory, trying to restrict its conflict with the environment, lowering and minimizing its consequences.

Despite the introduced legislative measures – such as limitation of max. allowed speed in settlements to 50 $km.h^{-1}$ and related further (sometimes even exaggerated) exploitation of traffic marking for limiting the intensities and, above all, the speed of motor vehicles, there is further increase in the number of car accidents in settlements with aggravated consequences (deaths and serious injuries of mainly the most vulnerable participants, i.e. pedestrians and cyclists). The main problem is to emphasize to the driver that he/she is moving in a different environment than in free landscape, and, therefore, it is necessary to adjust his/her traffic behaviour to the respective environment! This can be required of drivers namely within the observation of basic traffic rules, regulations and signs and generally within respecting the rules of mutual interpersonal respect. But as there are various individualities among road

traffic participants, there are various vehicle types in the traffic flows, the traffic is carried out under variable climatic conditions etc., not everything can be covered by rules and signs. Moreover, the existing rules are not always fully respected.

For this reason it is necessary to concentrate on using such measures which will not restrict the drivers of motor vehicles by legislative means any more, but, in fact, will "force" them to adjust the driving speed to local conditions. This means designing not only psychological, but namely physical calming elements, suitable for individual local and traffic conditions, which will highlight the importance of signs and regulations.

2. Traffic Calming on Urban Roads in our Technical Regulations

Traffic calming of the environment on UR is presently a necessary step in the process of gradual improvement of conditions favourable for pedestrian and cyclists' operation on the roads, but also for the inhabitants of the neighbouring built-up areas. The conditions for traffic calming implementation are not identical for all types of UR. Here, above all, we must realise that traffic calming is not carried out on all UR, but only on UR of class II and III, or on through-roads of class II and III (in accordance with Act on roads), i.e. on functional groups B and C (in the sense of ČSN 73 6110), which provide possibilities for traffic calming implementation. On UR of class I (urban motorways and main local distributor roads) traffic calming is undesirable, while on UR of class IV (minor access roads) the conditions for traffic calming have already been implemented.

It applies to certain parts of the UR network, as well as its individual sections and intersections. Traffic calming inevitably represents a complex activity, whose effect and level of efficiency depend on the extent of applied territorial, architectural and transport solution. That is why the existing design regulations in the Czech Republic are presently being expanded to include the area of traffic calming of UR in particular. In assessing the suitability of designed traffic calming measures to specific roads, the main social criterion is traffic safety.

During 1995 to 2001 the research team members of the Department of Road Structures worked on the development, or participated in the development, of standards and other technical regulations concerning the problems of designing speed humps, exploitation of small and mini roundabouts, designing housing areas and especially technical regulations defined the general conditions for implementing traffic calming on UR ("TP 132 - The Principles of Traffic Calming Design on Urban Roads", "TP 145 - The Principles of Designing Clearways Passing through Municipalities" and "VL 7 - Selected Elements of Urban Roads for Traffic Calming"). The research team is presently engaged in the innovation of the basic design standard ČSN 73 6110 "Design of urban and similar roads", which standard covers traffic calming principles listed in above mentioned technical regulations.

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The Influence of the Qualitative Economic Information on the Control Effectiveness of the Building Firm

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Enforcement of IS/IT in building company management

Basic prerequisites for using of information technologies in civil engineering related to used information systems as a source of a competitive advantage. Application of modern information systems in a building company management: Outsourcing in the sphere of IS/IT management, e-Business (B2B), e-Commerce, Business Process Reengineering (BPR), Enterprise Resource Planning (ERP), Customer Relationship Management (CMR), Supply Chain Management(SCM). The economic processes in the building firm and the **information sources of effectiveness evaluation**. Accounting - implement of the enterprise strategic control. The structure of accounting - financial accounting and management accounting. The accounting statement - balance sheet, profit and loss account, notes on the accounts. The reliability of the information system of financial accounting. Methods for the goining of information - controlling. The evaluation of capacity and effectiveness of the firm, of economic results and of the financial position of the firm. Management accounting and its objectives with the enterprise strategic control. Fundamental objectives of the management accounting. Objectives of the management accounting in the relation to financial and costs accounting. **Management information systems and management accounting.** Accounting - a tool of the enterprise strategic control. Management accounting and controlling. Management accounting and determining Processes. Determining objectives with long - term and short - term effects. Financial analysis systems.

