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Dear readers,

This volume of the journal Communications – Scientific Letters of the University of Žilina is devoted to transport and its technology, control and economics. Transport system represents a complex of measures and tasks which have to be solved. The research priority of solving transport problems is of direct concern to authorities, businesses, citizens and the transport industry. It addresses both passenger and freight transport.

Transport plays a key role in people's everyday lives and is a decisive factor in economic competitiveness and employment. The promotion of its sustainable development without sacrificing either economic growth or the freedom of movement has become a central objective of the European Union policy. Transport has to face the challenge of supporting future economic development and subsequent traffic increase without degrading the quality of transport services and protecting the environment. Research and technology developments have an important role to play and are providing the European Transport System with innovative vehicle and transport technology and new forms of transport organisation and infrastructure. The successful future of transport depends on the use of different modes of transport and their coordination in operation. The solutions must be based on technological advances, must develop integrated, "greener" and "smarter" transport systems for the benefit of the citizen and society, respecting the environment and natural resources.

The editorial board of our journal is looking forward to Slovak and foreign experts who deal with transport problems to use our scientific letters as a platform for publishing outcomes of their scientific and research activities.

Pavel Surovec

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EXPERIMENTAL EVALUATION OF SELECTED METHODS FOR MULTIGROUP TRAIN FORMATION

The purpose of this research project was to compare advantages and disadvantages of selected methods for multigroup train formation. Three simulation models of the marshalling yards were developed to generate and evaluate results for the selected methods. This paper summarizes the steps of the analysis and the results.

Key words: *multigroup train formation, marshalling yard, computer simulation*

1. Introduction

Railway transport influences the growth of many national economies. The railway transport should improve its competitiveness against other modes of transport, in particular the road transport. The following measures have to be taken: 1) implementation of research results and modern control methods and better utilization of the system capacity; 2) modernization of its infrastructure and equipment; 3) cost cutting through employment reduction; 4) improvement of the energy management and consumption; 5) safety improvements; and, 6) implementation of information technologies.

Train formation is one of key elements influencing the effectiveness and profitability of the freight railway transport. The process of train formation is costly and time consuming, requires significant resources, and produces a relatively high number of work-related injuries.

Presently, two key trends influence the profitability of the train formation process:
- consolidation of the train formation process in a number of highly-specialized and well-equipped marshalling yards, and
- increased customer demand for timely deliveries to support their just-in-time production.

Solutions to address these trends can be organized in the following three categories:
- operation management,
- infrastructure, and
- information systems.

This paper focuses on analyzing potential solutions within the operation management category. In particular, we examine the selection of the most effective method for multigroup train formation.

2. Methods for multigroup train formation

In general, the methods for multigroup train formation can be classified in two main groups [1]:
- step methods, and
- simultaneous methods.

Under the step method, the cars are first sorted based on the direction of their destination and assembled randomly on sorting tracks. Next, the cars are assembled sequentially into their final train formations based on the predetermined groups. In the second step, two activities are performed:
- move and arrange individual cars to sorting tracks, and
- assemble sorted cars into final trains.

Under the simultaneous method, the cars are first sorted to groups and then, in the second step, sorted based on the direction of their destination. Therefore, at the end of sorting, all cars are assembled in the final trains.

3. Research methodology

At the beginning of this research, we chose parameters whose values were used to evaluate and compare the selected methods for multigroup train formations. The term “Parameter Value” refers to values derived from measured characteristics, which can be used as a criterion for evaluating and comparing the selected methods.

Methods were evaluated and compared using the following criteria:
- time required for formation of a selected number of trains,
- number of tracks used for sorting,
- number of backward movements of humping locomotive to re-sort cars,
- number of movements of shunting locomotive to assemble outbound trains,
- time of use of the humping track,
- distance traveled by the humping locomotive, and
- distance traveled by the shunting locomotive.

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Both types of methods, step methods (traditional, square, simple, double, imposition, balanced increase) [1] and simultaneous methods (elementary, triangular, geometric, geometric with backward sorting) [2], [3], [4] were analyzed.

Specific methods of each type were selected based upon their actual and potential use.

The purpose of this analysis was to:
1. conclude whether it is possible to establish empirically mathematical formulas that could be used, given specific inputs (i.e., number of trains), to estimate time needed for a certain number of multigroup trains formation and, at the same time, evaluate potential use of these mathematical relationships for general use in various applications,
2. conclude whether it is possible to find some mutual dependences among formulas, described in point 1 above,
3. conclude whether it is possible to observe a statistically significant correlation between time required for train formation and all other selected parameters, and
4. formulate general recommendations for multigroup train formation in practice.

3.1 Computer simulation

Parameter Values were derived from a computer simulation.

The term "computer simulation" should be understood as an experimental analysis of real-life processes using a computer simulation model. The use of a simulation model enables performing a large number of experiments, generating and evaluating outputs, and identifying the optimal solution for use in the real-life application.

3.2 Villon simulation tool

Simulation models used for estimation of Parameter Values were built using the Villon simulation tool. This tool was developed in cooperation between the University of Žilina and the Simcon company. This tool is used for computer simulation of railway operation as well as operation of other transport modes.

The Villon simulation tool allows simulation results to be recorded to output files. Data recorded to the output files may be presented as a table, diagram or figure. These data may then be exported in an Excel format for further analysis and evaluation [5].

3.3 Simulation models used for examination of methods of multigroup train formation

Three simulation models of marshalling yards were created to generate Parameter Values:
- VirBa,
- Stará Harfa,
- Teplička.

The VirBa simulation model was built at first. The infrastructure of VirBa model has the serial layout of siding groups. The infrastructure used in this model is fictitious. Other two models – Stará Harfa model and Teplička model – followed thereafter. These models were built to verify VirBa model results. Stará Harfa model uses infrastructure of Žilina zr.st. marshalling yard. This infrastructure was chosen in particular because of this yard's parallel layout of siding groups. Teplička model uses infrastructure of Žilina-Teplička marshalling yard, which is presently under construction. This infrastructure was chosen in particular because of the yard's serial layout of siding groups that is the only one of the kind in the Slovak Republic.

3.4 Simulation experiments

Each simulation model was built to run a specific number of experiments. These experiments were identical for each of the three models. As mentioned earlier, each model was used to analyze the ten selected methods. For each method, six individual experiments were performed. These six experiments compose one test group and differ from each other by a number of assembled outbound trains.

The first experiment begins with two trains and the number of the trains increases by one in the subsequent experiments to a final number of seven outbound trains in the sixth experiment.

Assembled outbound trains are formed by cars that enter the simulation models on inbound trains.

The number of inbound trains and assembled outbound trains is equal in each experiment (i.e. all the cars that enter the simulation model on inbound trains exit the simulation model in assembled outbound trains).

Each train is composed of the same number of cars, namely nine cars. A unique destination is defined for each car. It means that during the secondary sorting each car belongs to a different group. The car (group) order in the inbound trains is generated randomly from a uniform distribution with parameters 1 and 9.

In each simulation model, ten packets of the simulation experiments were designed (i.e. one observed method = one packet). Each packet consists of six simulation experiments. So for each simulation model 60 simulation experiments were defined.

4. Research results

To answer the questions discussed in part 3 (the purpose of analysis), it was necessary to analyze Parameter Values obtained from computer simulation.

The analysis consisted of the following steps:
1. to evaluate whether formation time of outbound trains correlates to a number of assembled outbound trains and to derive correlation formulas ($y = ax + b$),
2. to analyze correlation coefficients (a, b) from formulas described in point 1 above and the correlation between calculated coefficients,

3. to examine whether (and to what degree) Parameter Values affect time needed for train formation, and
4. to compare results among the simulation models.

4.1 Correlation between time needed for train formation and a number of assembled outbound trains

In this step, data consisting of the start time of the departure sidings occupation were analyzed to examine the correlation between time needed for train formation and a number of assembled outbound trains. The occupation starts after displacement of correctly assembled outbound trains.

From the measured Parameter Values we derived the following formula for each method. This formula indicates linear dependence between the formation time and a number of assembled outbound trains.

4.2 Analysis of correlation coefficients (a, b) and the correlation between these coefficients

The objective was to analyze differences and ratios among correlation coefficients derived from the selected methods. Results were compared across simulation models.

Results (differences and ratios) obtained from simulation models were not equal. Therefore, it is not possible to generalize results of any of the simulation models. In other words, results from the simulation of one marshalling yard can not be used in another marshalling yard.

4.3 Influence of Parameter Values to time needed for train formation

In this step, we evaluated whether linear dependence exists between selected Parameter Values. The following pairs of selected Parameter Values were analyzed:

- distance traveled by the humping locomotive (independent value) and formation time required for a selected number of trains (dependent value),
- distance traveled by the shunting locomotive and the formation time required for a selected number of trains,
- distance traveled by the humping locomotive and the time of use of the humping track,
- number of backward movements of humping locomotive to re-sorting cars and the distance traveled by the humping locomotive,
- number of movements of shunting locomotive to assemble sorted cars into final train and the distance traveled by the shunting locomotive,
- number of tracks used for sorting and the time required to assemble a selected number of trains from ordered groups from sorting sidings
- number of tracks used for sorting and the number of backward movements of humping locomotive to re-sorting cars,
- number of tracks used for sorting and the number of movements of shunting locomotive to assemble sorted cars into final train.

In addition, ratios among all Parameter Values were analyzed. The purpose of this calculation was to find out if the ratio of values of two selected Parameter Values of the selected method is equal for each number of assembled outbound trains. If a ratio of a pair of Parameter Values is equal for a different number of assembled outbound trains, then it is possible to declare the validity of this ratio for the specific marshalling yard. In this case it would be sufficient to calculate the ratio between selected Parameter Values only for one number of assembled outbound trains. Following this it may be possible to calculate another Parameter Value for the remaining number of assembled outbound trains. It will be not necessary to obtain this Parameter Value with the help of computer simulation.

The results of this analysis did not fulfill the expected assumptions. Therefore, it is not possible to generalize the results from one simulation model and use the results from one marshalling yard in another marshalling yard.

The ratio analysis for selected Parameter Values showed that only the simulation models with serial layout of siding groups produce approximately equal results for each observed number of assembled trains.

4.4 Comparison of results among simulation models

Finally, the results of the simulation analysis were used to develop ranking of the observed methods for multigroup train formation. Criteria of ranking were all Parameter Values.

By comparison based on formation time required for three or more assembled outbound trains, the three best methods were – triangular simultaneous method, geometric simultaneous method and geometric simultaneous method with backward sorting. Only by formation of two trains the traditional step method was the most efficient.

The traditional step method showed the best results by comparison based on distance traveled by the humping locomotive by assembling two or three trains. Only in the Stará Harfa model the traditional step method was the best method in the formation of four trains. By formation of two, three or four trains (the Stará Harfa model) these methods follow in rank – triangular simultaneous method, geometrical simultaneous method and geometrical simultaneous method with backward sorting.

The simultaneous methods achieved the best results by comparison based on distance traveled by the shunting locomotive because after the secondary sorting, the cars on the outbound train are correctly assembled. As a result, the distance traveled by the shunting locomotive equals zero. When step methods are used, it is necessary to assemble cars to train and to move them to the departing group. The traditional step method showed the worst result at comparison based on this criterion. Other step methods have approximately equal results (values are about 75% of the value measured for the traditional step method).

The top three methods based on time of use of the humping track for three to seven assembled outbound trains were respectively - the triangular simultaneous method, geometric simultaneous method and geometric simultaneous method with backward sorting. The traditional step method was the best method only when forming two trains.

When comparing the number of tracks used for sorting, the geometric simultaneous method and the geometric simultaneous method with backward sorting were equally effective and were the most efficient. The following methods ranked in efficiency as follows – triangular simultaneous method, square step method, imposition step method and double step method. The elementary simultaneous method and the traditional step method showed the worst results.

By formation of two or three trains the traditional step method showed the best results by comparison based on the number of backward movements of the humping locomotive in order to re-sort cars. In the formation of four trains, the traditional step method and all simultaneous methods (except the elementary simultaneous method) showed equal results. By the formation of five or more trains the simultaneous methods (except elementary simultaneous method) showed the top three results.

The simultaneous methods were the most efficient based on the number of movements of the shunting locomotive in order to assemble the sorted cars into the final train, because they are correctly assembled on the outbound trains after the secondary sorting is finished. These methods are followed by the imposition step method. The traditional step method was the least efficient.

5. Conclusion

The following facts (in reference to the research goals from part 3) were found by the experimental evaluation of selected methods for multigroup train formation:

1. It is possible to estimate the formula from the measured Parameter Values for dependence between formation time and a number of assembled outbound trains. This formula signifies the linear dependence of time on the number of trains (Fig. 1). The comparison of coefficients indicated that it is not possible to generalize the results of any of the simulation models. Therefore, we conclude that it is not possible to derive generally valid formula to calculate time required for train formation in any marshalling yard.
2. The differences and ratios of correlation coefficients (a, b) of linear dependence formulas obtained from simulation models were not equal. Therefore, we conclude that it is not possible to generalize the observation results from any of the simulation models.
3. The analysis of ratios between the selected Parameter Values showed that only the simulation models with a serial layout of siding groups produce approximately equal results for each observed number of assembled outbound trains.
4. The triangular simultaneous method, geometric simultaneous method and simultaneous geometric method with backward sorting produced the best results using any of the Parameter Values (Fig. 1).

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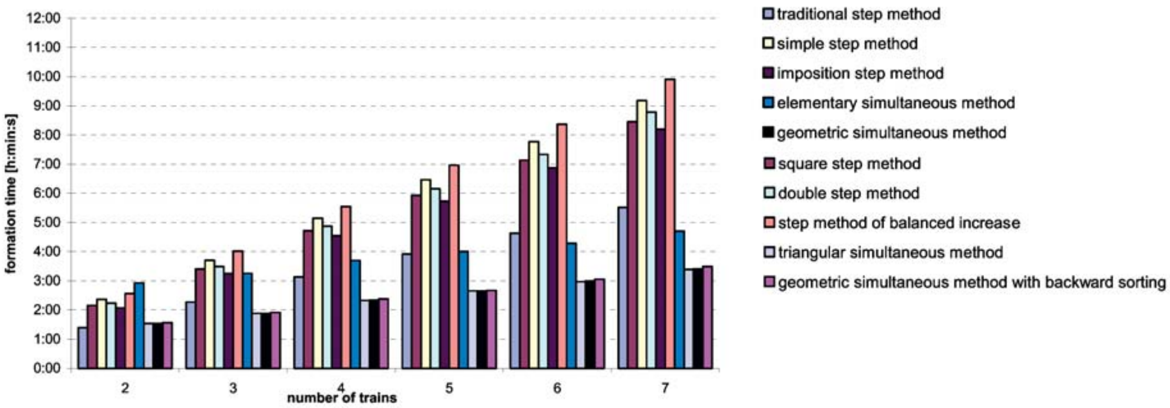

Figure 1. Comparison of formation time on Teplička model

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THE EXACT AND NEAR OPTIMAL SOLUTION OF THE COMPETITIVE UNCAPACITATED LOCATION PROBLEM

This paper is dedicated to the recent unprecedented boom of new supermarkets and hypermarkets in middle Europe. The motivation is to provide for the newcomers the tool for decision support, and to help answer the questions: "Is still economically advantageous to build new shopping malls and where to locate them?" We introduce the four versions of data correcting algorithm and three heuristics: simple exchange heuristic, exchange heuristics enhanced by simulated annealing metaheuristic, and genetic algorithm. All these methods were examined at the benchmarks of practical nature. This research showed the data correcting method as useable for practical instances of this problem. There were also identified interesting dependencies between the computational time and the number of competitors.

1. Introduction

In the area of middle Europe enormous boom of supermarkets and hypermarkets in the last years can be observed. They quickly get a favour of customers and are very popular. In this context arises a question where the limits for supermarket chains extensions are. Before the newcomer comes or before the existing supermarket chain is extended, it is essential to estimate if these steps can bring a profit. The future success of a shopping center depends on the quality of services, competitive advantages, sale management, and location of the store. The location of the store is considered as the most important because the neighbourhood of shopping center determines the level of competition, costs for supply management, labour costs, volume of demand, etc. In this paper we deal with the quantitative approach which allows performing a simple analysis of the supermarket chain extension. This approach can be used as a decision support tool for this difficult problem.

This paper is organized as follows. Section 2 presents a mathematical model of this problem. Section 3 is dedicated to the data correcting method, which allows solving this model to optimality. In section 4 the used heuristic methods are briefly described and in section 5 the results of computational experiments are presented. The set of benchmarks was generated from the digital road network of the Slovak Republic (Cenek, Jánošíková, 2000). To conclude, section 6 attempts to identify an applicability area of presented exact methods.

2. The Competitive Uncapacitated Location Problem

Let us assume that we can neglect some secondary indicators like decreased proneness to save money, possibility to shop cheaper, and subsequent economic grow. Thereafter, the investor's decisions to built a new shopping center do not have substantive influence on incomes and expenses of the customers. The customers still need to satisfy their demand and must manage their budget. For a short time period we can suppose that the cost of a shopping center location, the operational cost, and the appropriate profit rate have to be covered by the profit of existing competitors. The success of a newcomer depends on competitive advantage and, as we can often see in practice, on appropriate location of the new shopping center.

This problem can be modelled by using the graph $G(V, E)$. Let $V = \{1, 2, 3, ..., n\}$ be a set of nodes where competitors, customers or potential newcomers are situated. We assume the aggregated customer, it means that one populated municipality represents one customer and the size of demand is proportional to the number of dwellers. Consider a set of arcs $E = \{(i, j): i,j \in V \}$ and let $d_{ij} \in \Re^+$ be the length of arc (i, j) in kilometres. The average purchase ability of the aggregated customer is denoted $w_i \in \Re^+$ for every $i \in V - (X \cup Y)$. The set $Y \subset V$ contains the nodes where the competitors are placed, and the set of potential locations of newcomers is denoted $X \subset V$. The deterministic costs for a shopping center location is denoted $f_j \in \Re^+$ for every $j \in X$. We set up the constants a_{ij} to have a possibility to estimate the proportion of customers' demand attracted by newcomers. The constants a_{ij} represent the shopping center $i \in X \cup Y$ attractiveness for the customer $j \in V - (X \cup Y)$. These constants should respect the preferences of customers, the service quality, and price rate, which all are very difficult to quantify. To keep a reasonable simplicity of the model we decided to use in a_{ij} calculation only the length d_{ij} between the shopping center i and the customer j. In accordance with (Benati, 2003) we used the formula $a_{ij} = \exp(-\beta d_{ij})$, where the β is the coefficient of spatial friction. This coefficient was statistically estimated in (Benati, 2003). Let x_j be a binary variable taking on value 1, if a new facility is located in j for every $j \in X$ and 0 otherwise. The size of demand, which has been taken over by all newcomers then can be expressed by the formula:

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$$w_i = \frac{\sum_{j \in X} a_{ij} x_j}{\sum_{j \in X} a_{ij} x_j + \sum_{j \in Y} a_{ij}}.$$

Consecutively, we can define the solved problem as the following combinatorial problem:

$$\max_{Q \subseteq X} f(Q) = \sum_{i \in V-(X \cup Y)} w_i \frac{\sum_{j \in Q} a_{ij}}{\sum_{j \in Q} a_{ij} + b_i} - \sum_{j \in Q} f_i, \qquad (1)$$

where $b_i = \sum_{k \in Y} a_{ik}$ and $Q = \{i: i \in X \wedge x_i = 1\}$. The objective function (1), see (Benati, Hansen, 2002) has a useful property, $f(Q)$ is a submodular function of Q. The submodular function is defined by the following property.

Definition: Let V be a set of elements and $f: 2^{|V|} \to \Re$ a set function, then f is submodular if and only if

$$f(S \cup \{j\}) - f(S) \geq f(T \cup \{j\}) - f(T)$$

$$\forall S \subset T \subset V, j \in V - T. \qquad (2)$$

3. Data correcting method

The mentioned property (2), submodularity of objective function, is used in data correcting method (DCM), proposed in (Benati, 2003) for the effective solution of the problem (1). This method is made up of three phases:

- Pre – processing phase,
- VNS heuristic,
- Binary search.

The purpose of the pre-processing phase used is the reduction of the size of the solved problem employing special inequalities. The essence of this algorithm is the branch and bound method. While the branching process is running, the current sub-problem is described by a pair of the sets S_0 and S_1, $S_0 \cap S_1 = \emptyset$. The set $S_0 \subset X$ contains variables that are fixed at value 1, $S_0 = \{ j \in X \mid \mid x_j = 1\}$ and the set $S_1 \subset X$ contains variables that are free, $S_0 = \{ j \in X \mid x_j$ is free variable$\}$. The submodularity of the objective function allows constructing several rules for x_j variables fixations at value 1 or 0. The data correcting method employs the inequalities (3) and (4) for the variables fixation. If we have the node of a branching tree determined by the sets S_0, S_1, and $j \in S_1$, then the variable x_j can be fixed at value 0, if the following inequality holds:

$$f(S_0 \cup j) - f(S_0) \leq 0. \qquad (3)$$

Likewise, if the node of the branching tree is determined by a pair of sets S_0, S_1 and $j \in S_1$, then in the corresponding sub-tree the variable x_j can be fixed at value 1, if the inequality holds:

$$f(S_0 \cup S_1) - f(S_0 \cup S_1 - j) \geq 0. \qquad (4)$$

The variable fixation is processed at the beginning of algorithm before the branching phase and also consecutively in every node of branching tree. We used the simple exchange heuristic method VNS (variable neighbourhood search) to decrease the number of processed branches during the tree searching and to improve the starting solution. The VNS improves the randomly generated starting solution. This process uses the permissible operations and is not completed until the algorithm gets stuck in a local optimum. This procedure works as follows: consider all feasible solutions obtained by moving a shopping center to an unoccupied location, by adding one shopping center to an empty node, or by removing a location. The algorithm computes the changes in an objective function and accepts the most suitable one. If no improvement has been found, then a local optimum is determined. This procedure can be intensified by metaheuristics, as well.

We built four versions of the data correcting algorithm. The first one is the *DCM B*, here we used the basic branch and bound method without the VNS heuristic. The second version, DCM ExH, employs the simple exchange heuristics and the third DCM SA1 is the version with the exchange heuristics enhanced by metaheuristic simulated annealing with the first-fit search strategy. The last version DCM SA2 applies the metaheuristic simulated annealing, which uses the best-fit strategy for neighbourhood search.

The computation of the upper bound of the objective function for every branch can intensify the branch and bound method. According to (Benati, 2003), as the upper bound for branch S_0, S_1, can be used the value $f^U(S_0, S_1) = \min[f_1^U(S_0, S_1) \cdot f_2^U(S_0, S_1)]$, where:

$$f_1^U(S_0, S_1) = f(S_0) + \sum_{j \in S_1} (f(S_0 \cup j) - f(S_0)) \text{ and}$$

$$f_2^U(S_0, S_1) = f(S_0 \cup S_1) - \sum_{j \in S_1} (f(S_0 \cup S_1) - (f(S_0 \cup S_1 - j)).$$

We used the depth first strategy for searching the branching tree.

4. Simple heuristics

We adapted several simple heuristics to solve this problem. These heuristics allow evaluating the effectiveness of the exact methods. We used the exchange heuristic (ExH) and simulated annealing (SA), which were used in the data correcting method. They both employ the best-fit strategy for neighbourhood search. We modified the genetic algorithm (GA) (Kratica, Tošic, Filipovič, Ljubić, 2000), which was originally addressed to the Uncapacitated Facility Location Problem. The good computational efficiency of the algorithms was achieved by the parameter tuning.

5. Computational experiments

The algorithms were implemented in Delphi and were tested on the set of 120 benchmarks randomly generated from the Slovak road network. The used PC is a machine equipped with a Pentium IV processor with a 2400 MHz internal clock.

The benchmarks are organized in six groups according to their size 15 × 30, 20 × 50, 30 × 50, 40 × 100 a 60 × 200 a 60 × 2100. Each group encompasses 20 instances of the problem. The first number in the name of each benchmark group is the robustness of set $Y \cup X$ and the second represents the number of aggregated customers. The last class of benchmarks, 60 × 2100, has a privileged place because this size of the problem could be considered as a size of real problems in the Slovak Republic. As candidates for a new shopping center location are considered here almost all district towns. The values of all coefficients in the objective function were randomly generated from the pre-defined intervals. The coefficient β was set at the value $\beta = 0.195$.

