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OF YOUNG RESEARCHERS AND SCIENTISTS

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SECTION 1

TRANSPORT AND COMMUNICATIONS TECHNOLOGY

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TRANSCOM 2013
10th European conference of young researchers and scientists

TRANSCOM 2013, the 10th international conference of young European researchers, scientists and educators, aims to establish and expand international contacts and co-operation. The 10th international conference TRANSCOM is jubilee. It will be held in the year when the University of Žilina celebrates 60 years since her constitution (1953 – 2013).The main purpose of the conference is to provide young researchers and scientists with an encouraging and stimulating environment in which they present results of their research to the scientific community. TRANSCOM has been organised regularly every other year since 1995. Between 160 and 400 young researchers and scientists participate regularly in the event. The conference is organised for postgraduate students and young researchers and scientists up to the age of 35 and their tutors. Young workers are expected to present the results they had achieved.

The conference is organised by the University of Žilina. It is the university with about 13 000 graduate and postgraduate students. The university offers Bachelor, Master and PhD programmes in the fields of transport, telecommunications, forensic engineering, management operations, information systems, in mechanical, civil, electrical, special engineering and in social sciences.

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Logistics audit

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Abstract. The competitive environment and costumers demands force the companies optimize their production processes. Maintaining quality of product or service offering brings the need to minimize costs and settings the supply chain on the high efficiency and function model. One of the necessary parts of rebuilding the logistic processes is logistics audit. The logistics audit can help companies increase competitive environment on the global market and without lost costumers. The paper is focused on the characteristic of basic steps in the logistics audit, which could be used by the company, if they need optimize own logistics chains.

Keywords: Logistics audit, logistic processes, procedure of logistics audit

Introduction

Economic trends in globalization are oriented for availability of goods and providing the quality of services. Customers are pushing the prices down and competition innovates the business processes. If companies want to operate successfully on the market, than have to apply the optimization and improvement methods. These facts are causing movement the logistics from theoretical and interdisciplinary science to practice and provide more possibilities for companies. It is quite difficult to set the right settings and application of logistics steps because we cannot measure something what we cannot even manage. The best way to get to know the logistics processes in the company is the logistics audit.

Characteristic of logistics audit

Logistics audit is the first phase of long-term projects in the company. Logistics audit is used for determining the efficiency of logistics processes as well if the company establishes a logistics department or for re-engineering of business processes.

Logistics audit is standardized and project evaluation process, which is aimed at the corporate office logistics management system [1]. It provides not only an independent and objective view of the business operations and logistics management system, but also proposes measures for the company resulting from the inspection results. Logistics audit is thus an effective tool for continuous improvement of the components of logistics processes.

In practice there are several approaches where logistics audit is applied, but main objective is to optimize the business processes and achieve the added value of logistics chains. Figure one shows the overall progress of logistics audit.

Fig. 1. Procedure of logistics audit.

Internal or external auditor can realize steps of logistics audit in the company. Table one includes advantages and disadvantages of both possibilities.

	Internal Auditor	External Auditor
Advantages	• authorized employee is well versed in the business and knows the environment, has easier access to the sensitive information of the company, • there are no communication barriers between staff and auditors questioned, as it already know, • internal staff are very familiar with the ongoing operations of the business and know the risks associated with these processes, • own employees can reduce the cost of implementing controls.	• amount of experience in auditing and control of the latest techniques to improve processes, • external auditor is not a member of leadership company, It carries the assumption that his decisions are acceptable and applied properly • objective and impartial view of the organization of processes and operations in the company.
Disadvantages	• lack of experience in the conduct of the audit, • weak skills in process improvement techniques, • appointed person may have a relatively low position in the company, which may result less from the management authority and hence lower efficiency of the proposed changes.	• relatively higher costs for the company, • impeded access to relevant information because of distrust of employees in some cases deliberately misleading the auditor.

Tab. 1. Compare of internal auditor and external auditor.

Determination of objectives

The first step for applying the logistics audit is to determine its objective. The company decides which part of logistics chain will be solved by logistic audit. Optimization can be oriented on the supply logistics, manufacturing logistics or distribution logistics. All decisions depend on requirements of company and its current issues. In this phase it is possible to set up the strong and weak sides of organization.

Analysis of current situation

Analysis collects all relevant information based on stated objectives. Based on performed analysis, it is possible to define the factors that influence the setting of priorities. Auditor in this phase uses observation, communication with employees and management of the company and thus

creates an objective view of the physical, financial and information flows and their mutual relations. The interaction between external environment and its impact to business operation has to be included into comprehensive audit work

For example, by using the logistics audit in practice the organization can define production plan, inventory management system, techniques and technological provision of financial flows and etc.

Status assessment

Logistics audit in this phase evaluates obtained information. Based on this phase, are defined "bottlenecks" and weak sides of company, which should be set up more effectively. For a deeper understanding of the real state of the company is necessary to divide the identified problems into smaller parts. Each logistics system consists of interdependent and independent material, information and financial flows and to streamline one of them influences the others. To further illustrate the reasons, that caused the current problems of companies, we can use the tools of quality management. Example of one of mentioned tools is Ishikawa´s diagram (figure 2).