Analysis of information systems

Possibilities the **graphs theory** use. For the analysis we can use method of analysis of systems structure complemented with elements of behaviour analysis, which are based on the principles of the graphs theory.Graphs theory use for analysis of information systems so that the needed information can be delivered into the right place in the right time. Information will be analysed, worked out, complemented and evaluated and after it it will be delivered into other places in the hierarchy of enterprise management.

Possibilities of inputting and working out of **fuzzy variables**: We cannot always precisely quantified mutual relationships – links and in many cases the verbal (vague) utterance is more fitting. In these cases it is possible to apply possibilities of analysis, which are based on the fuzzy variables theory. Aplication of **neural networks** in construction: Scheduling of construction project is an important task in the management of construction projects - model considering the total project cost minimalization. In this formulation, resource leveling and resource – constrained scheduling are performed simultaneously. The proposed model is solved using the patented neural dynamics model of Adeli and Park.

Application - an information system supporting contractor´s **logistics in construction company**. Logistics – the principles of logistics management are currently being more and more applied in enterprise management as an adequate part of the whole management, which contributes to its effectiveness. Logistics and its basic principles, which are based on

minimisation of logistics costs, i.e. costs connected with delivery, storage, transport and logistics services connected with it, being as a complete supported by the well functioning information system, is being to a larger and larger extent applied not only in the delivery process or possibly storage, but also it is becoming one of the paramount factors of the entire project management. Highlights of logistics in construction industry in relation to the lifetime of a constructed facility. IS/IT – selection and implementation, assurance of the company´s permanent growth in desired directions. Information system and its relationship to the company milieu. Risks faced in selection and implementation of IS in affinity to IT.

Increase of portion of **sub-deliveries in volume of building companies works** and their rising influence on economic and other results of constructions and building companies represents a significant factor of sustainable growth of building enterprises life-cycle. However, it requires creation of functional and flexible securing of sub-deliveries management, which can be characterised by three basic areas of problems – a selection of a subcontractor, sub-deliveries management, evaluation of sub-deliveries and subcontractors particularly as feedback for their selection and management. That all with the aimed use of project management methods. Each of these areas includes more partial problems: organizational and information securing of sub-deliveries, decision on work execution by the form of a sub-delivery, quality management of sub-deliveries, database of subcontractors, inquiring, selection and evaluation of subcontractors, management of sub-deliveries implementation.

Analysis of EU building market

Building companies have to prepare their strategies in appropriate way. With integration is connected a lot of advantages and also many problems and threats. The basic steps of preparation competitive strategy are: the quantification of objectives, analysis of external environment, analysis of branch, analysis of internal conditions and in the end set the strategy and its application. The building market of the European Union is from the volume of construction investments point of view the largest worldwide. In the European Union most is invested in Germany in spite of the lengthy economic recession in the last years. Further, there follows Italy, France, Great Britain, and Spain. The contribution deals with analysis of the building market development in the EU individual countries with emphasis on situation in Germany and in the chosen candidate countries including the Czech Republic.

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Composites Based on Bioglass

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New composite materials such as glass composites can potentially be used in orthopedic in the form of substitutive or connective elements. Their mechanical and biocompatibile properties should approach as much as possible the properties of the human bone, the strength characteristics should be at least the same and the modulus of elasticity should be close to the value characterizing the human bone and they should have a sufficient porosity, to enhance a bone growth. However, by the biocompatibility is meant now not only a passive biocompatibility or an inertness that is the facilitation of the growth of the tissue around the implant without any signs of toxicity but especially the bioactivity, i. e. the assurance of a specific biological response on the interface of the material, resulting in the formation of a solid bond between the material and the tissue.

In the literature, we have found the application of siloxanes as a biomaterial. In the publication [1] polydimethylsiloxanes alone, hardened with peroxides, introduced for a longer time (up to 105 days) into laboratory rats are tested and in a further work [2] a composite membrane on the basis of polysiloxanes and cholesterol carbonate was prepared. The result of the experiments is the finding that hardened polysiloxane is biocompatible.

Glass fibers are the most common of all reinforcing fibers for polymeric matrix composites. Their main advantages are low cost, high tensile strength, high chemical resistance and good insulating properties [3]. In our study we have prepared glass-siloxane composites, stress analysis, surface analysis and materials designs were performed to reach desired physical and biomedical properties.