The characteristics of all the mentioned heuristics can be seen in Figs. 1 and 2. Here we can see the total computational time (Fig. 1) and successfulness of heuristics in the optimal solution search (Fig. 2).

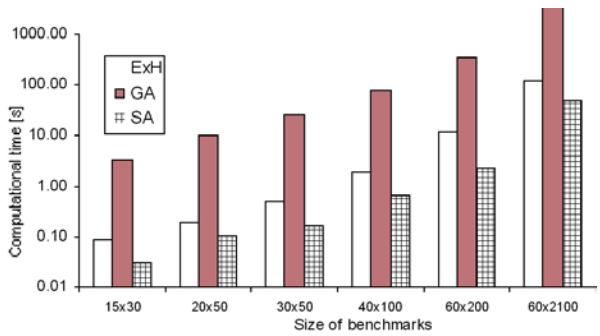

Fig. 1. Total computational time of heuristics

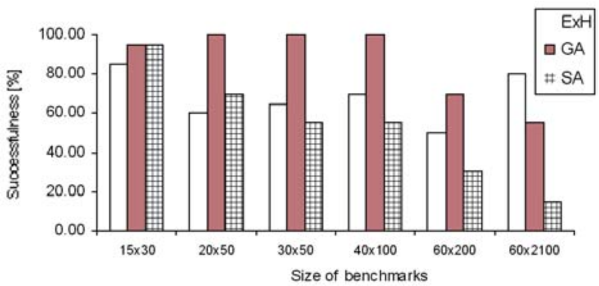

Fig. 2. Successfulness of heuristics

The total computational time for exact algorithms can be seen in table Tab. 1. The graphical representation is depicted in Fig. 3. Here, we can see the growing trend of the computational time and benefit, which was brought by using the VNS heuristic. The comparison of exact algorithms (Tab. 1) showed that the use of the simple exchange heuristics fits small-sized problems. The more sophisticated VNS heuristics (DCM SA1, DCM SA2) are more appropriate for large-sized problems.

Total computational time of exact algorithms Tab. 1

Size	DCM	DCM	DCM	DCM
15 × 3	0.01	0.01	0.03	0.65
20 × 5	0.35	0.33	0.37	2.96
30 × 5	0.58	0.55	0.65	5.99
40 × 10	21.24	20.24	20.60	40.56
60 × 20	13383.19	12578.75	29511.54	12043.71

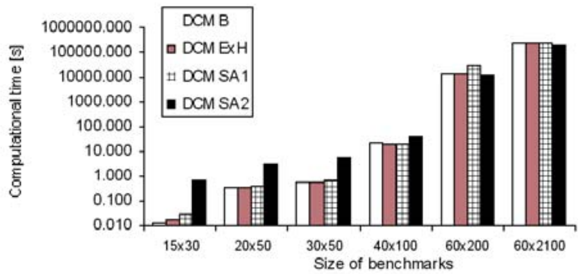

Fig. 3. Total computational time of exact algorithms

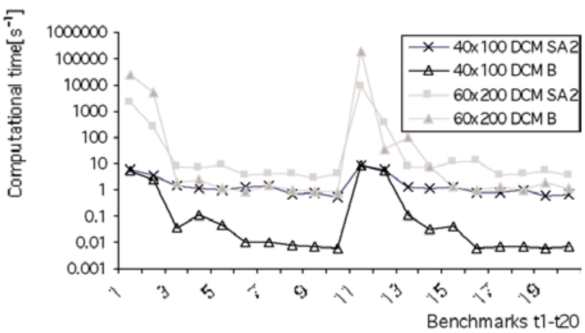

Fig. 4. Computational time of exact algorithms

As we mentioned, each class of benchmarks (t1–t20) was generated almost in the same way. The difference was only in the number of the already placed competitors. We divided the group of benchmarks belonging to one class (20 benchmarks) to two subgroups (t1–t10 and t11–t20, both 10 benchmarks). The number of competitors within each subgroup is distributed regularly. For the first benchmark the number of competitors is $|Y \cup X| / 10 - 1$ and for the tenth benchmark the number of competitors is equal to $|Y \cup X| - 1$. Thus, the first and eleventh benchmarks in each class have equal numbers of the placed competitors. As it can be observed in Tab. 2 and also in Fig. 4, the computational time of exact algorithm strongly depends on the number of competitors. The enormous computational time can be seen on the first benchmarks of each subgroup and then it rapidly goes down. The benchmarks t1, t2, t11 and t12 show the most adverse computational time in each group. The number of nodes where some competitors are placed is here less than 20 % of the all-possible shopping center

The computational time of exact algorithms Tab. 2

Benchmark	40 × 100		60 × 200		60 × 2100	
	DCM B	DCM SA2	DCM B	DCM SA2	DCM B	DCM SA2
t1	5.017	6.039	2235.66	12166.224	25923.924	19526.161
t2	2.409	3.613	270.471	255.388	5116.966	4958.842
t3	0.034	1.397	1.614	7.448	1.962	46.299
t4	0.110	1.182	0.241	7.128	2.536	149.956
t5	0.049	0.940	0.069	9.133	1.098	135.135
t6	0.009	1.340	0.045	3.651	0.892	44.451
t7	0.010	1.440	0.063	4.308	1.503	98.819
t8	0.008	0.712	0.028	4.133	0.982	46.392
t9	0.007	0.809	0.025	2.670	0.866	49.563
t10	0.006	0.520	0.026	3.969	0.790	52.970
t11	8.339	9.059	10485.07	9159.76	1198356.147	182900.021
t12	5.023	6.064	387.717	365.059	37.256	181.564
t13	0.116	1.296	1.722	7.894	97.224	234.092
t14	0.031	1.095	0.062	7.157	8.107	162.974
t15	0.041	1.268	0.101	10.720	1.296	88.031
t16	0.006	0.752	0.141	12.436	1.060	81.829
t17	0.006	0.764	0.030	3.383	1.273	96.511
t18	0.007	0.942	0.029	3.993	0.939	84.630
t19	0.006	0.620	0.032	5.540	1.989	87.633
t20	0.006	0.713	0.043	3.725	1.200	85.331

locations. This interesting phenomenon was observed for all exact algorithms and for all sizes of benchmarks.

6. Conclusions

The described experiments have shown that the present exact solving methods are able to compute the Competitive Uncapacitated Location Problem to optimality in acceptable computational time for instances of problems, which correspond to reality. This model and algorithms can be used as a tool for decision support and allows analysing the possibilities of the shopping malls chains extension. The notably long computational time was measured for problems with a small number of competitors, but fortunately this cases do not correspond to any practical application of the discussed model. The supermarkets or hypermarkets have been already placed almost in every district town. The district towns were considered as the candidates for further extension of the shopping mall chains.

The real operation costs of the shopping malls, purchasing power of the population and etc., were not at our disposal. We estimated the lower and upper bounds for each interval and all the input data were randomly generated from these intervals. This fact could have an impact on the obtained results.

This approach can be used as a complementary tool in a decision-making process. An expert using several feasible solutions and his own knowledge and experience can choose a final solution. The interactive system for decision support (Bednár, 2002) can be a good help for experts.

Acknowledgement

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SUPPLY IN MARKETING PROCESS OF ROAD TRANSPORT

In defining the term marketing we can come out from the sole term, which means that the term marketing is necessarily connected with market activities. These activities are arranged in a particular sequence called a marketing process. Marketing process in road transport differs in many ways from the one in the manufacturing sphere, which is determined by the fact that a road enterprise provides services. This article deals both with the issue of marketing process in road transport and position of supply in this process.

1. Introduction

Market factors are an essence of the market. These factors comprise elements acting in the market as a base and elements – relations among them. Development of the market mechanism is determined by the existence of elements with a stabilization function. However, these elements have no sense without mutual interaction -movement and relations. It implies that market factors could be divided in the elements with *stabilization function* and the elements (relations) with *mobilization function*. Jedlička [1] named these elements stabilizers and mobilizers.

Stabilizers are the following elements:
- *entrepreneur, customer, goods.*

Mobilizers are the following elements:
- d*emand, supply*.

Of course, the position and relations between the stabilizers and mobilizers are the key determinants of the whole marketing process.

In general, *the supply* as the mobilizer of the market expresses one direction of move, which occurs between stabilizers – entrepreneur and customer. It represents a sum of tangible and/or intangible products, which sellers are willing to offer to buyers in the market in a way that allows to satisfy both sellers` and buyers` needs.

The market cannot emerge and exist without the fundamental market stabilizers (entrepreneur, customer, and goods) and without two market mobilizers (demand, supply) it is not able to carry out its function. On the one hand the supply is represented by an entrepreneur and on the other hand, it effects a demand, which is represented by a customer. *A dialectic essence of both supply and demand effects results in a competition function* [1].

Apart from this dialectic view, a supply in road transport can also be determined as one of the basic marketing terms in road transport and also as one of the steps in the marketing process, which starts when the needs arise and ends when they are satisfied.

2. Marketing process in road transport

According to Kotler [2] marketing is:

"... social and regulating process through which individuals and groups gain what they need and require through creation, supply and exchange valuable goods with others".

Marketing as a term has been defined in scientific literature by many theoreticians who have developed a great deal of definitions, but the definition quoted above pertinently describes and sequences particular *basic marketing terms* in a way to properly characterize the chronological succession of the marketing process. See Figure 1.

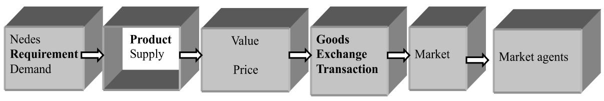

Fig. 1. Succession of marketing process

2.1 Need, Requirement, Demand

Need means lack of some kind of satisfaction. No firm evokes it, it is itself only in a person [2]. Neither employees of a marketing department evoke it, it has already existed before.

Requirement is a summary of the specific variants, which could meet this need. Whereas there are only a few human needs, there are a lot of requirements, which are constantly formed by the society [2].

Demand comprises lots of requirements for the specific products (goods, services) accompanied by the opportunity and willingness to buy them. So, requirements become the demand if they are supported by purchase power [2].

In case of *road transport* these terms get slightly different dimensions. It is rare to see *needs for transport* (maybe in a case of buying

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a car, when a buyer wants to test its parameters). If transport is one of solutions to satisfy human needs (for instance, visiting friends, taking a way to work etc.) there arises *requirement for transport* as a means of transportation. A – sort of transport has not been specified, there is specified only the need on the level, in which transport is considered to be one of the possibilities of its satisfying. If those interested specify their requirements for transportation (specify mode of transport) and express their ability to pay for it, the requirements become the *demand*. While in the stage of a requirement for transportation it could be met by any mode of transport (road, railway, air transport etc.), in the stage of a demand those interested have already decided for a specific mode of transport. If they have decided for road transport they confirm their decision by buying a transport ticket or signing a freight contract. [3]

Because the marketing theory associates the demand with a concrete product, it is also necessary to do it in transport. It means to associate demand with transportation. A customer does not express his interest in transport but in a possibility of transportation. From this point of view it is effective to introduce the term demand for transportation or *demand for transportation of the specific mode of transport*. Application of the marketing definition (the demand is amount of goods or services, which customers are willing to buy at a specific price [2]), allows to define this marketing term from a standpoint of road transport as volumes ***of transportation and other services, which are customers willing to buy at a specific price***. [3]

A graphical connection of these terms is shown in Fig. 2.

An assessment of requirements is several times greater in transport, for example demand for transportation in road transport. Until a customer decides for a particular transport operator, his requirement could be taken into consideration by several transport operators.

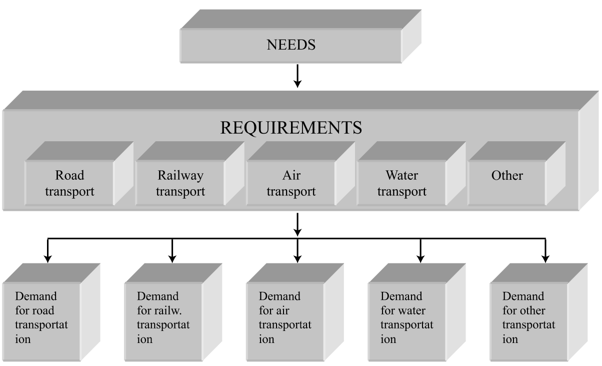

Fig. 2. Process of shiftings of needs and requirements to demand in transport

The demand is especially affected by factors lying outside a transport area. It is called a *derived demand*. This is the reason why the requirements for a protection of the environment are not realizable. If it were, consequently there would be decrease in the trade, freight transport and passenger transport. This is out of any transport policy power.

2.2 Product, supply

The next marketing term – product is obviously associated with some material – physical matter. In case of road transport this term expresses intangible goods – services, which satisfy a customer's requirements for transportation. Results of this activity are quantitatively expressed in performance of road transport firms.

Performance in road transport is determined by results of a combination of a *dispositional part* and *real part*. The term *dispositional part* is to be understood as a planned and organized arrangement of transportation processes, in other words, as an application of specific know-how for effectual transportation (for example, forwarding agency). The *real part* of the performance is a single transportation.

Other view of a road transport firm performance offers an application of the marketing theory, which divides a road transport firm performance to operational and market one. *Operational performance* is an offered transport performance, which becomes a *market performance.* Operational performance can be, for instance, and average transport distance. Market performance is, for instance, tons per kilometer and passengers per kilometer. Philosophy of inputs and outputs in a road transport firm is illustrated in Fig. 3. [3]

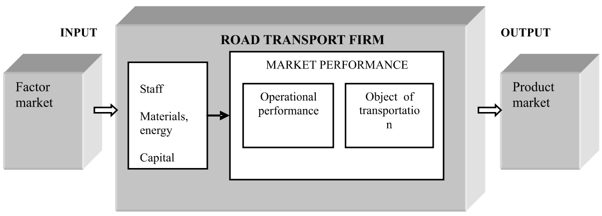

Fig. 3. Input – output of road transport firm

Volume of a market performance represents quantification of products of a road transport firm – *transportation services*. Supply is formed by potential transportation services, which a firm wants to offer to its customers.

The supply is another marketing term, which in road transport could be defined as a *volume of transportation and other services, which road transport firms are willing to offer in the transportation market at a specific price.* This definition is formulated this way for the following reasons:

1. Market price should cover seller' s production costs.
2. This view on a supply allows a mathematical formulation of the supply as a function of the price.

Marketing philosophy implies that in the process of developing and forming a supply of a road transport firm emphasis must be put both on the requirements for transport and the demand for road transportation. A typical example is a fact that not even in the *public transport* firms the supply is formed without regarding actual demand for the transportation. In this case demand is source of input data for scheduling links. Demand is determined through market research or other methods. [4]

Freight transport firms or taxicabs are more responsive to a customer's requirements.

Forwarding agencies have special position in the transportation market and work between the demand and supply of the transportation as "intermediates of supply".

2.3 Value, costs

Marketing theory [2] explains the *value* of a product (goods, services) as a customer's assessment of attributes of goods or services enabling to satisfy its needs. *The ratio of received benefits to invested costs* determines customer's perceived value of [3]. The benefits received from a transportation service – named *utility* – are determined by the attributes of transportation services (qualitative elements such as: speed, safety, comfort, availability and complexity of services), which should satisfy customer's needs. Invested costs of a transportation service by a customer are determined by a price for the transpiration service and all other costs associated with use of the transportation service. The value is a key criterion of choosing a product. After considering the price for transportation and assessing utilities of the available transportation services, the customer decides for a particular transportation service of a specific transport firm.

2.4 Goods, exchange, transaction

When people decide to satisfy their needs and requirements by a chosen product then it becomes *goods*, which is the object of a *transaction*. When exchange is carried out on the base of an agreement, then it is a transaction.

The exchange and transaction play an important role in a marketing of transport. If sellers want a transaction to be effectual, it is necessary to analyze what customers expect. Road transport firms have to analyze expectations of their customers, their requirements for transport means (speed, safety, comfort), shipping time, payment conditions and quality of additional services. If transportation services meet customer expectations, it is probable that exchange will be made and then transaction can be confirmed by an agreement.

2.5 Market

The terms exchange and transaction are closely connected with the term market. Marketing theory recognizes the following types of markets [2]:

- factor market and producer market,
- intermediary market,
- product market,
- government market.

Transport firms with their specific kind of services are related to all of these types of markets, because for their product - transportation and its selling they need inputs, intermediaries and customers.

The definition, which stated that the market is an area of services and circulation of goods [2], can be applied to *transportation market* which can be from the standpoint of a demand and supply divided in *transportation market for freight transport* and *transportation market for passenger transport*.

Both transportation markets for freight and passenger transport *are not homogenous*. Road transport firms offer services for various segments of customers over various geographical area. There are lots of varied criterions for a market segmentation of the transportation market, which enable to look at it from various points of view.

Simplified notions of functioning of the transportation market lead to the conclusions that the market is a sufficient instrument for development of optimal proportions within the transport system. However, foreign experiences indicate that opposite is true. For this reason the transportation market is under regulations. Incentives for *regulation* come from the government because transport services fulfill lots of various social and economic functions.

2.6 Agents on the transportation market

The producers sometimes provide their products to customers or firms without help of intermediaries. This activity is under control of the marketing department *Forwarding* agencies in road freight transport can be seen as marketing agents. *Travel agencies* play this role in passenger transport. Finally, forwarding agencies and travel agencies are customers of transport firms.

3. Supply and supply strategy

If a road firm has enough information on market environment, knows its internal possibilities, strengths and weaknesses, it is "qualified" to form its supply. *Forming the supply of a road transport firm is necessarily determined by a supply strategy.* The whole process of forming the supply should be guided by strategic decisions with the aim to develop an attractive supply. The *supply strategy* is to be in the focus of every firm, because it means a "playing ground".

The term strategy has its origin in Greek language, in which it means art of a leader, commander. In the past this word meant in business terminology the ability to decide with a great proficiency. Nowadays the *term strategy* covers a specific *scheme of sequence, which outlines how set goals are to be achieved in given conditions.*

*The **significance** of the strategy is to reach adequate effectiveness of all involved activities and to integrate all elements into one unit, which provide for prospects to the given object.*

Supply is *an object* of a supply strategy. The supply will be effective if there is a corresponding demand. There is no point to design a supply without a demand. Marketing tools can support an attractive supply.

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Marián Gogola *

APPLICATIONS OF METHODOLOGY OF CALCULATION OF THE NUMBER OF CONNECTIONS (MCNC) IN SOLVING TRANSPORT ATTENDANCE

This paper deals with the new MCNC (Methodology of Calculation of the Number of Connections) which is focused on the problem of transport attendance in the Zilina county. Starting from the calculation of passenger demands, social-economic parameters and the resulting calculation of the modal split, the allocation of vehicle schedule into an optimisation matrix is modelled. In the last step, the MCNC algorithm calculates a number of connections to achieve optimisation. This methodology can be used with other methodologies to find a better solution for transport attendance, to find a better solution for integration of the transport system. It is also possible to use the MCNC as additional methodology to calculate economic efficiency of the transport system.

1. Introduction

The bus passenger transport has been faced with specific problems caused by the collapse of the government-regulated transport market. Economic problems can take various forms and be measured in various ways, including changes in technologies, etc. By and large, transport problems are assessed in terms of enlarging transport costs, reducing transport quality. A general problem is the cost level of bus operation in the context of the establishment of a harmonised and liberalised transport market. This task was solved in the IMTRASY project by a team of PhD students at the University of Zilina. They participated in Mondialogo Engineering Award, the first worldwide intercultural contest seeking ideas for sustainable technical improvements in developing countries. The first task was to develop a methodology for the future provision of accessible transport services in the Zilina county which could best meet the varying needs of people.

2. Finding a problem

The number of bus or railway connections per one workday was analysed in every village and town in the Žilina county. The research focused on operating time, number of connections and social-economical analysis of citizens in each village or town in the Žilina county. The research reviewed the team approach, identified various ways of improving its response to the travel needs of people and recommended a future approach. The project focused also on the possibility of integration of bus and railway passenger transport.

For methodology development it was necessary to calculate a number of bus and railway connections, which provided information about the current situation. Many bus connections follow a parallel path with railway transport. From the economical point of view, it is waste of funds.

3. Design of methodology

The research aimed at finding the best methodology, which can work with parameters, we identified. A design of methodology took into account the research conditions and conditions of public passenger transport system. The research compared different methodologies of modelling such as aggregate and disaggregate. Disaggregate modelling has some disadvantages such as detailed and specific input data. It is also based on specific mathematical theories, which can be used only by experts.[4] Aggregate models have more advantages for application in the new methodology. For this purpose, we decided to use the first step of aggregate models. Citizens of each village or town were analysed with the help of structural parameters which are used by transportation modelling.

4. Proposal of methodology

Methodology of Calculation of the Number of Connections (MCNC)

The calculation is based on high level of statistical and econometric skills. It is based on methodology of specific mobility, structural parameters and the first step of aggregate modelling. [4] The MCNC consists of 3 steps.

Step1 Calculation of transport demands parameters

The research focused on the preparation of the background parameters to assess the transport demands. The calculation needs

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the overlook of the following social-economic parameters in every town/village:

- Total population of town/village, (*P*),
- Economically active population, (*EA*),
- Number of schoolchildren at the age of 6–15, (*SCh*),
- Children (age 0–5), (*Children*),
- Students (highschoolers and undergraduates), (*ST*),
- Number of job positions, (*NJP*),
- Number of job positions in tertiary sector/services, (*NJP*3),
- Number of places in kindergartens, elementary schools, (*FP*),
- Number of places for students, (*SP*).

The analysis parameters NJP, NJP3, FP and SP in each town and village were used in the calculation of number of people who must commute daily to work or school.

Calculation of the number of purpose trip

$work = EA - NJP$

$schoolchildren = SCH - FP$

$study = ST - SP$

However, the calculation mentioned above doesn't take into account other citizens, who travel sporadically by passenger transport systems. Methodology takes into account the specific mobility in the workday. Specific mobility helps to forecast and model the number of trips, citizens make per one workday.

The next step provides a number of all passengers travelling to work, schools or for other purpose out of their own village.

For this purpose, the project designs the transport demands parameters:

- *P* – total population in town/village
- *PT* – the parameter indicates the number of citizens who travel daily to work or schools
- *Other* – the parameter indicates the number of citizens not included in PT
- *Owc* – the parameter indicates the number of citizens who don't use individual automobile transport (IAT) to travel to work or school,
- *TP* – parameter indicates the total number of citizens who are potential passengers for public passenger systems,
- *PIAT* – percentage of number of people who travel to work or schools by IAT

Calculation of transport demands parameters

$PT = work + schoolchildren + study$

$Other = P - PT$

$Owc = Other - (Other \cdot PIAT)$

For calculating the *Owc* parameter, the methodology used a percentage of citizens travelling by IAT to work, schools or other destination. There was different percentage in urban and village areas: in the city area (23 %) and in the village area (19.44%). [2] The TP parameter can be calculated using the equation as follows:

$TP = PT + Owc$

The Origin-Destination matrix was generated using the *TP* parameter. There were data providing the information about citizens who travelled from the place of origin to other destinations. The matrix provided an exact record of citizens and their destinations. It also provided information about a number of passengers who travelled in the same direction. Based on this output, the methodology could calculate the number of connections.

Step 2 Assessment of bus and rail connections

Assessment of connections was designed with the help of average parameters *PT* and *TP*. The research made an hypothesis that not all the people, who were potential passengers (*TP*), would travel in the same day and at the same time. Connections were distributed according to peak hours. The total number of bus connections was calculated with the help of parameters *PT*, *TP* and *BC* for each village. The project also determined a rule that the number of connections from the village equals the number of connections to the village. Therefore, it was possible to calculate the number of connections to and from the village.

Calculation of connections can be made using the equation as follows

$$NC = \frac{\left[\frac{PT + TP}{2}\right]}{VC}$$

NC – number of connections
VC – vehicle capacity

In this step, the real number of connections was compared with the proposed number of connections. The result was the optimised number of connections based on the proposed number of connections.

Step 3 Assessment of running transport flow and adaptation of connections

The optimisation considered the time taken when a passenger travelled to and from a village. The methodology also respects that the passenger flow is not uniform and has the peak hours. [3] The passenger flow grows up in the morning (between 6 AM and 8 AM hours) and it has higher flow rate in the traffic. In the afternoon, when passengers come back, the flow takes more time with lower flow rate (between 2 PM-5 PM). [1]

5. Practical applications of MCNC

The MCNC helped the IMTRASY project with optimisation of bus and railway connections in the Zilina county. The project also suggested the methodology for integration of bus and railway transport. This result represents saving about 27 % in cost per passengerkilometer. [1]

This methodology can be used with other methodologies to find a better solution for transport attendance, to find a better solution for integration of the transport system. It will also be possible to use this MCNC as additional methodology to calculate economic efficiency of the transport system.