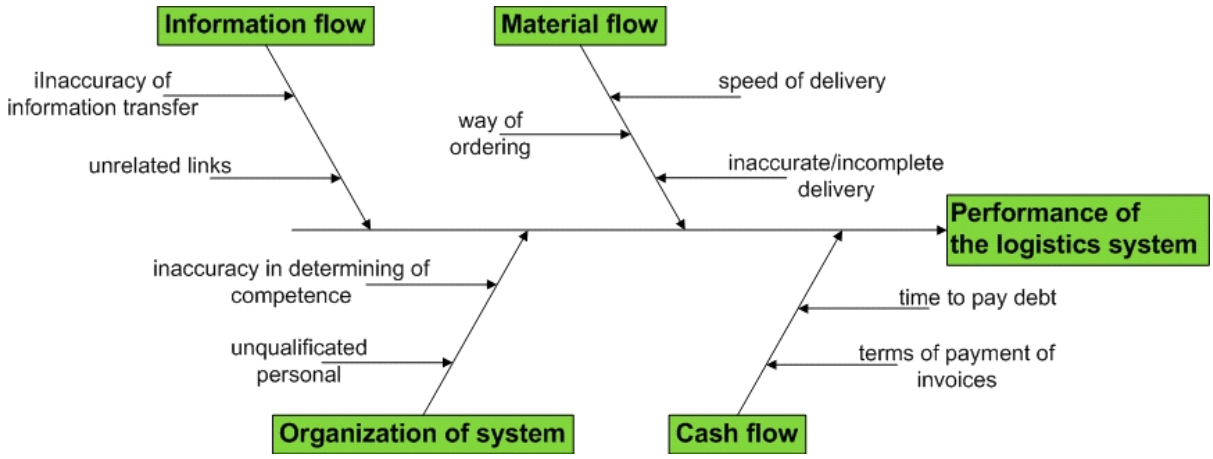

Fig. 2. Cause and effect diagram.

Suggestions of possible solutions

The proposals of logistics audit have to solve current situation in the organization and improve the business indicators. It is not just the response to the specific business problems, but also logistics audit can bring preventive measure. Auditor should propose the several measures that can help the management to simplify the logistics flows (by the financial and technological company possibilities).

If management of the company receives proposals of logistics audit it is necessary to set up the indicators of logistics chains and business operation. Indicators allow assessing the change of business performance and efficiency. System of indicators depends on the type of company and its field of business, for example in practice it could be:

- level of customer satisfaction,
- decrease in inventories,

- increase the overall performance of the logistics system,
- increase the performance of business processes and reduce their time,
- additional possibilities depending on the current situation of organization.

Conclusion

To increase the effects from applied logistics audit continuous monitoring and using the proposed solutions is required. Then the company can objectively evaluate the benefits of suggestion measures or rework settings the business processes and logistics system as a whole.

In competitive environment it is necessary for companies to use their strong sides and eliminate the weak ones. Companies have to define their strong sides correctly in the first step of logistics audit and then they can use them effectively. Weak sides should be identified, restricted and taken into measures for their improvement or removing.

This contribution describes only one way to optimize the logistics system, which depends on the auditor's skills and his knowledge. Auditors can use more optimization methods such as: ABC analysis, Graph theory or Theory of mass operation and many others.

References

[1] Komora logistických auditorů [online]. Stanovy komory. Dostupné na internete: http://kla.cz/stanovy/ (marec 2013).

[2] Komora logistických auditorů [online]. Metodika logistického auditu. Dostupné na internete: http://kla.cz/metodika-auditu/ (marec 2013).

[3] KRÁLOVENSKÝ, J.; MAJERČÁK, J.: Postavenie dopravy v logistike, Edis, Žilina, 2001, ISBN 0-7100-888-5

[4] NEDELIAKOVÁ, E., DOLINAYOVÁ, A., NEDELIAK. I.: Manažment v železničnej doprave 1., EDIS ŽU v Žiline, 2. rozš. vydanie, 164 s., ISBN 978-80-554-0478-3

Research on the Brake Fluid Testers

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Abstract. This paper describes selected issues on the safety of vehicles equipped with a hydraulic braking system. The mechanism of the aging factor and the results of quality control parameters of brake fluid based on glycol were presented. The results obtained from the two devices devoted to test the boiling point of the brake fluid on a selected group of vehicles were compared.

Keywords: transport safety, vehicle operation, working medium.

1. Introduction

Transport safety is a very complex and important issue for human beings. Whether it is the transport of passengers, commuting to work, travelling with a family, leisure, or goods transport [3]. The threat of the road transport demands continuous development of safety-related systems of vehicles and road infrastructure.

The brake system has a decisive impact on the active vehicle's safety [1]. The purpose of this system is to reduce speed and effective stopping of the vehicle. Requirements for vehicle brake systems were stipulated in the Regulations of the 13th United Nations Economic Commission for Europe (UN ECE) [8]. These requirements concern braking motion stability during braking and reliability of the system. Figure 1 shows the percentage of vehicle defects that caused the accident.