The siloxane precursors LUKOSIL 901 and LUKOSIL M130 resins (commercial products of Lučební závody Kolín, Czech Republic) were used. The composites were prepared from plain-woven cloth V240 (E-Glass, VETROTEX, Litomyšl, Czech Republic), and from satin-woven fabric 21055 (R-glass, VETROTEX, Saint Gobain, France). The soaked prepregs were stacked, cured at 250°C, then cut to pieces of the required size (40×8×2mm), and cured / pyrolyzed at 200-350°C in nitrogen.

The Young's modulus of elasticity in tension and in-plane shear modulus were measured using the electrodynamic resonant frequency tester ERUDITE. The flexural strength was determined with groups of samples processed under identical conditions by a three-point bending arrangement on the material tester MINIMAT. The character of surface was studied by using the image analysis system LUCIA.

Mechanical testing of glass composite samples, dimensions of which enabled to use strain gauges, while applying loading forces in parallel direction to the composite laminae, has been prepared. More complex information about glass composite will be obtained (E, G,

Poisson's ratio μtp, stress limit values $\sigma_{1,3lim}$ both in tension and compression, provided that $\mu_{ij} = -\varepsilon_i / \varepsilon_j$) by three-point bending tests, four-point bending tests, flexural tests and resonance measurements. To ensure a full contact between the tested samples and the hydraulic jaws, special fixtures were manufactured combined with bone cement.

If we compare the mechanical properties of these glass composites with mechanical properties of human bone, we can see first of all sufficient strength and a relatively low value of modulus of glass composites [4].

Not only a composite material exhibiting high strength values has been looking-for. Based on a complex analysis, the glass composite exhibits a compromise between required both mechanical properties (a relatively sufficient strength value and a low modulus of elasticity, comparable with that of human bone, and biological properties (a sufficient porosity), which would be favorable for tissue and bone in growth, has been developed. Next step of our project will be also biotolerance testing. The biotolerance testing of our glass composites have two parts, tests in-vitro and tests in-vivo (implantation into rats) namely cytokine level observation (observation in the extract of newly formed tissue surrounding the implant the inflammatory cytokines interlukin-I (IL-1β) and the tumor-necrosis factor (TNF-α)) and histological observation (standard histological examination (painted with haematoxylin-eosin), creation and a quality of capsular connective tissue, including inflammatory cells in the implant neighbourhood).

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Evaluation of Investments in Advanced Manufacturing Technology

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Advanced manufacturing technologies (AMT) such as CNC, PVS, CIM etc. make it possible for organisations to respond quickly and efficiently to market requirements and to preserve or strengthen their position in terms of competition. In view of their strategic nature appropriate evaluation of investments in AMT is therefore of considerable importance.

Organisations introducing advanced manufacturing technologies continue to evaluate the related investments in a traditional manner. Attention is primarily paid to financial benefits of the investment, whereas its qualitative or strategic effects are not part of the evaluation framework. One frequently cited reason for this is that AMT are considered to be purely a means of facilitating a more economical management of resources or addressing existing manufacturing problems – e.g. a low capacity exploitation, low labour productivity, a high reject rate, or high operating costs and stock levels. There are rather exceptional cases where AMT are viewed as a means of improving key factors of success in competition such as flexibility, quality, quick response in terms of innovation etc.

Traditional approaches to evaluation of investments build on a financial analysis of investment options. Such evaluation is focused on financial effects of the investment, which are most often measured in terms of cost savings, profit increases, the rate of return, the repayment period, the net present value or internal interest rate. It is apparent that, inherently, traditional approaches to evaluation of investments cannot take account of qualitative and strategic benefits, such as increased production flexibility, higher efficiency of processes, a more speedy response to changes in demand, shorter delivery periods, easier diversification etc. As it is impossible to pinpoint the real benefits of investments in AMT using only financial criteria, it is necessary to adopt a comprehensive approach to the evaluation exercise.

A good investment decision is conditional upon a comprehensive evaluation of all effects associated with the relevant investment, including those which are difficult to quantify e.g. acceleration of pre-production stages, improved quality or flexibility, or a better interaction between various business functions. The building blocks of a comprehensive approach to evaluation of investments include a financial analysis and an analysis of qualitative and strategic benefits of the investment.

