VOLUME 1 NUMBER 1 2008

TRANSACTIONS ON TRANSPORT SCIENCES

Ministry of Transport

TRANSPORT RESEARCH CENTRE

CZECH TECHNICAL UNIVERSITY

TRANSACTIONS ON TRANSPORT SCIENCES

Publisher: *Ministry of Transport,* nábř. L. Svobody 1222/12, 110 15 Praha 1
Czech Republic
E-mail: *info@transportsciences.org*
URL: *www.transportsciences.org*

Editorial Office: Olga Krištofíková
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Periodicity: Quarterly
Language: English
Scope: International scientific journal for transport sciences
Print version: ISSN 1802-971X
On-line version: ISSN 1802_9876
Registration Number: MK EČ E 18012

Each paper in the journal is evaluated by two reviewers under the supervision of the International Editorial Board.

Distributor: CDV – Transport Research Centre, Líšeňká 33a, 636 00 Brno, Czech Republic, journal@cdv.cz

Invitation

Let me welcome you at the opening of pages of a brand new international scientific quarterly Transactions on Transport Sciences, edited by the Czech Ministry of Transport. We decided jointly with domestic scientific circles to give origin to the journal, so as to promote exchange of ideas, theories and practical experience between Czech and international transport scientists and industry specialists.

The transport industry is now more than ever undergoing tremendous changes, absorbing and employing breakthrough technologies, attracting in growing extent private resources. Both intermodal and intramodal competition among operators creates a constant demand for new scientific discoveries, and so does the generally growing strive for transport solutions friendly to the endangered environment. The journal should contribute to this development by dissemination of discoveries and solutions that could one day become generally adopted transport technologies.

Our Ministry, jointly with the Editorial Board, would like to invite all transport scientists and dedicated specialists to take part in the discussion running in journal's volumes. And I wish to the new journal much success and to its readers an affluent and never-ending adventure of thinking.

Emanuel Šíp
Deputy Minister of Transport

Dear readers,

You are opening the first edition of the new scientific journal dealing with the transport research issues and enabling to present the results reached at various scientific disciplines related to transport to the broader professional audience.

The journal will be published quarterly by the Ministry of Transport of the Czech Republic with cooperation of the Czech Technical University in Prague and CDV – Transport Research Centre.

The launch of this journal has been motivated by an urgent need to present the applied transport research results, which is a crucial part of the European Framework Research Programmes. It is aimed to serve as a significant tool to emphesize the importance and efficiency of the European applied transport research outcomes and reflection of the national and international subjects' involvement in fulfilling such goal. It is useful to present the research results in a renowned journal dedicated to the specific scientific domain.

This journal has been established with the aim to reflect the publication needs of the Czech and foreign transport research on a scientific level. It is designated to the domestic and international scientific community as a tool for transfer and promotion of the national research abroad.

All papers are peer reviewed by two reviewers and the editorial board is formed by renowned Czech and foreign transport research experts.

We are convinced that the new journal will find its place among the scientific publications as an important information tool for the broader professional public and will bring the up-to-date scientific knowledge in the transport domain. We hope that this journal will become also a welcome means of promotion of the transport achievements in the Czech Republic and abroad.

Editors in chief

Miroslav Svítek Karel Pospíšil

Decision processes in Communications Multi-path Access Systems applied within ITS

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ABSTRACT: The paper presents multi-path communications access systems decision processes applied within ITS (Intelligent Transport System). A competent decision process based on precisely quantified system requirements using a performance indicators tolerance range represents a critical part of the ITS access communications system. The goal of the described process is to keep the communications service continuously available with no influence on changing conditions in time and served space. Either the family of CALM standards based system or the specifically designed and configured L3/L2 switching represent relevant a solution for such a multi-path access communication system. The method of different paths service quality evaluation and the selection of the best possible active communications access path are introduced. The proposed approach is based on Kalman filtering, which separates a reasonable part of noise and also allows the prediction of the individual parameters' near future behavior. The presented classification algorithm applied to the filtered measured data combined with deterministic parameters is trained using training data, i.e., a combination of the parameters' vectors time line and relevant decisions. The classification process results are dependent on the size and quality of the training sets.

KEY WORDS: Intelligent transport systems, performance indicators, localization, navigation, multi-path access, decision processes

1 INTRODUCTION

The first step in addressing the ITS applications is the analysis and establishment of performance requirements on telematics applications done in co-operation with the end-users and organizations like the Railways Authority, Road and Motorways Directorates, Air Traffic Controls. The next step represents a decomposition of the systems requirements to the individual subsystems of the telematics chain.

The list of representative telematic performance indicators was developed and is widely accepted in structure (Svitek, 2005) or (Svitek & Zelinka, 2006):

- Safety - risk analysis, risk classification, risk tolerability matrix, etc.
- Reliability - the ability to perform required functions under given conditions for a given time interval
- Availability - the ability to perform required functions at the initialization of the intended operation
- Integrity - the ability to provide timely and valid alerts to the user when a system must not be used for the intended operation

- Continuity - the ability to perform required functions without unscheduled interruptions during the intended operation
- Accuracy - the degree of conformance between a platform's true parameters and its estimated values, etc.

A substantial part of the performance parameters analysis regarding the telematics application is represented by the decomposition of these parameters to individual subsystems of the telematics chain, including a proposal for the macro-functions of individual subsystems and information relations between macro-functions. Part of the analysis is the establishment of requirements on individual functions and information linkage so that the whole telematics chain should comply with the above defined performance parameters.

The completed decomposition of performance parameters enabled the development of a methodology for a follow-up analysis of telematics chains according to various criteria - optimization of the information transfer between a mobile unit and the processing centre, maximum use of the existing information and telecommunication infrastructure, and so on.

One of the criteria appropriate for transport-telematics applications with a Global Navigation Satellite System (GNSS) is synthesis of the telematics system with minimized performance requirements on a locator, as well as a communications solution resulting in the performance parameters of the telematics application to be maintained. This synthesis does not relate only to the technical or technological part of the solution because the safeguarding of performance parameters of telematics applications is to be ensured by organizational and legislative instruments as well.

The transport telematics field deals not only with its own technologies of the ITS systems but particularly with organizational, economic, managerial and other implementing instruments of such systems, including the evaluation of the impact of ITS systems on the carriage of persons and goods, the acceptance of the approach by drivers, passengers, and the increase in the capacity of goods transport.

2 COMMUNICATIONS SOLUTION

Telematic sub-system requirements

Mobility of the communication solution represents one of the crucial system properties, namely in the context of, frequently, very specific system requirements.

The following communications performance indicators quantify communications service quality (Svitek & Zelinka, 2006), (Svitek & Zelinka, 2007) or (Zelinka & Svitek, 2007):

- Availability
  - Service Activation Time
  - Mean Time to Restore (MTTR)
  - Mean Time Between Failure (MTBF)
- VC availability
- Delay is an accumulative parameter and it is influenced by
  - Interfaces rates
  - Frame size
  - Load / congestion of all in-line active nodes (switches)
- Packet/Frames Loss, and
- Security

Performance indicators applied for such communications applications must be transformable into telematic performance indicators structure and vice versa. The indicators transformability simplifies system synthesis. The additive impact of the communications performance indicators vector $\overrightarrow{tci}$ on the vector $\overrightarrow{\Delta tmi}$ of telematic performance indicators can be expressed by Eq. 1, however, only under the condition that the probability levels of all studied phenomena are on the same level and all performance indicators are expressed exclusively by parameters with the same physical dimensions – in the described case in time or to time convertible variable (Svitek & Zelinka, 2007):

$$\Delta\overrightarrow{tmi} = TM \cdot \overrightarrow{tci} \tag{1}$$

Transformation matrix construction is dependent on the detailed communication solution and its integration into the telematic system. The probability of each phenomena appearance in the context of other processes is not deeply evaluated in the introductory period, when the specific structure of transformation matrix is identified. However, each TM element is consequently evaluated in several steps, a process based on the detailed analysis of the particular telematic and communications configuration and its appearance probability in the specific context of the whole system performance. This approach represents a subsequent iterative process managed with the goal to reach a stage where all minor indicators (relations) are eliminated and the major indicators are identified under the condition that relevant telematic performance indicators are kept within the given tolerance range.

Details of iterative method are discussed in (Svitek & Zelinka, 2007) or (Zelinka & Svitek, 2007). The method is designed as broadly as possible with the clear aim to be applied in the widest possible range of telematic applications. This method can also be successfully used for identification of "CALM" criteria, i.e., the tolerance range of each performance indicator, to be able to decide which alternative access technology is, in a specific time and space, evaluated as the best possible alternative.

2.1 COMMUNICATIONS SOLUTION STRUCTURE

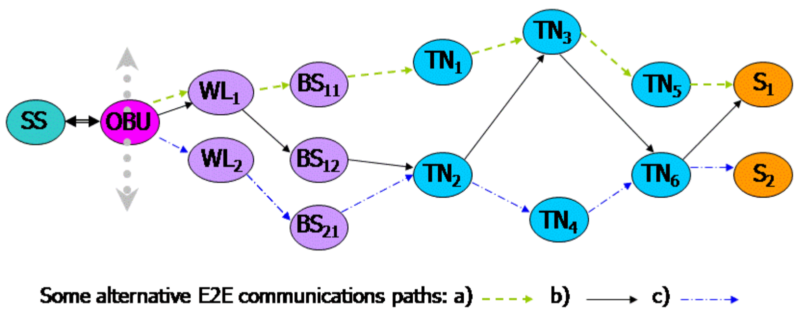

Figure 1: Telematic chain diagram

Figure 1 presents a typical telematic sub-system chain diagram (specifically the solution for the pilot project Airport (Svitek & Zelinka, 2007) and (Zelinka & Svitek, 2007). The outdoor unit consists of GNSS (Global Navigation Satellite System) GPS (Global Positioning System)/Galileo Sensing System (SS), On Board control and display Unit (OBU) and Wireless mobile communication units (WL_i). The terrestrial communication part consists of a set of mobile cellular Base Stations (BS_{ij}) as well as the terrestrial network based on L2 switches/nodes (TN_i) interconnected with Servers (S_i).

One core technology can be selected as the core solution, if possible. However, some areas need to be covered by alternative solutions. We will discuss the principles of procedures which support the selection of the best possible communications solution quantified by performance indicators and by some other parameters, e.g., service costs, as well. The technical implementation is described by the standard CALM, even though alternative solutions are also available, e.g., based on L3/L2 switching principles.

The typical general transport telematic access solutions with the combination of a wide range of access technologies is shown on Fig. 2 (Wall, 2006).

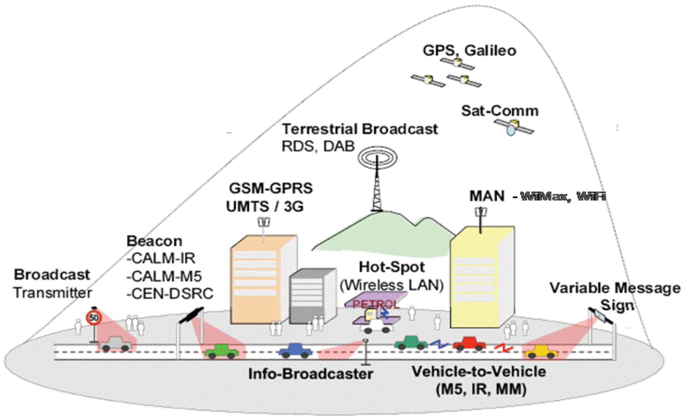

Figure 2: Transport telematics communications access solutions

2.2 MULTI-PATH ACCESS BASED ON CALM AND L3/L2 SWITCHING.

The family of standards ISO TC204, WG16.1 "Communications Air-interface for Long and Medium range" (CALM) represents a widely conceived concept of switching to the best available wireless access alternative in a given time and area. The substitution process of existing paths by the alternative wireless access solution is understood as the second generation of the handover principle.

Both generations of the handover action are started based on an evaluation of the performance indicators set. BER (Bit Error Rate) or packet RTD (Round Trip Delay) are typical but not the only possible performance indicators used for decision processes in data networks. Switching to the alternative path is relevant only if available tools of the lower layer are already unable to resolve performance limits. Simultaneous action on more layers can be counterproductive action.

Second generation handover action can be evoked also by the identification of a more suitable alternative, e.g., by the appearance of an alternative service with better cost conditions, even though the existing alternative is technically sufficient and safe.

An adaptive communications control system has the following architecture:

- *1st layer – Cellular Layer (CL)* - represents the feed-back control processes of parameters like transmitted power, type of applied modulation, etc. The goal of processes on this layer is to keep the given set of managed parameters, for example Bit Error Rate (BER) or Round Trip Delay (RTD), within the required limits
- *2nd layer – the first generation of handover (1HL)* - represents the seamless switching process between different cells of the same mobile network. Such an approach is applied in mobile systems like GPRS, EDGE, UMTS, Mobile WiMax (IEEE 802.16e) or WiFi (IEEE 802.11), via the amendment IEEE 802.11r. The 1HL layer shares relevant information with the CL layer (delivered usually as one system) so that there is no risk of counterproductive simultaneously operated processes on both layers - of course only in the case it is correctly designed and operated

- *3rd layer – the second generation of handover (2HL)* - is mostly dependent only on identification of the service performance indicators. Cellular systems are not usually designed as open systems with appropriate application inter-faces (API) so that there is mostly not a potential for the interconnection with the management of these lower layers. It is certain that the effective management of the 2HL layer can be reached much more easily if 1HL and LC layers share relevant information with the managed layer 2HL

Communications access systems used in transport telematics are:

- Cellular systems, including 2.5G GSM and UMTS
- Mobile Wireless Broadband (MWB) with cells usually much larger than UMTS cells – today namely communications systems based on IEEE Std. 802.16e and the up-coming IEEE Std. 802.20
- WiFi (IEEE 802.11 based) different alternatives - a, b, g and cellular mode option (802.11r)
- DSRC (5.8GHz)
- M5 based on standard IEEE 802.11p
- IR (Infra Read) communications solutions
- IEEE 802.15.x based solutions: Bluetooth – 15.1, UWB (Ultra Wide Band) - 15.3, ZigBee - 15.4
- Millimeter wave technology (62-63GHz) used in conjunction with radar signals at similar frequencies
- Satellite communications exclusively applied for emergency and “special applications”
- W-USB (Wireless USB)
- Other media to come

Only some of presented systems have cellular architecture. In the case that the system is not cellular we can omit the 1HL layer of the presented model.

In CALM standard vertical decomposition to the individual subsystems is applied for each communications access path. Each layer can share the support of more alternative access solutions in one subsystem, when it is possible and effective. However, management remains exclusively and strictly in the horizontal layers architecture. The 1HL layer is understood only as an optional extension of L2 with no principal influence on the whole system architecture. Relevant information needed for qualified decisions is shared between layers exclusively via relevant control system structures. CALM architecture is discussed in (Wall, 2006) and (Zelinka & Svitek, 2007). CALM applies the exclusively still not widely spread IPv6 protocol which allows, due to its extensive abilities, to continuously remotely trace active applied alternatives. Handover is accomplished in CALM exclusively on the L2 of the TCP(UDP)/IP model, i.e., out of TCP/IP competences. Handover competences given to this L2 is a suitable alternative for most of the wireless solutions.

The authors evaluated CALM an orientation as appropriate approach, however, connected with quite an extensive R&D representing a remarkable time period. As a response to the urgent need of an acceptable solution the authors proposed an alternative approach based on L3/L2 TCP/IP switching operated in a specific configuration and settings. This solution is understood as only an interim and, in functionality, limited substitution, however, with a much less demanding and therefore faster implementation.

3 ACCESS PATHS EVALUATION AND THE DECISION PROCESS ON POTENTIAL SEAMLESS SWITCHING TO THE ALTERNATIVE SOLUTION

The following paragraphs describe one of the potential approaches to the decision processes, which are much less discussed than the switching approaches and their management. The proposed methodology is based on following principles:

- Measured parameters are processed by the Kalman filter. Such a process separates a reasonable part of noise and also allows for the prediction of the individual parameters' near future behavior
- A set of measured parameters extended by deterministic parameters, for example economical criteria is available together as a vector **x**
- Based on time lines of vector x, it is feasible to classify the best possible technology selection. The classification algorithm is trained using the time lines of training vectors **x** and the relevant selected paths - see for example (Svitek, 2006)

This solution does not necessarily require 2HL communication with the other layers, but nevertheless, it would be a much more efficient solution if such communication is at least partially possible in future implementations.