6. Conclusion

The MCNC is not only a theoretical methodology. It was for first time implemented in the IMTRASY project. The project solved the optimisation of bus and railway connections in the Žilina county. The project developed the methodology, meeting the requirements the project made. The MCNC contains an analytical solution in the field of equations in space and time. This resulted in the draft of strategy which is to develop a more fully accessible transport system in the Zilina county. This methodology could help to solve the optimisation of transport attendance and design the integration of bus and railway passenger transport.

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APPLICATION OF RCM PRINCIPLES IN THE AIR OPERATIONS

Maintenance organizations assist in ensuring that all aircraft, their systems and parts are operated or maintained under controlled conformity to national and international airworthiness standards. Ensuring that these standards are met involves a vast network of organizations and personnel. To develop and then to comply with effective standards and procedures for maintenance program is never-ending process, which is responsible for the coordination and management of all maintenance activities and consequently manufacturing activities too. The RCM program provides a logical way of determining if preventive maintenance makes sense for a given part, system or the whole aircraft. The RCM concept completely changes the way in which the preventive maintenance is viewed. It is widely accepted fact that not all parts benefit from preventive maintenance.

The Background

Within the final twenty years of the last century, aircraft maintenance procedures have changed in general, perhaps more than any other management and technological discipline. The changes are due to a huge increase in the number and variety of physical assets (structural systems, equipment), which must be maintained on any place in the world, much more complex designs, new maintenance technologies, and changing policy of maintenance organization and its responsibilities.

Maintenance practices effectively respond to changing expectations. These include a rapidly growing awareness of the extent to which equipment failure affects safety and the environment, a growing awareness of the connection between maintenance and product quality, and increasing pressure to achieve high unit availability and to contain costs.

The changes are testing attitudes and skills in all branches of industry to the limit. Namely in aviation the maintenance people have to adopt completely new ways of thinking and acting, as engineers and as managers. At the same time the limitations of maintenance systems are becoming increasingly apparent, no matter how much they are computerized.

Reliability Quantification

A reliability-centred maintenance (**RCM**) program consists of a set of scheduled tasks generated on the basis of specific reliability characteristics of the aircraft they are designed to protect. The aircraft is composed of a number of systems and subsystems, a vast number of parts and assemblies. All these items can be expected to fail at one time or another, but some of the failures have more serious consequences than others. Certain kinds of failures have a direct effect on operating safety, and others affect the operational capability of the equipment. Operational reliability of an aircraft has to be defined and authoritatively prescribed with unique meaning anywhere adopted in the world.

The consequences of a particular failure depend on the design of the item and the equipment in which it is installed. One of the key goals of certification process and continued airworthiness standards in aviation is that each safety-critical structural part has a reliability of at least 0.999999999 ("nine 9's") per flight hour; in other words, the probability that a particular safety-critical system will fail is no more than one in a billion for each flight hour. Regulations seek to achieve this goal through a combination of requirements for design, analysis, test, inspection, maintenance, and operation. The development of rulemaking process in recent decades has been driven by the following factors:

- Increasing performance in air transportation with consequently increasing density of air traffic operations.
- Continued high level of public and administrative concerns in air transportation safety.
- The introduction of new technologies, which have advanced the efficiency of the air transportation system and provided opportunities to improve safe life of an aircraft.
- Lessons learned from investigations of civil aviation accidents and incidents.
- Changes in international air transportation regulations and policies.

Reliability Centred Maintenance in Development Phase

The envisaged operational conditions and real environment of aircraft operations form crucial factors for maintenance program development. The impact of failures on the aircraft airworthiness, and hence their consequences for the operating organization, are

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predicted and established primarily by the aircraft designer. Experiences outgoing from recent similar design conception, predicted operational load cases with normal operational wear and the results from tests effectuated with simulated loadings on prototype can be used in this first step. On this level we are speaking about inherent reliability characteristics.

failure could affect operating safety or have major economic consequences.

Reliability Centred Maintenance in Operational Phase

The definition of major economic consequences will vary from one operating organization to another, but in most cases it includes

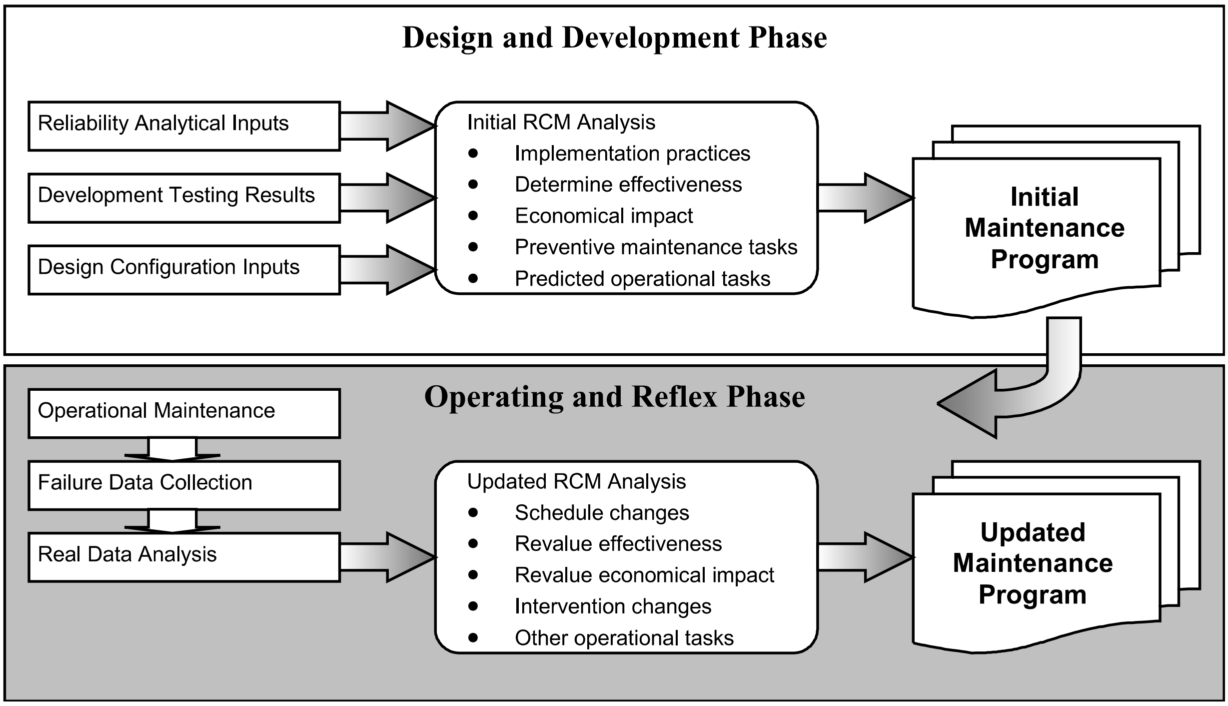

Fig. 1 How the RCM goes to real life

Expected impact on effectiveness and economics of aircraft operations have to be analysed with the key goal to make good and executable maintenance program. There are a great many items, of course, whose failure has no significance at the system or the whole aircraft level. These failures are tolerable, in the sense that the cost of preventive maintenance would outweigh the benefits to be derived from it. It is less expensive to leave these items in service until they fail than it is to try to prevent the failures. Most such failures are evident to the operating crew at the time they occur and are reported to the maintenance crew for corrective action.

Some items, however, have functions whose failure will not be evident to the operating crew. Although the loss of a hidden function has no direct consequences, any uncorrected failure exposes the aircraft to the consequences of a possible multiple failure as a result of some later second failure. For this reason items with hidden functions require special treatment in a scheduled maintenance program with preventive maintenance intervention.

The development of a maintenance program has to reduce the potential reliability problem by a quick, approximate, but conservative identification of a set of significant items – those items whose any failure that impairs the operational capability of the equipment or results in unusually high repair costs. At the same time all items with hidden functions must be identified, since they will be subjected to detailed analysis along with the significant items.

Once the aircraft is introduced into the service, the operational phase of maintenance program starts. The aircraft operator is obliged to develop credible system for collecting and reporting each accident and incident relevant to operational reliability. Structured database has to give responses helping in quantifying probability of repeated occurrences of registered events. Registered events relevant to operational reliability are failures, malfunctions or other types of faulty operation. The analysis itself is based on evaluation of the consequences for each type of malfunctions to which the item could be exposed. The logic used to organize this problem investigation and reporting, leads to categories of failure consequences:

- *Safety consequences*, which involve possible danger to the equipment and its occupants. Limits for random characteristics are standardised in aviation.

- *Operational consequences*, which involve an indirect economic loss in addition to the cost of repair. Preventive maintenance actions have essential effect on operational costs in aviation.
- *No operational consequences*, which involve no economic loss other than the cost of repair applying RCM theory to aircraft. These failures have to be registered too, because potential future incident can be signalised.

Operational Reliability Dataflow

In the case of commercial aircraft continuous evolution of the design requirements promulgated by airworthiness authorities and the feedback of hardware information to designers by operating organizations have led to increasing capability for safe and reliable operation. Thus most modem aircraft enter service with design features for certain systems and items that allow easy identification of potential failures. Similarly, various parts of the airplane are designed for easy access when inspection is necessary or for easy removal and replacement of vulnerable items. A host of instruments and other indicators provide for monitoring of systems operation, and in nearly all cases essential functions are protected by some form of redundancy or by backup devices that reduce the consequences of failure to a less serious level.

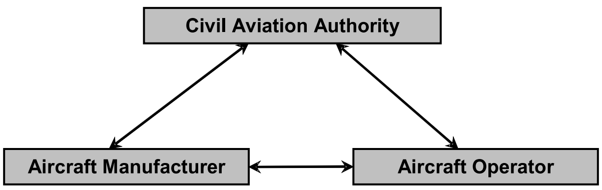

Fig. 2. Operational reliability data feedback

Complex equipment of the older generations of aircraft that has not benefited from such design practices will have different and less favourable reliability characteristics, therefore, less capability for reliable operation is envisaged. Since preventive maintenance is limited by the inherent characteristics of the equipment, in many cases RCM analysis can do little more than recommend the design changes that would make effective maintenance feasible.

The role of civil aviation authorities is to work with the operators and manufacturers of aircraft and engines to define and implement a proactive process that includes the following key elements:
- Data collection.
- Database management.
- Risk analysis.
- Risk management/action.
- Monitoring effectiveness.

Specific tasks should follow the process of RCM development:
- Manufacturers, with the advice and consent of operators and the appropriate civil aviation authority (CAA), should define data requirements and processes for sharing data. Comprehensive flight operations quality assurance systems should be used as a starting point.
- Operators should provide required data, as agreed upon.
- Manufacturers should solicit data from additional sources, such as International Civil Aviation Organization and others, to augment the operational database.
- Manufacturers, with oversight from the CAA and the assistance of operators, as required, should collect, organize, and analyze data to identify potential safety problems.
- Manufacturers should recommend corrective action for potential safety problems and seek consensus by operators. The CAA should make sure that actions proposed by manufacturers and operators will be effective, making regulatory changes and mandating compliance as appropriate.
- Manufacturers and operators, with oversight from the CAA, should monitor the effectiveness of corrective action and the safety management process.

The principles of reliability-centred maintenance still apply, and the decision questions are the same. The answers to these questions, however, must reflect the design characteristics of the aircraft.

Summary of RCM Principles

The complexity of modem aircraft generation makes it impossible to predict with any degree of accuracy when each part or each assembly is likely to fail. For this reason it is generally more productive to focus on those reliability characteristics that can be determined from the available information than to attempt to estimate failure behaviour that will not be known until the aircraft enters into the service. When developing an initial program, therefore, only a modest attempt is made to anticipate the operating reliability of every item. Instead, the governing factor in RCM analysis is the impact of a functional failure at the system level, and tasks are directed at a fairly small number of significant items – those whose failure might have safety or major economic consequences.

These items, along with all hidden-function items, are subjected to intensive study, first to classify them according to their failure consequences and then to determine whether there is some form of maintenance protection against these consequences.

The first step in this process is to organize the problem by partitioning the aircraft into object categories according to areas of engineering expertise. Within each of these areas the aircraft is further partitioned in decreasing order of complexity to identify significant items (those whose failure may have serious consequences for the aircraft as a whole), items with hidden functions (those whose failure will not be evident and might therefore go undetected), and non-significant items (those whose failure has no impact on operating capability). As this last group encompasses many thousands of items on an aircraft, this procedure focuses the problem of analysis on those items whose functions must be protected to ensure safe and reliable operation.

The next step is a detailed analysis of the failure consequences in each case. Each function of the item under consideration is examined to determine whether its failure will be evident to the operating crew; if not, a scheduled-maintenance task is required to find and correct hidden failures. Each failure mode of the item is then examined to determine whether it has safety or other serious consequences. If safety is involved, scheduled maintenance is required to avoid the risk of a critical failure. If there is no direct threat to safety, but a second failure in a chain of events would have safety consequences, then the first failure must be corrected at once and therefore has operational consequences. In this case the consequences are economic, but they include the cost of operating capability lost as well as the cost of repair.

Whereas the criterion for task effectiveness depends on the failure consequences the task is intended to prevent, the applicability of each form of preventive maintenance depends on the failure characteristics of the item itself. For an on-condition task to be applicable there must be a definable potential failure condition and a reasonably predictable age interval between the point of potential failure and the point of functional failure. For a scheduled rework task to be applicable the reliability of the item must in fact be related to operating age; the age-reliability relationship must show an increase in the conditional probability of failure at some identifiable age (wear out) and most units of the item must survive to that age. The applicability of discard tasks also depends on the age reliability relationship, except that for safe life items the life limit is set at some fraction of the average age at failure. Failure finding tasks are applicable to all hidden function items not covered by other tasks.

Development of RCM

The process of developing an RCM program consists of determining which of these scheduled tasks, if any, are both applicable and effective for a given item. The fact that failure consequences govern the entire decision process makes it possible to use a structured decision diagram approach, both to establish maintenance requirements and to evaluate proposed tasks. The binary form of a decision diagram allows a clear focus of engineering judgment on each issue. It also provides the basic structure for a default strategy – the course of action to be taken if there is insufficient information to answer the question or if the study group is unable to reach a consensus. Thus if there is any uncertainty about whether a particular failure might have safety consequences, the default answer will be yes; similarly, if there is no basis for determining whether a proposed task will prove applicable, the answer, at least in an initial maintenance program, will be yes for on-condition tasks and no for rework tasks.

It is important to realize that the decision structure itself is specifically designed for the need to make decisions even with minimal information. For example, if the default strategy demands redesign and this is not feasible in the given timetable, then one alternative is to seek out more information in order to resolve the problem. However, this is the exception rather than the rule. In most cases the default path leads to no scheduled maintenance, and the correction, if any, comes naturally as real and applicable data come into being as a result of actual use of the aircraft in service.

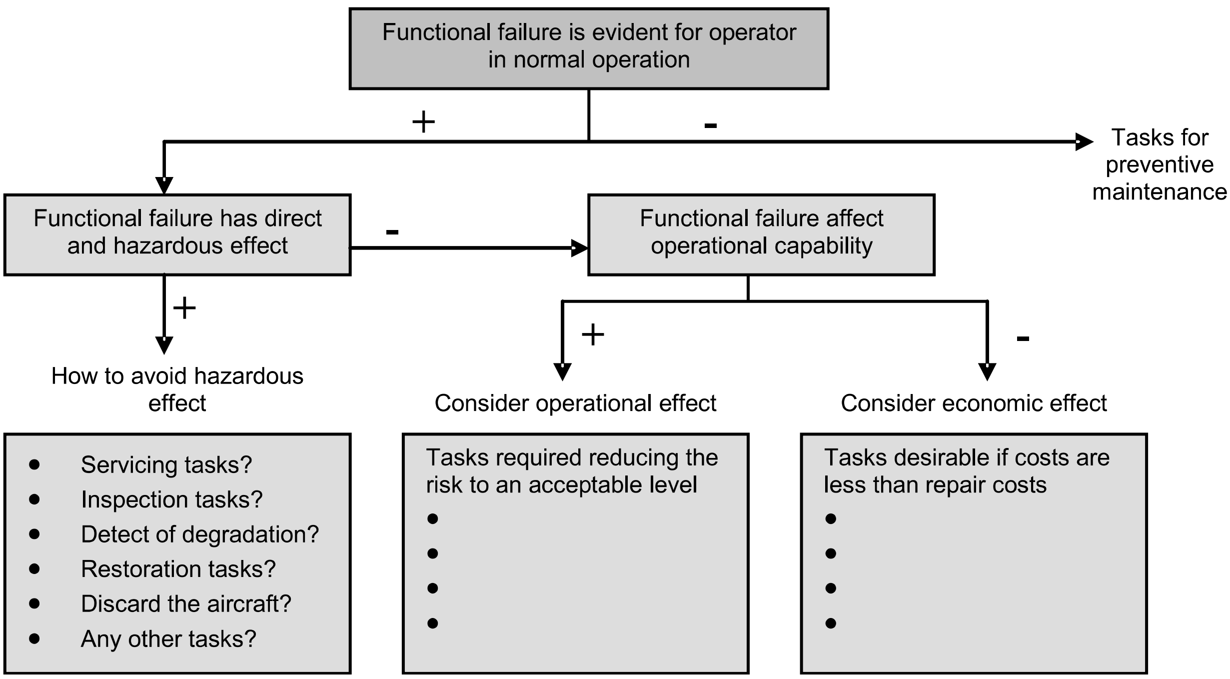

Fig. 3 Decision making

Decision Logic

The decision logic also plays the important role of specifying its own information requirements. The first questions assure us that all failures will be detected and that any failures that might affect safety or operating capability will receive first priority. The remaining steps provide for the selection of all applicable and effective tasks, but only those tasks that meet the criteria are included. Again, real data from operating experience will provide the basis for adjusting default decisions made in the absence of information. Thus a prior-to-service program consists primarily of on-condition and sample inspections, failure finding inspections for hidden function items, and a few safe life discard tasks. As information is gathered to evaluate age reliability relationships and actual operating costs, rework and discard tasks are gradually added to the program where they are justified.

The net result of this careful bounding of the decision process is a scheduled maintenance program that is based at every stage on the known reliability characteristics of the aircraft in the operating context in which it is used. In short, reliability-centred maintenance is a well-tested answer to the paradox of modem aircraft maintenance – the problem of how to maintain the systems in a safe and economic fashion until we have accumulated enough information to know how to do it.

RCM will allow one to obtain the full design operating ability of the aircraft. It does not necessarily identify a new series of maintenance tasks. It identifies which tasks are most applicable, which are ineffective and provides a framework for developing an optimal preventive maintenance program.

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NOTE ON THE COORDINATION OF PERIODIC PROCESSES IN TRANSPORTATION SYSTEMS

The article deals with a coordination of periodic processes in transport systems. It introduces some basic mathematical models useful in process optimization. It also shows some examples of everyday transport practices where this optimization can be used.

1. Introduction

Users of transport systems often declare their interest in velocity. However, it does not mean technical velocity of transport means. They concern the "velocity of displacement", i.e. the distance between the origin and destination divided by the transport time. And it is often true that this value is strongly influenced by coordination between transportation processes.

Let us consider several examples:

A. A passenger travels from the village V to the town W using first a local train from V to a station S and afterwards an express train from S to W. It is obvious that the travel time from V to W is strongly influenced by the waiting time for the train changing in S and, consequently, by the coordination of the transport processes of local and express train operation.

B. A passenger walks from his house H to an urban bus stop S_1, then he/she travels by bus from the stop S_1 to the stop S_2, using any from the two routes r_1, r_2 operating between S_1 and S_2. It is obvious that the total duration of the trip from H to S_2 is strongly influenced by the waiting time for a bus at the stop S_1 and, consequently, by the coordination of the transport processes on the two routes.

C. A wagon is loaded at a station A and its destination is the station B. However, it has first to use a train to a marshalling yard Y and after some manipulations there to use another train from Y to B. It is obvious that the total duration of the trip from A to B is strongly influenced by the manipulation time in Y and, consequently, by the coordination of the processes in Y.

D. A person drives his car from his home H to his office O passing through a signalized road intersection I. It is obvious that the total duration of the trip from H to O is strongly influenced by the waiting time in front of the junction I and, consequently, by the coordination of the processes at I.

If we consider the cases A., B. and D. we can imagine that the displacement activities may be more complicated:

A. There may exist many local trains coordinated with several express trains in several stations.

B. There may exist many routes coordinated at many common legs.

D. There may exist many processes at several junctions to be coordinated.

The complex problems of optimal coordination can be a bit simplified introducing a periodicity:

A. To introduce a periodic timetable (a "Takt Fahrplan" in German), e.g. to repeat the departures after each hour.

B. To introduce a periodic time table, e.g. to repeat the departures after each 12 minutes.

C. To introduce a periodic schedule, e.g. to repeat the processes each day (it was already done in the major part of marshalling yards).

D. To introduce a "cyclic" mode of operation, i.e. to repeat the green signals e.g. each 80 seconds (a big part of junctions work in a periodic regime now).

In the sequel we shall try to formulate the coordination problems in a general mathematical way.

2. Basic mathematical models

One can find many different periodic point processes (more precisely: time-point processes) in transportation systems, e.g.:

A. The departures of express trains from the station S_1 for the station S_2 are scheduled for 6:42, 7:42, 8:42 etc. This defines a point process p_2 = 6:42, 7:42, 8:42, ... = 6:42 + $k \times$ 1:00, k = 1, 2, ... (the reason for using p2 will be seen later)

B. The departures of urban transport buses from the stop S_1 for the stop S_2 are scheduled for 6:06, 6:18, 6:30, 6:42, etc. p_1 = = 6:06, 6:18, 6:30, 6:42, ... =. 6:06 + $k \times$ 0:12, k = 1, 2, ...

C. Wagon collection process on the sorting siding s_1 of a marshalling yard is concluded each 6 hours at 3:20, 9:20, 15:20, 21:20. p_1 = 3:20, 9:20, ... = 3:20 + $k \times$ 6:00, k = 1, 2, ...

D. At a signalized road intersection I, the green light start each 80 seconds for the given stream S_1 of vehicles e.g. p_1 = = 5:00:12 + $k \times$ 0:1:20, k = 1, 2, ...

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Usually, the periodic point processes are not isolated. On the contrary, there exist sets of mutually influenced processes and, usually again, the processes have either the same period, or the least common multiple of the periods, which is not very much greater than they are. For instance:

A. Besides the process p2 we have another process p_1 = 6:28, 6:58, 7:28, ... = 6:28 + $k \times$ 0:30 representing the arrivals of local trains to the station S_1 from the station S_3. In this case, the corresponding periods are p_2 = 1:00 = 60 min., p_1 = 0:30 = 30 min., the common multiple p = 60 min. = $2 \times p_1$ = = $1 \times p_2$.
B. Besides the process p_1, corresponding to a route r_1 we have another process p_2 = 6:00, 6:20, 6:40, ... = 6:00 + $k \times$ 0:20 representing the departures of buses of another route r2 from the stop S_1 for the stop S_3 via the stop S_2. In this case, the corresponding periods are p_1 = 0:12 = 12 min., p_2 = 0:20 = 20 min., the common multiple p = 60 min. = $5 \times p1 = 3 \times p2$.
C. Besides the process p_1, corresponding to the sorting siding s_1 we have another process p_2 = 1:30, 9:30, ... = 1:30 + $k \times$ 8:00 corresponding to the sorting siding s_2. In this case, the corresponding periods are p_1 = 6:00 = 6 h., p_2 = 8:00 = 8 h., the common multiple p = 24 min. = $4 \times p_1 = 3 \times p_2$.
D. Besides the process p_1, corresponding to the stream S_1 we have another process p_2 = 5:00:45 + $k \times$ 0:1:20, k = 1, 2, ... corresponding to another stream S_2, which is in collision with S_1. Here $p_1 = p_2 = p$ = 80 seconds.