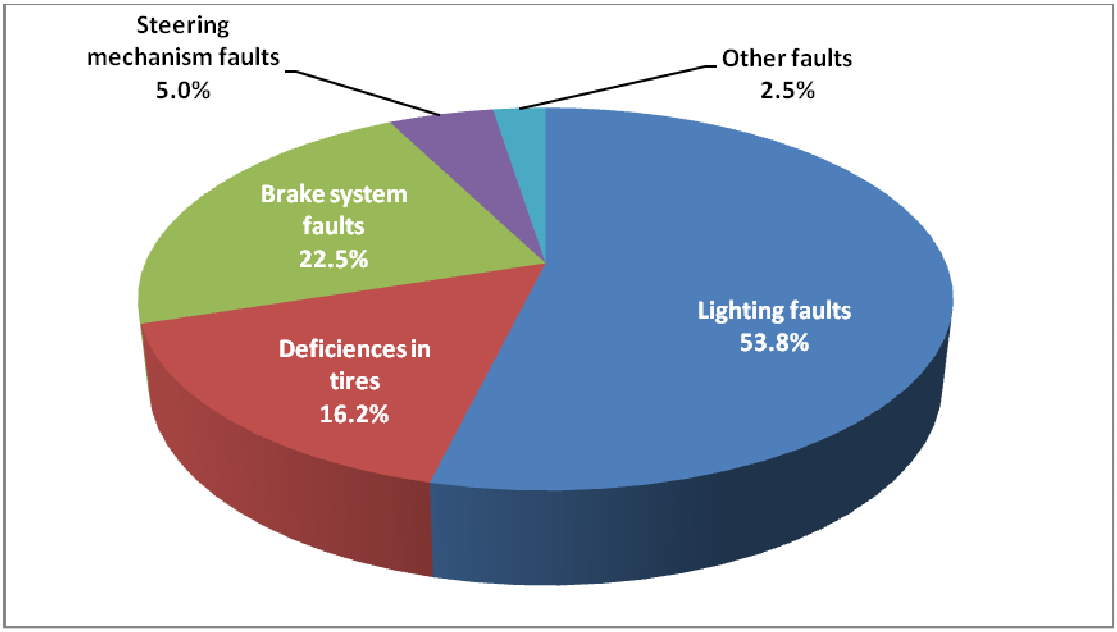

Fig. 1. Road accidents due to vehicle disability in 2011 in Poland [5].

The statement shown in Figure 1 points out that for 22.5% of the causes of road accidents are responsible defects occurring in the brake system. More than half of the 53.8% of road accidents is

related to deficiencies in the lighting of the vehicle. Other causes of accidents are defects in the tires equal to 16.2%, the steering defects – 5% and the others – 2.5%.

Passive safety refers to the elements and units that have an impact on reduction of the harmful effects of accidents for all occupants of the vehicle [9].

Inner passive safety is responsible for reducing the risk of injury or death of the driver and passengers, or damage to baggage transported. External passive safety reduces the likelihood of injury to other road users (e.g. pedestrians) [7]. Such a task is carried out by a vehicle body structure, crumple zones designed to absorb the impact energy and reduction of the acceleration affecting the vehicle occupant. The energy released by the collision is absorbed by the lighter object, which means a higher risk for pedestrians, cyclists and drivers in smaller vehicles [4].

Construction safety means that the vehicle should ensure the efficient performance of the systems providing safety: at the desired level throughout the life of the vehicle, in any weather conditions and in all road situations [7]. Of great importance are performance of the brake system, the steering system and the other systems responsible for the transport safety.

The concept of active safety means all factors designed to minimize the likelihood of a collision or accident. An important feature of this safety is the fact that it concerns the mechanisms and devices that allow the driver to take a specific action prior to the collision [6].

The article presents selected quality control parameters of brake fluid in a selected group of vehicles. The research results from two measuring devices to test the boiling point of the brake fluid were compared.

2. Issues on the Wear within the Hydraulic Brake Systems

Like any other technical system, the hydraulic brake system components subject to wear. The wear problem concerns not only construction components but also the working medium – the brake fluid. The complexity of modern hydraulic brake system is mainly due to its links with other systems supporting the driver. These systems are: integrated ABS (Anti-Blocking System), ASR (Anti Skid Regulation), ESP (Electronic Stability Program), BA (Brake Assistant), but also ACC systems (Adaptive Cruise Control), "Stop & Go", etc.

The essential elements of the braking system are as follows: the master cylinder with a servo or ABS pump, steel and flexible wires and executive elements and friction elements (i.e. a disc with blocks or a drum brake and brake shoes), as well as additional mechatronic systems [2].

For the proper functioning of the entire brake system are important properties of the working medium. It is important to maintain an appropriate level of brake fluid, its frequent inspection and replenishment or replacement of the fluid when quality parameters deteriorate. Car manufacturers recommend replacement of brake fluid every two years or when the course of about 40,000 km.

Cleanness of the fluid is essential for the proper functioning of the ABS, ESP, etc., technical properties of the fluid such as low water content are very important. As it is well known glycol-based brake fluids are hygroscopic and absorb moisture. The best method of determining the water content is to measure the boiling temperature of the fluid.

2.1. Selected Results of the Research

In the conducted research for this purpose are used two testers for boiling point of brake fluid. These devices are shown in Figure 2.

Comparative tests of brake fluid control equipment were conducted in 10 vehicles. Some measured results of brake fluid on vehicles are gathered in Table 1. The percentage of water in the fluid was roughly determined by means of the water content tester. Then the measurements of brake fluid boiling point were conducted using two types of testers.

Fig. 2. The brake fluid testers, BOSCH BFT 100 and ATE BFT 320.

	Vehicle type	Year	Mileage [km]	Water concentration [%]					Boiling temp. BOSCH [°C]	Boiling temp. ATE [°C]
				0	1	2	3	4		
1	VW Passat Variant	2007	216,000			x			228	187
2	Škoda Fabia	2002	210,000		x				210	189
3	Hyundai I30	2009	85,800	x					246	264
4	Nissan Quashquai	2012	5,169		x				267	261
5	Suzuki SX4	2009	42,600			x			204	198
6	Renault Thalia	2006	66,900			x			212	208
7	Kia Cee'd	2009	62,000		x				216	244
8	Kia Carens	2007	76,798			x			194	185
9	Kia Cee'd	2006	186		x				228	227
10	Citroen C6	2006	48,777		x				232	242

Tab. 1. Measured results of brake fluid in the vehicles.