3.1 ESTIMATION AND PREDICTION OF MEASURED PERFORMANCE DATA VECTOR P(N)

Let us define parameter vector p(n) in the time interval n. We will suppose that the dynamics of parameter p(n) evolute based on the following model (it is supposed that p(n-1) is known):

$$\boldsymbol{p}(n) = \boldsymbol{A}(n)\boldsymbol{p}(n-1) + \boldsymbol{b}(n) + \boldsymbol{q}(n) \tag{2}$$

where A(n) is a transition matrix, b(n) is the deterministic vector of constant parameters and q(n) is the vector of Gaussian noise with the following property:

$$\begin{aligned} &E[\boldsymbol{q}(n)] = 0 \\ &\operatorname{cov}[\boldsymbol{q}(n), \boldsymbol{q}(i)] = 0 \text{ for } n \neq i \\ &\operatorname{cov}[\boldsymbol{q}(n), \boldsymbol{q}(i)] = \boldsymbol{Q}(i) \text{ for } n = i \end{aligned} \tag{3}$$

The equations (2) and (3) represent "the evolution form of an unknown parameters vector".

In many cases we cannot measure the vector of an unknown parameter p(n) directly, however, we can measure another vector z(n) that depends on unknown parameters as follows:

$$\boldsymbol{z}(n) = \boldsymbol{D}(n)\boldsymbol{p}(n) + \boldsymbol{r}(n) + \boldsymbol{w}(n) \tag{4}$$

where D(n) is a transition matrix, r(n) is a deterministic vector of constant parameters and w(n) is the vector of Gaussian noise with the following property:

$$\begin{aligned} &E[\boldsymbol{w}(n)] = 0 \\ &\operatorname{cov}[\boldsymbol{w}(n), \boldsymbol{w}(i)] = 0 \text{ for } n \neq i \\ &\operatorname{cov}[\boldsymbol{w}(n), \boldsymbol{w}(i)] = \boldsymbol{W}(i) \text{ for } n = i \end{aligned} \tag{5}$$

The equations (4) and (5) represent "the evolution form of a measurement vector".

The algorithm for the estimation of a vector $\hat{\mathbf{p}}(n)$ of unknown parameters together with its covariance matrix S(n) can be summarized:

$$\begin{aligned} &\hat{\mathbf{p}}(n) = \hat{\mathbf{p}}_e(n) + \boldsymbol{H}(n)(\boldsymbol{z}(n) - \boldsymbol{r}(n) - \boldsymbol{D}(n)\hat{\mathbf{p}}_e(n)) \\ &\mathbf{S}(n) = \boldsymbol{S}_e(n) - \boldsymbol{H}(n)\boldsymbol{D}(n)\boldsymbol{S}_e(n) \end{aligned} \tag{6}$$

where $\hat{\mathbf{p}}_e(n)$ is an extrapolated estimate from the last step, $\mathbf{S}_e(n)$ is a covariance matrix of extrapolation and H(n) is the Kalman gain. All the mentioned parameters are possible to be recursively computed from the last estimated parameters characterized by $\hat{\mathbf{p}}(n-1), \mathbf{S}(n-1)$ according to the form:

$$\begin{aligned} \hat{\boldsymbol{p}}_e(n) &= \boldsymbol{A}(n)\hat{\boldsymbol{p}}(n-1) + \boldsymbol{b}(n) \\ \boldsymbol{S}_e(n) &= \boldsymbol{A}(n)\boldsymbol{S}(n-1)\boldsymbol{A}(n)^T + \boldsymbol{Q}(n) \\ \boldsymbol{H}(n) &= \boldsymbol{S}_e(n)\boldsymbol{D}(n)^T\left(\boldsymbol{D}(n)\boldsymbol{S}_e(n)\boldsymbol{D}(n)^T + \boldsymbol{W}(n)\right)^{-1} \end{aligned} \tag{7}$$

Equations (6) and (7) are understood as "the Kalman filtering algorithm".

Now, we suppose the non-linear evolution of an unknown parameter vector (2) and a measurement vector (4) through known non-linear functions f(.) and h(.):

$$\boldsymbol{p}(n) = f(\boldsymbol{p}(n-1)) + \boldsymbol{b}(n) + \boldsymbol{q}(n) \tag{8}$$

$$\boldsymbol{z}(n) = h(\boldsymbol{p}(n)) + \boldsymbol{r}(n) + \boldsymbol{w}(n) \tag{9}$$

The main idea is to linearize the equations (8) and (9) with the help of the first two components of Taylor series in the extrapolated value $\hat{\mathbf{p}}_e(n)$ (extended Kalman filtering):

$$f(\boldsymbol{p}(n-1)) = f\left(\hat{\boldsymbol{p}}_{\boldsymbol{e}}(n)\right) + \frac{1}{2}\cdot\left.\frac{\partial f(\mathbf{p})}{\partial \mathbf{p}}\right|_{\mathbf{p}=\hat{\mathbf{p}}_e(n)} \cdot \left(\boldsymbol{p}(n-1) - \hat{\boldsymbol{p}}_{\boldsymbol{e}}(n)\right) \tag{10}$$

$$h(\boldsymbol{p}(n-1)) = h\left(\hat{\boldsymbol{p}}_{\boldsymbol{e}}(n)\right) + \frac{1}{2}\cdot\left.\frac{\partial h(\mathbf{p})}{\partial \mathbf{p}}\right|_{\mathbf{p}=\hat{\mathbf{p}}_e(n)} \cdot \left(\boldsymbol{p}(n-1) - \hat{\boldsymbol{p}}_{\boldsymbol{e}}(n)\right) \tag{11}$$

Based on the equations (10) and (11) non-linear equations (8) and (9) are transformed into a linear form and Kalman filtering could be used.

Kalman filtering can be started by the first measurement z(1). The initial parameters should be set up as:

$$\begin{aligned} \hat{\mathbf{p}}(1) &= \mathbf{H}(1)(\mathbf{z}(1) - \mathbf{r}(1)) \\ \mathbf{H}(1) &= \left(\mathbf{D}(1)^{\mathrm{T}}\mathbf{W}(1)^{-1}\mathbf{D}(1)\right)^{-1}\mathbf{D}(1)^{\mathrm{T}}\mathbf{W}(1)^{-1} \\ \mathbf{S}(1) &= \left(\mathbf{D}(1)^{\mathrm{T}}\mathbf{W}(1)^{-1}\mathbf{D}(1)\right)^{-1} \end{aligned} \tag{12}$$

3.2 SWITCHING AS A CLASSIFICATION PROCESS

Let us introduce the vector x as the vector carrying information about the values of performance parameters in a sample time. The items of vector x are either deterministic or random processes with the help of the Kalman filtering described above.

Let us define the classification problem as an allocation of the feature vector $\mathbf{x} \in \mathrm{R}^{\mathrm{D}}$ to one of the C mutually exclusive classes knowing that the class of $\mathbf{x}$ takes the value in

$$\langle \Omega = \{\omega_1, \ldots\ldots, \omega_C\} \rangle$$

with probabilities $P(\omega_1), \ldots, P(\omega_C)$, respectively, and x is a realization of a random vector characterized by a conditional probability density function $p(\mathbf{x} \mid \omega),\ \omega \in \Omega$. This allocation means the selection of the best suited telecommunication technology based on knowledge of x vector.

A non-parametric estimate of the ω-th class conditional density provided by the kernel method is:

$$\hat{\mathrm{f}}(\mathbf{x} \mid \omega) = \frac{1}{\mathrm{N}_\omega \cdot \mathrm{h}_\omega^{\mathrm{D}}} \cdot \sum_{\mathrm{i}=1}^{\mathrm{N}_\omega} \mathrm{K}\left(\frac{\mathbf{x} - x_{\mathrm{i}}^{\omega}}{\mathrm{h}_\omega}\right), \tag{13}$$

where $K(\cdot\cdot)$ is a kernel function that integrates to one, h_ω is a smoothing parameter for ω-th class, N_ω stands for the sample count in class ω and $\mathbf{x}_1^\omega,....,\mathbf{x}_{N_\omega}^\omega$ is the independent training data. The density estimate defined by (13) is also called the Parzen window density estimate with the window function $K(\cdot\cdot)$.

It is a well-known fact that the choice of a particular window function is not as important as the proper selection of smoothing parameter. We use the Laplace kernel defined by the following Laplace density function:

$$f_L(x;\mu,\sigma) = \frac{1}{2\cdot\sigma}\cdot\exp\left(-\frac{|x-\mu|}{\sigma}\right) \tag{14}$$

where $x \in R, \mu \in \mathrm{R}, \sigma \in (0,\infty)$.

The product kernel is used with a vector of smoothing parameters $\boldsymbol{h}_\omega = (h_{1\omega},.....,h_{D\omega})$ for each class ω. The product kernel density estimate with Laplace kernel is then defined as

$$\hat{f}(\mathbf{x}|\omega) = \frac{1}{N_\omega}\sum_{i=1}^{N_\omega}\prod_{j=1}^{D}\frac{1}{2\cdot h_{\omega,j}}\exp\left(-\frac{\left|x_j - x_{i,j}^\omega\right|}{h_{\omega,j}}\right). \tag{15}$$

Smoothing vectors $\boldsymbol{h}_\omega$ are optimized by a pseudo-likelihood cross-validation method using the Expectation-Maximisation (EM) algorithm.

To rank the features according to their discriminative power the standard between-to within-class variance ratio is employed. This method is based on the assumption that individual features have Gaussian distributions. The feature vector $\mathbf{x} \in \mathrm{R}^D$ takes the value to one of C mutually exclusive classes $\Omega = \{\omega_1,........,\omega_C\}$. The probabilistic measure $Q_{d,i,j}(d,\omega_i,\omega_j)$ of two classes separability for the feature d (d-th component of feature vector) is defined as

$$\mathrm{Q}_{d,i,j}(d,\omega_i,\omega_j) = \frac{\eta\cdot(\sigma_i+\sigma_j)}{|\mu_i-\mu_j|}, \tag{16}$$

where ω_i and ω_j are classes and symbol $\eta = 3.0$ denotes the real constant specifying the interval taken into account (probability that the observation of a normally distributed random variable falls in $[\mu - 3.0\cdot\sigma, \mu + 3.0\cdot\sigma]$ is 0.998). The smaller the value of the measure $\mathrm{Q}_{i,j,d}$, the better the separation of the inspected classes made by the feature d is. For $\mathrm{Q}_{i,j,d} < 1$ both classes are completely separable. The measure is similar to the widely used Fisher criterion.

For multi-class problems, the two-class contributions are accumulated to get a C-class separability measure Q(d) for the feature d:

$$\mathrm{Q}(d) = \sum_{i=1}^{C}\sum_{\substack{j=1\\ i\neq j}}^{C}\mathrm{Q}_{d,i,j}(d,i,j). \tag{17}$$

All the features in the training data are then sorted according to their Q(d) measures. The function Q(d) is similar to a significance measure of the d-th component of a feature vector. The subset of n first features is selected as an output of this individual feature selection method. The drawback of the method is the assumption of unimodality and the fact that only linear separability is taken into account. On the other hand, the individual feature selection method based on the between-to within-class variance ratio is very fast.

The presented classification approach is effectively applicable for relevant decision processes used to select the best possible alternative access from the set of available paths. The decision is based on the evaluation of both random, as well as deterministic, processes. The introduced approach enables continuous decision processes training.

The presented method allows implementation to be started with no information flow between the layer 2HL and layers 1HL and CL. However, the proposed solution is deliberated to be open for future extensions in information resources to let the decision process improve by the application of potentially available information, like the status of layers 1HL and CL.

4 CONCLUSION

The main goal of our research is to introduce a new generation of Intelligent Transport Services (ITS) which can be continuously available (on a defined probability level). Due to the regular complexity of areas covered by telematic services we have concentrated on the wireless access solution designed as seamless switched combination of more independent access solutions, i.e., a multi-path access system.

The process of access solution switching has been the subject of intensive R&D and different approaches have already been published. One of alternatives – a family of standards CALM - represents a promising response to ITS requirements. However, due to the complexity of the proposed solution it is inevitable that a quite remarkable amount of time to resolve all issues can be expected. The proposed alternative approach, based on L3/L2 TCP/IP switching operated under a specific configuration and settings, is understood only as a potential interim and, in functionality, a limited substitution, however, with much less demanding and therefore faster implementation conditions compared, for example, to the ones of CALM.

The method of different paths evaluation and the decision process background has not been as widely discussed as the core switching alternatives. One of the possible approaches was studied and the core principles of the proposed solution are presented.

The measured parameters of all available alternative access paths are processed by the Kalman filter with the aim of separating a reasonable part of the data noise. The Kalman filter also allows for the prediction of the individual parameters' near future behavior. The filtered flow of the measured parameters vectors can then be extended by deterministic parameters, for example the economical criteria. The resultant vector **x** time line allows the classification of the best possible technology selection from those for which the relevant time line of vectors **x** is available. The classification algorithm is based on the training procedure using relevant training data – i.e. a line of training vectors **x** and relevant to data selected paths. Due to the fact that only linear separability is taken into account, the individual feature selection method based on the between-to within-class variance ratio represents a very swift approach.

The presented classification approach is applicable for relevant decision processes on the top layer of the communications system management to select the best possible access alternative from the set of available paths. The decision is based on an evaluation of both random, as well as deterministic processes, and the introduced approach enables continuous decision processes training, as well as the future information resources extension obtained namely from potentially available lower layers of the multilayer adaptive communications management system.

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Scanning Electron Microscopy Method as a Tool for the Evaluation of Selected Materials Microstructure

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ABSTRACT: This paper introduces CDV's research on microstructure evaluation of two selected materials used in pavements or structures, i.e. cement concrete and bitumen. A Scanning Electron Microscope (SEM) has been used as the main equipment. In the case of cement concrete time-dependent changes in the microstructure of self-compacting concrete (SSC) are described. The microstructures and differences in void and pore system of matured SSC with commonly used micro-fillers are also shown here. In the case of bitumen the paper anticipates that the relationship between the composition, structure and usable properties of bitumen have not yet been clarified enough. The SEM method requires an appropriate preparation as the raw bitumen samples can not be watched directly. The oil fraction, precluding the observation, must be eliminated. Nevertheless, its removal may cause a modification of the original structure, and this might consequently have an impact on the results of the observation.

KEY WORDS: SEM, microstructure, bitumen, concrete, cement

1 INTRODUCTION

Two selected materials have been studied in the recent CDV's research on microstructure evaluation: cement concrete and bitumen. In the case of cement concrete a degradation process has been being observed and in the case of bitumen an appropriate way for microstructure study has been researched.

1.1 CEMENT CONCRETE

Recent concrete development points to an application of many types and volumes of admixtures and additions. They are added to concrete to obtain the special properties of fresh concrete (e.g. SCC - Self-compacting Concrete) or the properties of hardened concrete (HPC - Hi-performance Concrete, LWAC - Light-weight Concrete). Usage of 3 or more different types of additions (fly-ash, slag, silica-fume, fine grounded limestone or additives (plasticizers, accelerators, stabilizers, air-entered agents, etc.) is common.

This paper describes the part of work realized as a part of a project called "Long-time changes of concrete microstructure and their properties".

The structure of hydration products (subsequent re-crystallization) rising in concrete microstructure within a short time after mixing concrete is well known. A generation of neoformations in cement mortar is a never-ending process. The question is how the material, concrete or mortar additives and admixtures, influences the concrete and mortar properties over a long time period and mainly if there is some probability that the usage of additives and admixtures or their combination, in connection to environmental activity, can cause changes in concrete structures (e.g., re-crystallization) that deteriorate the properties of the concrete and the realized structure.

1.2 BITUMEN

Heavier loads, higher traffic volume and higher tire pressure demand a higher performance of pavements. A high performance pavement requires bitumen that is less susceptible to high temperature rutting or low temperature cracking (Chen et al., 2003).