A combined analysis of both financial effects and qualitative benefits of an investment may result, for example, in quantification of the overall level of appropriateness of the investment applying a criterion of overall investment utility. The first step in such an analysis is the identification of financial and non-financial factors to be considered in evaluating investment options. The next steps in the process of determining the overall level of investment utility consist in rating the relevant factors in terms of their importance, assessing the impact of each investment option on each of the factors (by means of points) and putting together a final list of investment options ranked according to the number of points.

In order to make sure that investments in AMT contribute, in the long term, to optimising the market position of an organisation, it is necessary for such investments to be consistent with the organisation's strategic aims. The degree to which strategic investment

decisions are consistent with the organisation‘s strategy can be tested using key parameters of the strategic plan. Such a review may, for example, be focused on the extent to which the investment is in line with aims concerning product and technological innovations, market expansion, diversification, integration etc. The more an investment project supports the respective strategic aims, makes use of strategic opportunities and addresses weaknesses and threats, the more attractive it is in terms of a business strategy.

Major strategic benefits of investments in AMT usually fall within three key strategic areas: improved quality, enhanced flexibility of processes and a higher degree of responsiveness to customer requirements. Evaluation of harmony between investments and a strategy is then focused on the benefits in terms of key criteria defined for each strategic area with the aim of establishing the overall rating.

The strategic importance of investments in AMT calls for addressing the issue of their evaluation in such a way as to ensure that strategic and qualitative effects are assessed in the same explicit and formal manner as is the case of financial effects. Only in this way can we reduce the risk of turning down attractive investment opportunities.

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Controlling and Marketing Strategy

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At present, when the service life of the goods on the market shortens as a result of continuous dynamic technical development, the marketing strategy must be included in the corporate strategy. The contemporary strategy planning must result in such corporate strategy which will not merely be a theoretical product of top managers but which will define the corporate targets and which will be an integrated set of methods and partial plans for reaching the intended target.

The system of strategic management is the tool for creating the marketing-orientated corporate strategy and its usage on an everyday basis. It is not an independent mechanism; it is just a function of the standard management system. It should be pointed out that any system primarily includes a cognitive part. It must enable and support the target creation process. Therefore, the desirable results are formulated and quantified within the system, not outside it. The management system generally means the set of technical and organizational measures and/or rules, which are supported by information and communication technologies. It enables for the collection of cognitive information, for the analysing of it and for the modelling of future development options, formalized decision making and distribution of decisive information.

The quality of the strategy does not depend on included noble statements and lofty intentions but on whether it enables the staff in the company and other people outside the company to work efficiently, thus surviving and at the same time flourishing in the long run. It is obvious that for the marketing-orientated corporate strategy preparation, formulation and publication there are more or less complex and successful methodologies and procedures. Including marketing strategy in the global corporate strategy enables usage of a broader variety of tools and aids which may simplify work to a certain extent. Furthermore, marketing-orientated corporate strategy enables a more complex evaluation of information and consequent exact processing of operative plans. The key task of strategic planning is to determine the data defining system, and the collection and controlling of information and its consequent processing.

Any strategy becomes successful when it is introduced in practice and as a result the determined corporate target is reached. One of the many tools, which are used in successful corporate management, is the controlling method. Systematic planning, efficient controlling of relevant elements and continuous management of separate activities and processes are the first precondition to introducing controlling into a company.

Controlling in the corporate management system is an integrated working system with data focused on the whole corporate process. It monitors variations from the plans and consequent measures. At present this is concerned not only with financial controlling and controls as was the case at the beginning of the 90s; nowadays the controlling process is a coherent analysis of all the corporate activities. The controlling task is to provide and elaborate data and to analyse obtained information. It means information logistics support within the corporate management process.

Managers (strategy creators) must define the controlling task as having a system of causal targets that can be influenced, optimal value of chosen criteria, targets evaluation, including their presentation form, and also as having a system which will enable decomposition of the strategic plan, and connection to the operative planning system and to the motivation system of the company. The managers creating corporate strategies should understand controlling as feedback for the management process. They evaluate variations of the indicators from the target, as regards those that are ahead of schedule as well as those that are delayed. The variations are analysed in detail and measures follow, which may change the targets and criteria or correct the strategy in relation to changing conditions.