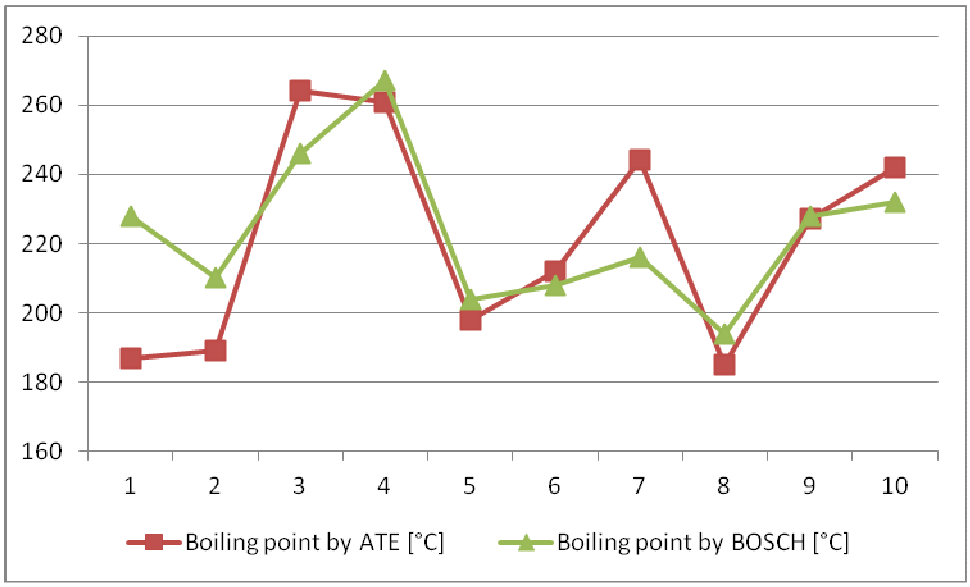

Fig. 3. Comparison chart of the course of the boiling point of the brake fluid on the base of studies conducted by means of two testers.

As shown in Table 1, there was some differences in the obtained test results. Graph showing the difference results of the boiling point of the fluid obtained by two testers is shown in Figure 3. In three cases, the differences in the results of measuring the boiling point were greater than 10%. In other cases, much smaller differences were shown in indications of measuring instruments.

3. Conclusions

In conclusion, it should be remembered that the fluid assessment is in the coolant expansion tank, so that in the actuators at the wheels the water content can be higher and boiling point of the liquid lower than the one in the tank. Water gets into the brake fluid from the surrounding air by rubber elements (osmosis). The amount of water absorbed depends on the type of rubber material, where it was installed in the car (front and rear) and the length of the cable.

In 30% of the vehicles tested differences in measurement instrument exceed the boiling point of about 10%. In other cases, much smaller differences shown indications of measuring instruments with less than 5%. The entire population of vehicles tested met the requirements for quality of the brake fluid. Each examined vehicle brake fluid boiling point was higher than the limit temperature of 180 °C, made by two gauges, and the water content below 3% (threshold point).

References

[1] BOCHEŃSKI, C. *Badania kontrolne samochodów*. WKiŁ, Warszawa, 2000.

[2] CABAN, J., HOLEŠÁ, L. *The Methods of the Determination of Glycol-Based Brake Fluids*. International Scientifical-Technical Conference of Students, Postgraduate Students and Young Scientists „Progressive Directions of Development of Machine And Instruments Building, Transport and Ecology", Sevastopol, Ukraine, 20-24.05.2013.

[3] GNAP, J., NOGA, M. *Vplyv zloženia dopravného prúdu na hluk v mestách*. Doprava a spoje: internetový časopis Žilinska Univerzita, 2012/1, s. 76-93.

[4] HUDAK, A., VRÁBEL, J. *Faktory ovplyvňujúce bezpečnosť styku pneumatiky a vozovky*. Doprava a spoje: internetový časopis Žilinska Univerzita, 2010/1, s. 99-106.

[5] Narodowy Program Bezpieczeństwa Ruchu Drogowego 2013-2020. KRBRD, Warszawa, 2013.

[6] SZCZURASZEK, T. *Bezpieczeństwo ruchu miejskiego*. WKiŁ, Warszawa, 2006.

[7] WICHER, J. *Bezpieczeństwo samochodów i ruchu drogowego, Pojazdy Samochodowe*. WKiŁ, Warszawa, 2004.

[8] Uniform provisions concerning the approval of vehicles of categories M,N and O with regard to braking. UN ECE, Regulation No 31.

[9] ZIELIŃSKI, A. *Konstrukcja nadwozi samochodów osobowych i pochodnych*. WKiŁ, Warszawa, 2008.

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Two-levels data model for optimization problems

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Abstract. We are interested in optimization where the distribution of the population in the plane is important to know. In this paper, we propose a two-levels, decomposition of spatially large geographical data without aggregating the population into single points, which is very common tool, but it is not very realistic and it can influence to the precision. We estimate the population into a plane and consequently, we need high resolution geographical data. We use OpenStreetMap as a free source of realistic data. We describe how to generate the two-levels model which consist of macroscopic and microscopic level. Furthermore, we introduce method for population estimation and describe related problems. Different values of the aggregation rate are also investigated. This value approximately illustrates how close the Two-levels model is to the reality. We believe that this approach to spatially large networks might be very useful for the operations research and economics communities.

Keywords: Graphs and Networks, Network Design, Optimization problems.

1. Introduction

The main goal of researcher working in optimization is to design better models and procedures for solving problems emerging in everyday life situations. The quality of results provided by the optimization depends on three basic elements - input data, mathematical models and solving algorithms. In this paper we describe how to prepare input data based on real geographical data. The source of input data we used is OpenStreetMap.

Typical problem which makes the applicability of modeling and optimization difficult is high level of data aggregation. For illustration, individual towns are represented only as one point (on a macroscopic level) and this one point represents all inhabitants inhabiting the whole town, but in reality 20 000 people do not live in one point (aggregation), but they exists in a certain space (on a microscopic level). Hillmans described aggregation errors in measuring distance between customers and locating facility [3]. We will show approach which minimizes these errors.