Bitumen is the residue from the vacuum distillation of petroleum oil. It consists of two main fractions: asphaltenes and maltenes (Loeber et al., 2000; Loeber et al., 1998; Masson et al., 2006). The asphaltenes are defined as the bitumen fraction that is insoluble in n-heptane. Asphaltenes are polar with a higher molecular weight than maltenes. The maltenes are soluble in n-heptane, are less polar and less aromatic than the asphaltene fraction and can be further separated into resin, aromatic and saturate fractions (Bearsley et al., 2004).

Bitumen rheological and mechanical properties, controlled by the chemical and physical interactions of individual fractions, are highly dependent on the temperature (Loeber et al., 1998; Chen et al., 2003). Bitumen represents complex multicomponent mixtures whose chemical properties, or more precisely structures, have not yet been explained (Masson et al., 2006; Sebor et al., 2001). The observation of bitumen structure is not easy because of its colloidal behaviour (Loeber et al., 1998). But the research of asphaltenes structure might help to explain the bitumen rheological properties. Scanning electron microscopy and environmental scanning electron microscopy (ESEM) have both been used successfully to image the asphaltene structure (Baginska et al., 2004; Bearsley et al., 2004; Loeber et al., 1996), because they offer a three-dimensional image that can be analyzed more easily than a two-dimensional one, usually obtained from optic techniques and transmission electron microscopy (TEM) (Rahmani et al., 2003). Electron microscopy has contributed considerably to the development of theories concerning the structure, composition, and properties of components of these blends and to the interpretation of their optical microscopy and applied research results (Wilson et al., 2000).

Yet SEM is unable to observe nonconductive oil samples, because the resolution is too low. For that reason the oil phase (maltenes), which is disturbing the observation, must be removed (Loeber et al., 2000; Loeber et al., 1998;). It may cause the change of the original structure and consequently have an impact on the results of the observation. Therefore the SEM observation requires a suitable preparation method (Loeber et al., 1998; Loeber et al., 1996). There are several methods of asphaltene-paraffin removal, such as mechanical means, hot fluid, addition of surfactant agents, crystal modifiers, and precipitation by different solvents. The precipitation by different organic solvents is the one used most frequently. This method is also used to examine bitumen chemical composition (Bragado et al., 2001).

This article introduces bitumen microstructures obtained with the use of SEM that enables us to evaluate a suitable sample preparation method for the SEM observation.

A sample preparation method that will not have an impact on the internal microstructure, i.e., that it will guarantee the observed sample is a product of degradation processes and not a result of an unsuitable sample preparation method, is necessary to find in order to understand the degradation processes progressing in bitumen at a microstructure level.

2 CEMENT CONCRETE EXPERIMENTS

2.1 PARAMETERS

For the experiment 40 different types of SCC mixtures of various types, with different amount of used admixtures or for different construction purposes, were designed. For this paper were used four mixtures marked F1, F3, F4, and F13 with a maximum amount of each type of micro-filler (stone-dust, fly-ash, limestone and slag). A complete composition of the selected concrete mixtures is presented in Table 1.

Table 1: The composition of the selected self-compacting concrete mixtures

Concrete mixture prescriptions		F1 (stone-dust)	F3 (fly-ash)	F4 (limestone)	F13 (slag)
Cement 42.5 R	kg	400	400	400	400
Fine aggregates 0-4 m	kg	830	870	700	760
Coarse aggregates 4-8 mm	kg	165	230	230	230
Coarse aggregates 8-16mm	kg	582	550	550	550
Filler	kg	160	160	280	220
Superplasticizer	kg	4	4	4	4
Water	kg	190	185	175	Unknown

Specimens (150mm testing cubes) of the mixture were prepared in February 2003. Specimens were demoulded after 24 hours and deposited into water at room temperature. Specimens of concrete for microscope study were prepared in April 2007. The presented pictures of concrete microstructure are about 4 years old. For SEM specimen preparation we used a diamond-charged saw and cut off a small piece from the edge of each cube.

All concrete specimens with a fracture area approximately 5x5 mm and micro-fillers were attached by self-adhesive carbon tape to a specimen holder and then coated by a golden film. Through coating a better image resolution was obtained due to removing the surface electric charge.

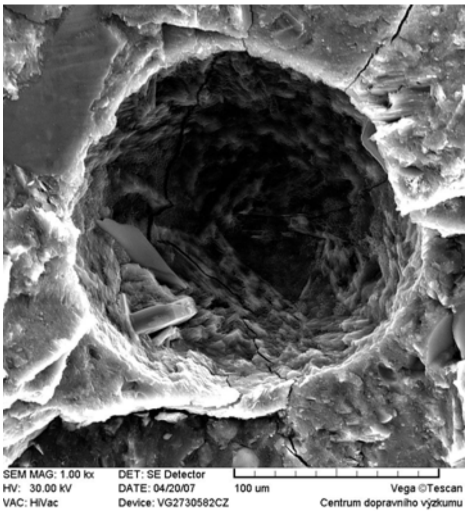
2.2 CEMENT CONCRETE MICROSTRUCTURE

The observation made by SEM method showed that there are some voids in the concrete microstructure with crystals of ettringite $Ca_6Al_2(OH)_{12}.24H_2O$ and portlandite $Ca(OH)_2$. Crystals of ettringite can form the shapes of needles, fibres or fan-shaped agglomerations and crystals of portlandite form shapes of tables or chips within a free space of voids (see Figures 1 and 2).

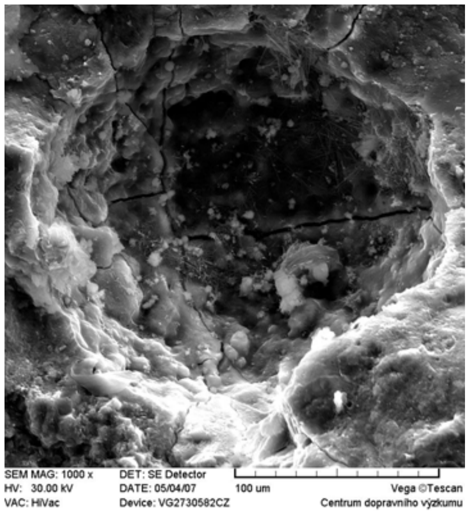
If these products of hydration reaction fill all the space of pores, it can produce stress leading to cracks or damage of the concrete. In this case the voids are relatively unfilled, as crystals of ettringite are still harmless for concrete strength.

A low amount of portlandite in the concrete matrix provides better sulphate attack resistance. On the other hand portlandite keeps a high alkalic pH in concrete, which is the principle of steel reinforcement passivation.

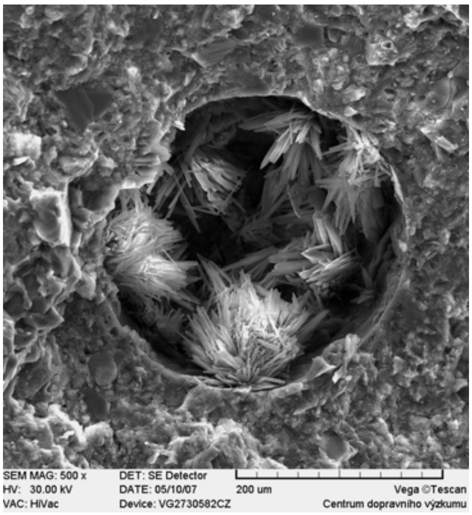
Only spherical fly-ash particles can be clearly viewable in the concrete matrix (see Figure 3). Other used fillers with variform particles are indefinable in hardened concrete.



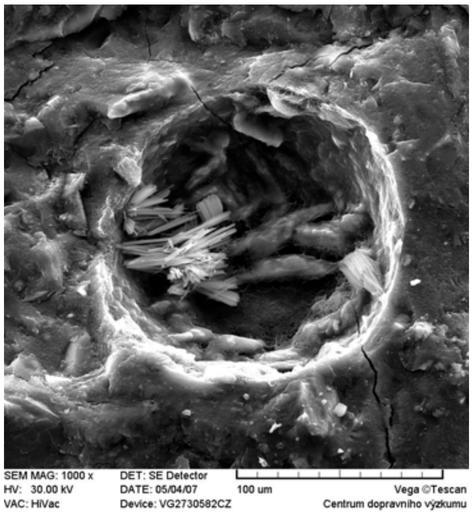
F1 – stone-dust



F3 – fly-ash



F4 – limestone



F13 (slag)

Figure 1: Voids in concrete matrix – various amount of ettringite and portlandite crystals

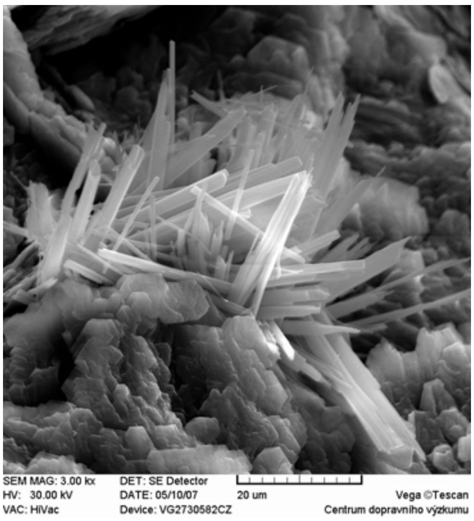


Figure 2: Detailed view of ettringite needles and portlandite tables in void space

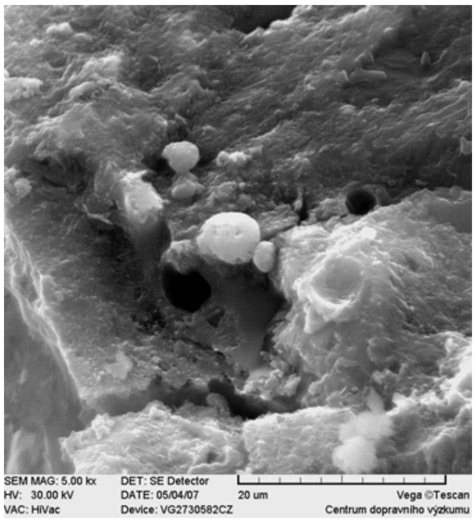


Figure 3: Fly-ash particles clearly viewable in the concrete matrix

3 BITUMEN EXPERIMENTS

3.1 PARAMETERS

The bitumen binders 70/100 from two producers were used for the observation. Their basic properties are shown in Table 2. Asphaltenes were obtained from the precipitation with n-heptane.

Table 2: Bitumen parameters

	Sample		
	1	2	3
Bitumen type	Air-blown 70/100	Straight-run vacuum residue	70/100
Penetration value at 25°C	85	109	89
Softening point [°C]	45.2	41.2	43.9
The yields of asphaltene recovery			
CSN 65 6073 [per cent]	14.0	6.6	-
Procedure A [per cent]	11.7	3.3	-
Procedure B [per cent]	13.8	5.7	-
Procedure C [per cent]	16.4	6.0	-
Procedure D, E [per cent]	-	-	7.4

3.2 THE PROCEDURES OF THE SAMPLE PREPARATION

There are several techniques of oil phase (maltenes) elimination described in ČSN 65 6073 (Czech National Standard) and some additional ones mentioned in Baginska et al., 2004; Bearsley et al., 2004; Bragado et al., 2001; Rahmani et al., 2003:

- The procedure based on ČSN 65 6073: dissolution of 1 g of sample in 40 ml of n-heptane, kept in the dark over night, 1 hour of boiling under the reflux condenser, 2 hours of keeping in dark, filtration through the filter paper, 1 hour of washing the filter paper in a Soxhlet extraction apparatus with n-heptane, 1 hour of washing the filter paper in a Soxhlet extraction apparatus with toluene, pouring the solution into a glass bowl, toluene evaporation above the water bath, 1 hour of drying in 110° C, measuring, repeating to the constant weight.
- Procedure A: dissolution of 1 g of sample in 40 ml of n-heptane, 1 hour of boiling under the reflux condenser, 2 hours of keeping in the dark, filtration through the filter paper, 1 hour of washing the filter paper in a Soxhlet extraction apparatus, drying.
- Procedure B: dissolution of 1 g of sample in 40 ml of n-heptane, kept in the dark over night, filtration through the glass filter paper Whatman GF/A, washing with n-heptane, 3 hours of washing the filter paper in a Soxhlet extraction apparatus, 8 hours of washing the filter paper in a Soxhlet extraction apparatus, drying.
- Procedure C: dissolution of 1 g of sample in 40 ml of n-heptane, 10 minutes of boiling, filtration through the glass filter paper Whatman GF/A, 1 hour of washing with n-heptane, drying.
- Procedure D: dissolution of 0,8-1 g of sample in 40 ml of n-heptane, kept in the dark for 24 hours, filtration through the glass filter paper Whatman, washing with n-heptane, drying.

- Procedure E: dissolution of 0,8-1 g of sample in 40 ml of n-heptane, kept in the dark for 24 hours, filtration through the glass filter paper Whatman, washing with n-heptane, 2 hours of washing the filter paper in a Soxhlet extraction apparatus with n-heptane, drying.

All the bitumen samples precipitated in n-heptane were coated and subsequently observed using the scanning electron microscope.

3.3 RESULTS AND DISCUSSION

The basic properties of applied asphalts from the two producers are introduced in Table 2. The different values of n-heptane asphaltene yields in samples 1 and 2-3 can be explained with the partial conversion of resins into asphaltenes. It can be supposed that this conversion occur during the bitumen processing, the air-blowing. Thus the values of yields of asphaltenes recovery in the air-blown sample 1 are higher than in samples 2 and 3.

The results of the observation are visible at Figures 1-5. The structure of the sample prepared according to the ČSN 65 6073 method is shown in Figure 4. It can be seen that the structure is smooth, featureless and shapeless. No microstructure is visible. It can be concluded that the procedure disrupted the original structure. This destruction could arise as the consequence of the procedure, when the dilution was poured into a glass bowl and the solvent evaporated.

For comparison the microstructure of the sample prepared according to the procedure A is introduced in Figure 5, in the same magnification (5000x). The microstructure of this sample consisted of asphaltenes micelles and is evident here.

In accordance with the authors' opinion, the size of asphaltenes micelles and the extent of their aggregation were influenced by the chemical type of the primary product and by the technology of asphalt processing in their samples. The observation of asphaltenes using SEM enabled us to discern micelles to a size 110-260 nm. The research of the Ural asphalts identified smaller particles in comparison with the Venezuelan asphalts. But the extent of aggregation was bigger.

In Figures 6-8 the microstructure of asphaltenes samples prepared according to varied preparation methods (procedure A, B, C) are represented in the same magnification (10 000x).

The methods differed from each other in the time of the sample preparation and various procedures of maltenes removal from the samples. Procedure C was the shortest and no extraction in a Soxhlet extraction apparatus was used. On the contrary, procedure B was the longest and extraction in a Soxhlet extraction apparatus lasting 11 hours was used. The purpose of this divergence was to evaluate the suitability of sample preparation procedures for SEM observation. The microstructure similar in all samples is apparent regardless of the chosen preparation procedure. It can be concluded that the procedures A, B, and C are equal considering the impact on the change of the original structure. From a time and technical point of view procedure C is the least demanding.

Figure 9 represents a sample marked as 2 in Table 2 prepared according to ČSN method.