The controlling departments in industrial corporations mostly focus on:

- Calculation of the product price with regard to the real production costs
- Management of profitability of business cases, i.e. from the price offer for the customer, through the development process and through to the sale to the customer, each time taking into account all possible effects
- Detailed evaluation of productivity orders with regard to controlling of work efficiency
- Introduction of a Balance Scorecard system and its usage within strategic decision making of top management

If a company struggles for long-term competitiveness it must not only define financial targets and methods of variation controlling within the process of reaching them but also it is currently extremely important to introduce a strategic system of corporate efficiency measurement. Balanced Scorecard (BSC) is such a system, which employs the controlling methodology.

The contemporary market environment is characterized by extensive competitive pressures. This increases the demands on the function of management and chief officers at all management levels. And, controlling, with its integrated controls, is one of the tools supporting management.

Controlling should be perceived as an integrated process of obtaining information and its consequent evaluation. Controlling does not only mean to monitor and control – it means also the managing and regulating process. Nowadays, controlling is a specific concept of corporate management based on the complex informational and organizational interconnection of the planning and controlling process.

It is not only the controllers that are responsible for high quality controlling. It is also most particularly the corporate management. The introduction of controlling into corporate management is related to the organization and to its financial situation. The costs include staff training and, in particular, the implementation of software support takes up a significant proportion of the fixed costs. To keep up in contemporary competitive struggles, a company must not be managed intuitively; it must be managed through systematic management through which it is sufficient to press a button on the computer keyboard.

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Energy Risk Management in the Czech Republic

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Risk Management for transactions with electricity and the related portfolio is a completely new area of a risk management science in the Czech Republic. Requirements for the risk management of portfolios with electricity transactions resulted from the opening electricity market in the Czech Republic as of 1.1.2002. The electricity market opening was critical mainly for 5 distribution companies, which have the highest electricity positions and the related risks. The proposed methodology for risk management of electricity transactions was successfully implemented in 3 distribution companies and the key solved areas are described in the following paragraphs.

The first step in the proposed methodology is concentrated on an open position calculation. An open position can be defined as a difference between the load prediction and the result of all transactions, which are used for buying / selling the electricity to cover the load prediction for the specified hour. There are 2 types of electricity transactions: with the fix volume in the specified time period and with the variable volume in the specified time period. The special algorithm for transactions with the variable volume (option transactions) was developed and proposed according to the option transactions characteristics.

The next step after the open position calculation is pricing the open position by using so called forward curves. The forward curves determine the price, which is relevant for the open positions in the different time periods (time buckets). Forward curves were calculated both from the historical data series from the local electricity market OKO and the real forward prices from the foreign electricity markets. The forward curve values themselves were calculated by using mean-reverting model, which enables to describe the special characteristics of the electricity prices development: seasonal effects, mean-reversion and price spikes. These characteristics are unique just for electricity markets and the behavior of electricity (commodity) prices is absolutely different from financial ones. Taking into account the usage of the markets defined, the historical OKO prices were used for modeling prices on the short end of the forward curve and vice versa the forward prices were used for the middle and long end of the forward curve.

The forward curves are used for calculation of so-called Mark-to-Market value. Considering the fact, that some prices on the forward curves are not the real market prices the term Mark-to-Model is used for this part of the calculation. The Mark-to-Model value is calculated separately for the individual hours and the open position is evaluated by relevant price from the forward curve. The open position in the individual hour is described by two main parameters: the opened volume and the price of the open position. The price of the positive open position is average price from all deals, which covers the predicted load volume. The price of the negative open position is the planed selling price of the electricity. Using both the price of the open position and the relevant price from the forward curve the price difference is calculated. The price difference is then multiplied by the value of the open position to reflect the underlying volume. Finally the present value of this multiplication is calculated. The discount factors values are derived from PRIBORs.

The risk profile of electricity transactions portfolio is described by Value-at-Risk (VaR) parameter. The Monte Carlo simulation process is applied for VaR calculation. The parametric and historical methodologies are not appropriate for the portfolios considered taking into account both the portfolio characteristics and the available historical data series. The volatilities and correlations are calculated using the exponential weighting. The proposed confidence level and the time horizon should be adjusted properly to the company strategy and other requirements (e.g. a time structure of financial planning). VaR calculation is definitely a daily process. In case of the electricity transactions portfolio the volume risk has to be incorporated into the VaR calculations and into all risk calculations.