The aim of this paper, however, is to demonstrate and describe two-levels data model. The spatially large microscopic level might be too big for us. The two-levels approach is the tool which we use for decomposition of microscopic level to macroscopic level while keeping the connection between them.

The paper is structured as follows. In section 2 we describe the OpenStreetMap. Section 3 deals with two-levels data model. Finally, in section 4, we summarize our conclusions.

2. OpenStreetMap

The project OpenStreetMap(OSM), born at University College London in July 2004, was founded by Steve Coast. OSM is an open source map server. All data and added information are available for free and cover the whole world. These data are mainly obtained from land register, public and government institutions. Similar to wikipedia, everyone can edit and create new data. OSM contains realistic actual data from the whole world an allows to get enormous number of large-scale heterogeneous networks such as roads, railways, shops, restaurants, hospitals, fire/police stations, etc. You can see [1] for more information.

3. Two-levels data model

In this section we illustrate the problems concerning the microscopic level on the example of the Slovak republic (SR). The problem is that if we want to use a microscopic level for the whole SR it is too big for optimization problems. The number of nodes of all roads is 579 257 and the distance matrix has 335 538 672 049 entries. We describe how to control the size of this graph using decomposition in first part. In the next part we introduce estimation of population into space not only into nodes of infrastructure. The reason for this estimation is allocating people in the plane.

3.1. Decomposition procedure

There are several decomposition methods (see [1]), in this article we demonstrate decomposition to segments according to logical membership (cities, towns, states, regions …). We decided to use the landuse of towns and villages as logical membership resulting. The result of this decision is that 2924 nodes at the macroscopic level (see Fig. 1a.) belongs to an 2924 independent microscopic level segments (see Fig. 1b.). The sum of nodes of all roads in all segments is 768 787. This is more than the number of all roads in SR because some of them are used more than once. The smallest village "Vyšný Skálnik" only has 9 nodes and the biggest town "Nitra" has 6900 nodes. The sum of all entries in separated matrices of segments is 676 582 467 which is considerably less than the items in the matrix of SR.

We had to solve this question: How can we go from one microscopic node in any town to any other node in another microscopic segment? We defined the in/out nodes in each town segment, which you can use as in/out gateways (see Fig. 1c.-1d.).

In proposed settings we keep the optimal shortest paths between all nodes just like in SR, but we make the matrix far smaller. This is possible, because we aggregate (all nodes into a main node), but we also keep all in/out nodes. The reason for keeping these nodes is that they are used for connecting the macroscopic level with neighboring segments. The same node is an out node for one, but an in node for his neighbor. We proposed a simple way how obtain the shortest path. First, we know the shortest path to each out node in the segment matrix for the starting and target node. Then at the macroscopic level we have the shortest paths between all in/out nodes that we need. Afterwards we generate a small temporary graph consisting of only all relevant in/out nodes and the start and target nodes. Finally we use the shortest path algorithm to find the optimal shortest path between the start and target nodes. This process is fast and we save a 99,8% of space.

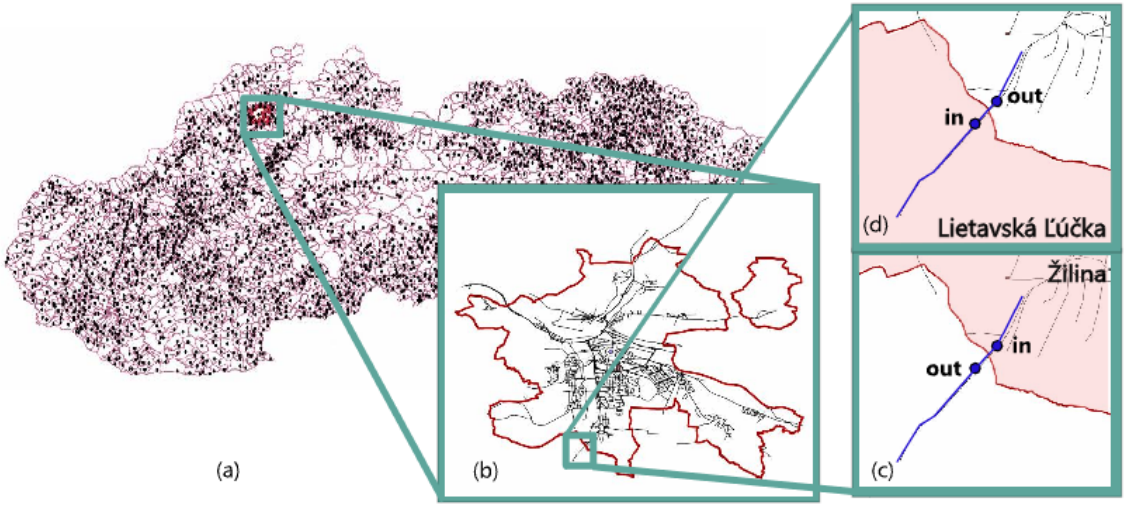

Fig. 1 **(a)** The macroscopic level consists of segments (landuse of towns). Each segment have main node (black point) at the macroscopic level. **(b)** The separate microscopic level (segment) of city Žilina. Figures **(c)** and **(d)** illustrate in/out nodes for two adjacent segments. The one same node is *"in"* node in Žilina and *"out"* node in Lietavská Lúčka.