2. Coordination

Having two processes at the same place it is quite natural to require some type of coordination between them. In general, we can meet different requirements:

2.1. Single and simple linking. We speak about *single linking* if we have two processes p_1, p_2 with only one linking between them, e.g. p_2 linked to p_1, symbolically $p_1 \rightarrow p_2$. We call this linking simple if both processes have the same number n of time-points in one period p and the process $p_2 = t_{21}, t_{22}, ..., t_{2n}$ (+ kp) is linked to the process $p_1 = t_{11}, t_{12}, ..., t_{1n}$ (+ kp). The quality of this linking can be expressed by the differences $d_1 = t_{21} - t_{11}$, $d_2 = t_{22} - t_{12}$, ..., $d_n = t_{2n} - t_{1n}$ put into an objective function $f(d_1, d_2, ..., d_n)$, e.g.

$f_1(d_1, d_2, ..., d_n) = \min\{d_1, d_2, ..., d_n\}$ (greater is better)
$f_2(d_1, d_2, ..., d_n) = \max\{d_1, d_2, ..., d_n\}$ (smaller is better)
$f_3(d_1, d_2, ..., d_n) = \max\{d_1, d_2, ..., d_n\} - \min\{d_1, d_2, ..., d_n\}$ (smaller is better)
$f_4(d_1, d_2, ..., d_n) = d_1^2 + d_2^2 + ... + d_n^2$ (smaller is better).

Among the abovementioned examples only the A can serve as the illustration of single linking, but, unfortunately, it is not simple (we have 2 arrivals within 60 min. but only one departure).

2.2. Double and multiple linking. We speak about *double linking* if:
a) We have both $p_1 \rightarrow p_2$ and $p_2 \rightarrow p_1$.
b) There exists another pair $p_3 \rightarrow p_4$.

In the case a) we speak about *double mutual linking* of the pair p_1, p_2.

We speak about *multiple linking* if there exist more than one linked pair (i.e. double linking is a particular case of multiple linking). We suppose we are given a set of time-point periodic processes $P = \{p_1, p_2, ..., p_m\}$ with periods $p_1, p_2, ..., p_m$ and the common period $p = \mu(p_1, p_2, ..., p_m)$ = the least common multiple of the periods $p_1, p_2, ..., p_m$. The mutual linking could be expressed by means of a *linking digraph* (= oriented graph) $G = (V, A)$, where the vertex set $V = \{1, 2, ..., m\}$ represents the processes $p_1, p_2, ..., p_m$, the arc set A represents linking, i.e. the *arc* $a = (i, j) \in A$ represents linking p_j to p_i i.e. $p_i \rightarrow p_j$.

Writing the time-point one has to take into account the common period p, i.e. if a time-point is represented by a number t_{ik} then $t_{ik} \in$ {0, 1, ..., p} must hold; if not, then it must be reduced mod p.

2.3. General single linking. We speak about general single linking $p_1 \rightarrow p_2$ if it is not simple. In the case of general single linking the processes p_1, p_2 may have different numbers n_1, n_2 of time-points in one period p and the differences d_i may be calculated from some selected n-tuples $t_{11}, t_{12}, ..., t_{1n}, t_{21}, t_{22}, ..., t_{2n}$, $n \leq n_1$, $n \leq n_2$.

Especially, if the linking $p_1 \rightarrow p_2$ intends to express a *train changing*, we denote T_1 the set of all time-points (= arrivals to the change station plus some time for walking from one train to another) of the process p_1 in one period p and T_2 is the set of all time-points (departures from the change station) p_2, but moreover both the sets T_1, T_2 are extended by adding the first time-point from the next period (i.e. we add the time-point $t + p$ where t is the first time-point from the period p). Then the number n is the maximum natural number allowing the n-tuples $t_{11}, t_{12}, ..., t_{1n}, t_{21}, t_{22}, ..., t_{2n}$ to have the following properties of "closeness": $t_{1i} = \max\{t \in T_1: t \leq t_{2i}\}$, $t_{2i} = \min\{t \in T_2: t \geq t_{1i}\}$. If in such a manner $t_{1n} = t_{11} + p$ and $t_{2n} = t_{21} + p$ then we omit t_{1n}, t_{2n} and we put $n - 1$ instead of n.

In our example A we have T_1 = {28, 58, 88}, T_2 = {42, 102} corresponding to the local train arrivals 6:28, 6:58, 7:28 and the express train departures 6:42, 7:42. Obviously, the first value of $n = 2$, t_{11}, t_{12} = 28, 88, t_{21}, t_{22} = 42, 102 . However, p = 60 and both 88 = 28 + p, 102 = 42 + p. Thus, we omit 88, 102 and put $n = 1$. $t_{11} = 28$, $t_{22} = 42$, $d_1 = 14$.

2.4. General multiple linking. We suppose we are given a set of time-point periodic processes $P = \{p_1, p_2, ..., p_m\}$ with periods $p_1, p_2, ..., p_m$ and the common period $p = \mu(p_1, p_2, ..., p_m)$ and the mutual linking expressed by means of a linking digraph $G = (V, A)$. In the case of general multiple linking we suppose there exists a general rule determining the number n, the values $d_1, d_2, ..., d_n$ and the objective function f expressing the quality of linking by means of the value $f(d_1, d_2, ..., d_n)$.

In practice it can happen that these processes are originated in different locations and their influence represented by a relation $p_i \rightarrow p_j$ "works" in a third location which needs some equalization of time-points. Usually, we use a value $o(i, j)$ said the *offset* which has to be added to the time-points of the process p_i before their comparison with the time-points of p_j.

The practical meaning of the offset can be demonstrated on our examples:

A. Let us suppose that the departures of local trains from the station S_3 are 5:38, 6:08, 6:58, ... = 5:38 + $k \times$ 0:30 and let the running time from S_3 to S_1 be $r(S_3, S_1)$ = 50 min. Then the arrivals to S_1 are 6:28, 6:58, 7:28, ... = 6:28 + $k \times$ 0:30 as we supposed above. Moreover, let the departures of express trains from their origin station S_0 be 5:32, 6:32, 7:32 etc., i.e. 5:32 + $k \times$ 1:00, just $r'(S_0, S_1)$ = 1:10 h. = 70 min. before their departures from S_1. Then we can consider the original processes p_1 = 5:38 + $k \times$ 0:30, p_2 = 5:32 + $k \times$ 1:00, the offset $o(1, 2) = r(S_3, S_1) - r'(S_0, S_1) + w_{12} = 50 - 70 + 5 = -15$ min. Hence the process p_2 = 5:32 + $k \times$ 1:00 = $= 32 + 60k$ (with one departure during the common period $p = 60$ min.) will be linked to the reduced process p_{r1} = 5:38 + + $k \times$ 0:30 + $o(1, 2) = 38 + 30k - 15 = 23 + 30k$ (with two departures during the common period 60 min.). Further calculations will be similar to the ones at the end of the part 2.3.

B. Similarly, the original processes can be represented by the departures from the terminals of the routes, but the offset will be exactly the difference of running times from the terminals to S_1 without any further correction. Let, for the simplicity, S_1 be the terminal for both routes. The "general rule" is the following: Let $T_1 = \{t_1, t_2, ..., t_n\}$ be the set of all departures of all routes from S_1 to S_2 within one period p. Suppose that $t_1 \leq ..., \leq t_n$. Let $t_{n+1} = t_1 + p$. Then $d_i = t_{i+1} - t_i$, $i = 1, ..., n$. The values $d_1, d_2, ..., d_n$ represent the waiting intervals of the passengers using the segment S_1, S_2 only.
In our example $d_1, ..., d_8$ = 6, 12, 2, 10, 10, 2, 12, 6 and:
   - $f_1(6, 12, 2, 10, 10, 2, 12, 6) = \min\{6, 12, 2, 10, 10, 2, 12, 6\} = 2$ expresses the danger of collision of two subsequent vehicles at the same stop,
   - $f_2(6, 12, 2, 10, 10, 2, 12, 6) = \max\{6, 12, 2, 10, 10, 2, 12, 6\} = 12$ expresses the maximum waiting time of a passenger,
   - $0{,}5qf_4(6, 12, 2, 10, 10, 2, 12, 6) = 0{,}5q(36 + 144 + 4 + 100 + 100 + 4 + 144 + 36) = 284q$ expresses for one period the total waiting time (in minutes) of the q passengers, boarding the vehicles during one minute.

C. On the contrary, here no running time will have to be considered. Instead, the offset $o(i, j)$ will represent the transfer time for employees and engines to move from the i-th siding to the j-th one after having finished the works transforming wagons into a train. The general rule for the calculation of the values di is similar to the previous one. In our example, neglecting offsets, we have (in minutes) $d_1, ..., d_7$ = 110, 360, 10, 350, 130, 230, 250, but the only objective function having a practical sense is:
   - $f_1(d_1, ..., d_7) = \min\{110, 360, 10, 350, 130, 230, 250\} = 10$
   It expresses the shortage of time necessary for the train creation from the wagons on the siding s_1 before the start of the same works at the siding s_2.

D. If the processes p_i and p_j work at the same intersection then the offset $o(i, j)$ will represent the duration of green signal for the stream Si plus the clearing time. If they work at different intersections then the running time between them will have to be added.

3. Coordination for changes

Let us turn to our examples. B) concerns the well known problem of coordination of public transport on common legs. C) deals with freight train formations and the methods of solution are similar to the previous ones. D) is the well known problem of signalised intersections. All three are described by many authors in many books and papers, see. e.g. the monograph [1]. One can say that the available methods satisfy the practical needs.

On the other hand the problem A) cannot be considered satisfactorily solved. In [1] and [2] one can find a heuristics and a linear programming model for time shift optimization, having given the set of trains operating on a general network. Other authors, e.g. [3], study the same problem, but limited to the "herring-bone type of network" using congruency calculations.

However, the authors have not yet met any paper dealing with the coordination problems, *optimizing*:

a) *the size of trains* for the given number of trains during the common period together with their *time shifts*
b) *the number of trains* during the common period together with their *size and time positions*.

The authors hope they have an idea of solution of the problem a) using mathematical programming. The problem b) seems to be open.

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THEORETICAL FRAMEWORK OF VEGA 1/1243/04 RESEARCH: INTERPERSONAL INTERVIEWS AND MOTIVATION

This paper is a result of the research project VEGA No. 1/1243/04 "Highly-educated human potential management and development". It deals with the importance of basic types of interviews used in human potential management and development. It presents and argues the results of a selective, orientation, appraisal and exit interview. It highlights positive and negative aspects of these types of interviews. It confirms that managers and staff from personnel departments can enhance their perception of these interview techniques. It must be borne in mind and remembered that there is always a very strong motivational accent in these interviews.

Keywords: *motivation, motivational accent, interview, managers, process, skill*

1. Introduction

In many organizations, the real work and out-of-work environment places very high requirements and standards on employees as well as managers. The phenomenon, which repeatedly assists individuals and groups to successfully cope with these requirements, is their motivation. Motivation, as a constantly nurtured inner process, by which individuals define, revalue and fulfil their aims, needs, aspirations, wishes and expectations. It is, however, quite often weakened by many negative situations and experiences. According to this knowledge, it is necessary for managers, experts and organization employees to continuously reinforce their own motivation levels as well as the motivation of their subordinates, superiors and organizationally equal co-workers. The reason of this intent interest is the fact that the motivation of employees and management personnel, including their identification with the organization, will condition the satisfaction and loyalty of customers [4]. This will also effect relations towards purchasers, suppliers and business partners.

2. Human Potential and Motivation Accent of Personnel Work

Human potential of an organization involves all the employees, experts and managers. It can also be defined to a large extent, as motivation, knowledge, skills, abilities, experiences and different ways of behaviour of all people within an organization. Enriching thought is that human potential consists of not only the structure and number of employees but also of aspects such as education and culture, human relations and ability to cooperate as well as to be receptive towards social and ecological factors affecting the environment, etc. [3].

Using meaningful administration of particular motivation criteria, it is possible to raise the level of experienced motivation of an organization's human potential by means of consistent motivating realisation of basic processes of management and development of human potential. This means that the focussing processes of work with human potential should be carried out with *strong motivation accent* so that, in this way, (even though indirectly) it can contribute to the growth of enthusiasm, satisfaction, identification and helpfulness of all members of an organizational team.

In this context it is reasonable to consider the necessity of motivation not only in large organizations, but also in smaller set-ups. Management of small and midsized organizations quite often overlook the fact that their employees have the same needs and aspirations as those workers employed in a large organization and, consequently, require the same level of motivation, perspective and education [1]. According to Brodsky [2] the main sources of motivation are needs and experience and the anomaly, which is often present, is that these feelings can have a subjective meaning for a percepted person. Therefore, the management must be aware of these individual needs of their subordinate co-workers and adjust the needs and aspirations to the overall needs of the team, department and whole workforce. We should mention here that the assertion of the motivation accent in the working process with people can lead, to a high level of fulfilment, mainly of a psychological nature, in both employees and managers within the whole of the workforce.

3. Interviews Helping to Increase the Motivation of Human Potential

The highest degree of motivation accent of focusing processes of management and development of human potential is most probably induced by the effective realisation of *selective, orientation, appraisal and outgoing interviews*. Apart from the specified prior aims, their purpose is to induce the trust of employees towards an organization, to strengthen their willingness to fully engage them-

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selves in particular activities that lead their behaviour to lend itself towards the achievement of an assigned vision or goal.

3.1. Selective Interview

The basis of the selective (admission) interview is to provide job applicants with true and sufficiently detailed information about the workplace, the organization as a socio-economic unit and, at the same time, gain an objective picture about of the real skills, abilities and personal attributes of applicants. This should be done in a form of a bilateral communication. Managers and experts from the organization should realise that this type of interview will enable them to recognise the complex potential of applicants and compare these personal competence complexes to the requirements of the position being offered to the applicant. Therefore, all the interviewers should be carried out by professionals featuring outstanding communicative skills and supportive understanding towards applicants. An objective of this interview is to create positive impression and *strengthen motivation of the most suitable applicant* (applicants) by enabling the applicant to accept a possible decision on being accepted for a particular job. The quality of the selective interview process mainly depends on a precise and technically well-managed preparation. In the stage of preparation, it is necessary to select the content and the form of a considered interview in advance. It is especially important to decide what information, signal, thoughts and *relevant attractive images* should be gained and given by both parties, i.e. interviewers and applicants. For this reason, the preparation of such an interview should come out from ongoing analyses of a considered working position, a detailed description of the job and specification of an applicant's abilities for the particular position. A thorough knowledge of all the facts based on written materials provided by the applicant is also necessary (CV, a covering letter, references, letters of application, certificates, etc.).

The applicants should prepare themselves for the interview and decide which is the most suitable (and at the same time the most honest and unstrained) method of presenting themselves. They should conduct themselves in such way that they would *motivate the representative of the organization*, to make the applicant the preferred choice. It is suggested that applicants should consider what the organization requires and expects from them. For example, they should pay attention to the creation of spectrum of people who have supplied evidences and information about them prior to the interview. The applicant should be well versed in areas, which highlight specific technical and administrative problems within the organization, specifically with reference to the job being offered. They should endeavour to gain as much information as is possible, concerning the organization prior to the interview.

A remarkable way to emphasise the motivation accent of selective interviews is in its initial stage – *opening of the interview*. The opening is the key factor, which determines the motivation shape of the interview process itself. The main idea at this level is that only in an atmosphere created by open and reciprocal trust with positive emotions (without any stress elements) it is possible to fulfil the main aims of the interview. These positive elements are: reciprocal communication, rising levels of motivation on both sides and a culmination of decisions of choice. It is known that no job interview can avoid stress and certain misgivings. Applicants as well as interviewers want to make a good impression, therefore, it is vital to focus on *elimination of these negatives*. Therefore, to create a motivation contact, at the start of the interview, it is preferable to cordially welcome an applicant, followed by an introduction to any organization representatives that may be present throughout the interview. It is important to inform the applicant of the format and the way in which the interview will be conducted. Conversation can be initialised by the use of some neutral topics such as weather, sport, town appearance, etc. A very positive approach can be the use of nonverbal communication – e.g. smile, handshakes, relaxed posture, showing genuine interest and leaning towards the applicant. Positive body language can be a very helpful approach in putting the applicant at ease in what could be a very stressful situation.

Subsequent stages of the interview should carry the signs of motivation emphasis. Organization representatives should be careful about asking *relevant and at the same time, ethical questions.* They should give the applicant sufficient time to ask his/her questions and willingly provide him/her with answers. At the termination of the interview, it is necessary to thank the applicant for showing interest, inform him/her that the organization will contact him/her to inform him/her on the results of the interview in due course. The interviewer should wish the applicant success in all of his/her future endeavours. Such "tiny" tools or wanted phrases at the final stage of the whole communication-motivational contact between applicants and organization can either reinforce the positive impression or destroy the whole effort.

3.2. Orientation Interviews

Orientation constitutes a specific process of management and development of human potential. It requires that the management establish an area of familiarisation of a new employee with the organization, its structure and values, as well as with working position itself and with a team of co-workers. This process encompasses efforts of involved representatives of the organization and also of the new employee himself/herself to shorten and intensify the process of getting acquainted with each other and adapting to new conditions, requirements, norms and approaches as well as expected skills related to the job to be performed.

As this process of orientation implies, a new employee will be faced with an abundance of new information, impressions, experiences, situations and confrontations, which he/she must try to manage. This period could be very stressful for a newcomer. The new recruit will encounter expectations and doubts whether he/she will successfully meet all the criteria concerning the required behaviour within the organization. Moreover, a new employee trying to become an equal member of the team may be exposed to a high degree of mental stress. That is why it is important that managers should aspire to help newcomers to integrate into a new position and into a new social background. Apart from well-prepared orientation programmes, an effective tool for this motivation effort from the position of a manager is the *orientation interview*.

When we consider the newest knowledge regarding the potential problems with management and development of human potential, it should be realised that there are three categories of orientation interviews, and these are entry (introductory), continuous (repeated) and final orientation interviews.

a) *Entry (introductory) orientation interviews* should open the whole process of getting to know and inure to new facts. The purpose of this interview is to get suggestions and to seek more concrete preferences and visions from a new employee about his/her work activity. In a motivational form of communication, (i.e. in a suitable pace and attractive structure) a senior manager should provide a new employee with all the relevant information dealing with his/her integration into the organization. To reinforce these factors, the manager should once again resort to a positive well-balanced use of non-verbal communication (smile, attentive gestures etc.). He should show a willingness to help at any time with occupational or social problem solving. This will result in the newcomer having a most pleasant beginning of a new phase in his/her professional life.
b) *Continuous (repeated) orientation interviews* should be orientated towards discussion involving facts about the organization and a given task, such as tweaking or changing and running orientation programme. This might involve answering obscure questions, problem solving issues that have been incorporated into a new working environment. These continuous interviews should be carried out with a strong motivation emphasis during the orientation period and they should be repeated. A suggested period for the realisation of continuous interviews is a minimum of two weeks, while the most suitable timescale for this motivational communication with a new employee is a period of 15 – 30 minutes every week. The interval of repetition of these interviews depends on the demands of the job position, level of openness of the working team and the ability of a newcomer to absorb the amount of new information. The new employee needs to monitor the success of his/her ability to solve conflicts and complications within the organization. Throughout these debates, *a manager should try to fortify the motivation of a newcomer* to remain within the organization so long as no difficulties with his/her working behaviour have appeared. The manager should motivate the new employees to exert their full potential with regard to their work effort. During this time, a new recruit should motivate a superior to enable him to give support even after the end of this process.
c) *Final orientation interview* is realised at the end of the process of orientation. It should be devoted to the total evaluation of the progress and results achieved in this orientation process. It should reflect both the views of the personnel specialist and the newly admitted (already orientated) employee. In this interview, both parties should continue in a motivation effort in the same way as in the previous interviews.

3.3. Appraisal Interview

Appraisal interviews are associated with highly complex methods of increasing motivation and constantly increasing quality of the complex performance of employees. They embody communication and motivational meetings during which time the superior worker discusses with an evaluated employee particular aspects of his/her working behaviour and endeavours to establish a process by which the future development of professional and personal potential of an employee is enhanced.

Consistently enforcing *motivation accent of appraisal interview* can consequently effect a deeper identification of an employee with the organization, to show willingness to increase systemic development of the working results of creativity and innovation, etc. In the practice of management and development of human potential, the most frequently chosen interviews fall into one of these categories: either an interview at the working performance level with negative aspects to its approach, or one with a positive approach towards working performance.
a) ***Motivational appraisal interview with particular defects in performance*** should be realised using the so-called "sandwich effect" technique. The idea is to implement in conversation negative warnings or problems that may affect the working performance between *introductory positive statement about performance and final motivation appeal for a future improvement* within the organisation. This means that at the beginning of the interview it is acceptable to put an employee into a positive mood by emphasising positive sides of his/her performance in an objective way. Consecutively, it is necessary, in a tactful and diplomatic manner to introduce problematic areas mentioned in an evaluative reference and give the employee the opportunity to express his/her opinion towards debated drawbacks. In a mutual discussion both the evaluator and the valuated employee should *together come to an agreement upon the elimination of arisen defects and upon the identification of the most useful motivation tools,* which could help to increase the degree of experienced motivation of employee in regards to remedies. When concluding the interview, the interviewer should repeatedly stress the positive merits of complex working behaviour of the employee. This will show that the organization, especially the interviewer trusts in the employee and in his potential. The interviewer should stress his willingness to help the employee in any future reparative effort required.
b) ***Motivational appraisal interview with a positive performance*** is commonly called in practise an appreciative appraisal talk. Its starting point is the knowledge that praise *and appreciation are important means of accumulation of involvement, loyalty and participation of many employees and managers.* In particular, the expression of appreciation and positive evaluation raises the satisfaction levels of the working effort and contributes to high levels of motivation. Opposite opinions sometimes appear pointing out to the fact that appreciative appraisals can be "dangerous". Some managers might be afraid of the fact that employees could misinterpret words of appreciation as areas of potential misuse of a situation, or even the offer of financial remuneration. However, this opinion is inaccurate, whereas

creative employees and managers (even though they do not often openly admit it) nurture the feelings of being appreciated by their superiors or colleagues. For this reason, it is very important in this type of interview, to realise that the employee believes that he/she is a valuable member of the working team and for this reason the manager should observe his/her working behaviour very positively and respect it. In this way, positively perceived appraisal conversation is a *strong motivation tool for the professional as well as the non-professional future of the employee.*

3.4. Outgoing Interviews

Outgoing interviews in combination with outgoing questionnaires can be a valuable source of important information and knowledge for the organization and its managing sections. This interview is the final and hence the most necessary form of communication and motivation meetings between the leaving employee and the direct superior manager who represents the organization.

This process can be understood as an official interview between the line manager (or a personnel department) and the employee and the manager should endeavour to find the reason why the employee chooses to leave the organisation, whilst at the same time thanking him/her for their working contributions to the organization. At this time, it is paramount that the manager should instil into the parting employee, *as positive impression about the organization as is possible.* Therefore, the outgoing interview should aim at motivation reinforcement of "future former" employees attitude that they would cultivate a positive image of the organization in the future.

From the point of view of systematic management and development of human potential, we can suggest the realisation of these basic types of outgoing interviews: forced leaving interview, retirement interview, resignation interview (accepted by management) and resignation interview (not accepted by management). From this group of interviews, the most problematic types of interviews are the Forced leaving interviews and Resignation interview not accepted by the management of the organization (undesirable leave).

a) ***Outgoing interview at forced resignation*** should be carried out together with the so-called "sandwich effect". Here, the managing director should explain to an outgoing employee the problems within the organization leading to the dismissal of the worker even though his work output was positive. This outgoing interview is recognised as the most unpleasant and traumatic episode of an interpersonal interview. To alleviate negative social impact of discharge it is necessary to conduct this interview *with an utmost degree of sensitivity*, while at the same time *showing shared emotional reaction* towards the dismissed employee. If it is possible or feasible, the manager should suggest ways in which the dismissed employee might renegotiate future redeployment in case the situation in organization gets better at a later date.

b) ***Outgoing interview of undesirable leave*** represents a motivation interview with an employee who shows a desire to resign from the organization but the management are reluctant to lose his potential within the organization. In this situation, the role of the director or a personnel manager is to hopefully persuade the employee to reconsider his/her decision to resign his/her post. This type of interview could be deemed as being an "anti-outgoing" interview, as its aim is to reverse the decision of the employee to resign from the organization. The processes and subsequent results of this type of interview depend heavily on *the communication and motivation skills of the directing manager* in presenting the interview in such way as to stimulate the employee to reverse his/her decision to leave the organization.