The volume risk modeling can be done using different methodologies. The standard approach to the volume risk is a stress tests modeling. The presented methodology uses also stress tests modeling, which is applied separately to the total load prediction values and the option contracts. Mainly historical data are used for the stress test construction. VaR for such modified open position is recalculated and the difference between VaR without and with the volume risk is compared and the volume risk effect on VaR is evaluated.

The results from the above-defined algorithms are available through the risk reports. The presented methodology distinguishes 3 groups of risk reports: analytical reports, daily reports and summary reports. The reporting structure reflects both the standard risk management processes and the management levels. The analytical reports support the daily routines in the Middle Office mainly in case of the requirement for a detailed analysis. The daily reporting is set for the tactical management and incorporates the risk management process into the daily management decision-making procedures in a company. The summary reports evaluate the trends of the portfolio characteristics including the risk profile and inform the top management about the current development. All reports have the part with comments, which describes the most important changes in the portfolio.

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Problem of the Choice and Optimal Subcontract's Prices Assesment

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Price arrangements of construction works related with subcontractor's selections are particularly complicated. Price provides significant informative function, however in real economy fulfils price this function only with certain proximity. It is consequence of the fact, that price forming affects different views (e.g. used resources, public interests and environmental).

Intensive IT- development and high fluctuation of workers constrains us to store efficiently all of available information (not only from price sphere), so that it may be subsequently used again. This special capability proved knowledge systems, which can with certain limitation make up for an expert in given branch, as far as he is not at present available, or possible support and improve the quality of his decision making.

For the sake of systematization and improvement of the optimal prices assessment process and subcontractors selection was in framework of mine theses designed method of the subcontracts prices estimation. This method was formalized in knowledge system for subcontracts management and proceeding and it is a part of system's *inference mechanism*, which further insists on unavoidable *knowledge base*.

Structure and content of the knowledge base should vary according to character of completed orders. Projected database will contain relevant entries about all of (sub-) contractors who the owner ever co-operated with. The base will contain both identification entries of the contractor (business firm, ID no., Tax ID, contacts) and information about completed contracts (contract identification, dates, prices) and final contractor's review. These data will be imported into the system by check-list (MS Excel form), which will person in charge complete on every implemented order for each supplier (subcontractor) and proceed electronically (e.g. via e-mail).

The fundamental presumption of the optimal subcontracts selection is analysis of particular subcontractor's tendering prices. Proposed system's inference mechanism must be able to set up order's price model (using information included in system database and data imputed during the consultation) and recommend user particular supplier including tendering price.

The largest data bulk for given case of optimal subcontractor's selection comprises of particular subcontractor's tendering prices. These prices will be imported into the expert system in tendering budgets, which arise from bill of quantity's evaluation performed by subcontractors. Estimate items are defined and sorted according to the chosen numeral code – the TSKP.

User can in the course of the consultation choose from a number of calculation methods- ways of price model's assemblage. The fundamental price analysis proceeds that way, that there are found "line-minimal prices" of the particular items and assessed general minimal value of the project. That can be regarded as the initial greatest lower of the supplier's tendering prices. It is also possible to let the system compile prices from tendering

prices limited supplier's circuit, e.g. recommended and elected supplier, two cheapest, or the second cheapest price, etc.

Important factor is exploitation of simulation subcontract's prices distribution and their statistical evaluation. In the database system will be stored all of demanded unit prices in detail and classification according to the TSKP. For any class-divided item will be calculated long-term average value (treated against excesses), which will be indexed per quarter. This "floating" average value together with lately obtained tendering item-prices serves to the simulation of possible distribution prices processed order's. User should in the course of analyses concentrate on items, which mostly affect consequent supplies prices – that are 20% of items, which make up 80% of prices.

Contribution of the designed system is also database function consisting in subcontractors rating. As consequence of their systematic rating will be subsequently profiled so-called "Top-suppliers", that will be further demanded. Low-class suppliers will be consequently eliminated from database and their prices will not be obtained any more, but there persists demand for new suppliers.

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The Effects of the Foreign Direct Investment with the Focus on Alternative Opinions

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The empirical works are focused on the issue of how the presence of the foreign firms, established through foreign direct investment affect the domestic firms´ labour or total factor productivity. Most of studies are conducted for the manufacturing sector in developed or developing countries because of appropriate data availability. The results are mixed: in some

Studies one finds insignificant influence of foreign direct investment on the productivity of domestic firms in manufacturing (Great Britain, Spain, Portugal), in others the impact even negative (India, Venezuela, Morocco), while most of the studies stated the positive effects (Mexico, Canada, Indonesia, China, Australia, Taiwan).