3.2. Estimation of population

Once we have microscopic level segments, we also need to layout the population. We know the town population as well as the roads in segment. Furthermore, from the OSM we can get buildings and town residential areas that are situated in each segment. There are several different ways of allocating population:

- into all road nodes of segment (+ simple, + without increasing graph size, - not comparable with reality, - layout of the land),
- only roads in town residential area (+ simple ,+ without increasing graph size, + more comparable with reality, - not all residential areas are in the OSM, - layout of land),
- into buildings of segment (+ simple, + comparable with reality, - graph increasing in size, - not all buildings are in the OSM and some towns are without buildings, +layout of land).

These three ways are simple, but if we want to automatize approximation process of town population, we will not examine every segment. Considering every building as a node with people is not applicable, because we would get a very large graph (plus 1 674 248 (the number of buildings in SR from OSM) to 579 257 nodes of roads (see Tab. 1.)), which we cannot easily use for optimization. Also not every existing building is included in the OSM. There are towns and villages without buildings or residential areas. Because of this diversity the process cannot be the same for every segment. We propose this algorithm:

1. If there are no buildings or residential areas in a segment, then we put all population into main segment node and stop. Otherwise we continue to the next step.
2. We create a spatial grid with items of constant size (size is arbitrary = size of square cells).
3. We divide all objects of the segment (buildings, residential areas) into grid cells based on coordinates.
4. We remove all grid cells that are empty (the result is land which we can consider settled)
5. Afterwards we allocate people into grid cells with regard to the number of buildings and fractions of residential areas in these cells.
6. Finally we decide the location of main node of grid cells and we connect them to the road network.

We called this technique *Grid Estimation Of Population* (GEOP). GEOP allows to create data models with different *Size Of Square Cells* (SOSC), so we can simply calibrate the size of grid cells to an estimation that we can solve. In the Fig. 2. you can see results for different values of SOSC.

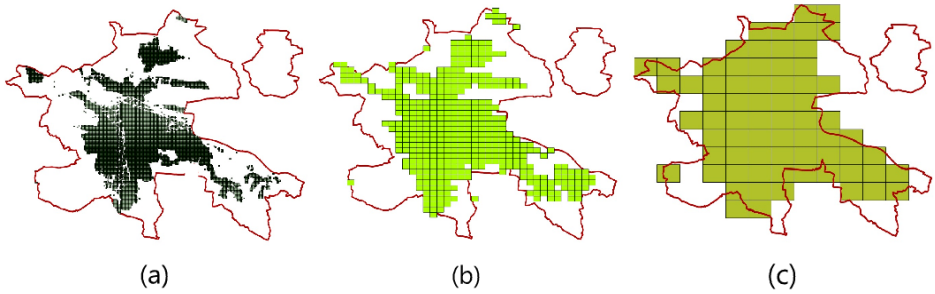

Fig. 2 The figure of GEOP result for different value of SOSC such as **(a)**50, **(b)**300 **(c)**1000, used on the city Žilina. We can see that if SOSC increase, than number of cells and quality of segment layout decrease.

A smaller value of SOSC is closer to reality than larger values. We did some experiments on the network of SR which we obtained from OSM. The results are in Tab 2.

There exists one more simple possibility how to make graph even smaller. The fact all nodes we need are the ones with population (added by GEOP) and nodes with degrees 1, 3 or more. We do not need nodes of degree two, because we can ignore them in the distance matrix, since they do not have any influence on the length of shortest paths. Results of this reduction are in Tab. 3.

Component	number of buildings	nodes in roads
SR	1 663 278	579 257
all segments	1 674 248	768 787
Žilina	17 816	6 745
Nitra	19 469	6 900

Tab. 1 The table contains number of buildings and nodes in roads in specific segment such as Žilina, Nitra and in all segments together and SR.

Component	Size of square cells (meters)					
	100	**200**	**300**	**400**	**500**	**1000**
SR	x	x	x	x	x	x
all segments	388 145	143 486	88 173	63 922	50 520	25 602
Žilina	2 885	869	446	281	205	70
Nitra	2 971	978	530	329	243	86

Tab. 2 Experiments results are in number of cells, which we obtain with GEOP. Žilina and Nitra are examples among of all segments.

Size of square cells (meters)	Component					
	all segments		**Žilina**		**Nitra**	
	N	**R**	**N**	**R**	**N**	**R**
100	1 156 932	601 248	9 630	5 329	9 871	5 909
200	912 273	335 393	7 614	2 812	7 878	3 528
300	856 960	261 348	7 191	2 204	7 430	2 965
400	832 709	227 737	7 026	1 959	7 229	2 678
500	819 307	209 088	6 950	1 842	7 143	2 563
1000	794 389	174 179	6 815	1 644	6 986	2 337

Tab. 3 Results of reduction are in number of graph nodes. Where N is without reduction and R is with reduction. Results are for different value of SOSC and specific segments such as Žilina, Nitra and all segments together.

4. Conclusion

In this paper we illustrated the problem of data aggregation and its influence on the solution of optimization problems. We proposed the two-levels data model that consists of the macroscopic level and microscopic level. This data model was tested by using different values of estimation (size of grid cells). The results have showed that lower value gives us finer approximation (subpartion) nearer to reality, but problem might be that the resulting network becomes too big. However, every example in Fig. 3 is a better approximation than only one point with the name of the town. The question remains how realistic approximation we want to obtain. Unfortunately there is constraint from optimization in the size of the network which we are able to solve. Furthermore, the proposed data model requires accruate data about the infrastructure and buildings. In order to improve existing OSM data, we are planning to continue our research focused on acquiring input data from images [4,5].

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References

[1] Cebecauer, M. *OpenStreetMap and Optimization Problems*. In Technika, technologies, telematics and informatics in the transport and logistics systems 2012. Pardubice: Univerzita Pardubice., in press.

[2] Haklay, H., Weber, P. *OpenStreetMap:User-Generated Street Maps*. Prevasive computing, IEEE CS. 1536-|1268/08, 2008.