It is important to draw attention to the fact that there is a potential danger when using these types of interviewing techniques. When trying to persuade an employee not to leave the organization the management can offer him/her *exceedingly* attractive benefits, which cannot and would not be offered to other employees at the same level of work competence. This could result in the workforce putting pressure on the organization to compensate all staff to the same level, which would not be feasible or cost effective. That is why it is necessary to carefully consider which stimulus is from the viewpoint of the organization still effective (endurable), and, at the same time, attractive enough for the employee who intended to leave.

The success of the interview depends on the *intensity of the desire of the employee* not to work for the organization. If it is obvious that the employee committed in his wish to leave the organization, the "anti-outgoing" interview will be unsuccessful. Nevertheless, if the interview continues and the highly qualified and valued member of staff is still required by the organization, the manager will need to show a high degree of motivation effort, at this stage. The fact that the employee has made a choice to leave the organisation may be changed if he/she is made to question his/her motivation and loyalty towards the organization.

4. Conclusion

Motivation of both employees and managers is the most important and at the same time, the most difficult process of effective management and development of human potential. Its difficulties emanate from the continuity of basic systems of each motivation effort.

In certain organizations these processes of selective, orientation, appraisal and outgoing interviews can have positive effects on the quality of existing systems of work within the parameters of human potential. A supportive idea among motivated and developing *employees* and managers is that there will certainly be a higher tendency to remain working within the organization longer and the "turn-over" rate of staff will decrease. In this way, a long-time employment will support the growth of productivity of human potential specific for a given organization. [5]. Therefore, the motivation effort, in spite of its intensiveness, has to be a fixed component of dynamic management and development of human potential.

Acknowledgement

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An objective of our next paper (December 2005) is to collect evidence drawn from a pre-planned and researched questionnaire involving issues relating to interpersonal skill and motivation of higher educated managers and employees from Slovakian, Czech, Polish and French universities.

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APPLICATION OF SUPPORT VECTOR MACHINES TO THE MODELLING OF INFLATION

In Support Vector Machines (SVM's), a non-linear model is estimated based on solving a Quadratic Programming (QP) problem. Based on work [1] we investigate the quantifying of econometric structural model parameters of inflation in Slovak economics. The theory of classical Phillips curve [8] is used to specify a structural model of inflation. We provide the fit of the models based on econometric approach for the inflation over the period 1993-2003 in the Slovak Republic, and use them as a tool to compare their approximation ability with those obtained using SVM's method. Some methodological contributions are made for SVM implementations to the causal economic modelling.

Keywords: *SVM's, time series analysis, quadratic programming, econometric modelling*

1. Introduction

Model specification and estimation are two major components in econometric modelling. They are often treated as two separate but closely related steps in econometric model building. In modelling economic quantities, probably the most important step consists of identifying the relevant influential factors.

This contribution considers the econometric modelling of inflation in the Slovak Republic. The main tools, techniques and concepts involved in econometric modelling of inflation are based on the Phillips concept [8]. According to the Phillips inflation theory the variable inflation is generated on a set of underlying assumptions. In any case, the analysed inflation rates are explained by the behaviour of another variable or a set of variables, in our case by the wages and the unemployment (independent variables).

In this paper the resulting SVM's are applied using an ε-insensitive loss function developed by V. Vapnik. We motivate the approach by seeking a function which approximates mapping from an input domain to the real numbers based on a small subset of training points. The paper is organised as follows. The next section will provide a quick overview of the concept of SVM's theory. Section 3 analyses the data, discuses the Engle-Granger estimator and SVM estimator, and presents the fitted inflation rate values by the classical regression methods and SVM's models in Slovak economics. A section of conclusions will close the paper.

2. Support Vector for Functional Approximation

This section presents quickly a relatively new type of learning machine – the SVM applied in the regression (functional approximation) problems. For details we refer to [11], [12]. The general regression learning task is set as follows. The learning machine is given n training data, from which it attempts to learn the input-output relationship $y = f(x)$, where $\{x_i, y_i \in \Re^n \times \Re, i = 1, 2, ..., n\}$ consists of n pairs $\{y_i, x_i\}_{i=1}^{n}$. The x_i denotes the ith input and y_i is the ith output. The SVM considers the regression functions of two forms [11]. The first one is

$$f(x) = \sum_{i=1}^{n} (\alpha_i - \alpha_i^*)\psi(x_i, x_j) + b, \qquad (1)$$

where α_i, α_i^* are positive real constants (Lagrange multipliers), b is a real constant, $\psi(./.)$ is the kernel function. Admissible kernels have the following forms: $\psi(x_i, x_j) = x_i^T x_j$ (linear SVM) $\psi(x_i, x_j) =$ $= (x_i^T x_j + 1)^d$ (polynomial SVM of degree d), $\psi(x_i, x_j) = \exp(-\theta \| x_i - x_j \|_2^2)$ (radial basis SVM), where θ is a positive real constant and other (spline, b-spline, exponential RBF, etc.).

The second regression function is of the form

$$f(x, w) = \sum_{i=1}^{n} w_i \varphi_i(x) + b, \qquad (2)$$

where $\varphi(.)$ is a non-linear function (kernel) which maps the input space into a high dimensional feature space. In contrast to Eq. (1), the approximation function $f(x, w)$ is explicitly written as a function of the weights w that are subject of learning.

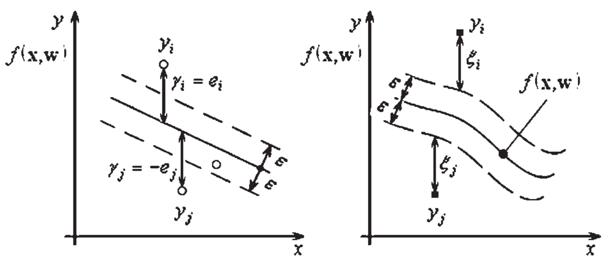

Fig. 1 The insensitive band for one dimensional linear (left), non-linear (right) function

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The Support Vector regression approach is based on defining a loss function that ignores errors that are within a certain distance of the true value. This type of function is referred to as an ε-insensitive loss function.

Fig. 1 shows an example of one dimensional function with an ε-insensitive band. The variables ξ, ξ^* measure the cost of the errors on the training points. These are zero for all points inside the band, and only the points outside the ε-tube are penalised by the so called Vapnik's ε-insensitive loss function.

In regression, typically some error of approximation is used. They are different error (loss) functions in use and that each one results from a different final model. Fig. 2 shows the typical shapes of three loss functions [2]. Left: quadratic 2-norm. Middle: absolute error 1-norm. Right: Vapnik's ε-insensitive loss function.

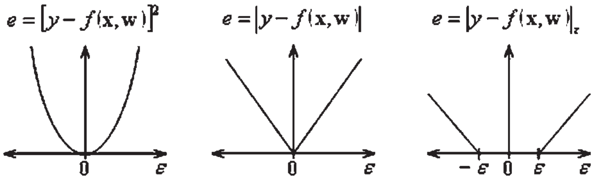

Fig. 2 Error (loss) functions

Formally, this results from solving the following Quadratic Programming problem

$$\min_{w,\, b,\, \xi,\, \xi^*} \; R(w, \xi, \xi^*) = \frac{1}{2} w^T w + C \sum_{i=1}^{n} (\xi_i + \xi_i^*)\,, \qquad (3)$$

$$\text{subject to} \begin{cases} y_i - w^T \varphi(x) - b \le \varepsilon + \xi_i & i = 1, 2. \dots, n \\ w^T \varphi(x) + b - y_i \le \varepsilon + \xi_i^* & i = 1, 2. \dots, n \\ \xi_i,\, \xi_i^* \ge 0 & i = 1, 2. \dots, n \end{cases} \qquad (4)$$

To solve (3), (4) one constructs the Lagrangian

$$L_p(w, b, \xi_i, \xi_i^*, \alpha_i, \alpha_i^*, \beta_i, \beta_i^*) =$$
$$= \frac{1}{2} w^T w + C \sum_{i=1}^{n} (\xi_i + \xi_i^*) - \sum_{i=1}^{n} \alpha_i(\varepsilon + \xi_i - y_i +$$
$$+ w^T \varphi(x_i) + b) - \sum_{i=1}^{n} \alpha_i^*(\varepsilon + \xi_i^* + y_i - w^T \varphi(x_i) - b) -$$
$$- \sum_{i=1}^{n} (\beta_i \xi_i + \beta_i^* \xi_i^*) \qquad (5)$$

by introducing Lagarnge multipliers α_i, $\alpha_i^* \ge 0$, ξ_i, $\xi_i^* \ge 0$, $i = 1, 2, \dots, n$. The solution is given by the saddle point of the Lagrangian [3]

$$\max_{\alpha_i,\, \alpha_i^*,\, \beta_i,\, \beta_i^*} \; \min_{w,\, b,\, \xi,\, \xi^*} \; L_p(w, b, \xi_i, \xi_i^*, \alpha_i, \alpha_i^*, \beta_i, \beta_i^*) \qquad (6)$$

subject to constrains

$$\begin{cases} \dfrac{\partial L_p}{\partial w} = 0 & \to w = \sum_{i=1}^{n} (\alpha_i^* + \alpha_i)\varphi(x_i) \\ \dfrac{\partial L_p}{\partial b} = 0 & \to \sum_{i=1}^{n} (\alpha_i^* + \alpha_i)\varphi(x_i) = 0 \\ \dfrac{\partial L_p}{\partial \xi_i} = 0,\ \dfrac{\partial L_p}{\partial \beta_i} = 0 & \to 0 \le \alpha_i \le C,\ i = 1, \dots, n \\ \dfrac{\partial L_p}{\partial \xi_i^*} = 0,\ \dfrac{\partial L_p}{\partial \beta_i^*} = 0 & \to 0 \le \alpha_i^* \le C,\ i = 1, \dots, n \end{cases} \qquad (7)$$

which leads to the solution of the QP problem:

$$\max_{\alpha_i,\, \alpha_i^*} \; -\frac{1}{2} \sum_{i,j=1}^{n} (\alpha_i^* + \alpha_i)(\alpha_j^* + \alpha_j)\varphi(x_i^T x_j) -$$
$$- \varepsilon \sum_{i=1}^{n} (\alpha_i + \alpha_i^*) + \sum_{i=1}^{n} y_i (\alpha_i - \alpha_i^*). \qquad (8)$$

After computing Lagrange multipliers α_i and α_i^*, one obtains the form of (1), i.e.

$$f(x) = \sum_{i=1}^{n} (\alpha_i + \alpha_i^*)\psi(x_i, x_j) + b\,. \qquad (9)$$

Finally, b is computed by exploiting the Karush-Kuhn-Trucker (KKT) conditions [3], i.e.

$$\begin{cases} b = y_k - \sum_{i=1}^{n} (\alpha_i + \alpha_i^*)\psi(x_i, x_k) - \varepsilon & \mathit{for}\ \alpha_k \in (0, C) \\ b = y_k - \sum_{i=1}^{n} (\alpha_i + \alpha_i^*)\psi(x_i, x_k) + \varepsilon & \mathit{for}\ \alpha_k^* \in (0, C) \end{cases} \qquad (10)$$

3. Causal Models, Experimenting with Non-linear SV Regression

We demonstrate here the use of SV regression framework for dynamic modelling of economic time series where the time series or variable, say inflation, to be modelled can be explained by the behaviour of another variable or a set of variables. First, we present an econometric approach for modelling and investigating the relationship between the dependent variable of inflation measured by *CPI* (Consumption Price Index) and the two independent variables are the unemployment rate (*U*), and aggregate wages (*W*) in the Slovak Republic. Then, the SV regression is applied. Finally, the results are compared between a dynamic model based on econometric modelling and an SVR model.

To study the modelling problem of inflation quantitatively the quarterly data from 1993Q1 to 2003Q4 was collected concerning the consumption price index *CPI*, aggregate wages *W* and unemployment *U*. These variables are measured in logarithm, among others for the reason that the original data exhibit considerable inequalities of the variance over time, and the log transformation stabilises this behaviour. Fig. 3 illustrates the time plot of the *CPI* time series. This time series shows a slight decreasing trend without apparent periodic structure.

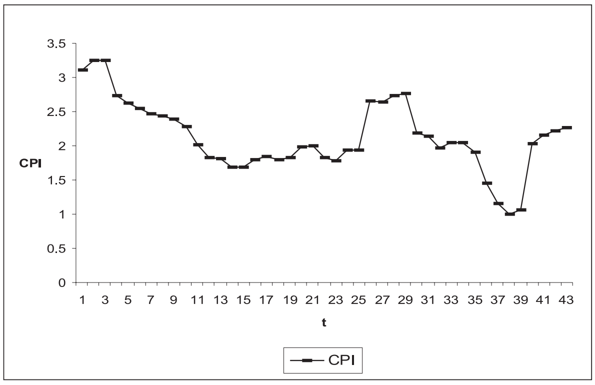

Fig. 3 Natural logarithm of quarterly inflation from January 1993 to December 2003

Experimenting with the linear transfer function models [1], the resulting reasonable model formulation was found

$$\hat{CPI}_t = 0.5941 - 0.0295W_{t-1} - 0.00359U_{t-1} + 0.84524CPI_{t-1} \quad (11)$$
$$(0.229) \quad (0.3387) \quad (0.1035)$$

$R^2 = 0.7762$; $F(3.40) = 45.089$; $d = 1.49$;
$d_L = 1.38$; $d_U = 1.67$

The model specification of (11) is the lagged dependent variable model in which the dependent variables, lagged one period, appear as independent explanatory variables. This model is based on a distributed lag model [9]. One of the primary reasons for using this functional form is to determine the long-run response of dependent variable to change in each of the independent variables. The *d* statistic for model (11) is 1.49, falling in the inconclusive region, making the decision concerning first-order autoregression indeterminate. In this particular case, a decision has to be made whether or not to correct the autocorrelation. At this point, we will use this model and not correct for autocorrelation. In model (11), the regression coefficients β_1, β_2 have not the appropriate magnitude. In addition, they are statistically insignificant at five percent level. In all probability the lagged dependent variable CPI_{t-1} substitutes for the inclusion of other lagged independent variables (W_{t-1}, U_{t-1}). The inclusion of CPI_{t-1} and W_{t-1}, U_{t-1} is redundant and overspecified the model. A graph of the historical and

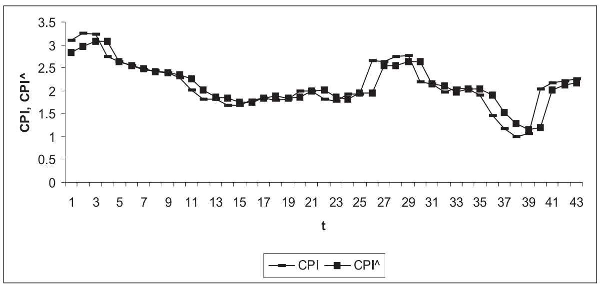

Fig. 4 Natural logarithm of actual and fitted inflation values (model (11))

the fitted values for inflation is presented in Fig. 4. The model follows the pattern of the current inflation very closely.

Finally another attempt was made supposing a more sophisticated dependence of current inflation on the previous observation performed with the help of SV regression. As stated in literature, we can not have a model in which the coefficients are statistically insignificant. We made an arbitrary decision which deleted "insignificant" explanatory variables. Then the equation

(11) becomes the first-order autoregressive process (Markov process) because the observation of *CPI* at time *t* depends only on the observation of *CPI* at time $t - 1$, i. e.

$$\hat{CPI}_t = \beta_0 + \beta_1 CPI_{t-1}, \quad (12)$$

where β_0, β_1 are unknown parameters. If CPI_t exhibits a curvilinear trend, one important approach to generating an appropriate model is to regress the CPI_t against time. In Tab. 1 the SVR results of inflation were also calculated using an alternative time series model expressed by the following SVR form

$$\hat{CPI}_t = \sum_{i=1}^{n} w_i \varphi_i(x_t) + b \quad (13)$$

which is a time series model where $x_t = (1, 2, ..., 43)$ is the vector of time sequence (regressor variable).We report the results in Fig. 5. Since this pattern of change is a common practice, we desire that our machine identify permanent changes and adjust the parameters to track the new process.

One crucial design choice is to decide on a kernel. Creating good kernels often requires lateral thinking: many measures of similarity between inputs have been developed in different contexts, and understanding which of them can provide good kernels depends on insight into the application domain. The Fig. 5 shows SVM learning by using various kernels. In Fig. 5a we have a piecewise-linear approximating function, while in Fig. 5b and Fig. 5c we have a more complicated approximating function. Both functions agree with the training points, but they differ on the three *y* values, they assign to other *x* inputs. The functions in Fig. 5d and Fig. 5e apparently ignore some of the example points but are good for extrapolation. The true $f(x)$ is unknown, and without further knowledge, we have no way to prefer one of them, and so to resolve the design problem of choosing an appropriate kernel in our application. For example, the objective in pattern classification from sample data is to classify and predict successfully new data, while the objective in control applications is to approximate non-linear functions, or to make unknown systems follow the desired response.

Tab. 1 presents the results for finding the proper model by using the quantity R^2 (the coefficient of determination) on our application of the best approximation of the inflation rate. Since the estimation method for the SVR models is without any sound of statistical theory behind it, the values of the quantity R^2 are basically intuitive, there are no "statistically correct" coefficients of determination for SV regression models. As the calculating of R^2 uses the residuals of the goodness of fit of the least squares line to the data, we will use the R^2 in the case of the SV regression line as well. As shown in Tab. 1 the "best" is 0.9999 for the time series models with the RBF kernel and quadratic loss functions. In the cases of causal models the best R^2 is 0.9711 with the exponential RBF kernel and ε-insensitive loss function (standard deviation $\sigma = 0.52$). The choice of σ was made in response to the data. In our case, the CPI, CPI_{-1} time series have $\sigma = 0.52$. The radial basis function defines a spherical receptive field in and the variance σ^2 localises it.

The results shown in Tab.1 were obtained using ε-insensitive loss function ($\varepsilon = 0.2$), with different kernels and degrees of capacity $C = 10^5$. We used partly modified software developed by Steve. R. Gunn [4] to train the SV regression models. The use of SV regression is a powerful tool to the solution of many economic problems. It can provide extremely accurate approximation of time series, the solution to the problem is global and unique. However, these approaches have several limitations. In general, as can by seen from equations (7), (8), the size of the matrix involved in the quadratic programming problem is directly proportional to the number of training data. For this reason there are many computing problems in which general quadratic programs become intractable in their memory and time requirements. To solve these problems many modified versions of SVM's were introduced. For example the generalized version of the decomposition strategy is proposed by Osuna et al. [7], the so-called SVM^{light} proposed by Joachims, Thorsten [5] is an implementation of an SVM learner which addresses the problem of a large task, and finally, in [10]

Tab. 1 The SV regression results of different choice of the kernels on the training set (1993Q1 to 2003Q4). In last column the approximation performance is analysed. See text for details.

Fig. 5	MODEL	KERNEL	σ	DEGREE-d	LOSS FUNCTION	R_2
a	causal	exp. RBF	1		ε - insensitive	0.9711
b	causal	RBF	1		ε - insensitive	0.8525
c	causal	RBF	0.52		ε - insensitive	0.9011
d	causal	polynomial		2	ε - insensitive	0.7806
e	causal	polynomial		3	ε - insensitive	0.7860
f	time series	RBF	0.52		quadratic	0.9999

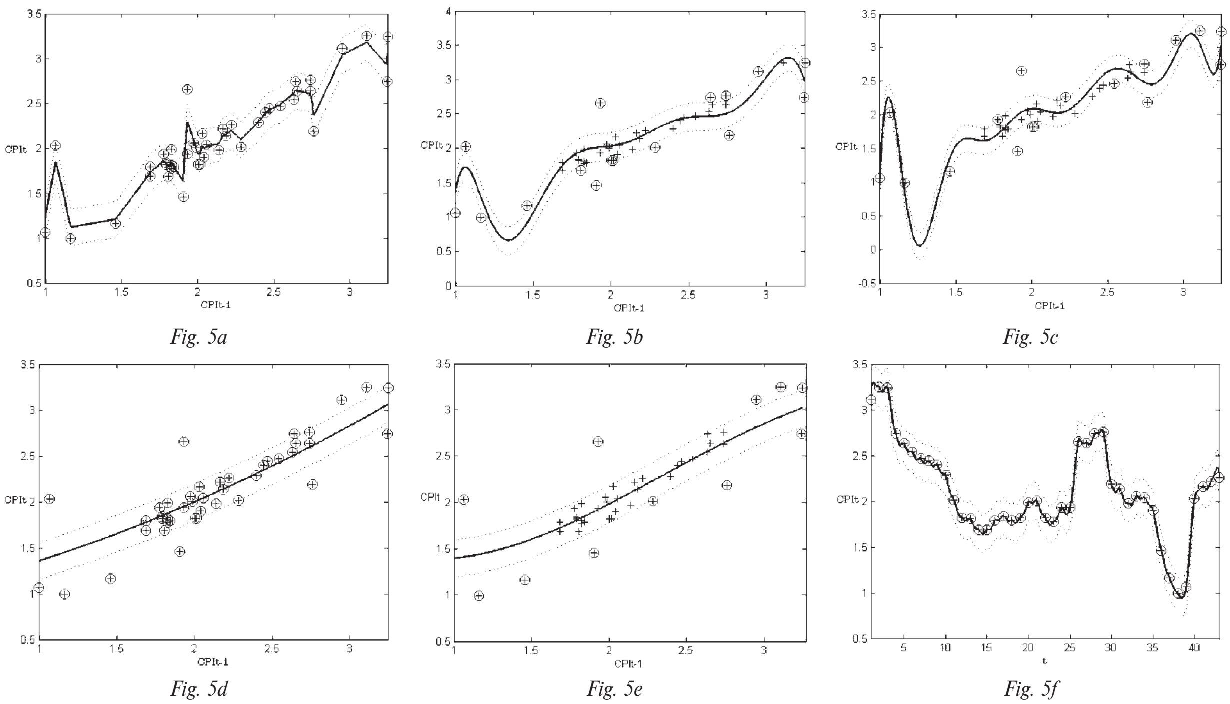

Fig. 5a *Fig. 5b* *Fig. 5c*

Fig. 5d *Fig. 5e* *Fig. 5f*

Fig. 5 Training results for different kernels, loss functions and of the SV regression (see Tab. 1). The original functions (plus points), the estimated functions (full line), the -tube (dotted lines) are shown. Fig. a, b, d, e, f correspond to a good choice of the parameters, Fig. c corresponds to a bad choice.

a modified version of SVM's so-called least squares SVM's (LS-SVM's) is introduced for classification and non-linear function estimation.

4. Conclusion

In this paper, we have examined the SVM approach to study linear and non-linear models on a time series of inflation in the Slovak Republic. For the sake of approximation abilities we evaluated eight models. Two models are based on causal multiple regression in time series analysis, and six models are based on the Support Vector Machines methodology. Using the disposable data a very appropriate econometric model is the regression (11) in which the lagged dependent variable CPI_{t-1} can substitute for the inclusion of other lagged independent variables (W_{t-1}, U_{t-1}). The benchmarking was performed between traditional statistical approaches and SVMs in regression approximation tasks. The SVM approach was illustrated on the regression function of (12), which was developed by statistical tools. This problem was readily solved by a SV regression with excellent approximation performance as it is visually clear from Fig. 5. Finally, the paper made some methodological contribution for SVM implementations to the causal economic modelling.

Acknowledgement

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CONTACT AREA AND NORMAL STRESS DETERMINATION ON RAILWAY WHEEL / RAIL CONTACT

It is important to study the field of railway wheel /rail contact area from the point of view of stress distribution for further investigation of running behavior of a vehicle when running on a rail track. There is a contact of two spatial geometrically defined bodies, which have characteristic material properties, by a power effect of a vehicle through the wheel on the rail. The contact point is transformed into the contact area as a result of the pressure of the bodies against each other. It is possible to acquire the image of the contact area and the stress which appears at the contact as a result of the application of a known calculation method or to set up own calculation methods. The paper deals with theoretical grounds of two computational methods. They are the Hertz method and strip method (according to Johnson [5]). The results of the contact area and normal stress numerical computation made by authors of the paper are stated and compared with the above mentioned methods and the results of the contact area and normal stress numerical computation made by the authors of the paper are stated and compared with the methods in references [7].) The contribution of the paper is to present the authors' computational results and compare the results with published results of other authors [7]. The authors reached the results with the support of their own computational program. The results are the base for other tangential contact stress research computations and base for other vehicle dynamics simulation computation in the future.