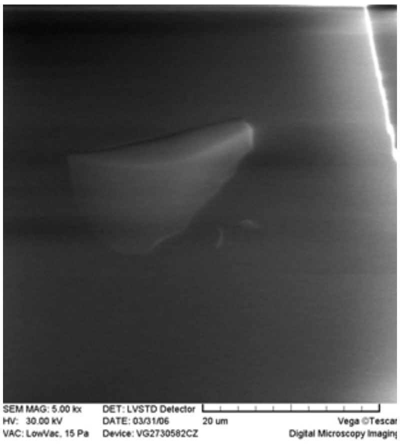


Figure 4: ČSN method

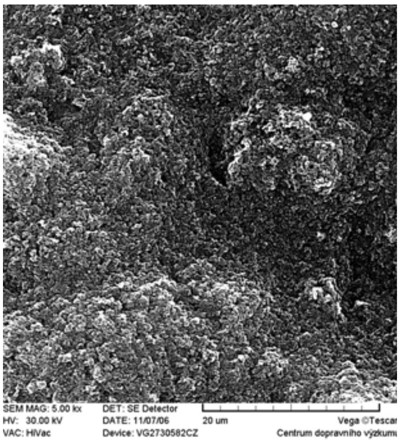


Figure 5: Procedure A

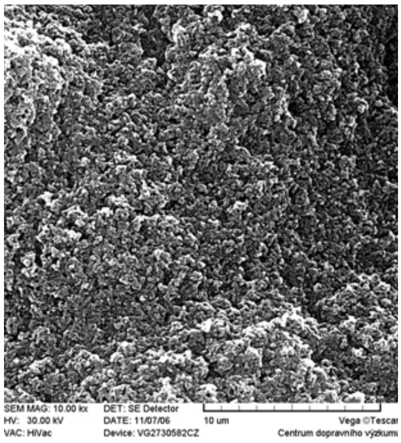


Figure 6: Procedure A

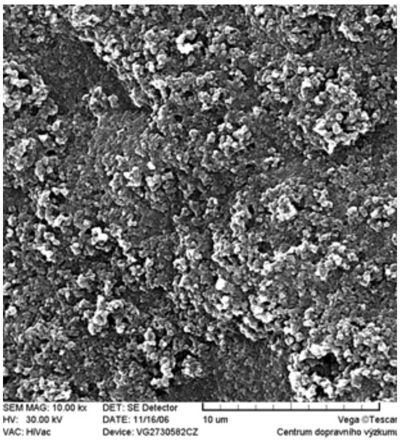


Figure 7: Procedure B

Figure 8: Procedure C

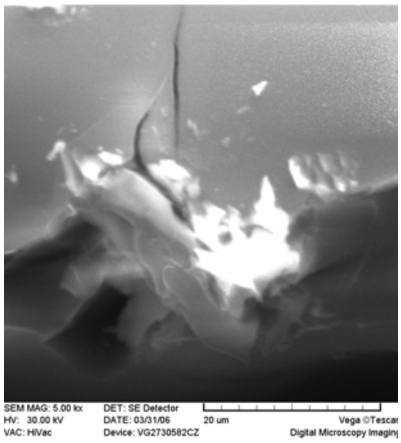


Figure 9: ČSN method

4 CONCLUSION

It can be supposed that the cement concrete microstructure investigation will lead to an understanding and obtaining knowledge of the relationship between concrete or mortar microstructure and their properties. As the concrete will be still maturing the investigation of all specimens will be repeated periodically during the solving of the project. For a comparison between laboratory prepared samples and samples affected by field conditions several additional samples of different types of matured concrete will be taken from existing structures with known concrete mixture composition.

The represented tentative results of bitumen microstructure research show that the study of bitumen microstructure is very deeply affected by the method of sample preparation. It is obvious that the preparation technique influences the microstructure itself. The procedure based on ČSN 65 6073 completely damaged the original asphaltene structure and so this technique can not be applied for the SEM observation. The tests will continue with all three types of samples using each of the described methods.

The object of following research will focus on whether the structural modification is caused in the preparation method or the sample type. The search for a considerate preparation and observational method is a prerequisite of the objective appraisal of degradation processes evidently progressing in asphalts, but not yet demonstrably documented at a microstructure level.

5 ACKNOWLEDGMENTS

The research described in this paper was established within the scope of research project of the Ministry of Transport of the Czech Republic under contract No. MD 04499457501.

The authors would like to thank The Research Institute of Inorganic Chemistry (Litvinov), namely Mr. Černý and Paramo, a.s. (Pardubice), and Mr. Plitz and Mr. Švadlák for their immense efforts in preparing the samples for observation.

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Noise and Vibration Reduction – the Cranktrain as a Main Powertrain Module

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ABSTRACT: This paper discusses how the multi-body dynamics approach combined with flexible body effects is being applied to predict the vibrations of crankshaft, bearing loads or cranktrain noise level due to structural flexibility. The oil film effects in the journal bearing are implemented with the use of a finite difference method. An application example of a Diesel inline four-cylinder engine is given in this paper to show this sophisticated simulation model and to predict the dynamic response of the flexible system and loads in the journal bearings.

KEY WORDS: noise, vibration, cranktrain, finite difference method, slide bearing model

1 INTRODUCTION

The efforts to reduce noise pollution in the urban environment and to satisfy the rising comfort demands, require low noise vehicle engines and power units. Thus comprehensive simulation methodologies and software tools are necessary during the design phase to analyze the complex physical events of noise generation and to transfer it to engines and power units.

The complex dynamics cranktrain model has been developed especially for these applications. It takes advantage of an outstanding simulation technology, which enables one to produce realistic results of engine dynamics and noise that are very close to the absolute ones.

For the design of internal combustion engines, the reliability of the cranktrain and slide bearings or the piston to liner contact is of central importance. Its design affects key functions such as durability, performance, wear and noise of the engine. Due to increasing specific loads, all physical effects have become important and they have to be taken into consideration by advanced simulation tools involving structural elasticity and dynamics.

2 SOLUTION METHODS

Finite element solutions show discrepancies as compared with the test dealing with dynamically loaded structures that undergo large rigid body motion. Such systems typically show geometric non-linearity and non-linear compliance between the different bodies. Solutions with the use of non-linear FEA have improved the accuracy of results yet have failed to provide a complete description of complex mechanical systems, including hydrodynamics and large rigid body motion.

Multi-body dynamics with flexible bodies combine the advantages of a geometric non-linear FEA and rigid body dynamics. The modal synthesis method for flexible bodies superimposes flexible effects on rigid body motion. The multi-body dynamics approach, including the effects of flexible bodies based on the modal synthesis method, tracks frequencies in the kHz range accurately and applies forces, kinematic joints and constraints robustly. This approach properly updates the mass properties to account for the changes in, for example, location and inertia due to deformation at each time step, and takes into account the Coriolis and gyroscopic effects too.

During the simulation, the hydrodynamic forces are calculated at every time step as a function of the relative position and velocity of the reference nodes on the flexible crankshaft and the engine block. This approach employs the impedance method, where forces are calculated as results of the eccentricity and eccentricity rate.

The multi-body dynamics code, ADAMS, is used in this work. The basic premise of the ADAMS flexible body methodology is to use the multi-body dynamics equations of motion for a system of rigid bodies with algebraic constraints, and to include modal coordinates from finite element analyses. The modal synthesis method for flexible bodies is applied to superimpose flexible effects on rigid body motion. Experience has proved that static modes, combined with fixed boundary condition normal modes, provide the best dynamic solutions. This approach has the advantage of efficiency over pure finite element methods for modeling the structural dynamic response of mechanical systems undergoing large rotational motion.

3 CRANKTRAIN MODEL

The multi-body dynamic model of the complete powertrain is shown in Figure 1. An engine block is connected to the ground by bushing supports.

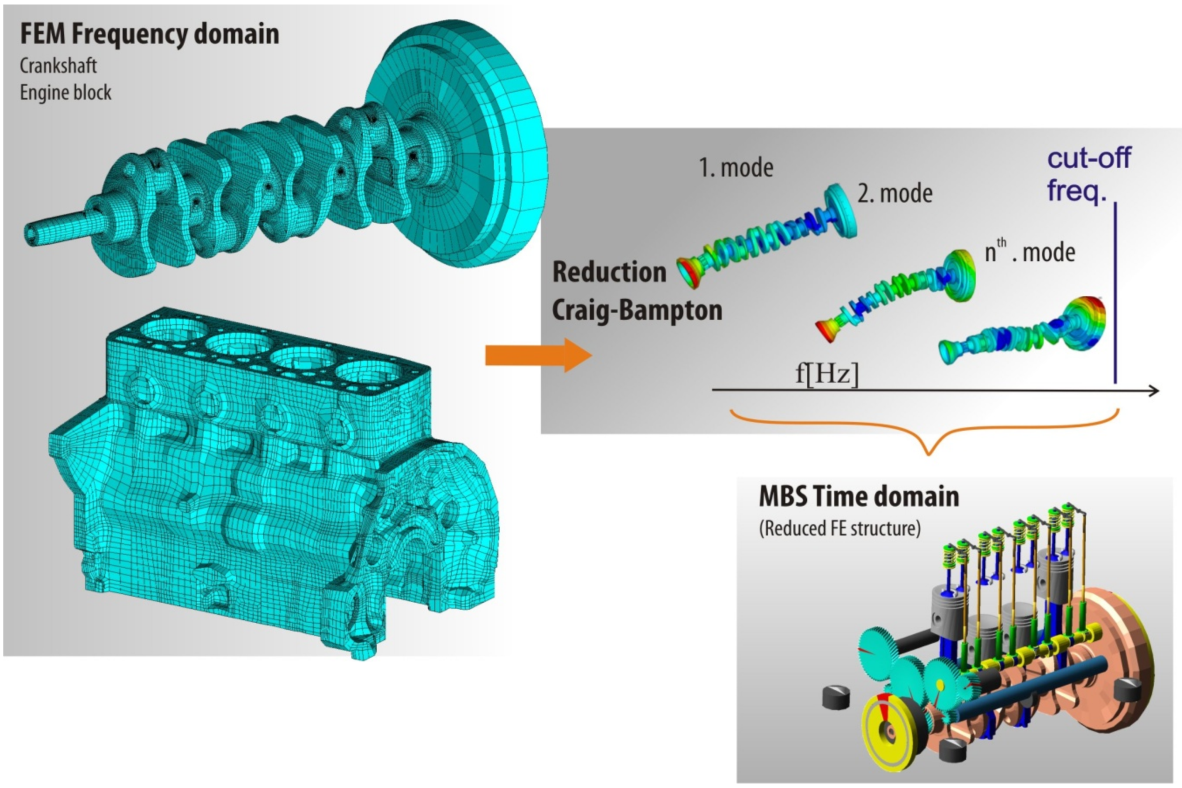

Figure 1: MBS model of powertrain with FE parts

The crankshaft and the engine block are modeled as flexible bodies, while the connecting rods and pistons are modeled as rigid bodies. A simplified model for piston side load takes care of the interaction between the piston and the engine block. The remaining parts of the system kinematics are modeled with mechanical joints defined in ADAMS between the different bodies of the engine.

All modes up to 10000 Hz were extracted for the crankshaft. A set of 80 Craig-Bampton modes was used for the crankshaft. Likewise, all modes up to 10000 Hz were included for the engine block. This ensures a good representation of static and dynamic deformation. Gas forces were applied to the pistons and the combustion chambers. Static mode shapes were selected on the cylinder bore to account for piston side loads.

4 SLIDE BEARING MODEL

A slide bearing can be described as a sleeve around a pin with a lubricating fluid. The lubricant is supplied within a suitable slot. Tangential and radial motion, in combination with a wedged gap, generate a pressure in the oil film in the slide bearing. The bearing loading is periodical and the pin center passes through the bearing trajectory.

Modern specialized slide bearing codes are enabled to deal with various physical phenomena, for example elasticity of a shell or a journal (EHD), Goenka (1986), mixed boundary conditions, cavitation phenomena, Oujja (2006), or thermal and pressure dependent oil viscosity (TEHD) presented by Thomas (2007). All these features can be used if the main object of interest is the slide bearing itself. However, including the given features has a tremendous effect on computation times. These require an application of simpler HD codes for the global powertrain dynamics. The hydrodynamic solution is decoupled from the dynamic solution of MBS Solver. Therefore, the equations are solved for several bearing working conditions (eccentricities and tilting angles) prior to the dynamic analysis. The MBS bearing results (e.g. forces and moments) are consequently considered as input conditions for separate bearing solutions.

The dynamic behavior of hydrodynamic bearings is described by the well-known Reynolds's differential equation

$$\frac{\partial}{\partial x}\left(h^3 \frac{\partial p}{\partial x}\right) + \frac{\partial}{\partial z}\left(h^3 \frac{\partial p}{\partial z}\right) = 6\eta\left(U \frac{\partial h}{\partial x} + 2\frac{\partial h}{\partial t}\right) , \tag{1}$$

where p is pressure
t is time
h is angle dependent bearing clearance
η is dynamic viscosity
U is effective velocity, and
x, z are coordinates

The Reynolds's equation (1) is transformed into a dimensionless form when applied to global powertrain dynamics. For the transformation details of Reynolds's equation see Butenschön (1976) or Rebbert (2000).

In classic formulation [1], the angle dependent dimensionless bearing clearance H is defined as

$$H = 1 + \varepsilon \cos\varphi \ , \tag{2}$$

where ε is the relative eccentricity, and
φ is the angle about the axis of rotation

However, the above definition (2) does not include tilting effects and must be transformed into the following form

$$H^* = H^*(\varphi,\gamma,\delta,\varepsilon) = H(1-\gamma Z\cos\varphi - \delta Z\sin\varphi) \tag{3}$$

where Z is the relative coordinate in the axis of rotation direction
γ is the first tilting dimensionless angle (for details see Figure 3), and
δ is the second tilting dimensionless angle

Now, the definition of H^* includes tilting effects and is inputted into the dimensionless Reynolds's equation.
The resultant differential equations describing the distribution of dimensionless pressure can be rewritten as

$$\frac{\partial^2 \overline{\Pi}_V}{\partial\varphi^2} + \left(\frac{D}{B}\right)^2 \frac{\partial^2 \overline{\Pi}_V}{\partial Z^2} + a(\varphi,\varepsilon,Z,\gamma,\delta)\overline{\Pi}_V = b_V(\varphi,\varepsilon,Z,\gamma,\delta) \ , \tag{4}$$

$$\frac{\partial^2 \overline{\Pi}_D}{\partial\varphi^2} + \left(\frac{D}{B}\right)^2 \frac{\partial^2 \overline{\Pi}_D}{\partial Z^2} + a(\varphi,\varepsilon,Z,\gamma,\delta)\overline{\Pi}_D = b_D(\varphi,\varepsilon,Z,\gamma,\delta) , \tag{5}$$

where $\Pi_D = \dfrac{p_D\psi^2}{\eta\overline{\omega}}$ and $\Pi_V = \dfrac{p_V\psi^2}{\eta\dot{\varepsilon}}$

and $\overline{\Pi}_V$, $\overline{\Pi}_D$ are the dimensionless pressures for tangential and radial movements,
D is the bearing diameter
B is the bearing width
$\overline{\omega}$ is the effective angular velocity
ψ is an independent bearing clearance
$\dot{\varepsilon}$ is a time derivation of dimensionless eccentricity, and
a, b_V, b_D are coefficients

The equation (4) describes oil pressure for the tangential movement of the journal and the equation (5) describes oil pressure for the radial movement of the journal. Both equations embrace the tilting effects.

The bearing model also includes the solution of cavitation phenomena. Cavitation usually occurs in the regions of diverging lubricated contact gap and implies sub-ambient pressures of the lubricant. These low pressures lead to a transformation of the liquid into a gas-liquid mixture; details are presented by Sahlin & Almquist (2007).

The solution of the differential equations is executed iteratively with the given boundary conditions employed, and with the use of a modified central difference method. The modifications concern the definition of a variable computational grid. The initial solution resolves the pressure profile for given boundary conditions very quickly, and then the main algorithm adapts the new computational grid according to the second derivatives of the pressure profile, see Figure 3. The second solution to the refined mesh is much more accurate.

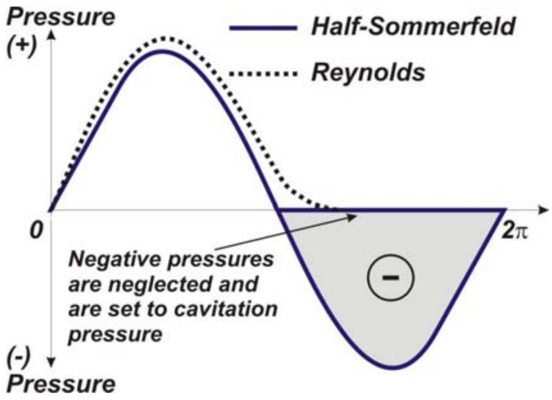

Figure 2: Schematic of cavitation boundary conditions

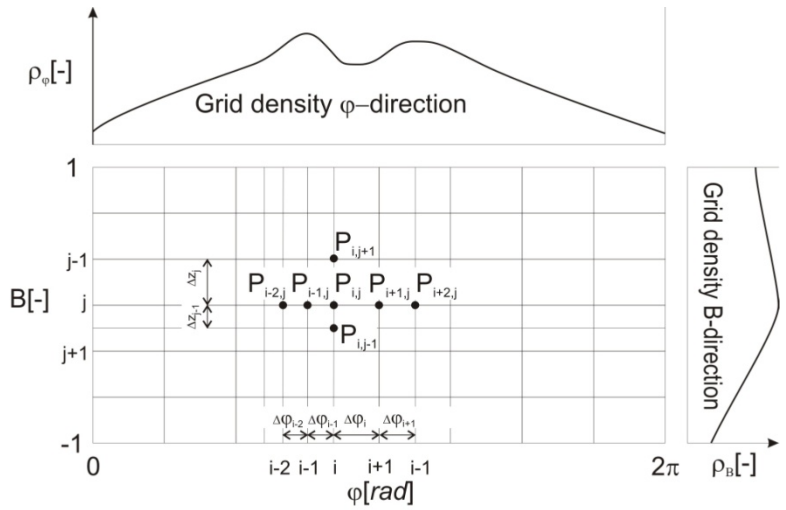

Figure 3: Variable computational grid for slide bearing solution

The results are saved in hydrodynamic databases representing dimensionless bearing reactions (forces and moments) to dimensionless states (eccentricity and tilting value).