As for the corresponding analysis concerning the effect of the foreign direct investment on the firm in the transition countries, it seems that there are so far only two such studies and both of them analyse the impact of foreign direct investment in the Czech manufacturing. The firs one by Djakov and Hoeckman (1998) finds that the presence of foreign direct investment established firms exhibits negative effect on the productivity of the domestic firms in the same industry. On the other hand, Jarolim (2001) using more recent data documented positive but insignificant effect. One may conjecture that the analogue future studies of Czech manufacturing would find the significant positive impact of foreign direct investment. The possible reason for the absence of the positive impact so far might lay in the negative side of the competition effect that in short-run may cause the sluggish productivity of the domestic competitors and even its eventual exit from the market.

All of the above mentioned studies were focused on the intra-industry spillovers. There is practically no direct empirical test of so-called inter-industry spillovers (backward and forward linkages effects) that seem to be more important but also much harder to capture empirically. An indirect test of such linkages was analysed for the Irish economy. The importance of the foreign direct in vestment is best illustrated by the fact that foreign firms account for roughly half of the employment, 80% of net output and over 85% of total export of Irish manufacturing. According that empirical study, foreign direct investment had a positive feedback on the entry of the indigenous firms and on the development of the domestic intermediate imputs industry. More specifically, the presence of foreign direct investment fosters initially the entry of the domestic firm in the intermediate sector due to its increase profitability that in turn induce the subsequent entry of both domestic and foreign firm in the upstream industries. Indeed, the pre-foreign direct investment structure of Irish economy, which were traditional and food-sector activities was dramatically changed through the effects of backward and forward linkages initiated through foreign direct investment. According to the empirical test opinion, the foreign firms, established through foreign direct investment have primary invested in the modern high-tech sectors leading to the rapid increase in importance of the high-tech sector in the Irish economic structure.

The Irish experience seems to be of an exceptional interest for the transition countries that urgently need to modify their economies. Namely, the entry of new firms – either foreign or domestic is the most important element for the fast restructuring of an economy and the most powerful way to sustain the economic growth in the long - run. On the other hand, the

old firms in the traditional countries, that include state enterprises and unrestructured privatised firms, cannot compete so well in a market environment and its prolonged support through budgetary subsidies, fiscal operations, tax offsets and arrears represents an inefficient use of resources and slows the economic growth rate. A policy of encouragement for new firms and foreign direct investment is – in accordance with this opinion – not enough. It seems to be essential that policy makers discipline the old sector through the imposition of hard budget constraints, exposure to competition and facilitation of exit procedures.

One reason for this is the market for factors which downsizing of old enterprises makes available to new firms. The empirical evidence – not only for Ireland – suggests that there is a threshold of around 40% in the contribution of new firms to employment which must be reached before the new sector can become an engine of growth. This group of opinion founds that the interaction between old firms and new firms lies at the heart of the growth process. When reporting on the new firms, they show that labour productivity of those firms in transition economies is initially much higher than in old firms. This, together with the assumption that those new firms are likely less capital intensive suggests that a transfer of labour and capital from old to new firms can be a potential source of growth. Whether the potential is realized depends on the discipline imposed on the old firms and the incentives and encouragement extended to new firms and incoming foreign direct investment by levelling the playing field.

Referring to the experience of Poland, this above mentioned point of view and opinion observes that hardening of budget constraints initially leads to a shedding of resources: assets, which can be bough cheaply by enterprises spun off from old firms without access to finance, as well as labour, which is either absorbed by the new firms or protected by a social safety net, the later representing a more efficient use of public resources than subsidies to ailing firms. Much of the initial recovery comes through better utilization of existing assets, a pattern that held true for Central Europe in the early years of transition. Once a track record of a satisfactory investment climate is established, de novo firms begin to invest. Indeed, it was not till the fourth year of growth that domestic investment picked up in Poland and not till the fifth year a take off in foreign direct investment was to occur.

Another opinion points toward the importance of a political consensus, to ensure a stable long – run policy environment, generalized rather than firm specific policies to encourage foreign direct investment, with a decided preference for export oriented ones, and an emphasis on raising the general level of education rather than providing targeted subsidies.