1. Introduction

An important parameter influencing the power effect of a wheel on the rail is the size and shape of the contact area as well as the normal stress distribution which has the impact on it. Nowadays various methods are used to find out the size of contact areas and stresses. It is necessary to mention the Hertz method as one of the oldest and up to date used methods. It provides acceptable results for a large area in spite of many simplifications. Another computational procedure is the stripe method which is, thanks to its results, close to reality and it is used in the following calculations. Nowadays, another group of calculation program systems (ANSYS, MSC.MARC, ADINA...) is used in certain situations. The systems work on the base of finite elements method theory. Searching of the solution of contact problems with the help of finite element method is not the subject of the paper.

2. Hertz method

Hertz method [4, 5, 6, 9] belongs to widely used methods of contact area and contact stress determination even in the present. We can simplify the wheel and rail contact as a contact of two cylindrical areas. The rail head surface, with the diameter $R_x^{(2)} = \infty$, $R_y^{(2)}$, presents one of the cylindrical areas. The running tread of the wheel, with the diameter $R_x^{(1)}$, $R_y^{(1)}$, builds a second idealized cylindrical area (conical area in reality). These two skew cylinders with mutually perpendicular axes touch each other at the contact area. This happens by the effect of the vertical wheel force Q. The Hertz solution of the two bodies contact problem comes from a presupposition that: material is homogenous, isotropic, material behaves elastically, displacements and stresses are bordered in space, the contact area is small with regard to the surface, the area is positive and plain, there is no surface slip, and there is no spin. [7]. In spite of the fact that many presuppositions are not fulfilled, or they are fulfilled only partially, the theoretical calculations show sufficient agreement with experiments.

$$A = \frac{1}{2} \cdot \left(\frac{1}{R_x^{(1)}} + \frac{1}{R_x^{(2)}} \right) \quad B = \frac{1}{2} \cdot \left(\frac{1}{R_y^{(1)}} + \frac{1}{R_y^{(2)}} \right) \qquad (1)$$

At first principal curvatures are calculated from the known profiles curvatures diameters.

The size of the half axes a, b, of the contact area is given by the following formulas with the usage of the Hertz method. It is used in practice [6]:

$$a = \alpha \cdot \sqrt[3]{\frac{3 \cdot Q \cdot (1 - \nu^2)}{2 \cdot E \cdot (A + B)}} \quad b = \beta \cdot \sqrt[3]{\frac{3 \cdot Q \cdot (1 - \nu^2)}{2 \cdot E \cdot (A + B)}} \qquad (2)$$

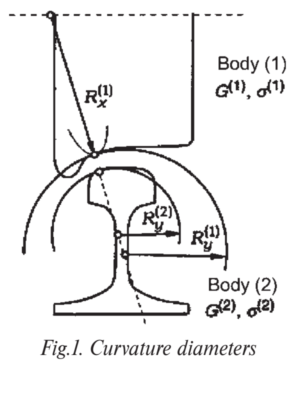

Fig.1. Curvature diameters

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Where
Q – is vertical wheel force,
E – is modulus of stiffness,
ν – is Poisson's ratio,
A, B – principal diameters of the wheel and rail curvature.

Body radius in contact point
$R_x^{(1)}$ – wheel (x-z cross section area)
$R_y^{(1)}$ – wheel (y-z cross section area)
$R_x^{(2)}$ – rail (x-z cross section area)
$R_y^{(2)}$ – rail (y-z cross section area)

Constants α and β in the formulae are given in tables and depend on the angle δ, which is defined:

$$\delta = \arccos \frac{|B - A|}{A + B}.$$

From which arises: $\cos\delta = \frac{|B - A|}{A + B}$ (3)

Values δ, α and β are given in the table of appendix [6].

The normal stress p, which is distributed in the form of ellipsoid, appears by the vertical wheel force Q effect, according to the formula:

$$p = p_0 \cdot \sqrt{1 - \left(\frac{x}{a}\right)^2 - \left(\frac{y}{b}\right)^2}$$

where is $p_0 = p_{max} = \frac{3}{2} \cdot \frac{Q}{\pi \cdot a \cdot b} = 1.5pstr.$ (4)

There is an example of two cylinder contact in Fig. 2 and Fig. 3, for more simplicity. One of the cylinders presents a wheel and has a diameter $R = 460$ mm, the second cylinder presents the rail and has the curvature diameter of 300 mm. The axes of both cylinders are perpendicular. If they were not perpendicular, we would have to take into consideration their angle when calculating relative curvatures A and B.

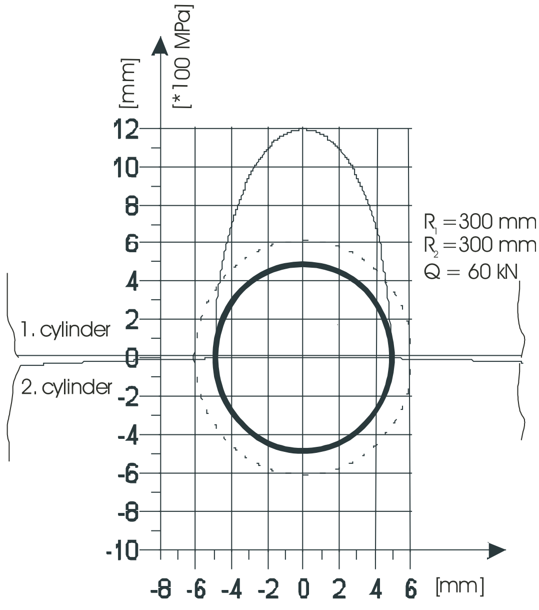

Fig. 2. Contact area shape and normal stress of cylinders with diameters 300 mm

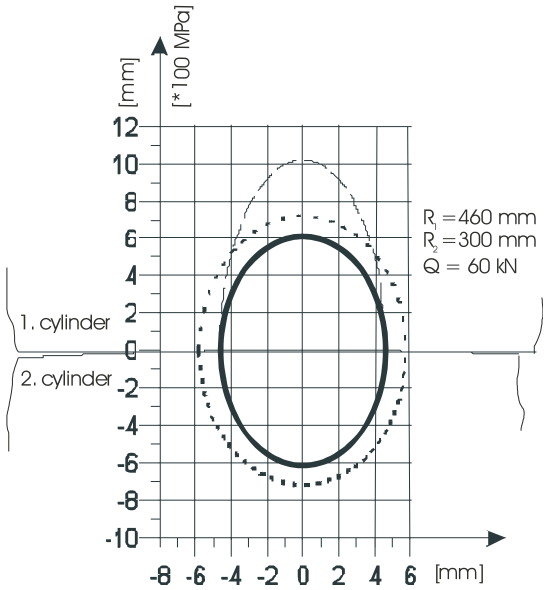

Fig. 3. Contact area shape and normal stress of two cylinders with diameters of 460 and 300 mm

The situation is changed when the real wheel and rail profiles are taken into account. The contact area acquires a non-elliptical shape with regard to a rapid change of the rail profile curvature diameter.

3. Strip method

Strip method [1, 4, 5, 6, 7, 9] presupposes quasi-static rolling. The principal idea of the theory is to take into consideration slim contact areas in the y-direction.

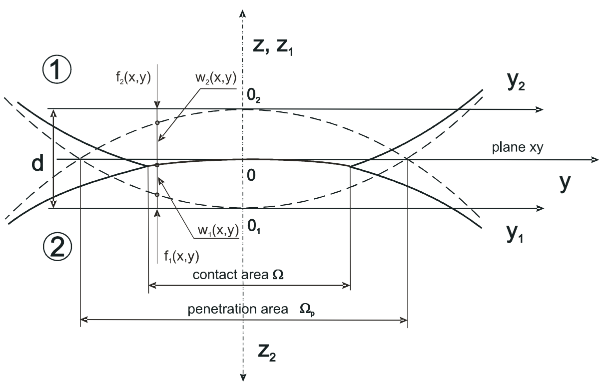

Fig. 4. Coordinate body system at the contact

In Fig. 4 there are two bodies in contact. Geometrical parameters (of railway wheel and rail) should be very similar in reality, deformation zones are similar too. In spite of this fact the parameters (the displacements w_1 and w_2) in Fig. 4 are rather different for better understanding of theory. In fact the contact area should be plane (parallel with the x-y plane).

The method presupposes the existence of two rotating bodies 1 and 2 with surfaces S_1 and S_2. The bodies touch in the point 0, which is at the same time the beginning of their spatial coordinate systems. The axes x and y determinate the horizontal base. We will mark the horizontal coordinate as the z – axis. If there is no influence of a normal force Q, then exclusively geometrical binding between the bodies exists.

If the bodies are pressed against each other by the normal force Q, there is a deformation and a contact area Ω between the bodies appears instead of a contact point.

- The geometrical profile shape of the first body surface will be marked $f_1(x, y)$, the geometrical profile shape of the second body surface will be marked $f_2(x, y)$.
- The elastic displacement in the z-axis direction caused by the deformation of the first body surface will be marked $w_1(x, y)$, the displacement in the z-axis direction caused by the deformation of the second body surface will be marked $w_2(x, y)$.
- The displacement of bodies centers against each other in the axis-z direction will be marked $d(x, y)$.
- The perpendicular distance between the points of the deformed bodies surfaces will be marked $\delta(x, y)$.

$$\delta(x, y) = f_1(x, y) + w_1(x, y) + f_2(x, y) + $$
$$+ w_2(x, y) - d(x, y) \tag{5}$$

A function $\delta(x, y)$ determines the dependence of the deformed bodies surfaces position. It has the zero value in the contact point.

$$\begin{aligned} &\delta(x, y) = 0 && \text{in the case of the } (x, y) \in \Omega \\ &\delta(x, y) > 0 && \text{in the case of the } (x, y) \notin \Omega \end{aligned} \tag{6}$$

A normal stress effects only in the sphere of the contact area Ω. Boundary conditions for the influence of the normal stress:

$$\begin{aligned} &\sigma_z(x, y, 0) = -p(x, y) && \text{in the case of the } (x, y) \in \Omega \\ &\sigma_z(x, y, 0) = 0 && \text{in the case of the } (x, y) \notin \Omega \end{aligned} \tag{7}$$

Body surface displacements from the elastic deformation $w_1(x, y)$ and $w_2(x, y)$ are calculated from the normal stress distribution in the contact [9].

$$w_1(x, y) = \frac{1 - \mu_1^2}{\pi \cdot E_1} \cdot \iint_\Omega \frac{p(x', y')}{\sqrt{(x - x')^2 + (y - y')^2}} dx'dy'$$

$$w_2(x, y) = \frac{1 - \mu_2^2}{\pi \cdot E_2} \cdot \iint_\Omega \frac{p(x', y')}{\sqrt{(x - x')^2 + (y - y')^2}} dx'dy' \tag{8}$$

In the formula (8) x and y are coordinates of the contact points.

After the insertion of the formula (8) into the formula (5), we will acquire the points in the contact.

$$\frac{1 - \mu_1^2}{\pi \cdot E_1} + \frac{1 - \mu_2^2}{\pi \cdot E_2} \cdot \iint_\Omega \frac{p(x', y') \cdot dx'dy'}{\sqrt{(x - x')^2 + (y - y')^2}} =$$

$$= d(x, y) - f_1(x, y) - f_2(x, y) \tag{9}$$

If we know the contact area and the normal stress distribution in the contact, we can acquire the normal force Q and the position of the point in which the force acts.

$$Q = \iint_\Omega p(x, y) \cdot dx \cdot dy \tag{10}$$

$$x_0 \cdot Q = \iint_\Omega x \cdot p(x, y) \cdot dx \cdot dy \tag{11}$$

$$y_0 \cdot Q = \iint_\Omega y \cdot p(x, y) \cdot dx \cdot dy \tag{12}$$

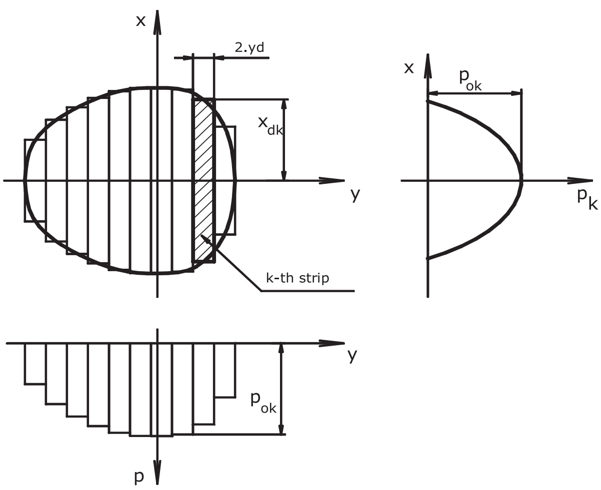

Fig. 5. Contact area division into strips normal pressure distribution in separate strips

The situation is more complicated in the case of the wheel and rail contact because we do not know in advance the acting normal (wheel) force Q and geometrical profile parameters of the touching bodies (wheel and rail).

The surface deformation $w(x, y)$ depends on surface functions $f_1(x, y), f_2(x, y)$ and on the approach d of both elastic bodies. The unknown distribution of the normal pressure $p(x, y)$ will be determined on the contact area Ω from the sum of the surface deformations of two bodies in the contact $w(x, y)$ [7, 9]. The base of the strip theory is the presupposition of contact area Ω symmetry, around y axis. The contact area will be divided into M strips with the length $2 \cdot x_{dk}$ and width $2 \cdot y_d$ perpendicular on the y-axis. It is done for purposes of our numerical calculation. Another presupposition is a semi-elliptic distribution of the normal pressure in the strip direction and a constant in the direction y.

The results of the calculations – examples

Wheel force:	100 kN	Wheel profile:	R-UIC S1002
Wheel diameter:	460 mm	Rail profile:	S-UIC 60
Lateral displacement:	0 mm.		

Ω – contact area
Ω_p – penetration area
p_0 – normal stress

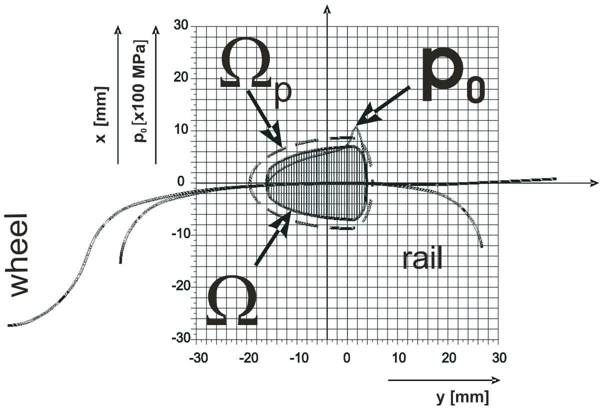

Fig. 6. Contact area and normal stress distribution. Graphs in Fig. 8. to Fig. 13. legend only.

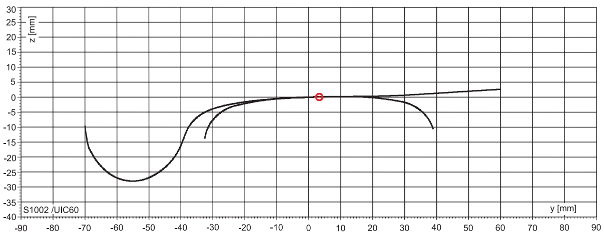

Fig. 7. Right wheel profile of R-UIC1002 and rail head profile S-UIC60 contact point

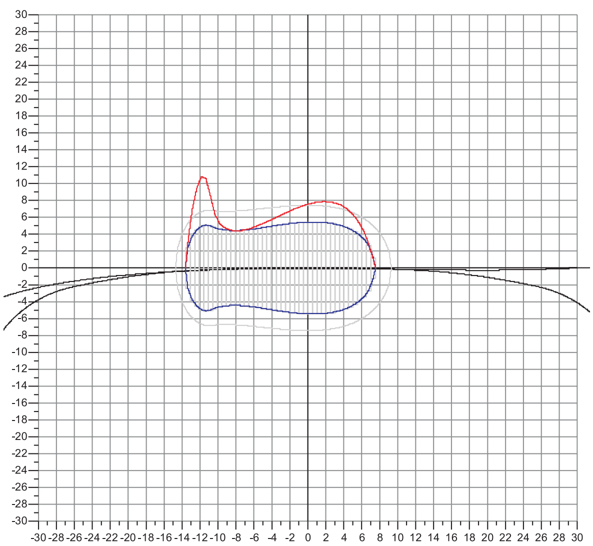

Fig. 8. Wheel lateral displacement state by 0 mm

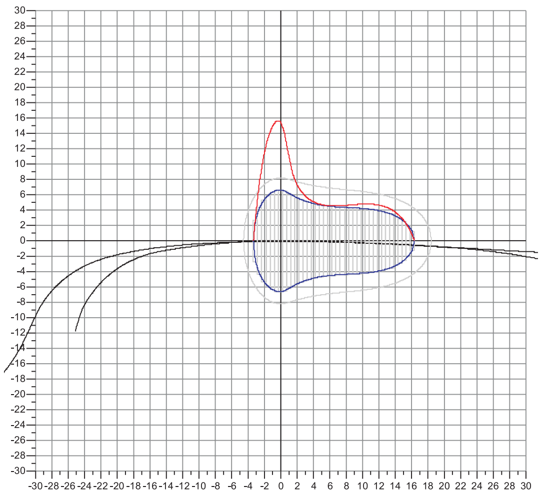

Fig. 9. Wheel lateral displacement state by 1 mm

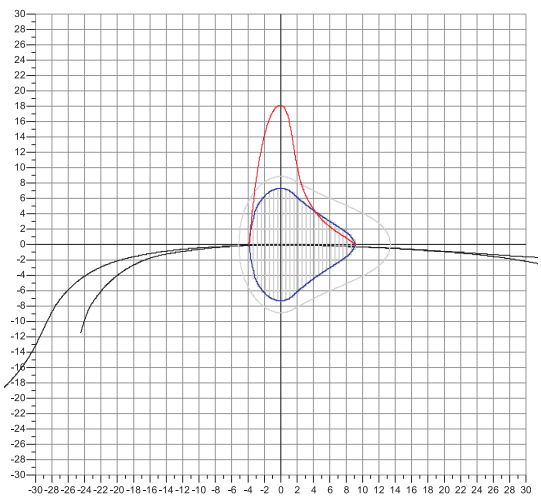

Fig. 10. Wheel lateral displacement state by 2 mm

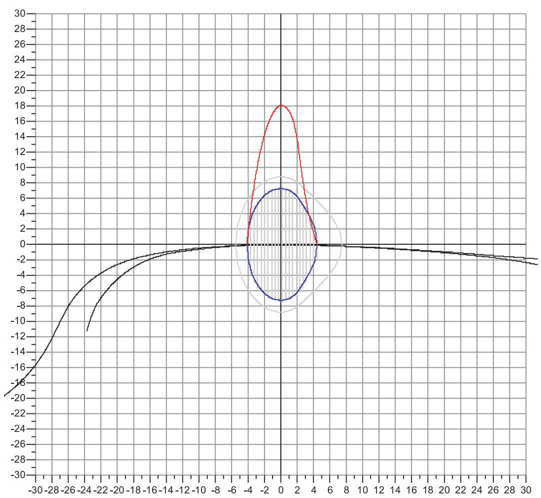

Fig. 11. Wheel lateral displacement state by 3 mm

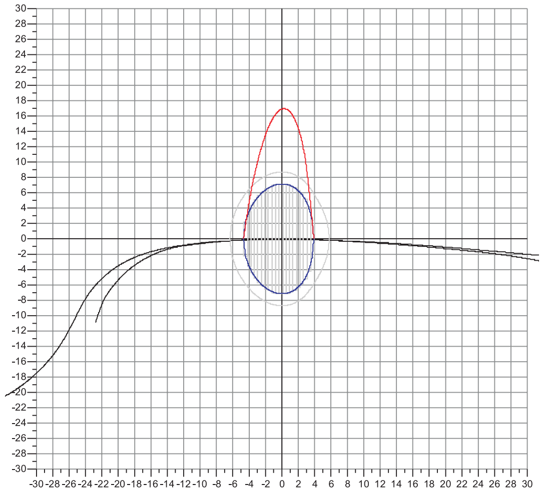

Fig. 12. Wheel lateral displacement state by 4 mm

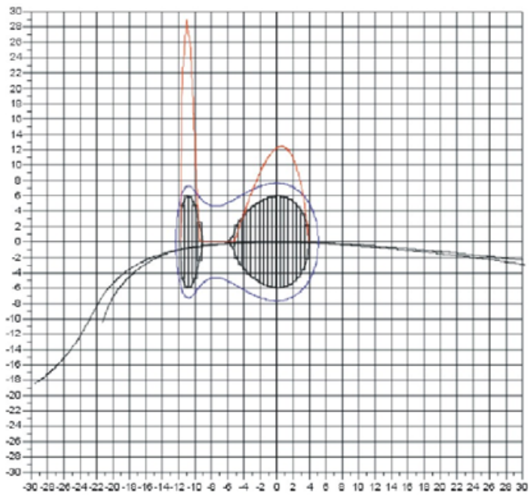

Fig. 13. Wheel lateral displacement state by 5 mm

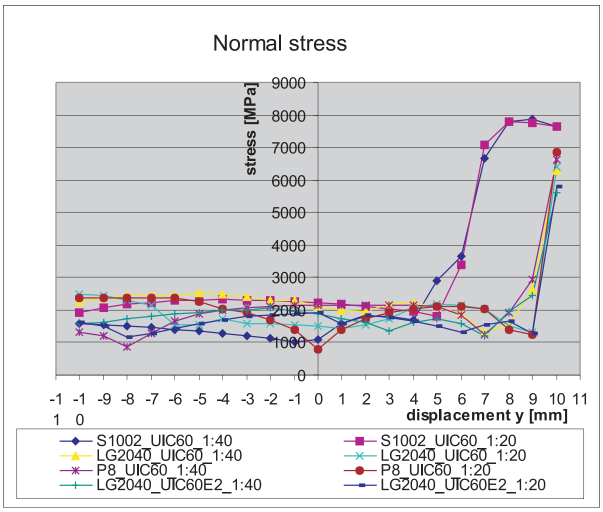

Fig. 14. Normal stress distribution [1]

The calculation is in the field of linear stress and strain and it does not take into account a plastic deformation.

4. Comparison of the calculation results according to the Hertz and strip methods.

Cylinders, angle of axes 90°, loading 100 kN, $E = 2.1 \times 10^6$ MPa, Poisson's ratio 0.277.

Profiles: wheel S1002, rail UIC 60

Cylinders, angle of axes 90°, loading force 100 kN, $E = 2.1 \times 10^6$ MPa, Poisson's ratio 0.277 Tab. 1.

Wheel	Rail	Hertz method			
R1	R2	A	b	area	p_{max}
300	300	11.65	11.65	106.7	1406.2
460	300	14.47	10.89	123.7	1212.5
625	300	16.91	10.42	138.39	1083.9
		Strip method			
R1	R2	X (a)	Y (b)	area	p_{max}
300	300	11.33	11.25	101.2	1582
460	300	13.66	10.61	115.1	1402
625	300	15.54	10.14	125.8	1289

Curvatures radii of a S1002 wheel profile and a UIC60 rail profile in the contact point at lateral movement of a wheel profile. Tab. 2.