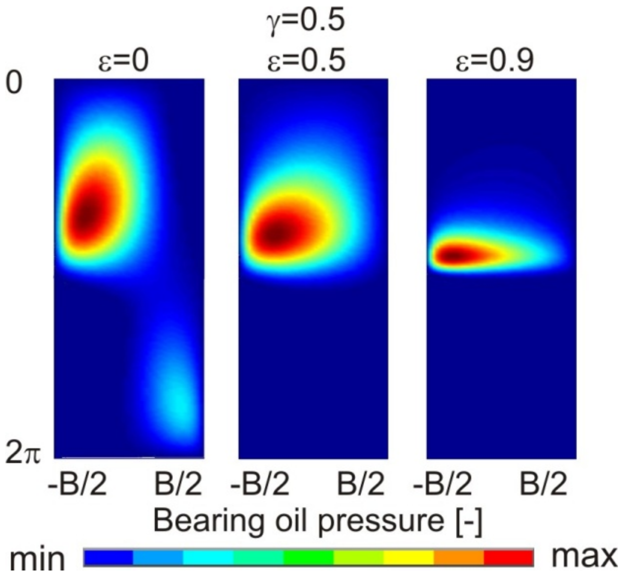

Figure 4: Dimensionless pressure distribution in bearing oil film for a dimensionless journal tilting angle γ=0.5 and three variants of eccentricities.

During the dynamic solution, MBS Solver subroutines ensure the database access and the necessary analytical steps (coordinate transformations, etc.). Figure 4 shows dimensionless pressure distribution in the bearing oil film for the first tilting angle γ=0.5 and three variants of relative eccentricities.

5 RESULTS DISCUSSION

Failures, and in particular the fatigue fractures, used to occur in connection with an increase in engine power, and with material savings. The fractures were not only caused by the forces arising from combustion pressure processes, inertial forces, or incorrect construction. In most cases, they were discovered to be the result of the periodical torsional vibrations of the crankshaft. Traditionally, there are three types of crankshaft vibrations: bending, torsional and axial vibrations. Bending vibrations are caused by periodical forces that operate perpendicularly on the crankshaft axis. These forces are radial and tangential forces on the crankshaft and imbalanced eccentric forces of the cranktrain. The natural frequencies of bending modes are given a free length of the crankshaft between the bearings. Free lengths of crankshaft between two bearings are very small and the natural frequencies of bending modes are high and there are no resonances at an engine speed range. Stiffness of the bearings and the engine block have a large influence on bending natural frequencies.

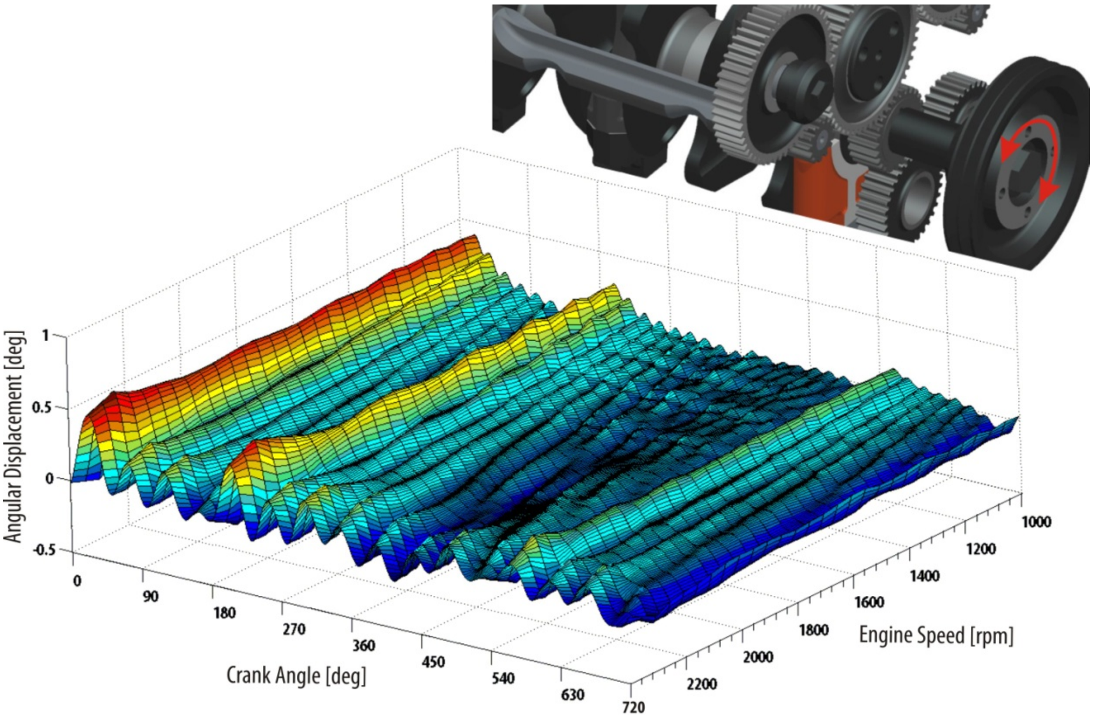

Figure 5: Results of crankshaft torsional vibration analysis in time domain

For most engines, the torsional vibrations of crankshafts are much more dangerous than bending vibrations. The forced torsional vibrations of the crankshaft are caused by time-dependent torques. Torsional vibrations reach high values in resonances when the frequency of a forced vibration is equal to the natural frequency. The resonances and relevant critical engine speeds cause an increase in noise and engine vibrations. All vibration types can be obtained from a complex computational model of the cranktrain.

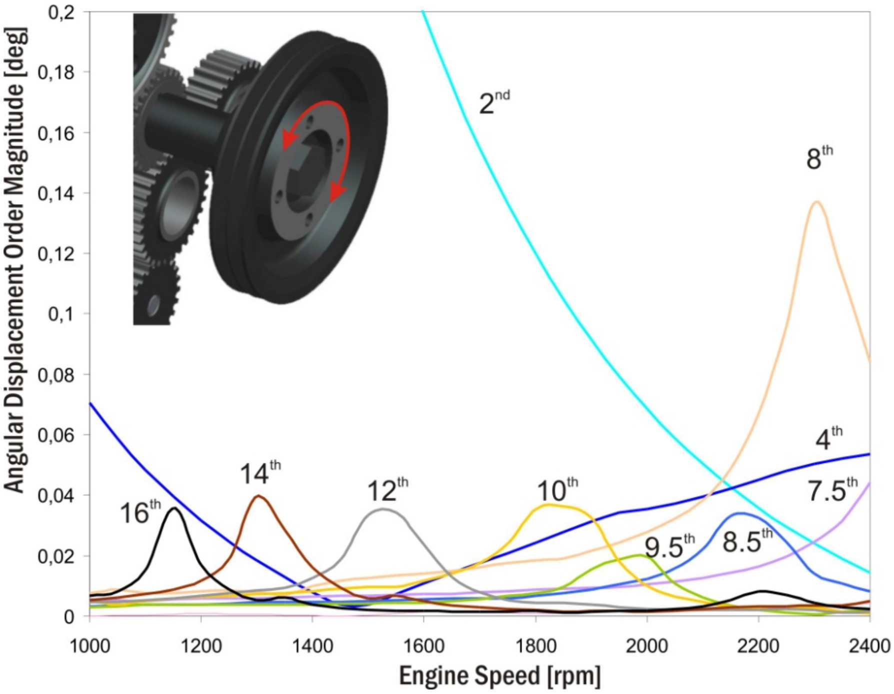

Figure 6: Results of crankshaft torsional vibration analysis in frequency domain

The results of the vibration analysis are shown in Figures 5 and 6. They present the results of the torsional vibration order analysis of the in-line four-cylinder diesel engine cranktrain without a damper vs. the engine speed in time and frequency domain.

6 CONCLUSION

Multi-body dynamics, with flexible effects such as torsional or bending vibrations of a crankshaft, applied to compute cranktrain dynamics of the engine has enabled an improvement in the NVH behaviour of the engine in the concept phase.
There are further areas for future research and development. They will focus on the quick EHD method – to capture local bearing deformation which is represented by a combination of elastic mode shapes coupled with a fluid film model.

7 ACKNOWLEGMENT

The problems mentioned above are being solved within the framework of the project No. 101/06/P032 by the Grant Agency of the Czech Republic. The authors would like to thank GA CR for the rendered assistance.

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Architecture of Tools and Processes for Affordable Vehicles

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ABSTRACT: The focus of this paper is on the description of the recommended functional requirements for the software architecture that enables the integration of tools and processes for large scale affordable vehicles and propulsion systems. These include: integration, processes, tools, affordability, repeatability, sustainability, integrity, etc. Prior to the discussion of the recommended functional requirements a brief description is given on the two types of integration environments (Monolithic Environments and Best Class Environments) along with a categorization of the different type of tools considered to be integrated within the environment. The four categories of tools addressed are Groupware, Project Management, Product Data Management or Product Lifecycle, and Engineering tools.

KEY WORDS: Software architecture, product and process representation, engineering tools, data, application

1 INTRODUCTION

When new processes are proposed, new tools discovered, mature tools exist, additional teams engaged, and distribution of work dispersed all are constrained by affordability, a description of what these new concepts are must be accompanied by a discussion of how they can be used. The “how” is the subject of this paper. What follows is a discussion of the salient features of a computing architecture that will support the Integration of Tools and Processes for Affordable Vehicles based upon the knowledge discovered in examining the unique and common needs of how product development is accomplished for vehicles and their respective propulsion systems. Once the recommended functional requirements are presented an example of how an implementation of the environment would be used to perform a simple distributed engineering analysis of an aircraft component is presented. In order for an organization to execute process du jour, it utilizes various software tools to carry out individual tasks within the process. For clarity, a software tool in this article is defined as “a software application used to perform or facilitate the execution of specified task in a process”. Here, software tools are categorized into four classes: Groupware tools (video conferencing, online meetings, teleconferencing etc.), Project Management tools (project schedules, distributing information, resource planning, team organization, process work flows etc.), Product Data management or Product Lifecycle tools (data, drawings, reports, models etc.), and Engineering tools (Computed Aided design – CAD, Computer Aided Manufacture – CAM, Computer Aided Engineering – CAE) (Sehra at all., 2006).

2 ENGINEERING TOOLS INTEGRATION

Over the past twenty five years the two primary paradigms that have emerged to perform Multidisciplinary Analysis and Design (MAD) are Monolithic Approach (MA) and Best in Class Approach (BCA) systems.

The monolithic MAD environment systems consist of a single application/tool that contains all necessary functionality to perform the desired analysis or design. If well designed, these monolithic systems contain a single database with a well-defined interface in which each functional module communicates all information through the centralized database. Each module appears independently in the system but must obtain all of its inputs and write all output that is needed by other modules to the centralized database. These systems also usually have standard Application Programming Interfaces (APIs) that enable communication with the monolithic system and at times the ability, with some effort, to add additional functional modules to the environment. In addition, these systems often have a High Order Language (HOL) that is used to combine the modules to solve a specified problem. A standard set of sequences written in this HOL are often available in these environments or a single sequence that can solve many variations of a predefined set of problems is used. The monolithic applications give users access to the HOL so they combine the available modules to customize the system to solve problems not accounted for in the standard set of sequences. These monolithic systems are typically easy to administer and are fairly robust with good error trapping and handling. However, if not well designed they can be rigid and difficult to customize and may require access to source code of modules that are being added to the system. Also, the monolithic systems do not deal well with highly distributed organizations and data. But most importantly they are usually built around a single discipline expertise, such as mechanical analysis, CAD, or KBE, and have marginal capabilities in other disciplines, such as controls, or computational fluid dynamics.

The BCA system typically uses a scripting language, such as Perl (Wall et al., 2001) or Tcl (Outsterhout, 1994) to “glue” together several independent application tools that provide the “best” functionality for a given discipline to define a process and solve a selected problem. Such existing approaches can be found in iSight (http://www.engineous.com), Model center (http://www.phoenix-int.com), MDICE (http://www.cfdrc.com), and Visual Doc (http://www.vrand.com). This approach “wraps” each application with the scripting language and defines simple input and output that a given application requires or generates. A major benefit of this approach is that it gives the end user access to the “best” technology available in a given domain and thus supports the “plug and play” Paradigm to a certain extent. This approach is much more portable to engineering domain experts since they can include their “best of class” application for a specific problem being solved. In theory this approach appears quite attractive, but in practice many problems arise with this approach. Each application has different data structures and formats. This can lead to difficult and inefficient data transfer between applications. Scripts for large-scale problems tend to become unruly/problem specific, and hence fragile, difficult to maintain, and not reusable. Also, more importantly, there is no well-defined manner to trap errors that occur during the process. This may not be an issue when combining only a few applications but when the number begins to approach the 10s or 100s the ability to determine if, when, where, and why a failure occurred becomes the critical element in the success of the BCA.

3 FUNCTIONAL NEEDS AND ARCHITECTURE

To best satisfy the requirements of product development in today's business environment a distributed BCA MAD is desired with the following qualities:

1. Product representation – a way to represent the product along with the design intent or rules;
2. Seamless access to varying fidelity best in class tools to evaluate or modify the design;
3. Process Representation with Secure Communication between all tools, data, and vested parties involved in the product development process;
4. Modularity that enables high level of reuse when moving from one application to the other.

Such a system will allow specialized communities to exist (Centers of Excellence) but will require them to publish and maintain with defined interfaces to their domain so that communications between the different domains can take place at a level that is required to evaluate the impact of one domain on another. If the interfaces are well defined and "published" on network they can be accessed anywhere, anytime allowing all participants access to the most recent product information and technology. Even though the specified functional requirements would allow communication and integration between the four classes of tools, the primary focus is on the integration of project Management tools, Product Data Management or Product Lifecycle tools, and Engineering tools.

To satisfy the integration requirements arising in the emerging product development processes in today's business environment a functional architecture is proposed. The integration of the tools will result in tangible benefits to a company and organization. It should also be evident that an ad-hoc approach to performing the integration of this plethora of widely distributed tools would not be adequate. Thus, a formal process should be adopted to developing an integration environment. This environment should enable the integration and communication across the various tools and data that are encountered during three product development processes. The functional architecture for an integration environment is henceforth presented. Here functional architecture is defined as a description of all functional activities to be performed to achieve the desired mission, the system elements needed to perform the functions, and the designation of performance levels of those system elements. Architecture also includes information on the technologies, interfaces, and location of functions and is considered an evolving description of an approach to achieving a desired mission. Throughout the remainder of the document the term Architecture and Functional Architecture will be used interchangeably. The Architecture shall be capable of supporting multiple analysis techniques and information standards for any discipline. Realizing the current investment in tools such as CAD/CAM tools and physics-based solvers (e.g., finite element modeling packages, computational fluid dynamics packages, computational electromagnetic solvers, etc.). The Architecture should not require a priori the use of any geometric representation, analysis technique or information standard. Additionally, different modules within the architecture should be easily replaceable or maintainable.