[3] Hillsman ,E., Rhoda, R. P *Errors in measuring distances from population to service centers*, 1978.

[4] Tarabek, P. *General vectorization of line objects in drawn maps*. Communications, 11(4)>65-68, 2009

[5] Tarabek, P. *A robust parallel thinning algorithm for pattern recognition*. SACI 2012, IEEE international symposium on applied computational intelligence and informatics, 75-79, 2012

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The Elimination of Security Risks Associated with Excessively Wide Vehicles on Open Roads and Road Tunnels.

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Abstract. In the context of creating safe environment in road tunnels is necessary to limit as much as possible any potential hazards by careful management proposal of the tunnel. One of the many hazards is wide oversized vehicle too, which, while also running straightforward does not affect the secondary continuous traffic lane on the freeway or expressway, but its circumvention for example by other oversized vehicle can be classified as dangerous. An enclosure area of road tunnel compounds the hazard. By early detecting of such vehicle and monitoring of the traffic flow behind this vehicle, it is possible to evaluate potential risks associated with maneuver of circumvention of oversized vehicle, which in addition to reducing safety risk, minimize the probability of congestion in this area. The basic precondition for early detection of arising congestion is built telematics infrastructure - sensors and actors. The aim is to reduce the security risks resulting from riding through the road tunnel by such action that inside the tunnel is inlets only fluent traffic flow with safety margins and safety speed.

Keywords: wide vehicle, circumvention of vehicles, road tunnel, open road, traffic control, monitoring of the traffic flow, detection, sensors, variable message signs

1. Introduction

This Roads in rural areas are different from urban roads in cities mainly topologically, what allowing vehicles to move much faster. Analyses of accidents on highways and expressways show that approximately 50% of fatal accidents are caused by a delayed reaction of driver to the obstacles and emergency situations and a further 25% of this category of accidents are caused by driving technique inappropriate to the conditions. Despite the fact that in the number of accidents are local roads leader, accidents on highways and expressways are almost always associated with fatal consequences. Some causes of accidents on motorways and expressways can be reduced or prevented with the use of higher forms of management and telematics applications.

Systems are basically divided into two categories, which differ depending on where is concentrated decision process: intelligent vehicle or intelligent highway/expressway. In case of intelligent highway takes the weight of information collection and transmission to the driver mainly infrastructure built along the road. In this case, freeway or expressway cover the telecommunications environment that allows you to collect weather, traffic, or other data in any desired section of the motorway, and after processing in the center then allows them to distribute to drivers in the form of verbal information or to variable message signs and information signs in the form of commands.

Information about extraordinary conditions is transmitted to the driver from the superior traffic center. The information is obtained by measuring or video surveillance. Great importance, however, have also received verbal information like police or service report, or from other drivers.

Unexpected obstacles on the road, but also in the immediate vicinity are often a source of accidents. The main reason is that the driver observed barrier at the last moment, when it can’t

safely stop or make an appropriate maneuver. Oversized vehicle running in slow lane also be an obstacle on the road, because his circumvention can be dangerous and this maneuver should be adequately reviewed in advance. As a consequence, may be a car accident or the occurrence of congestion.

2. Road Tunnel Environment

Modern road traffic systems not impose focus only on security but also on ecology and growing economic needs of passenger and goods transport. The development of expressways and highways requires minimizing of the height differences and prefer especially in mountainous terrain systems tunnel - bridge, due to the reduction of the slope rising and falling gradients. In such traffic system is tunnel one of the main critical points, where the main risk factor is an accident with injury or death, fire, explosion or leakage of toxic gases and liquids. In contrast to roads or railways in the open country, in the tunnel is user getting into terms that will "force" him investor, respectively tunnel operator and therefore then they are also responsible for ensuring that in the case of a problem the user will have a reasonable chance of rescue.

Comparing the statistics of accidents in road tunnels, it is clear that the number of accidents on 1 km of length per a year is significantly lower than the number of accidents on open road. This is mainly due to the absence of junctions inside the tunnel and minimal weather impact on traffic (visibility, slippery roads, snow, frost, etc.). However, when we compare consequences of bigger accidents in the tunnel, they are much higher than on the normal roads, due to the enclosed area of the tunnel. First of all accidents with fire can have disastrous consequences often included a significant number of victims of human life.

In the context of creating safe environment in road tunnels is necessary to limit any potential hazards as much as possible by careful proposal of tunnel management. This goal can be achieved by continuous detection of all kinds of hazards and by taking adequate measures, eg. raising the alarm according to the rules having a priority, sending effective and appropriate messages to users of the tunnel, when appropriate.

3. Transport of Overloaded and Oversized Vehicles in Slovakia

Limit dimensions of the heavy vehicles establish legislative regulations of each country. In our region is the maximum of height - 4 m, wide - 2.5 m and length - 16.5 m with semitrailer and 20 meters with trailer. Exceptions are given for the transport of large and heavy loads that cannot be reduced due to its construction (reactor, turbines, buildings, etc.).

National Motorway Company in Slovakia NDS a.s. consider routes and determine the conditions of excessive and oversized transportation on the roads which belong under their report. Authorization procedure for special use of roads by excessive and oversized trucks, as well as process of administrators to determine the conditions are regulated by Methodical instructions MDVRR SR 1/2008, valid from 1.6.2008.