Nr.	shift	Wheel curvature	Rail curvature
1	-10	820.44	299.99
2	-9	1084.3	300.01
3	-8	1640.84	300.04
4	-7	3402.45	300.06
5	-6	30184.75	300.06
6	-5	2652.18	300.05
7	-4	1384.58	300.02
8	-3	899.57	300
9	-2	659.38	299.96
10	-1	508.64	299.97
11	0	392.26	300
12	1	199.82	93.87
13	2	181.21	81.68
14	3	161.68	80.14
15	4	139.91	80
16	5	113.78	79.99
17	6	21.01	13.72
18	7	108.78	27.63
19	8	40.39	23
20	9	26.61	17.01
21	10	21.09	14.9

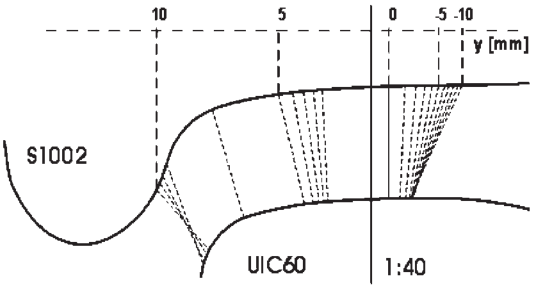

Fig. 15. Contact points at lateral movement of a wheel profile

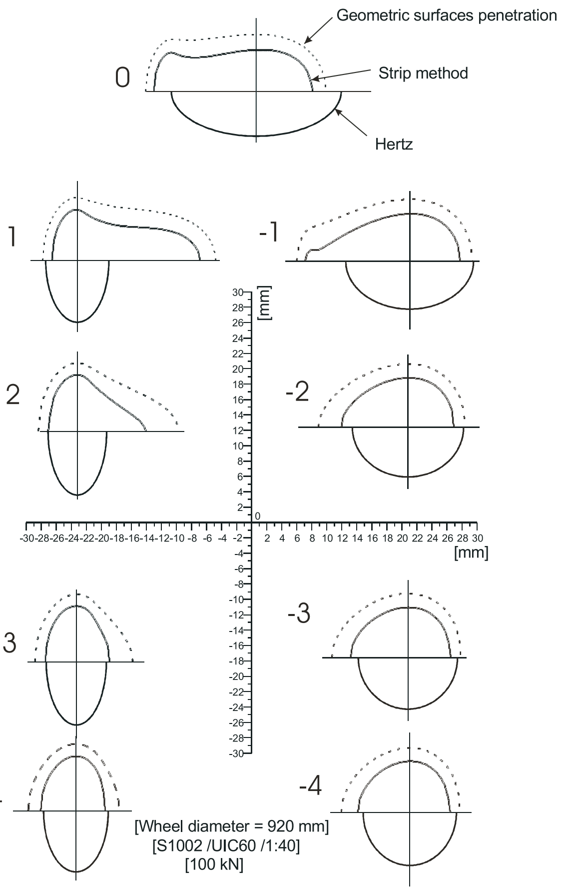

Fig. 16. Shape and size of contact areas for S1002/UIC60/1:40/Q100kN/D920 movement +/- 4 mm [1]

Many researchers have worked in the field of analysis of shape and size of the wheel and rail contact area. The main axis in the case of the strip method is the longer distance of longitudinal and transversal border lines.

More or less according to the main interest of their professional specialization, they used either apparatus of derived formulae (Hertz, Kalker, Knothe, LeThe) or procedures based on the finite element method (Wriggers).

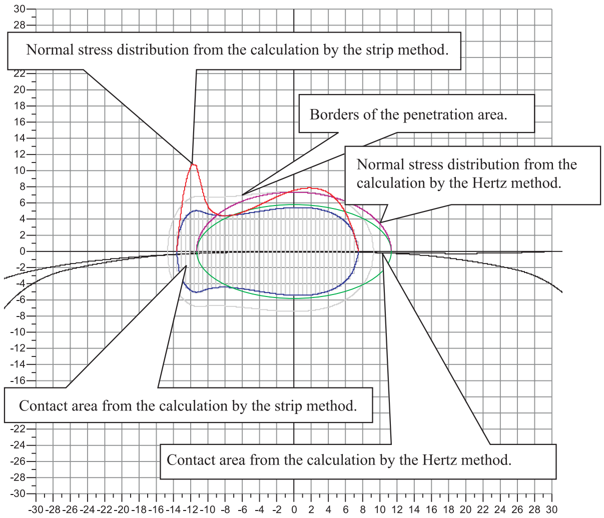

Fig. 17. Contact area calculated by the Hertz and strip method and normal stresses at zero movement of a wheel profile corresponding to the methods

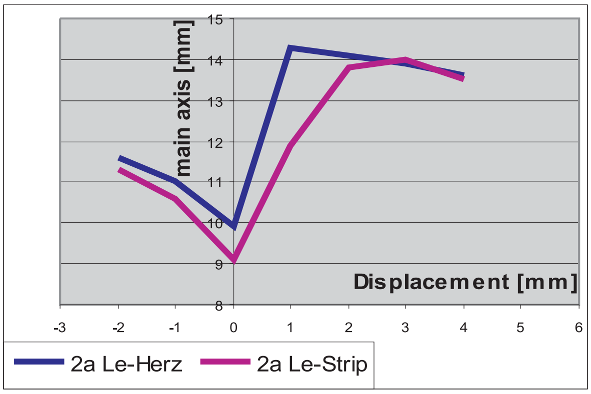

Fig. 18. The principal axis length of contact ellipses calculated by the Hertz method and by the strip method Le The Hung [5]

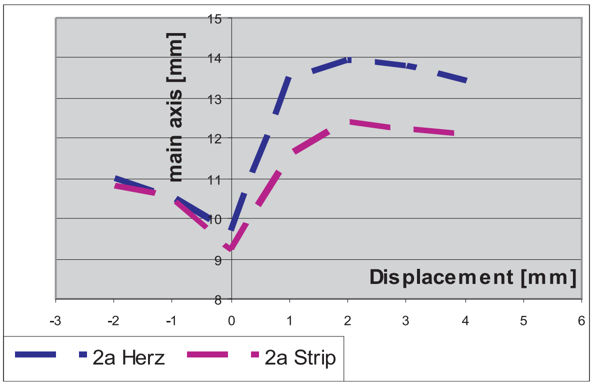

Fig. 19. The principal axis length of contact ellipses calculated by the Hertz method and by the strip method Lack-Gerlici [1]

In the previous text the calculations were done on the base of the Hertz and strip method in the field of the linear theory of stress and strain.

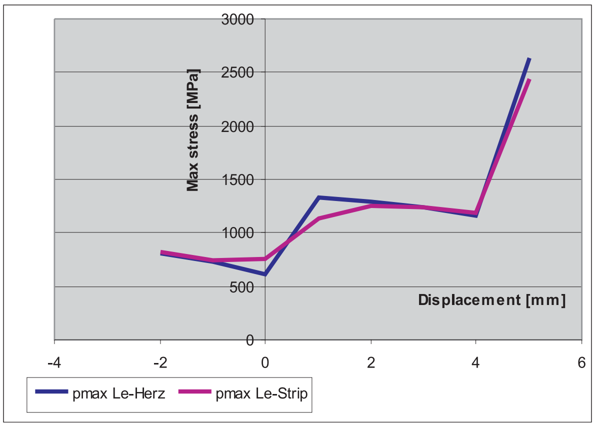

Fig. 20. Size of maximum stress in the contact area calculated by the Hertz method and strip method – Le The Hung [5]

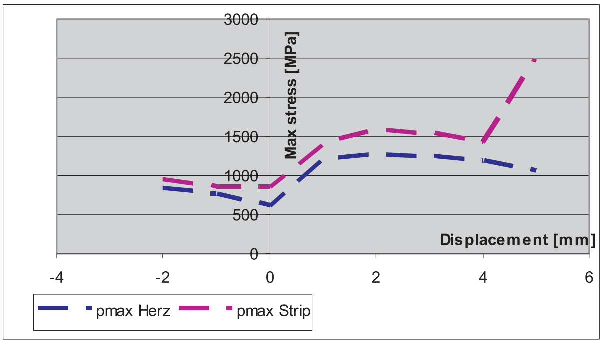

Fig. 21. Maximum stress size in the contact area calculated by the Hertz method and strip method – Lack-Gerlici

The reason why it is necessary to work in the field is crucial for the choice of research methods and the evaluation of geometrical and force phenomena which arise at the rail and wheel contact.

The shape and size of the contact area and the normal stress distribution is the core of the interest in this case.

A plausible analytical determination of the normal stress should follow after an analysis of geometric characteristics and should proceed for a possible analysis of the rail and wheel contact, or ride mechanics, or the whole train dynamics.

The aim of the comparison is to prove correctness or better to say acceptance of an analytical research method of the problems as a base for further analysis. In this case, it is not possible to mark all the calculations as correct or incorrect. More aspects influence differences in numerical expression. The greatest influence has the following: the chosen method of the numerical calculation, the chosen accuracy of the calculation, material characteristics, geometrical characteristics (wheel and rail profile shape, rails slope, nominal wheel radius). In Figs. 18 to 21 there is a comparison of calculation results of the main and side contact ellipses length and a normal stress maximum with the help of the Hertz and strip methods. If we look at the results shown in the figure it is possible to judge the suitability (probably correctness) of the method itself and the rate of the results identity which have been acquired via the application of the same method by various researchers. In the first case (suitability and usability of the method), it has been proved that the methods provide more identical results in the case which is more suitable for them mainly from the point of view of geometrical shapes of the contact bodies.

The Hertz method is for sure approved and acceptable for further analysis where we require speed of data numerical elaboration, uniformity in the calculation procedure (special algorithm is quite good available) for geometrically more simple bodies shapes.

The strip method extends possibilities of calculations by an analysis of non-elliptical contact as well. Another procedure of the calculation enables to find out the normal stress distribution which can be different from the Hertz procedure. The results published in [7] were used for the graphs in Figs. 18-21. On the base of entry data from the same literature: UIC60, S1002, 1:40, 60kN, $E = 2.1 \times 10^6$ MPa, Poisson's ratio $= 0.277$, they were calculated according to the procedures mentioned in the paper.

5. Conclusions

In the paper, the well known calculation procedure by Hertz, which results in contact ellipses, was used for searching the shape and size of the contact area as well as for searching the contact normal stress. The ellipses do not always provide a sufficient idea about a real contact area and from it arising normal stress. The Hertz method was compared with a new version of the strip method, which provides more precise results. In both methods, we work with simplified presuppositions which deal with an elastic model. The methods and their results were used for judging the influence of various profile shapes of wheels and rails on the shape and size of the contact area and normal stress. The results proved a significant influence of contact bodies shapes (wheel and rail) on the shape and size of the contact area as well as on the stress size and distribution over the contact area. The contact was understood as quasi-static not taking into account influences and consequences of a wheel rolling.

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Pavel Drdla – Jan Hrabáček *

WEB SITE CONTENTS OF MUNICIPAL TRANSPORT UNDERTAKING AS A MODERN COMMUNICATION TOOL FOR ENHANCING QUALITY OF TRANSPORT SERVICES

The paper deals with web site contents of Municipal Transport Undertakings. In the paper there are introduced kinds of information in use improving and intensifying communication between customers (passengers) and transport operators. These data come from research results of several Municipal Transport Undertaking web sites.

There is also mentioned an informative minimum, which is found to be necessary and should not be omitted.

1. Introduction

At present the Internet plays an important role in citizens' lives as a source of information. Urban transport is not an exception as well. Quality level of web site contents of particular urban transport systems varies from municipality to municipality [1]. Data used for this article have come from a wide self-analysis of Municipal Transport Undertaking (MTU) web sites in the Czech Republic. Their list does not have to be definitive.

Czech MTU web sites were compared with MTU sites in Germany or in German speaking countries.

The level of basic essential transportation information is quite the same. German web sites contain more advertisements and their visual impression is fancier. It seems the accent is put more on impression than on content comparing to Czech web sites. On the other hand there are few Czech MTU web sites having a translation to foreign language. This shortage is found necessary to be improved. The authors don't regard the level of Czech MTU web sites as being worse than the level of those abroad.

2. Web site content of Municipal Transport Undertakings

Below there is a basic information structure appearing at many either official or, in some cases, unofficial web sites of MTU systems:

a) *General information:*
- basic data about the Urban Transport Operator,
- contacts;

b) *Transport information:*
- basic information about the urban transport system,
- a journey map or an interactive journey map,
- list of stations and stops,
- stop timetables or line timetables,
- connection searching,
- information of tie-in system P+R (Park & Ride), B+R (Bike & Ride) and K+R (Kiss & Ride),
- information for disabled persons,
- service centres,
- W@P and SMS services;

c) *tariff information:*
- fares, tickets and tariff zones,
- full condition of carriage (+ also abstract),
- inspection + competence of inspector,
- where to buy a ticket,
- prepaid chip cards;

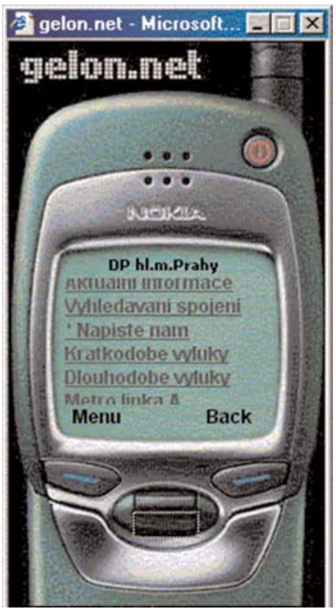

Fig. 1. Wapalizer of W@P pages of MTU in Prague

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d) *service changes and disruptions:*
- long-term service changes,
- short-term service changes,
- topical information about urban transport,
- future plans and changes;

e) *passenger help and services:*
- help, complaint procedure,
- important places (offices, schools, hospitals ...),
- street and stop searching,
- lost property;

f) *other information and matters of interests:*
- history of urban transport,
- photos,
- interesting things concerning urban transport,
- special periodical edited by the operator,
- fan-club,
- promotion and special trips (special transport service, historical cars, etc.)
- contests, games, entertainment;

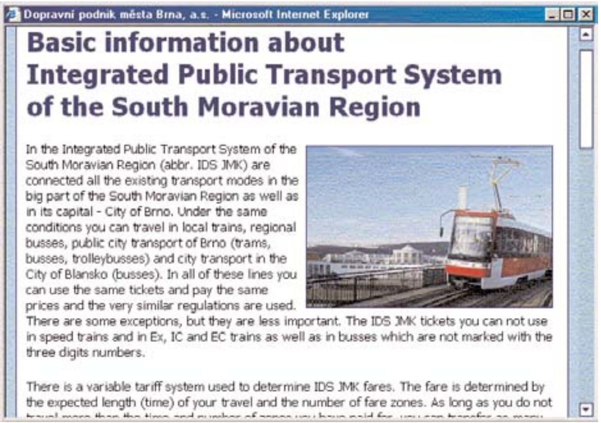

Fig. 2: Basic information about urban transport system (Brno)

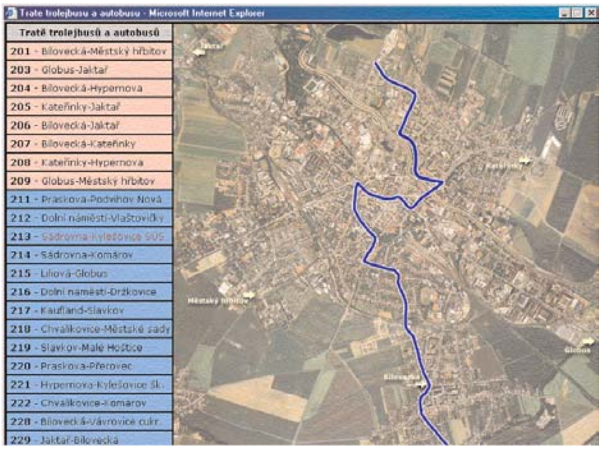

Fig. 3: Interactive journey map (Opava)

g) *others:*
- job opportunities,
- additional services (car repair shop, tire service, car-wash, advertisement on vehicles etc.),
- other information (press releases, articles concerning urban traffic and MTU etc.);
- useful links,
- questionnaires, quizzes,
- FAQ's,
- views of passengers (discussion group),
- other web site properties (sitemap, searching, up-dating ...).

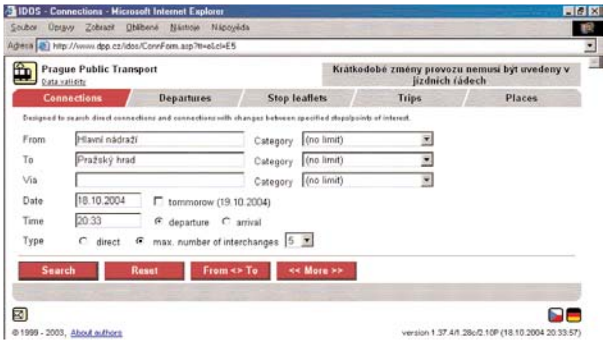

Fig. 4: Connection searching – input data (Prague)

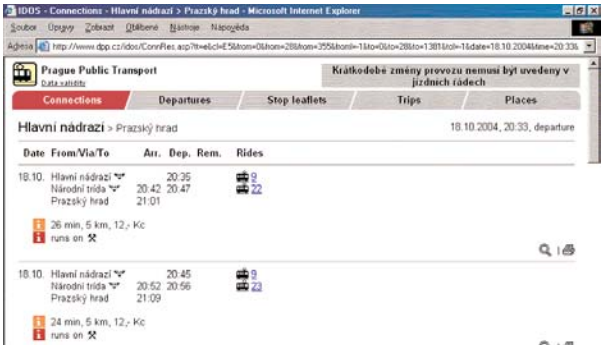

Fig. 5: Connection searching – output data (Prague)

3. Web site informative minimum

It stands to reason that the above mentioned list of several links is not used to such an extent at the biggest Municipal Transport Undertakings [2]. Though, the bigger the municipality (and its transport undertaking) the better and more extensive the content of its web sites.

Nevertheless, so-called informative minimum of web sites of any MTU system should be maintained. Every MTU system is supposed to present itself on the internet as a modern communicative tool.

Below, there are minimal web site data concerning an urban traffic operation:
- basic data about the urban service operator and contact,
- basic data about the urban service system,

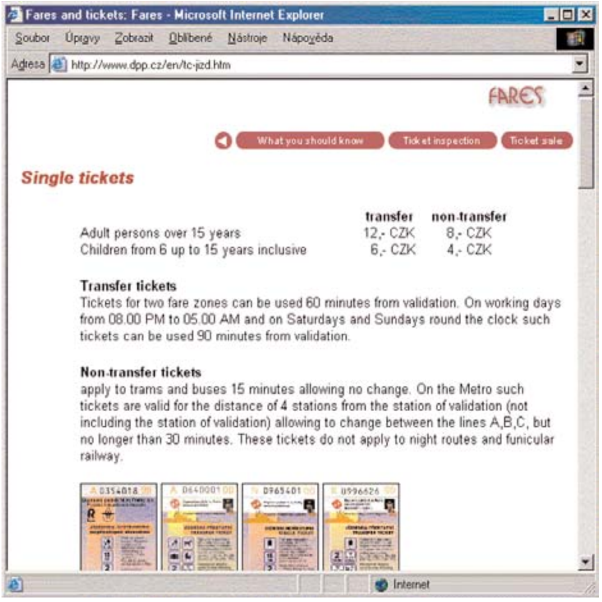

Fig. 6: Tariff information (Prague)

- a journey map,
- timetables,
- fares and tickets and tariff zone information,
- full conditions of carriage,
- real time information and service changes and disruptions.

In this case a passenger is not provided with enough information. He or she could perceive it as partial operator's lack of interest for customer and his or her transportation and enhancing of transportation quality in general.

4. Conclusion

The authors of the paper tried to summarise the problem of Municipal Transport Undertaking web site contents in connection with its practical daily use in relevant transport systems in the Czech Republic.

According to the authors improving the quality of communication between passenger and operator via internet as a modern communication tool contributes to the increase of consciousness of the MTU system in any municipality. Both authors welcome any comments on this topic.

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[2] internal data of Municipal Transport Undertakings in the Czech Republic

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Norbert Adamko – Antonín Kavička – Valent Klima *

TOWARDS VERSATILE SIMULATION MODELS OF TRANSPORT NODES

The paper deals with analysis of characteristics of simulation tools and models which are required for support of dispatcher's decisions in real operation, training of dispatchers and education. Further, a concept of simulation tool is discussed that will allow the construction and development of simulation models in which support for re/design of railway system, its management and also the training of dispatchers will be integrated.

Keywords: *On-line simulation, operative control, operational planning*

1. Introduction

Simulation methods currently represent widespread techniques supporting optimisations related to railway systems. The mentioned optimisations mainly pay essential attention to infrastructure design, to organisation of technological processes as well as to compositions and dimensions of various kinds of resources. Dominant utilisation of simulation tools supports *tactical* (middle-term) and *strategic* (long-term) planning related usually to infrastructural or operational proposals, which are supposed to guarantee optimal (or at least effective) behaviour of modelled system from the long-continuing (statistical) point of view. That traditional simulation support is included within the frame of so called *off-line planning*.

A simulation model (simulator) supporting off-line planning is based on "artificial" inputs and not on interconnections with a real-time operation. Hence an important role, within the stage of simulation model building, is played by a collection and analysis of input data. The most common procedure is to realise a statistical analysis of historical or prognostic data and on this base to implement corresponding input generators (this approach is called *input analysis*). Another (less commonly used) way how to realise simulator's inputs is to utilise an identical input flow which occurred in the past in reality (this approach is denoted as *data-driven* or *trace-driven simulation*).

The most important part, and from the implementation viewpoint also the most difficult, is represented by processes' control modelling. The control in this sense can be understood as a sequence of decisions which react to occurrence of identified problems (a problem is here interpreted as intervention of a control element). In the case that a modelled system is purely deterministic (does not contain any randomness) it is quite easy to realise control following a fixed plan. This plan is composed of anticipated reactions (decisions) to an expected sequence of occurrences of specified problems in concrete time instants (within the frame of a planning period).

The mentioned kind of plan can be defined for instance in the form of a flowchart (e.g. using formalism of Petri nets as models of simulator's decision-making mechanisms [7]. An example is depicted on Fig. 1.

Substantially more difficult case is related to a situation when the problem occurrence is of a stochastic character, i.e. the time instant of a problem's appearance is not predictable and so it is not possible to plan a corresponding reaction in advance. A control element takes a decision when a given problem was identified either just in a moment of its occurrence or slightly in advance – such a character of decision-making process is called an *operative control*. Apparently a solution of such problem is not possible to fold directly in any plan.

Modelling of operative control compared with modelling of control by a fixed plan represents a considerably more complex task. In the field of modelling and simulation, a significant attention is paid to research and development of appropriate techniques focused on modelling of *operative control*, i.e. modelling of an *intelligent decision-making* related to managing workers.

2. Short-term planning in a factory railway system

The character of railway transportation systems, from the mentioned point of view, seems to be mixed. In some kinds of railway systems dominates an operation using a fixed plan (e.g. modern marshalling yards [1] or passenger stations) and in others an operative control plays a key role (e.g. factory railways or port sidings).

Let us take a factory railway as an illustrative example. The operation of factory railway has to cope with the occurrence of many input flows' irregularities, which is not the case in other kinds of railway nodes. It means that the operative control is quite typical for a factory railway operation. On the other hand there exists no agreement between the railway company (usually operating on a relatively large geographic territory) and connected factory railway,

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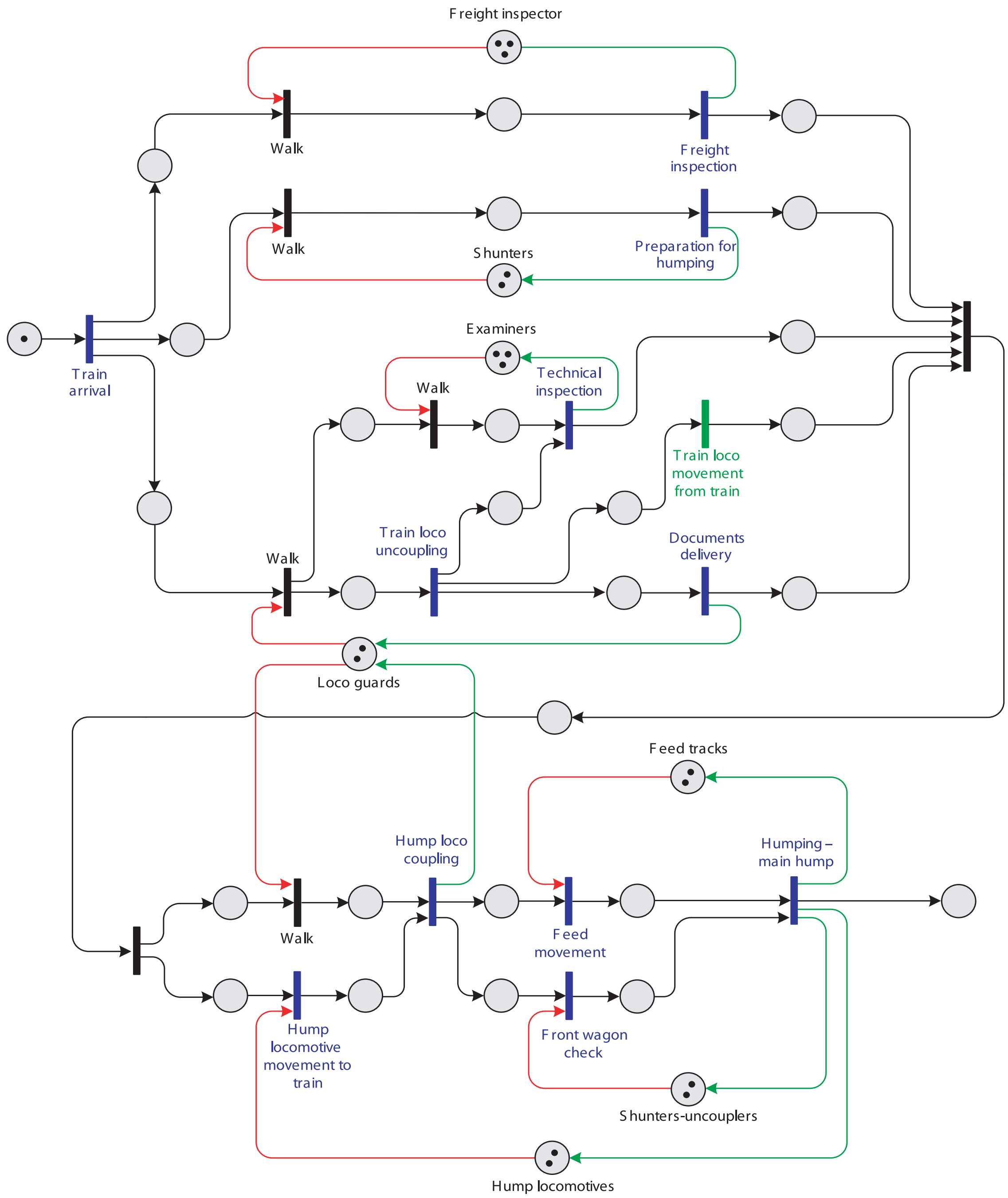

Fig. 1 Petri net as a model of service plan related to trains arrived in marshalling yard

which would be based on the sophisticated plan reflecting effective utilisation of resources belonging to both subjects. So, there is an urgent question: "How to prepare (with the help of simulation) an appropriate operational plan respecting requirements of both concerned parties?" The simulation model (with the motivation to consider a quality of strategic and tactical intensions) has to include a lot of operative decisions and, therefore, a resulting plan is made on a lower level of robustness, i.e. its application for the factory railway within another time interval (another day, week etc.) is less likely. In addition the plan construction represents a highly time-consuming process. Operative decisions are in this case understood as simulation model features reflecting essential reactions to the input data. For example, an experimenter has to decide where to displace wagons (because of capacity problems), which can't be shunted to unloading places. This situation can occur for example once a month. There are a lot of problematic situations within factory railways, which are only rarely similar.