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Data Trasmission Measurement for Analyse of System Parameters in ITS

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The application and usage of various wide-area (long range) to personal-area (short range) wireless technologies (GPRS, DECT, Bluetooth, etc.) and associated services in automobiles has arrived. It is essential for implementers to understand the parameters and capabilities of these technologies. The monitoring of the current movement of modes of transport, technological maintenance vehicles, and transportation units (containers, goods, and persons) was and is an interesting technical problem.

The selection of location identification technology depends primarily on the system requirements of ITS (Intelligent Transportation Systems) applications supporting the processes of the transport chain, such as availability, security and reliability of information, integrity, response dynamism, etc. Reliability is the ability to perform required function under given conditions for a given time interval. Availability is the ability to perform required function at the initialization of the intended operation. Integrity is the ability to provide timely and valid alerts to the user when a system must not be used for the intended operation. Continuity is the ability to perform required function without non-scheduled interruption during the intended operation. Accuracy is the degree of conformance between a platform's true parameter and its estimated value. Transport safety means the safe movement of vehicles over the transport infrastructure.

In road transport, systems are starting to emerge which are similar to railway and aviation systems, i.e. anti-crash systems, automatic vehicle control, recognition of traffic situations, and other situations where information on current locations plays a dominant role. The transportation of hazardous substances and goods will also be tracked. The system requirements are availability of > 99.7% , integrity of < 2 s, response dynamism of < 10 s, localization (by type of transport) of < 2 m, safety of S W, HW, and data. The choice of technology is usually a compromise between the system requirements of applications and technological opportunities with a view to economic entities.

It is used notebook, server, mobile phones and wireless modules for measurement data trasmission of wireless technologies in ITS. It is used the own measurement software. This program is installed in the notebook and it is written in the program Microsoft Visual C++. It is used the library Win Inet for communication with Internet. The measurement proceed in the following way. At first it is sent out the demand on server about the sized file with the random data content. After it is received data in the mobile data station. Data acceptance runs to the moment of receiving the last sign. It is possible to measure statically or dynamically. Dynamic measurement allows to evaluate dependence the transfer rate on the car speed. It is reduced the transfer rate by higher speed of vehicle movement. It is happened to connection faults more frequently. These connection faults are random and it depends on many factors (e.g. net overload, atmospheric influence, dependence on position transmitter / receiver). The transfer rate increases with the higher data size. On the other hand it is happened connection faults and data transmission take longer. Then given measurements have different numbers of

measured samples. It is measured at least 100 samples. This measurements are processed statistically and taken out to the graph. Some of graphs it is the dependence time necessary for transmission sample on given samples. It means e.g. passage zone with the lower signal. Next is the graph percent occurrence for the mean value estimation and dispersion. Scales in these graphs are different for overstriking details. The dispersion increase with the higher data size. Therefore it is necessary to decrease the appropriate scale.

It was used a standard statistical method for processing of results, which utilize probability density. This probability density is approached by rates of measurement data. The linear interpolation is implemented among of measurement data. The next statistical parameters will be used for measurement data processing. It is possible to calculate the mean value estimation experimentally as a moment of the probability density. The maximum likelihood estimation is the value of a parameter, in which the probability density function has a maximum value. It means in praxis that measurements occur around this value (likelihood) the most frequently. The advantage of this estimation is especially in that it is remote values resistant. Selection standard deviation uses for evaluation of the measurement values reliability. The measurement value will be in defined interval by the theoretical normal distribution with the probability 95 %.

It was proved by measurement that the transfer rate increases with higher data size and by vehicle movement was connection stability much lower. The biggest variations in transmission was caused by switching channels and influences, which isn't possible to specify (reflection signal, randomly disturbance of radio signal, etc.). The measuring notebook didn't have the influence on accuracy of measurement (measure values of measuring quantities was about four orders greater than the accuracy timer). It wasn't proved the influence of operating system with measuring program (computer performance was severalfold greater than the required performance for control of measuring application). It wasn't proved the distance influence on the transfer rate of technology DECT, while Bluetooth technology is high dependent.

It is necessary take into account, by utilization DECT and Bluetooth for data transmission to the vehicle, individual properties is taken by measurement and it is concerned to transfer data to the vehicle in one-shot larger data size. Data, which do not require on-line updating, is good to save in the vehicle memory and to transfer them in one-shot data size into the standing vehicle. Next suggested process will concentrate on the description of signal faults and physical principle of this faults.

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INDEX