Product Representation

The current state-of-the-art in product representation is a "single parametric associative model, referred to as a Master Model. The Master Model concept traditionally contained only geometric information, but has now been extended to contain any critical information that may be needed throughout the life of a product. The Master Model is a single logical representation of the product that may be distributed geographically of between several different databases or applications, the point being that there is a single representation of a product without any duplication of information. All users begin from and update a single representation of the product to ensure consistency. A CAD system (UniGraphics, ProE, Catia, etc.) along with a PDM (e-Matrix, Windchill, etc.) system are typically combined to create a master Model. Many companies are also coupling the Master Model with KBE systems resulting in what is called an "Intelligent Master Model" (IMM) or Smart Product model (SPM). This allows design intent and rules to be maintained with the model along with the model representation itself. Typical KBE system employed are AML, Inlet and UG Knowledge Fusion. A few features that are desirable for the IMM are:

1. Ability to quickly generate a representation of a product
2. Support parametric and topological changes
3. Maintain and document the design intent
4. Demand Driven Calculation – the product representation should perform only the calculation that are required to determine the result of a desired analysis or functional evaluation
5. Capture the knowledge and design intent of the product
6. Ability to quickly generate the domain specific analysis and design models when parametric or topological changes are made. This feature is key to supporting high fidelity analysis and numerical zooming early in the design process
7. Support Dependency Tracking - the product representation should automatically track the dependencies between various objects and properties within the model

Seamless Access to Engineering Tools and Data

Multidisciplinary. It is no longer acceptable to perform design analysis in the technical disciplines separately. Any "optimization" at the component or subsystem level will lead to a sub-optimum system. There are various approaches to this problem. It is important to remember that multidisciplinary simulation couples physical processes and the design of an interface has therefore to be based on physical understanding, and not only on implementation issues. There are many tools which assemble simulation programs used for a workflow together in an integrated environment, but even those environments need, as a core element, interfaces for the physical interaction between, the simulation programs and the models used.

Multi-level/Fidelity Zooming. The applied vehicle technology architecture, in general, should allow consistent analyses to be performed at all levels within the system. Similar multidisciplinary applications, so as to the importance of interfaces to Multi-level analysis. The term Multi-level is also known as numerical zooming or higher fidelity forward. The fundamental goal is to bring higher fidelity information up to a system view of the model where the application can "see" the effects of all the constituents interacting together. The definition of higher fidelity information includes 1-dimensional through 3-dimensional Computational Fluid Dynamics (CFD), experimental data and historical rules of development.

With a BCA approach the need to "glue" together different types of applications becomes a critical aspect of the environment. Earlier programs such as iSight and Model Center use scripting languages as this glue. This requires wrapping an application in a scripting language such as Perl, Tel, or Python (Claus at all., 1991) to expose the application or data that one wishes to bring into the environment. These applications expose parameters in this environment by parsing the applications input and output text files. With this technique the application is exposed as a single entity based on a set of input and output parameters. This technique works reasonable well when less that half a dozen applications are involved in a given process and when they reside on a single platform. Also, the size of the inputs/outputs from the application is restricted to small text files (a few megabytes). This technique tends to break down when the number of applications grows beyond 10 – 25 and the inputs/outputs of a given application are non-text files and are of a large size (100s of megabytes to gigabytes). A great deal of knowledge has to be included in the wrapper to interact with the application on the lowest possible level that the application will support. The wrapper that exposes the object (application, hardware, etc.) will be referred to as a service provider. AQ service provider exposes discrete functionality of an object by a set of attributes to the environment; the functionality exposed is referred to as a service. The act of inserting the service into an environment is referred to as publishing. Two types of service providers are envisioned: Method Service Providers and Context Service Providers. A Method Service Provider publishes one or more methods associated with a given application where a Context Service Provider publishes one or more pieces of data associated with a product model (IMM or SPM). The following are required key features creating service providers:

1. Wrap with an object oriented language
2. Communicate intermediate results back to the client
3. Develop standard interfaces for application domains
4. Trap errors encountered within the application and pass meaningful information back to the client
5. Enable the application in a server mode to allow finer granular interaction between the wrapper and the application
6. Expose the application at a level of granularity that supports the most reusability
7. Once the service providers have been created it must then be published with attributes so the environment knows where it is and what it can do. Some examples in the world are: Sun’s Jini Technology (Lutz, 2001), web Services Sun ONE, Microsoft´s.Net (http://sun.com), Globus, Integrated Virtual Product Development (iVIP) etc.

Classification of Interfaces

Simulation tools have usually been designed as stand-alone applications in a prescribed work flow. Any two tools rarely use the same native model description or data structure. Interfaces provide a means of communication between two or more coupled applications. Interfaces can be categorized in terms of work flow aspect. Here, a distinction can be made between uni-directional and bi-directional interfaces (Sehra et al., 2006), Fig. 1. A uni-directional interface is needed if one program is used as a pre-processor for a second program. Typical examples are grid generators for fine element analyses. Bi-directional interfaces handle the flow of information between two running simulations. Typical examples are co-simulation interfaces.

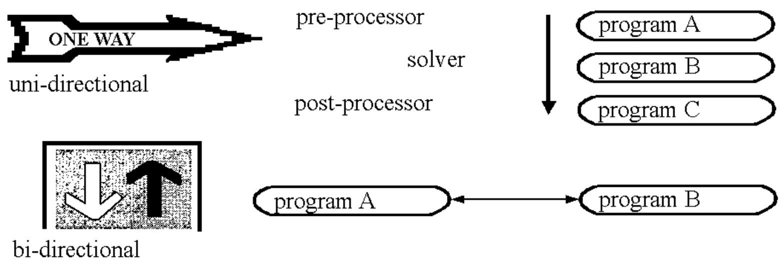

Figure 1: Uni-directional and Bi-directional Interfaces

The concepts of a connector object within the vehicle architecture is centered on providing a suite of objects that allows two components to connect together whether they are of the same/different discipline, same/different fidelity or same/different computing platform and have the object to handle all the intricacies of that connection. A way to illustrate this concept can be served by describing how this connector object would work in assembling a vehicle engine numerically. Although engine components are the basic building blocks of propulsion simulations, connector objects are the means by which components communicate and provide the technology support for zooming and the required expansion/contraction/averaging of data. Connectors are represented in the architecture as objects. Additionally, the connector object provides a means to introduce distributed processing into the subject engine simulations. Connectors not only facilitate “what” data moves but also “how” the date moves around within the simulation. When the nature of the simulation determines that a connector doesn’t add anything, or isn’t needed, the effect of the connector is a data pass-through operation (Sehra et al., 2006). Pictorially these concepts can be illustrated in Fig. 2.

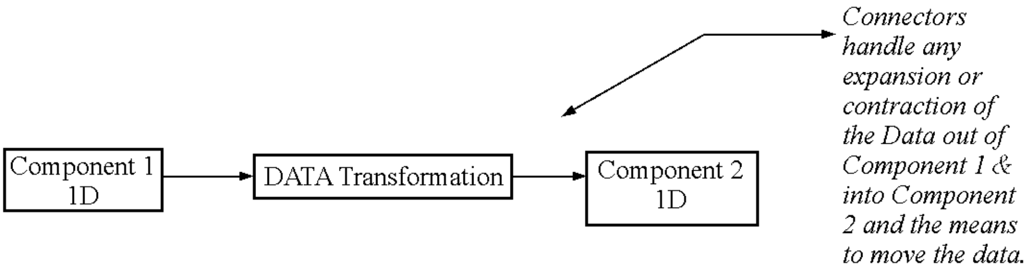

Figure 2: Effect of the connector

The connections between the engine components which are the source of the data and the methods are implemented with C++ classes called “connectors”. Every such connection between a source component and a destination component uses two different connectors, a source connector and a destination connector. Thus a component has one input connector for each input and a many output connectors as there are other components which use this component’s output as input data. The connectors, upon creation, determine whether the mating connector is local or remote. A local connector is the same process and hence the two connectors may directly call methods of one another in order to request and transfer data. A remote connector is a different computer and hence requires communication of messages in order to exchange data. COM (http://www.zgdv.de), COBRAQ (Pattison, 1998), Java RMI (Fintan, 2002), and PVM (Niemayer & Knudsen, 2002) are representative libraries that could be used to transport the data.

When an engine component is ready to execute, the connector transfers the data from the message to the engine component object. The very significant advantage of this approach is that there are no software concurrency problems because of multiple engine components updating concurrently in different machines. This allows all remote communication from other engine components in other computers to actually become communication calls to the single component which then distributes the data request or data reply information to the individual C++ objects representing the engine components, avoiding software concurrency issues.

4 PROCESS REPRESENTATION AND COMMUNICATION OF DISTRIBUTED DATA, APPLICATIONS, AND VESTED PARTICIPANTS

The subject applied vehicle technology architecture is comprised of the hardware and software computer systems needed to perform all the required analyses that are involved in vehicle design. This architecture must operate within a highly distributed, heterogeneous modeling and computing environment (Sehra et al., 2006). The envisioned architecture is an object oriented peer-to-peer (P2P) service based open architecture that must support the specified layers, shown in Fig. 3. Starting from the bottom of the figure, Layer 1 consists of the computer hardware in the system. Next, Layer 2 functionality addresses the need for hardware resource management, such as load balancing on the hardware. Layer 3 represents the abstraction or the separation of the services/object from the hardware and "exposes/publishes" these services on the network as network services. In addition to the publication this layer must support the "discovery" of services by clients and the communication with or between the services. Finally, the top layer, Layer 4, represents an object model that enables the combining of the services to represent a process or multi-service transaction. This layer must also support the execution of this object representation of the process and the passing of information from service to service.

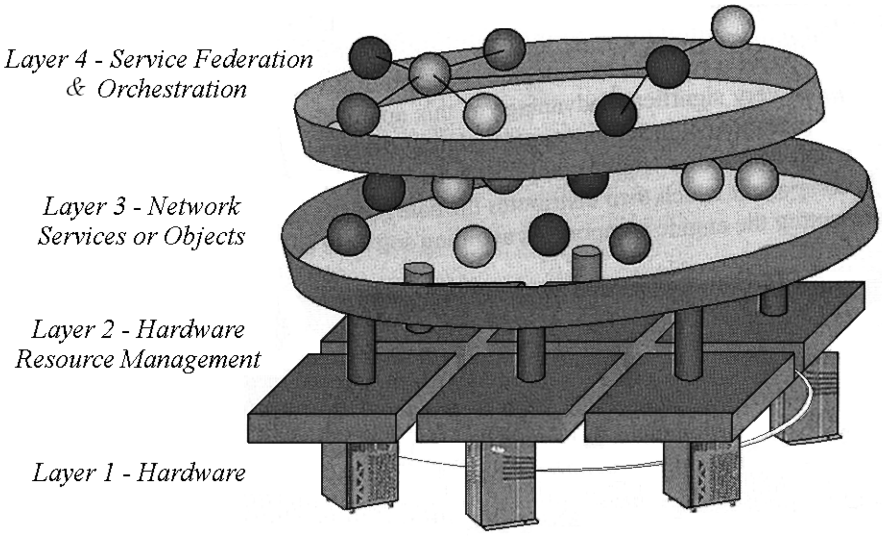

Figure 3: Recommended architectural functional layers

<u>Level 1 Hardware Computing Environment</u>
The architecture should run natively on multiple hardware platforms and operating systems. At a minimum it should operate under Unix, Linux, and the Microsoft Windows systems.
<u>Level 2 Hardware Load Balancing</u>
The architecture enables the use of available load balancing applications, such as Platform Computing´s Load Sharing Facility, IBM´sLoad Leveler, and NASA Ames´ Portable Bath System (http://www.csm.ornl.gov) etc.
<u>Level 3 Network Services – Service Oriented Architecture (SOA)</u>
SOA have three basic components (Service Requester, Service Registry, and Service Provider) and three basic functions (Publish, Find, and Bind).
<u>Level 4 Service Federation and Execution Coordination – An Object Model for Service Orchestration</u>
The P2P service-oriented architecture proposed targets multiparty service transactions. A collection of all registered service providers is referred to as a service grid. This is essentially level 3 in Fig. 3. A nested transaction is composed of a federation of providers that came together for completing a transaction. Hence, the primary function of Level 4 is to combine and orchestrate communication between the services in Level 3. The service providers do not have mutual associations prior to the transaction. They come together for a specific transaction. A standard object model representing these three components in a nested transaction is critical for the applied vehicle technology architecture. The object that represents the process, action, and data can be created by any end-user, application, or service and act as a service requestor and submit the object to the environment for execution. The object that represents the process must support different types of execution strategies for the process such as sequential, parallel, looping and conditionals. It must also account for the mapping/relationship of data between steps or services in the process. Finally, it is desirable that the process object support recursion.

5 MODULARITY – MAXIMALIZATION OF REUSE

The BCA creates the need to link together disparate applications with different needs and different data structures. This tends to create the development of applications that work on a very specific problem or narrow range of problems. One of the primary goals of an environment should be to develop a system that maximizes reuse when moving from one application, project, or product development to another. This will at least attempt to minimize the resources needed to get the next design applications to a point where it is useful in a timely fashion. An environment that promotes maximum reuse will have the following features:

1. Use an object oriented approach for the environment (Java, C++, etc.)
2. Create Common Object Models for specific domains (CAD, CAE, Optimization, etc.) and pass these objects around to the services when possible
3. Create standard interfaces for services
4. Create generic wrappers for applications
5. Separate product data from applications and their wrapper
6. Have at least one “champion” of the environment

Although all of these sound logical they are by no means trivial elements when undertaking a new development effort. A major portion of the resources used when going over to a new application is in the development of the product models (Stodola, 2007). That is the Master Model, Intelligent Master Model or Smart Product Model. Also, to modify existing components and to bring in additional applications at any given time takes a considerable amount of effort to do properly if you desire reuse. Finally, item 6 is essential but often easily over-looked. If an organization does not commit the resources to have an individual who is a “champion” of the environment the effectiveness of the use of the environment will be greatly hampered.

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Statistical Analysis of the Impact of Selected Factors on the Rate of Accidents

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ABSTRACT: The main purpose of this statistical analysis was to find objective relationships between the indicators of traffic accidents in selected European countries and the factors which are no doubt important for the safety of road traffic, for example, general prevention of accidents and the relevant requirements of the road traffic regulations, training and examination of new drivers, the post-examination period, sanction system, technical parameters of roads and vehicles, and, last but not least, the influence of important social climates. In the assessment of the results, the index of corruption perception was also considered, which has proven an important modifier of influence of the mentioned key factors.

KEY WORDS: Road accidents, analysis, influencing factors, index of corruption perception.

1 THE SPECIFICATION AND OBJECTIVES OF THE ANALYSIS

The objective of the analysis was to assess, within the project of the Ministry of Transport Nr. 1F54L/033/160, "The stationary complex system of driver education and motivators for traffic rules observance on highways and roads" in an objective manner, i.e., using mathematical and statistical methods dependant on the rate of accidents, quantified by the number of fatal injuries in traffic accidents on the following selected (so-called explanatory) factors (the mentioned analysis serves at the same time for work on the project of the Ministry of Transport Nr. CG711-014-160 "Methods and tools for increasing the reliability of the human factor in highway traffic safety in the Czech republic"):

- General prevention and road traffic regulations
- Training
- Examination of new drivers
- Post-examination period
- Sanctions
- Roads and vehicles (technical parameters)
- Social events

The analysis has been carried out based on the data on the rate of accidents in nine selected EU countries (the CR, Spain, Great Britain, Greece, Hungary, the Netherlands, Portugal, Sweden and Slovenia) during the period from 1970 to 2005.

2 INPUT DATA

The statistical data on the rate of accidents have been taken from the following defined official sources. Qualitative assessment of the considered explanatory factors has been obtained in the form of an expert assessment, in particular from inputs received from the project SUNFLOWER+6 (www.sunflower.swov.nl).

2.1 ORGANIZATION

1.1.1 CENTRE OF TRAFFIC RESEARCH

The website of CDV[1] (www.cdv.cz) contains a large amount of statistical data concerning accidents on roads. Data are publicly available for the period 1995 – 2002.

1.1.2 IRTAD (INTERNATIONAL TRAFFIC SAFETY DATA AND ANALYSIS GROUP)

Data about the number of fatal injuries per 100 000 citizens in each of the nine considered countries are available on the website of IRTAD[2] (www.irtad.net).