Let us mention several factors negatively affecting a robustness of the factory railway operational plan:

- Irregular composition of incoming flows of wagons which may require additional shunting and, therefore, prompts the use of additional resources.
- Acyclic working regime of manipulation resources related to loading-unloading places.
- Shunting in connection with a preparation of a wagon set before attendance and a consequent loading-unloading on the specialised places -a configuration of trackage (spur tracks in factory halls) as well as an order of individual wagons within the incoming trains are essential.
- Conflict between rail and road freight traffic due to requirements for manipulation resources and for the same loading-unloading places.
- Reaction to operative client's demands related either to specific kind of wagon or consignment.
- Conflicts on the railway crossings.

A modification of input conditions (data) in order to reach a higher level of operational plan robustness already represents the way of problem solutions (e.g. eligible timetable of incoming trains, adequately pre-sorted incoming trains etc.). It is important to realise what properties are expected from a simulation tool to be effectively applicable to the construction of a factory railway operational plan, i.e. which of its features can compensate longer preparation of less flexible plans. The simulation tool has to enable very quick plan modifications and subsequently their verification for the purpose of strategic and tactical planning. The following tool features support the mentioned requirements:

- Transparent entering of succession of individual steps related to preparation of wagon set before the corresponding attendance and operation on loading-unloading places. It is essential to support all infrastructural input data by graphical editor displaying the trackage. In addition, simulation tool editors should dispose of automatic routines focused on filling out required parameters according to initial partial data defined by the user.
- Possibility to create macros which represent frequently repeating standard procedures, e.g. transposition of empty wagons to an available track in factory hall and their loading. In the case it is needed to repeat the mentioned procedure, a corresponding macro is called and it is not necessary to pay attention to individual steps any more. Actual experience indicates that a definition of macros' palette should be prepared for each factory railway model individually because each factory railway disposes of unique trackage configuration.

It is quite complicated to compare the use of a simulation for the optimisation of a factory railway operational plans to other kinds of railway nodes, which usually process higher quantity of wagons (marshalling yards, passenger stations etc.). In spite of this fact, we can offer the examples of tasks which can be successfully solved with the help of simulation and bring evident benefits for the factory railways as well as for the surrounding railway network:

- Modelling of consequences related to a growing production (input and output flows rate changes).
- Investigation of changes associated with train timetables and operational plans and their potential optimisation.
- Rationalisation of the fleet of mobile resources – shunting locomotives, personnel, manipulation resources.
- Considerations of intended investments in the infrastructure or in the mobile resources versus operational costs.

3 On-line simulation and information system

Let us ask a question if once constructed, verified and validated, simulation model can be helpful as a control support (with required modifications) even after implementation of a real system. This situation can be understood as "a disconnection" of the simulator from artificial, statistically obtained data, and "a connection" to real data which are continually produced by a real system. Running such a simulation model represents so called *on-line simulation*, which can support operational planning and control.

The concept of the on-line simulation differs from the classical off-line simulation mainly due to the following features:

- Simulation model is *directly connected with a real system* (e.g. with information/disposition real-time operating software system) and the values of its selected (input) state variables are updated directly from reality (it is a special case of data-driven simulation).
- Duration of individual simulation trials should be *substantially faster* than realisations of corresponding processes in reality. Such condition is required because the proposed solutions (plans) based on the results of the simulation trials have to be still feasible within the current real situation.

So, the workers from operative control level expect from the on-line simulation some kind of a support serving for analysis of actual status of a real system and consequently for the construction of short-term operational plans (*on-line planning*), which are subsequently applied within the real system (e.g. scheduling and rostering of resources etc.).

What methodology is supposed to be applied for the needs of the on-line planning? There are principally two approaches suitable for that purpose. The first one is based on the rule that new planning is made only in the case when the current plan substantially differs from reality and hence it is not applicable any more (this concept is called *reactive planning*). The second approach called *proactive planning* makes trials with the aim to improve an existing plan. The simulation run is executed periodically to look for potential problems which can occur in the near future. The basis for plan's construction or modification is formed by results of series of simulation trials which are focused on the different prospective operational scenarios originating from the present state of a real system.

In the on-line simulation there is not enough time for evaluation of the prospective scenarios. Hence the experimenter has to use a strategy, which enables to use relevant findings from the simulation trial, which are still valid in the operational situation.

It was mentioned above that an on-line simulator is directly connected to a real process. However, the typical implementation of such a connection is realised via a real-time information system (updated directly from real processes), which represents a source of data for the on-line simulator. From that point of view, an on-line simulation model can be understood as an integration of a simulation model with a corresponding information system [2]. Then it is obvious that the success of an on-line simulation highly depends on the quality of the relevant information system. In the case of a factory railway, the real-time information system has to contain data about

- accurate position of each piece of the rolling stock,
- incoming and outgoing trains and their compositions,
- routings of wagons within the frame of each sorting stage etc.

It can be said that properties of all advanced contemporary railway information systems are quite close to the requirements of an on-line simulation.

Thanks to integration of the on-line simulator and information system it is possible to evaluate prospective operation scenarios and in addition to it, produce even reconstruction of processes realised in the past. This is so called *retrospective simulation* and it can be very useful for the analysis of critical events caused either by a control element or technical-technological deficiency or unexpected character of incoming flows of wagons/trains.

4. Using simulation model in the process of training and education

Another alternative utilisation of simulation tools and simulation models is in the area of vocational training courses for dispatchers and educational courses at schools. It is evident that the dispatcher shares the responsibility related to the railway node operation and so he has to be properly trained before starting his vocation. This process is costly and quite time consuming. It is impossible to tackle theoretically all problems which can be encountered in practice. It means that the dispatcher starting his job will probably meet situations which were not dealt with in his training and therefore there is quite a big potential of wrong decisions with negative consequences (not only from an economic viewpoint). Therefore it would be useful to encourage dispatchers to study their nodes not only under standard conditions but also in exceptional situations. Certainly it is not admissible to make experiments within a real operation because of economical and safety reasons (e.g. it is not permissible to cause a crisis merely for the training of dispatchers).

Simulation models can represent very convenient tools and environments, within the frame of which the dispatchers can investigate a railway node under various situations including critical ones. Moreover, important infrastructural and operational changes and their consequences can also be studied. Let us mention main advantages of utilisation of simulation tools within the dispatchers' training:

- Detailed introduction to a concrete node and its operation under various conditions (infrastructure, incoming flows, technological processes, performance parameters, node limits etc.).
- Possibility to train an operative control of a railway node even under crisis conditions.
- Experimentation with different variants of technological processes applied within a railway node.
- Prompt verification of the consequences related to the just taken decisions.
- Subsequent analysis of quality of the dispatcher's decisions made by a supervisor.
- Relatively low training costs.

The simulation model reflects a real system (railway node) and its operation within the computer environment. In addition, the simulator intermediates a depiction of permanent and temporary elements and focuses also on modelling of decision-making processes. It means in fact that the simulator performs activities which correspond to the dispatcher's real actions. Utilisation of a simulation model as a training tool enables substitution of a real dispatcher by a trained dispatcher. The simulator presents to a trained person all relevant data needed for a decision-making process (run-time animation outputs, statistical observations, graphs etc.) and on the other hand it is able to accept those decisions. Such a simulator is called a *interactive simulation model.*

The simulation model is able to identify a set of potential problems which are supposed to be solved during a simulation trial. The user (a trained dispatcher) selects from the palette those of identifiable problems whose solution he would like to carry out.

When such a problem occurs the simulator offers potential alternative solutions (if they exist) and the user can choose one of them according to his proper considerations. That decision is then accepted and it represents an integral part of simulation trial. The problems not solved by a user are solved by integrated software algorithms. The mentioned flexible approach leads the user to focus only on the problems which he is interested in and not on currently unsubstantial ones.

It should be emphasised that even the most accurate and detailed simulation model cannot be identical with reality and entirely substitute real operational experience. However, there is no doubt that the mentioned kinds of simulators can represent a suitable part in a complex educational programme for railway node dispatchers.

5. Conclusion

The prospective computer simulation, focused on a railway system design and its operation, will obviously encompass simulation models integrating individual supporting stages (design – planning – control – training) depending on the ongoing quality of corresponding information systems. In order to successfully manage the mentioned integrated approach it is essential to utilise an appropriate flexible architecture of a simulation model. The authors have been cooperating on the development of such a simulation support with the help of original agent-based simulator's architecture [8].

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Martin Čapka *

THE BLOCK MATCHING ALGORITHM AND ITS USE FOR VEHICLE MOTION DESCRIPTION

This paper deals with principles of Block Matching Algorithm (BMA) and its use for vehicle detection and tracking. The Block matching plays essential role in motion estimation employed in the MPEG compression standard. The current frame is divided by BMA in smaller, fixed size blocks. These blocks are then matched in the previous frame in order to estimate their displacement between two successive frames. BMA supplies us with information referred to as motion vectors. Motion vectors are next processed to gain relevant data for vehicle detection and tracking.

1. Introduction

The present expansion of automated systems for everyday life applications is caused mostly by the growth of computer memory and processor speed. Computer vision area can be seen as a good example of such intensive computations systems, whose use becomes more feasible with the advances in computing power. Object tracking is a key computer vision topic aiming at detecting the position of a moving object from a video sequence. Motion detection and estimation is very important for video encoding. The Block matching principle, which is used in MPEG compression standard to estimate motion between images in sequence, provides so for the mentioned goal very interesting information – motion vectors associated with image points.

2. The Block Matching Algorithm

The BMA is based on partitioning each frame in a given sequence into square blocks of a predefined size (in pixel: 8 × 8 or 16 × 16 ...) and detecting their displacement between the *anchor* (actual) frame and the previous one called target frame as well. For each block of the target frame the searching inside a given scan area is performed. It provides a matrix of displacement vectors (DVM) associated with it. Each block encloses a part of the image and defines in the previous frame, a "*scan area*", centred in the block centre. The block is shifted pixel-by-pixel inside the scan area, calculating the match value at each shift position. This is shown in Fig.1.

The similarity between blocks can be evaluated on the basis of several matching measures. The mostly used criteria are the Normalised Cross- Correlation Function (NCCF) (1), the minimum of Mean Square Error (MSE) (2) or the minimum of Mean Absolute Difference (MAD):

$$NCCF = \frac{\sum_{i,j} [A(i,j) \times (B(i,j)]}{\sqrt{\left[\sum_{i,j} A^2(i,j)\right] \times \left[\sum_{i,j} B^2(i,j)\right]}} \qquad (1)$$

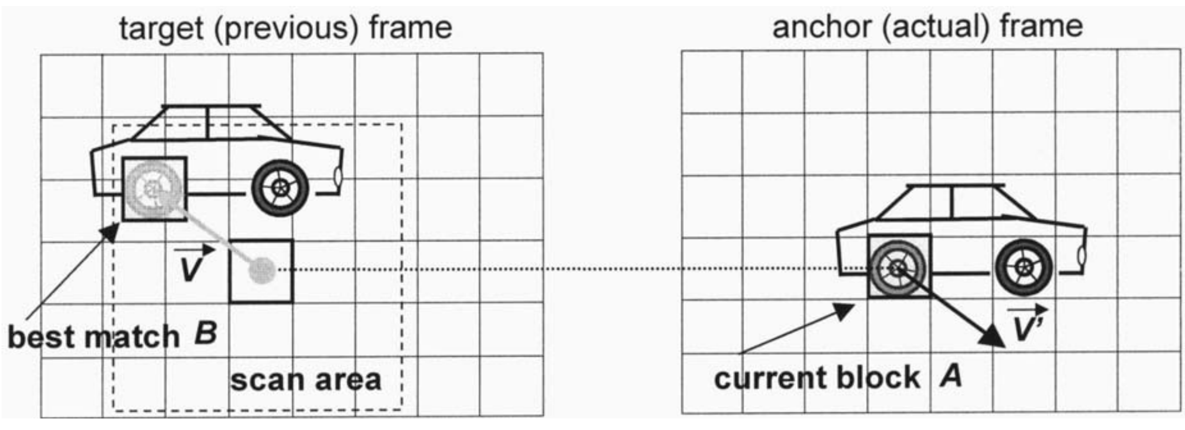

Fig. 1. The Block Matching Principle

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$$MSE = \frac{1}{N_1 N_2} \sum_{i,j} [A(i,j) - (B(i,j)]^2 \quad (2)$$

$$MAD = \frac{1}{N_1 N_2} \sum_{i,j} \left| A(i,j) - (B(i,j) \right| \quad (3)$$

where " × " represents the product between the corresponding element's value of matrix "A" and matrix "B". Indexes i, j roll all over the matrix size N1, N2. The size of the scan area has also impact on time consumption, mainly in case of exhaustive search. Therefore, the highest possible block displacement between two frames should be taken into account by setting the size of the scan area. Though there are many improvements [1] on searching strategies, it is convenient to keep it as small as possible.

The matching process produces a displacement vector V' between the position of the block in the anchor frame and its best match in the previous frame. In the actual frame, the reflected vector $V' = -V$, applied in the block centre represents the block displacement as well as its tracking information.

3. Noise elimination

Unfortunately, mostly due to noisy tone fluctuations, the BMA generates many wrong vectors over static blocks located on the background. A small modification to the conventional block matching algorithm can be made in order to lower the effect of this kind of noise – the threshold which defines the maximum difference between two corresponding blocks under which they are considered matching.

The threshold value is applied first on the computed matching criterion between the current block and the corresponding block without displacement in the target frame. If the block similarity does not exceed the threshold value, the current block is considered then as motionless and no more matches are evaluated. This technique results in a significant computational saving [3].

The unavoidable tone fluctuations of moving objects between successive frames cause that the BMA usually produces also a noisy DVMs. Noisy vectors may have a significant influence on segmentation of vehicles. As mentioned in [7], the noise found in the DVMs may be modelled as the presence of outliers in a rather regular vector field. A vector median filter is often used as a reliable tool to smooth these differences. The median value of a set of n scalars is defined as $(n/2)$th element of the ordered set. For the two-dimensional vectors the output of the vector median filter by [2] is obtained by taking the element of a set of vectors which minimises the sum of the distances from all the other elements, with distances evaluated on the basis of the *L2-norm*., in the R × R space. The distance between two vectors, $u[a,b]$ and $v[c,d]$ is given by:

$$\| \vec{u} - \vec{v} \|_{L_2} = \sqrt{(a-c)^2 + (b-d)^2} \quad (4)$$

If we simply use the median filter on DVM, most of no null vector entries are changed into null-ones since the neighbourhood tends to be dominated by null vectors. Due to this inadmissible erosion of the connected components not only the splitting of several vehicles occurs, but also they may be recovered very poorly or even completely lost.

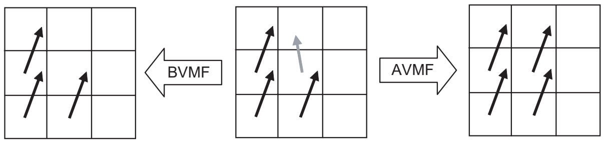

Fig. 2. The application of basic (left) and adaptive (right) vector median filter on DVM (middle)

Fig. 2 left shows an example how the vector in the centre of the "8- neighbourhood" is going to be deleted rather than made similar to its no null neighbours because it has more null neighbours than no null ones.

To overcome this, an "adaptive" filter has been devised in which only no null vectors are taken into account during the smoothing process (Fig. 2 right). That is, each no null vector is turned into the vector median computed on the basis of its no null 8-neighbours. This operator may be viewed as an adaptive statistical order (or rank) filter in which the order changes as a function of the local characteristics of the signal [6].

4. Detecting of moving objects

After the restored DVM are obtained, the next step is to detect vehicles by grouping together connected clusters of blocks having similar (and nonzero) displacement vectors. The grouping process is basically a sequential, iterative connected components labelling algorithm ([4]) in which the blocks having no null displacement play the role of "foreground points" and two blocks are considered neighbours if they are 8-connected and the *L2-norm* of their displacement vectors is less than a threshold *Th*:

$$\| \vec{u} - \vec{v} \|_{L_2} = \sqrt{(a-c)^2 + (b-d)^2} \leq \mathrm{Th} \quad (5)$$

This process is sometimes referred to as *δ-labelling*. Moreover, in [7] it was decided to filter out the groups consisting of very few blocks in order to increase robustness with respect to noise. The value of the threshold on the group size depends on the size of the block with respect to the size of vehicles. The labelling is run on every frame and produces a matrix, called *label_map*, having the same size as the DVM. After obtaining the *label_map*, another matrix, named *resized_map*, is produced. It is obtained by enlarging the *label_map* to the size of the original frame so as to have a matrix with labelled objects at the same resolution as the image. This matrix will be used in the tracking algorithm.

5. Tracking of vehicles

The tracking algorithm relies on the actual frame's block matching and labelling outputs. The labelling output consists indeed of a set of temporary labels which will be updated by the tracking step according to the block-level tracking information provided by the BMA and embedded into the DVM. Given the set of the blocks belonging to a labelled object in the actual frame, we translate every block in the previous-frame's *resized_map* by a vector equal to its reflected DVM entry ($V' = -V$) and evaluate the amount of overlap of the temporary label assigned to the object with the labels in the previous frame.

The process is described in Fig.3 where the middle part shows the temporary labelling of an object in the actual frame and the left one the established labelling of objects in the previous frame. To track the object "4" we reflect the DVM and we shift back the blocks by the reflected vectors over the previous frame's *resized_map*. Each shifted block will overlap *NxN* pixels of the previous *resized_map* pixels: these pixels represent the label entries for the considered block which will be used to determine the final global label value. As shown in Fig. 3 left the block may overlap labelled pixels (grey-hatched) as well as un-labelled ones (white). Scanning all the pixels of the shifted label "4" we calculate the number of entries for each different pixel label. After repeating these operations for each block we finally obtain an array of label values, where each cell contains the number of the entries for that label value. The number of the cell that contains the maximum number of entries will be the new label for all the blocks of the actual object. With reference to Fig. 3 left, it is evident that the maximum number of entries will be found at the location number "5" of the mentioned array. Consequently, Fig. 3 right shows the result of tracking the temporary label "4", which has been turned into label "5".

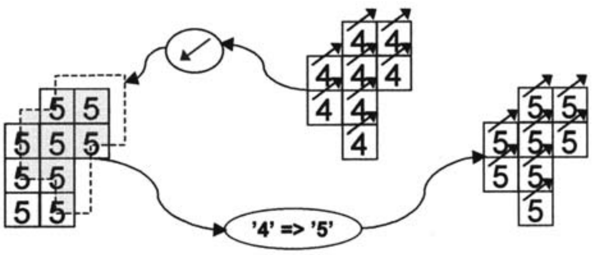

Fig. 3. Tracking of vehicle.

If for a certain temporary label we find no overlap with the *resized_map* of the previous frame, then a new unused label value will be given to this label (it is a "new born").

6. Conclusion

Moving objects evolve in the scene. Frame by frame we can recover their shape at the resolution of the BMA's blocks grid (for example, see Fig. 4). Objects motion, together with low-resolution shape recovery, noise and consequent filtering operations, may cause substantial changes in a shape and size of vehicles. For these reasons it may happen that the maximum number of overlapped pixels corresponds to the "unlabelled" label. The problem arises especially in case of objects made out of a few blocks. If we simply assigned the object the label corresponding to the maximum number of overlapped pixels we might label as a "new born" an object which conversely could be tracked. Hence, in this situation we look for the presence of labelled pixels and choose as the new label for our object the label value with the maximum number of pixel entries.

Fig. 4. Vehicle's shapes at the resolution of the BMA's blocks grid.

Experimental results in [7] and [3] show that the block matching principle with its enhancements as correlation threshold, adaptive filtering, grouping and tracking is quite effective in detecting and tracking vehicles. The worst problem with the BMA seems to be its computational load. For this reason, every pre-selection of "blocks of interest" may help to reduce the amount of data to be processed. Very useful pre-selection is provided by threshold differencing between the actual frame and background. As for a vehicle detection, there can be still some over-segmentation effect when vehicles are too big with respect to block size. The correction of perspective influence can in many cases bring also more accuracy on motion description.

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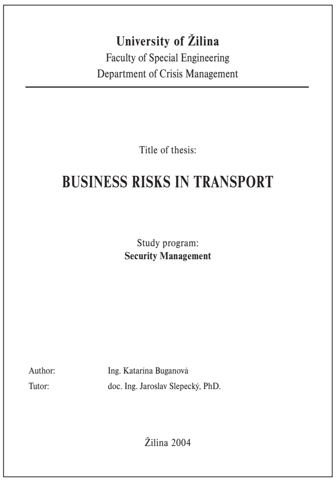
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Žilina 2004

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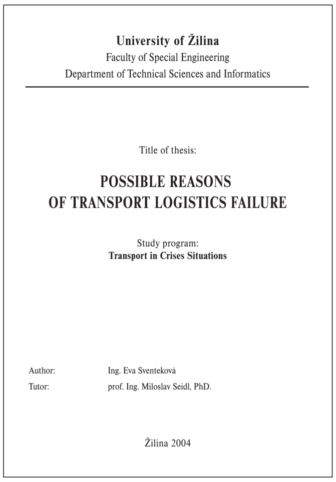
Summary

Business activities in transport have undergone various changes due to new market conditions. Globalisation and entry of the Slovak Republic into the European Union have brought not only unlimited opportunities but also new and unknown risks. Transport companies managers are aware of increasing rate and complexity of risks. However, they do not know how to handle them. This thesis deals with business risks regulation in transport companies. Its main objective is to develop new business risks regulation methodology. This methodology includes methods of creative thinking as well as operational risk management by means of Balanced Scorecard method. Although high quality security management, crisis management and risk management cannot guarantee success of a company, they can limit probability of its failure to a great extent.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Žilina 2004

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Summary

An application of logistic principles to transport processes is a crucial task in still developing business environment. This thesis deals with causes of transport logistics violation and failure. Its main goal is to analyse these causes and to suggest measures necessary for operation renewal of a transport system. We also discuss transport safety and evaluation of transport system risks here. The thesis suggests a solution to the elimination of transport logistics failure as well as risks evaluation methods in transport logistics.

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