2.2 ANALYZED DATA

For the purpose of the analysis, each of the nine assessed countries is characterized by:
- The time line determining the number of fatal injuries per 100 000 citizens (graph, table);
- The explanatory factors characterizing the environment – expert assessments;

Those qualitative factors are included in the original study in the form of a table specifying changes in the environment in each of the 9 monitored countries during 1970 – 2005.

For the assessment of issues in each country during the monitored period, the data received from the conclusions of the research task SUNFLOWER+6 were used, as defined above – specific data for each country are provided in the final study of the TWIST project in the appendix at the end of this study.

3 STATISTICAL ANALYSIS

The analysis of the relationship between the rate of accidents and selected factors has been carried out on a sample of 9 EU countries – the Czech Republic, Spain, Great Britain, Greece, Hungary, the Netherlands, Poland, Sweden and Slovenia. It is based on a time line containing data from the period 1970 – 2000 specifying:

- The development of the rate of accidents expressed by the number of fatal injuries per 100 000 km;

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[1] *Varující vývoj dopravní nehodovosti na silnicích v ČR ve srovnání se zahraničím*
URL: <www.cdv.cz> [cit. 2005/07/15]

[2] *Selected Risk Values*
URL: <http://cemt.org/IRTAD/IRTADPUBLIC/we2.html> [cit. 2008/03/03]

- Qualitative levels of individual explanatory factors – general prevention and road traffic regulations; training; examination of new drivers; post-examination period; sanction system; roads and vehicles; social climate.

For example, the data concerning the Czech Republic are as follows[3]:

Table 1: Influence on Road Safety

No influence	
Small (positive) influence	S
Big positive influence	B
Negative influence	**N**

Table 2: Qualitative levels of individual explanatory factors (Czech Republic)

Explanatory factor / year	**65**	**68**	**70**	**71**	**72**	**74**	**78**	**89**	**90**	**91**	**97**	**01**
General prevention and road traffic regulations						B	B		**N**		B	B
Training										B		S
Examination of new drivers												**N**
Post-examination period												S
Sanction system												**N**
Roads and vehicles	S											
Social climate		**N**	**N**	**N**	**N**			**N**	**N**	**N**		

For comparison, data on Sweden are as follows:

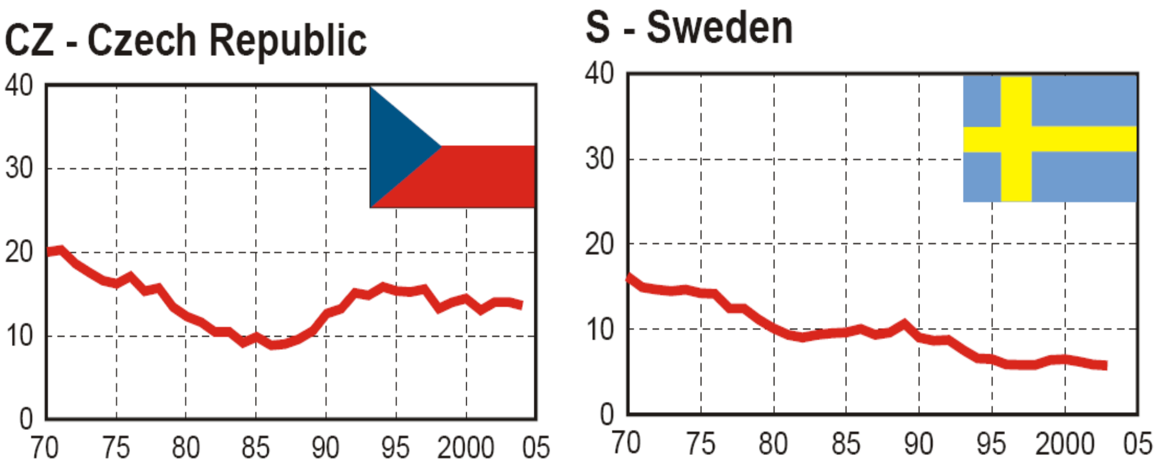
Table 3: Qualitative levels of individual explanatory factors (Sweden)

Explanatory factor / year	**72**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**
General prevention and road traffic regulations	B	B		B	S	S	S	B	B	S		S	B	B	B	S
Training								S	B		B					
Examination of new drivers			B						B		B					
Post-examination period																
Sanction system				B												
Roads and vehicles																
Social climate																

3 http://sunflower.swov.nl/ *SUNflower+6 - A comparative study of the development of road safety in European countries*

Explanatory factor /	90	91	92	93	95	96	97	98	99	00	01	02	03
General prevention and road traffic regulations			B	B		S	B	S	B	S			
Training	B			S									
Examination of new drivers	B												
Post-examination period	B												
Sanction system	B	S	B	B								B	
Roads and vehicles					S	S					S		B
Social climate													

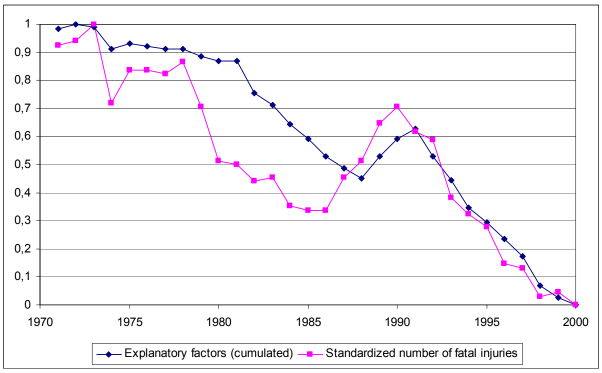
And finally, the development of the rate of accidents, expressed by the number of fatal injuries per 100 000 inhabitants (comparison between the Czech Republic and Sweden):



Graph 1: The development over time of the rate of accidents and explanatory factors

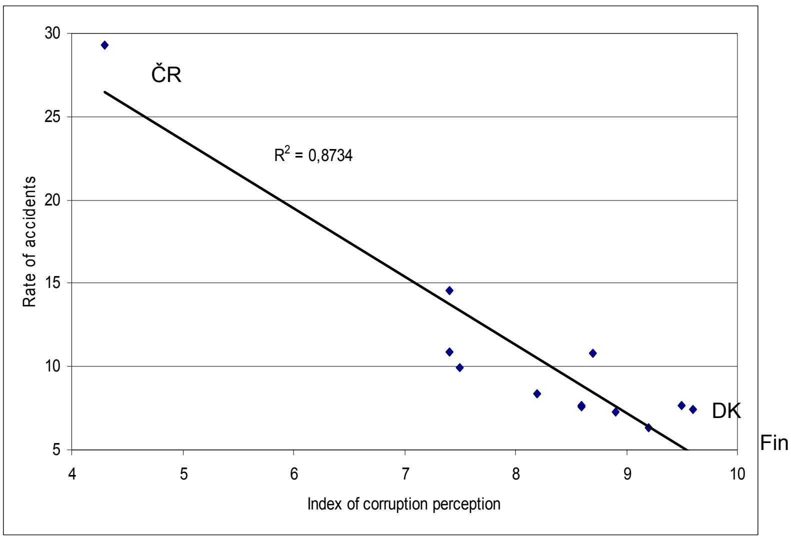
The input data shown above were available in a form which required, before the analysis itself, relatively wide pre-processing (quantification of factors, weighing of factors and countries, various transformations of data, etc.) which is not a part of this version of the submitted report. From a mathematical point of view, methods of non-parametric correlation analysis were used for processing, resulting in the following conclusions:

- The selected explanatory factors determine in a decisive manner the rate of accidents, and it is not therefore necessary to consider an introduction of other explanatory factors. This fact is obviously demonstrated, not only by the following graph No 2, but it is also objectively achievable by exact statistical methods – more than 90 % of all changes in the rate of accidents can be clarified just using the considered explanatory factors.



Graph 2: The development over time of the rate of accidents and explanatory factors

- The analysed data have proven that the following group of explanatory factors has a decisive influence on the rate of accidents – sanctions system, general prevention and relevant requirements of the road traffic regulations, roads and vehicles, and the social climate. The influence of other factors (the level of training, examination of new drivers, post-examination period) cannot be considered as demonstrative.
- An internal classification of the sanctions factored into several components allows for the identification of fundamental components. In this regard, the following have proven fundamental - the quality of imposed sanctions (the amount of fines, point system, banned driving, progressive rates in the case of repeated delinquency, existence of discouraging sanctions for especially unwanted delinquency), the quality of the method and consistence of enforcing the sanctions (communication between the Police and the acting authority, a progressive increase in sanctions, etc.) and the quality of bodies dealing with delinquencies.
- The influences of the social climate and its changes on the rate of accidents are important. For example, "fast" democratising processes in post-communist countries negatively influenced the rate of accidents, in particular in the Czech Republic. Another argument documenting the importance of this explanatory factor is the surprisingly high value of the determination coefficient expressing the relationship between the index of corruption perception and the rate of accidents, this time expressed as the number of fatal injuries per road kilometres in selected countries – Austria, Belgium, Czech Republic, Germany, Denmark, France, Finland, Great Britain, Ireland, Norway, the Netherlands and Sweden – see the following graph No 3.



Graph 3: The relationship between the rate of accidents and the index of corruption perception

- Another identified factor is the fact that events negatively influencing the rate of accidents do not have an entirely recurrent nature and show certain inertia. For example, the poorer moral of drivers resulting from social changes, a low quality sanctions system, etc., have a stronger negative influence on the rate of accidents than the “reverse” changes with positive influence – there is no “return” to the original status.
- In addition to the influence of the aforementioned main explanatory factors, attention in the analysis was also paid to the assessment of the influence of some specific characteristics of training – the necessity to undergo at least a part of the driving training with a professional driving school, the obligation of a basic preparation of teachers, existence of a control system of teachers and driving schools, a minimum number of obligatory hours of practical driving training, the real number of undergone driving training hours, the length of the practical examination and the existence of a testing period. In this regard it is possible to state that none of the mentioned characteristics of training has proven a statistically significant influence on the rate of accidents expressed in the number of fatal injuries per the selected number of citizens, respective per the selected number of road kilometres (the same conclusions are valid for the number of injured persons in traffic accidents).

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http://sunflower.swov.nl *SUNflower+6 - A comparative study of the development of road safety in European countries.*

Traffic deaths per 100 000 population since 1970
URL:<http://www.cemt.org/IRTAD/IRTADPUBLIC/we2.html> [cit. 2008/03/03]

Selected Risk Values
URL: <http://cemt.org/IRTAD/IRTADPUBLIC/we2.html> [cit. 2008/03/03]

Varující vývoj dopravní nehodovosti na silnicích v ČR ve srovnání se zahraničím
URL: <www.cdv.cz> [cit. 2005/07/15]

Integration of logistic systems into regional transport services using road cargo transport

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ABSTRACT: The paper deals in the analytic part with problems of taxes and charges paid by users of road transport. Our team found that those payments are lower than for railroad transport, so that toll system implementation can't incite movement of transport from road to railroad. New partnerships between road and railroad companies can be set up here. This will lead to intermodal systems with savings on tolls, namely domestically, but in international transport. The proposal part of intermodal system deals with systems like Mobiler and Cargo Domino or Modalohr and Cargo Beamer. The conclusion is a better regional service technology and costs savings thanks to the cooperation of road and railroad transport. Intermodal systems are destined for a minimal hauling distance of 600 km with accompanied or unaccompanied transport.

KEY WORDS: Cargo system, logistic system, road, rail, transport.

1 INTRODUCTION

This paper sums up the partial results of the ongoing task „1F53A/126/520 Basic logistic systems applications in cargo transportation in defined regions and its optimal function".

In the year 2006 a partial goal in the proposed solution for logistic systems was supported by railroad transport in logistic chains and rationalization of technology in transport of LCL and FCL consignments in railway transport. Research objects by the end of the year 2007 have their goal in the establishment of an optimal number of formation yards and centers for the manipulation with LCL´s.

Other partial goals (System rationalization of regional and national traffic network) were focused on finding reasons for decreasing the demand in railroad cargo transport and on other customer requirements. Basic logistic aspects related to the compact logistic chains have been found here. On this account a questionnaire has been formed. It has been filled by approximately 150 companies from the industry and business branches. From the questionnaire it follows that road transport is cheaper, more flexible and provides more logistic services than railroad transport does.

With regard to road-transport price an analysis of taxes and tolls has been made. The analysis dealt with taxes and tolls, which are paid by users of road transport and subsequently the impact of road-toll implementation on the competitive strength of road transport has been solved. Our results are that road transport is holding its strong position on transport market and it will be really hard to change it. Partially "The proposal of new intermodal road/railroad system" resolved find such system of service, which will fully accept cooperative relationships between two economic entities, each of them focused on different types of transport. We made a general analysis of the transport market in Switzerland, to find relevant answers for the general region-service using the road/railroad transport combination. The knowledge we got has been used for a summarization of recommendations for economical subjects in the Czech Republic.

2 ANALYTIC PART

From the statistical prognosis results the decreasing trend in railroad cargo-transport. The revitalization has to be consulted with experiences from West Europe, where it is usual that regional tracks are modernized only for passenger transport.

In the Czech Republic it is important, that manipulating tracks and handling areas for trucks have to remain after revitalization of regional tracks. If we ignore this rule, the intermodal systems, for example CargoDomino or Mobiler, can't be implemented. The part called "Proposal of new technology for regional services while using intermodal transport" follows. These problems will be solved in the year 2007, to find an optimal number of formation yards and centers for LCL consignments processing.

3 THE LIBERALIZATION OF THE TRANSPORT MARKET

From the submitted text it was seen that the liberalization of the transport market will bring much higher competitive pressures between different kinds of transport. Also the enforcement of cooperation between road and railroad transport is going to be very difficult, as the Swiss examples show. The Swiss federal rails AG, which have year by year problems with profitability, have another problem with the growth of competition in the railroad transport in the form of increasing number of private railway carriers.

Based on detailed analysis of Swiss rails we expect that it will be very hard for Czech Railways to realize transports of one-wagon and group-of-wagons transport of packages in the future.

Expected possible threats:

1. Cargo transport is on the second position (under passenger transport) from a timetable-creation point of view,
2. Whole-network tact-timetable influences train-forming plans in cargo transport, so that the demand time table is transiting to supply time table.
3. The biggest weakness of national railroad cargo transport system is that it has never been orientated to general area servicing,
4. Capacity is also induced by the homogeneity of each train on certain track. Nowadays the speed of fast trains, Eurocity trains or Intercity trains is rather comparable with transit goods-trains,
5. For general area service of customers without a direct railroad-connection the CargoDomino system is advantageous, which is unpretentious on system technology or technical road/railroad container reloading equipment,
6. The positive progression of railroad transport can be supported by strict legislation, which will restrict road transport via strictly abiding with the rules of traffic operations or self and social rulings.

4 THE SERVICE OF THE REGIONAL AND NATIONAL TRANSPORTATION NETWORK AND ITS RATIONALIZATION

In this section, an analysis of taxes and tolls paid by users of road transport has been done. The conclusion was that road-users pay less than railroad-users do. In the connected toll accounting proposal the idea is presented that the toll implementation will not decrease the competitive strength of road transport. Here will be a space for co-operative relationships between road and railroad haulers (using intermodal transport), which will lead to cost-savings in the case of tolls.

One part of the solution is in the intermodal system for the operation of an engaged area called Mobiler or CargoDomino (national transports) and Modalohr or CargoBeamer (international transports). All systems are described in detail with the advantages and disadvantages of each system. The solution is attached with pictures in the enclosure. This section is followed by the technology of area service via intermodal transport and here high possible savings in co-operation were found, due to the nonpayment of tolls. Intermodal systems are profitable from 600km for accompanied or unaccompanied transport. This year a detailed analysis of railroad transport in Switzerland was completed and the results from this are in implementation for our conditions.

5 TECHNOLOGY OF AREA SERVICE VIA INTERMODAL TRANSPORT

The proposal of transport system logistic applications, which uses a combination of road and railroad transport, can be applied on a wall-to-wall service of the area including a proposal of haulage intermodal units.

Nowadays a few types of verified systems are under operation with a documented positive impact on modal split, economic effects and the discharge of road infrastructure.

Such systems include Mobiler, Cargo Domino, Modalohr and eventually CargoBeamer.

From figure 1 it can be seen how such a service can be realized via different types of trains. On the picture with red arrows is an illustrated service of stations on regional tracks or eventually way stations via slow goods trains. Those trains will carry cargo to railway centers.

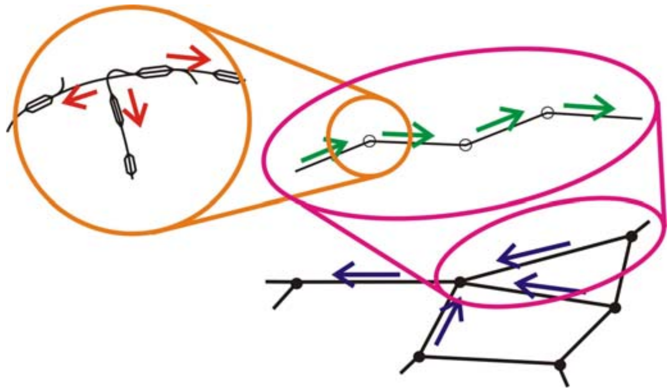
In the railway centers the cargo will be switched to continuous trains (green arrows) and the cargo will be transferred to the formation yard. Here “higher quality” cargo trains will be formed according to final destination (blue arrows).

The above mentioned, and described in the project, intermodal systems are modest regarding technical equipment for the manipulation of intermodal units.

In all cases it is horizontal reload. By the system Mobiler and Cargo Domino the reload can be realized near the manipulating track on hard surfaces. Road cargo carrier rides longways to the manipulating track with as much minimal distance as between loading areas for a smooth reload. A prerequisite is maximal vertical tolerance between the loading areas ± 15 cm.

Premises for the utility of the system:

1. A sufficient number of cargo wagons,
2. Availability of wagons,
3. Suitable informative and control system,
4. Electronic carriage document,
5. Service of railway station by slow goods trains twice a days,
6. Implementation of system “Night jump”,
7. Minimal demand on manpower.



Source: Authors

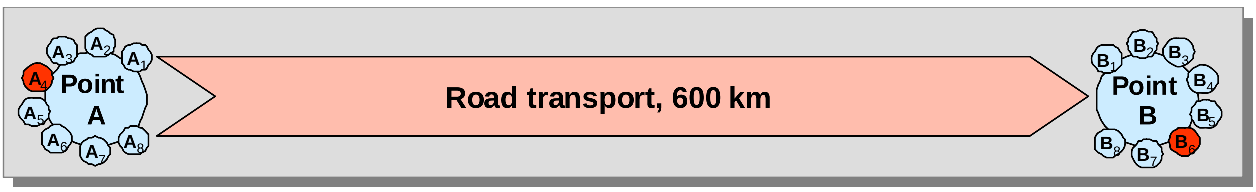
Figure 1: Schema of wall-to-wall area service via railroad transport

6 ECONOMIC EFFECTS ARISING FROM CHANGES IN MEAN OF TRANSPORT FROM ROAD TO RAILROAD

a) Direct road transport

Figure 2 represents the organization of direct road transport with two possible scenarios. In the first one, goods carrier serve at the place A customers A1 to An (consigner) and after traveling 600 and more km will serve target customers (receivers) B1 to Bn.

In the second scenario smaller goods carriers (<12 tons) will serve at the place A service of customers A1 to An (consigners) via a circular journey and gives the package to a logistic centre. In the logistic centre the packages will be consolidated according to directions and the cargo carrier (>12 t) will transport them to logistic centre in the area B and in the area B those packages are redistributed via a circular journey to target customers (receivers) B1 to Bn.



Source: Authors

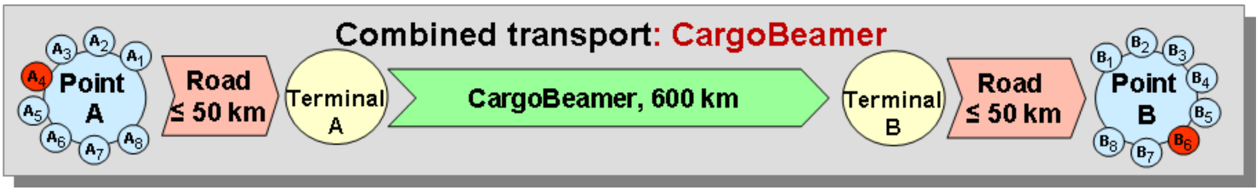
Figure 2: Direct road transport

Disadvantages of this system:

- low speed of transport,
- separation of the drive from the family,
- toll payment,
- attrition of infrastructure, congestions, accidents and so on.

b) Combined transport road/railroad

Figure 3 shows the organization of intermodal transport with the haulage of packages via road transport and their transport between areas A and B is supported by railroad transport. The combination of these means of transport derives benefit from both means of transport.



Source: Authors

Figure 3: Combined transport road/railroad

Advantages of this system:

- relieves the road infrastructure,
- no payment for toll,
- better labour conditions for drivers,
- lower carriage charges,
- lower production of pollutants.

If a higher cooperation between road and railroad transport will be seen high savings on toll can be achieved. From the shown schemes large savings can be evaluated. On the forwarding distance 600 km there will be savings of 4.20 Kč/km (for trucks with engines EURO III and 4 and more axles) which makes 2 520 Kč for one journey.

7 THE POSSIBILITIES OF A MORE EXTENSIVE USE OF RAILROAD TRANSPORT

During the solving of this problem, we made a list of investigations by approximately 150 companies from industry branches and from business sectors. The lists of investigations that were sent back by e-mail were over 20 % of the total.

The target of the list of investigations was on usually used means of transport and on required logistic services. The results are clear: 86 % of companies use road transport and only 9 % railroad transport. The answers nearly correlate with the statistics yearbook; each year the share of railroad transport is smaller and smaller compared to road transport.

Nearly 73 % of companies solve questions about means of transport and only 27% leave it to a forwarder. If we can achieve a change in that share, the situation will be much more positive for mass types of transport, like railroad transport.

If we exclude the clear influences leading to a change from road to railroad transport, like rises in the price of fuel, tolls or bottlenecks on the infrastructure with hypo-permeability (rise of congestions), than nearly 43 % of companies are unsatisfied with railroad service offers.

From the answers in the section targeted on road transport it was seen that only 20 % of companies realize their transport with their own vehicles. This is not surprising with regard to the high number of licenses for prosecution of road transport in Czech Republic. We also asked for additional services offered by external haulers and the highest interest was in the following services: compounding of packages 13 %, manipulation (loading and unloading) 19 %, distribution organization 13 % and delivery on agreed time 24 %. Other services are nearly equal with no more than 10 %. Highest requirements are on delivery Just in Time and Just in Time Sequence, because interviewed companies are connected to the supply chains for the automobile and the electro-technical industries. Road transport is used for international transports by 42 % and for intrastate by 58 %. ´We can agree with these values, because intrastate transport support also transports ovenware and raw materials. Road cargo transport offers many advantages to their users, such as: higher speed 22 %, flexibility 16 %, door-to-door transport 14 %, price 11 %, availability 8 % and just in time supply 8 %. It's possible that if we will ask for a smaller number of decisive priorities, then the percentage volumes will be different (higher). The flexibility of road cargo transport is incomparable for other means of transport. Therefore road transport will always be part of logistic chains.

In the railway transport is 100 % of transports realized by external haulers. We can assume that it was in 100 % ČD, a.s. Polled customers said, that they take an interest in additional services from external haulers on the related logistic centers. Namely for JIT 22 %, consolidation of packages 10 %, manipulations 17 % (loading, unloading, reloading) and stocking 10 %. Other services had less than 10 %. From the answers it is clear that we have to support the development of logistic centers with a minimum of two means of transport and a wide spectrum of services.

Railroad transport also offers other advantages like: manipulation 17 %, price 32 %, lower costs per transported ton 17 %, high-capacity wagons 17 %, transport of dangerous articles 17 %. High-capacity wagons have nearly a double higher capacity than road cargo vehicles. That fact is followed by lower price for transported ton.

Statistical prognosis shows a decreasing trend in railroad cargo transport in West Europe. In West Europe regional tracks are revitalized only for passenger transport. In contrast, in the Czech Republic we must keep manipulating tracks and hard surfaces at the stations on regional track for the development of intermodal systems. We can’t implement systems like CargoDomino, Mobiler and so on, if we don’t keep the above mentioned terms

8 CONCLUSION

This paper deals, in the analytical section, with the problems of tolls and charges which are paid by users of road transport and the conclusion is that the charges are smaller than in railroad transport. The authors think that the toll for using road routes will not decrease the competitive strength of road transport to the benefit of railroad transport. There is a possibility to establish a cooperative relationship between road – railroad transport.

The proposed intermodal road/railroad system gives a wall-to-wall service of regions via Mobiler or Cargo Domino and for international transport and proposed two systems (Modalohr or CargoBeamer). In conclusion the partial output is focused on area service technology using intermodal transport road/railroad and authors point out that the intermodal system is profitable for a minimum distance 600 km for both types of transport (accompanied or unaccompanied).

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The presented results are part of the task VLC2005CDVUP announced by the Ministry of Transport "Concept of public logistic centres in the Czech Republic in context of the importance of strengthening multimodal freight transport" with the solving period 2005-2008.

Technical Notes on GDF, GEOGRAPHIC DATA FILES Information support for the visually impaired Project R&D MD

1 WHY ACTUALLY CREATE AN INFORMATION SYSTEM FOR THE NICHE USER GROUP OF THE VISUALLY IMPAIRED?

- Equal opportunity; all (consequently also handicapped people) have the same right to information
- It is an adverse civilization factor that has an increasing tendency

2 BACKGROUND

For the safe movement of blind and weak-eyed people it is important sufficient and unambiguous information is obtained, mainly in a haptic way (white cane, stepping, etc.), while acoustic information is often supplementary. It is important that the amount of information is optimal (minimized), and its sequencing comprehensible. The principle of safe movement for the visually impaired consists of a sufficient number of easily and unambiguously identifiable orientation points and their sequence (creating guiding lines). Examples of these points are identifiable as home corners, retaining walls, parts of fences, and, sometimes, regular flowerbeds. However, many other points do not need to fulfil this function. In the event of snow these points are covered - grass kerbs, haptic elements and surface changes on walkway (natural and special pavement). Complementary to the function of haptic obtained information is acoustic information. This information serves for identification and routing. Blind people are able to move very well in a known environment with the help of the other senses and a blind cane. But in the case of an unknown environment he or she needs assistance from the surroundings. Information which one generally considers trivial becomes absolutely vital for blind people.

3 SYSTEM DESIGN

A system should respect the needs and recommendations of the end user group. The frequency of data providing in familiar environment may be one time per fifteen to thirty minutes. Orientation in an emergency situation has to be with an immediate response with a frequency of one time per minute. For navigation wide walkways are recommended without having to walk across a square, and the system has to integrate information about public transport (nearest bus stop etc.).

A significant set of functions that influence the system design is possible to define according to a few levels:

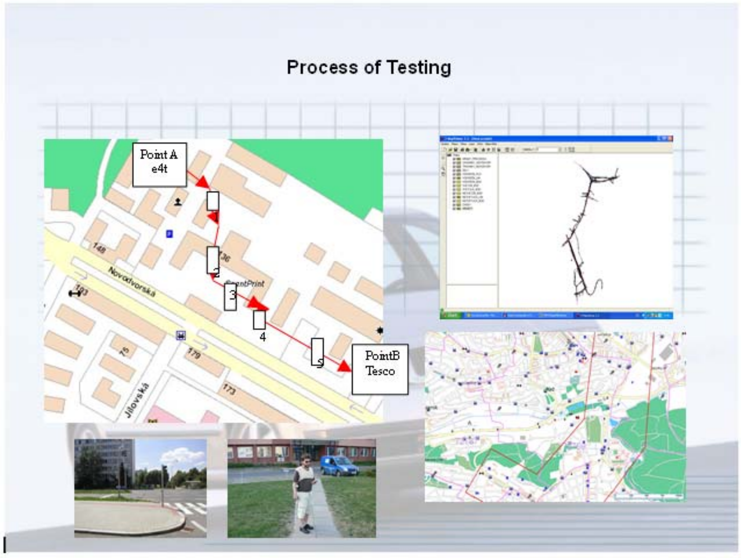
- Frequented zebra crossing without acoustic signalisation, passing tracks and roads. Blind people would rather use a longer, safer way with sound signalisation than take the risk of crossing roadway at unknown places.
- Navigation of extensive areas, loss of orientation points in front of railway stations, as well as supermarkets, walking in a straight direction are difficult for the visually impaired, blind people deviate from the direct way without recognising this situation.

- Unexpected and dangerous obstacles, badly parked cars on sidewalks (threats from unforeseen entrances to the roadway), awkward advertising columns, unsecured excavations etc.

4 TESTING AND RESULTS

For the purposes of testing a local part of Prague – Prague Lhotka was proposed. At the testing visually impaired people have participated, together with developers of the system. The system is based on the platform MDA (iPAQ 6500, QTEK 9110) with a voice output and an external GPS receiver. The testing simulated situations on how to get from place A to place B using public transport.

On the following slide the process of testing is demonstrated.



At the present time the final report is formulated from the research project and discusses the potential integration of the system among other systems supporting the visually impaired.

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Instructions to the autors

1 GENERAL GUIDELINES

Papers based on accepted abstracts and prepared in accordance to these guidelines are to be submitted through the journal's web site www.transportsciences.org.

All papers, using Microsoft Word2000 (or newer) are **limited to a size of at least 4 and no more than 8 single-spaced pages** on A4 paper size (297 mm X 210 mm), including figures, tables, and references and should have an **even number of pages**. The paper's top, bottom, right and left margins must be 2.5 cm. No headers, footers and page numbers should be inserted.

2 TITLE, AUTHORS, AFFILIATIONS

The title of the paper must be in title letters, Times New Roman, font size 16, and aligned left. Use more than one line if necessary, but always use single-line spacing (without blank lines).

Then, after one blank line, aligned left, type the First Author's name (first the initial of the first name, then the last name). If any of the co-authors have the same affiliation as the first author, add his/her name after an & (or a comma if more names follow). In the following line type the institution details (Name of the institution, City, State/Province, Country and e-mail address of a corresponding author). If there are authors linked to other institutions, after a blank line, repeat this procedure.

The authors name must be in Times New Roman, regular, and font size 12. The institution details must be in Times New Roman, *italic*, and font size 10.

3 ABSTRACT

The abstract should start after leaving eight blank lines. Type the text of the abstract in one paragraph, after a space behind the word abstract and colon, with a maximum of 250 words in Times New Roman, regular, font size 12, single-spaced, and justified. After leaving one blank line, type KEY WORDS: (capital letters, Times New Roman, font size 12), followed by a maximum of five (5) key words separated by commas. Only the first letter of the first key word should be capitalized.

4 THE TEXT

The main body of the paper follows the key words, after two blank lines (i.e., two blank lines between the first heading and the key words). The body text should be typed in Times New Roman, font size 12 and justified. The first line of the paragraphs should be indented 5 mm except the paragraphs that follow heading or subheading (i.e., the first line of the paragraphs that follow heading or subheading should not be indented). Never use bold and never underline any body text.

4.1 HEADINGS AND SUBHEADINGS

The headings are in capital letters, Times New Roman, font size 12. Subheadings are in title letters Times New Roman, font size 12. The headings and subheadings must be aligned left and should not be indented.

Leave two blank lines before and one after the heading. There should be one (1) blank line before and after the subheadings. All headings and subheadings must be numbered.

If a heading or subheading falls at the bottom of a page it should be transferred to the top of the next page.

4.2 FIGURES AND TABLES

Figures, line drawings, photographs, tables should be placed in the appropriate location, aligned centre, and positioned close to the citation in the document. They should have a caption, Times New Roman font size 12, with a colon dividing the figure number and the title (Figure 1: Material properties) and should be numbered consecutively, e.g. Figure 1, Figure 2, Table 1, and Table 2.

4.3 REFERENCES

At the end of the paper, list all references with the last name of the first author in alphabetical order, underneath the heading REFERENCES, as in the example. The title of the referred publication should be in italic while the rest of the reference description should be in regular letters. References should be typed in Times New Roman font size 12. citation standard ISO 690.

More details can be found at **www.transportsciences.org**.

TRANSACTIONS ON TRANSPORT SCIENCES

Volume 1 | **2008** | **Number 1**

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