Statistical data for the year:	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
The greatest width [m]	8,30	8,50	8,08	7,50	8,50	7,15	7,50
The greatest height [m]	6,10	7,00	7,20	7,37	8,00	6,00	5,57
The greatest lenght [m]	57,00	58,00	58,00	83,53	83,53	75,00	71,00

Tab. 1. Statistical data about oversized transports (source CDB SR)

4. Excessively Wide Vehicles

As excessively wide vehicle can be considered (except the Methodical instructions MDVRR SR 1/2008) any vehicle that exceeds for Slovak republic specified maximum width of 2,5 m for truck, but when it is not wider than 3.0m, which is subject of the obligation apply for a permit from the competent administrative authority.

This vehicle while running straightforward does not affect the second ongoing traffic lane on the freeway or expressway, but circumvention for example by the other wider vehicle can be described as a kind of hazard. The hazard is compounded by enclosure area of the road tunnel, where sidewalls are barriers to circumvention with using of the hard shoulder what is possible on the open roads. It is necessary to reduce to minimum any potential hazards such as the circumvention of the excessively wide vehicle on the expressway or highway leading through the road tunnels.

Appropriate action can be taken in case that such vehicle has been detected early enough (in time before entering the enclosure section of road tunnel). Subsequently, it is necessary to monitor traffic flow located behind of this excessively wide vehicle in the direction of travel, in order to evaluate the potential risks resulting from the circumvention maneuver of this vehicle. Characteristics and composition of the traffic flow behind the excessively wide vehicle are changing in time (faster vehicles change their position by changing lanes, avoiding slower vehicles), therefore it is necessary to perform monitoring on the minimum three locations before the road tunnel. Monitored section should be also equipped with the action elements of the control system - variable message signs and variable informative panels serving to enter commands and information to the whole traffic flow resp. to specific driver.

Under the monitoring of the traffic flow situated behind excessively wide vehicle is necessary to detect every single individual vehicle - measure at least its dimensions such as width, height, length and class of vehicle, but also the average speed of the vehicle and, last but not least position of a vehicle within the traffic flow in monitored section and within the traffic lane they moving in.

Monitored vehicles in traffic flow behind the excessively wide vehicle can be divided into categories:

1. personnal car - width up to 2 m
2. truck - width up to 2,5 m
3. truck - width over the 2,5m up to 3.0 m but which is not subject of the obligation apply for a permit from the competent administrative authority.

The first category of vehicle can be considered as category with minimum risk and in principle, it would be enough for drivers of such vehicles only highlight (warn) the increased attention in circumvention maneuver of excessively wide vehicle on the open communication, or directly in the road tunnel. The second category of vehicles is risky because it is the circumvention of excessively wide vehicle by truck (relatively wide vehicle). The maneuver of circumvention on the open road should be accompanied by warning to increased attention in circumvention because of danger of traffic accident. However, circumvention in the road tunnel should be appropriately evaluated by the control system considering the real width of the excessively wide vehicle and wide vehicle behind him and also considering their exact position within its traffic lane.

In case that circumvention of excessively wide vehicle is possible under certain circumstances (respect of commands), then it may be allowed with warning and continuous monitoring by tunnel vision system, but if the system will evaluate that circumvention is dangerous, fast traffic lane is closed for heavy vehicles going directly behind the excessively wide vehicle with appropriate information about circumvention ban by heavy vehicles or information about ban for specific vehicle identified by number plate.

The third category of vehicles can be directly identified as hazardous / dangerous. Circumvention excessively wide vehicles by excessively wide vehicle is only possible under certain circumstances, and only on the open road, circumvention in the closed section of the road in a tunnel should be prohibited.

5. The Emergence of Congestion as a Result of Excessively Wide Vehicle Moving on the Road

As a result of excessively wide vehicle moving on the highway or expressway may be the emergence of congestion due to the less experienced drivers don't want to circumvent this vehicle and those which want to circumvent it have to reduce its speed. There can occur shock waves and level of service decreasing.

Whereas the traffic flow is described by variables such as density, speed and intensity, we can apply here theory about the spreading of liquid. Tracking of the discontinuities (shock waves) in traffic flow is one of the basic problems of traffic engineering. The shock wave can be defined as the spreading of density or intensity changes in or against direction of traffic flow. Shock waves are generated right in places with narrowed road (excessively wide vehicle creating the similar conditions like narrowed road) at the certain density of traffic. In such area, passing vehicles must reduce their speed to pass along the obstacle. If the intensity and density is relatively high, so the place where the vehicle must reduce their speed because of the previous vehicle braking, it moves against the direction of incoming vehicles. In this point on the road are created conditions for the spreading of the shock waves.

The basic precondition for early detection of emerging congestion, telematics infrastructure has to be built – sensor part of the traffic control system which provides information such as traffic volume, density, speed of traffic flow and the resulting level of service, but also it has to be able to determine the cause of the congestion, in this case it is excessively wide vehicle.

To early harmonization of the traffic flow in case of excessively wide vehicle occurrence must be used emergency traffic lanes on highway or expressways, resp. safety bays but still on the open road, not inside the road tunnel, when by using of variable message signs is driver of detected excessively wide vehicle prompted to stop at the edge of the roadway or in the safety bay, so that traffic flow accumulated immediately behind this excessively wide vehicle can safely avoid this vehicle. This command is issued either before entering the road tunnel, or immediately after it. It depends on the characteristic of the traffic (level of service) moving behind this excessively wide vehicle. If the quality is reduced, it is unacceptable that we let inside traffic flow in this condition with the starting congestion, therefore the appropriate action should be performed before entering the road tunnel. If the quality of the traffic (level of service) complies with absolutely fluent traffic flow and traffic density is not high, it is no necessary to take any action before entering to the road tunnel.

6. Conclusion

The first important thing is to let in to the road tunnel only harmonious and fluent traffic flow with sufficient distance between vehicles and with elimination of all potential hazards resulting from driving in enclosed area of road tunnel. One of the risk factors that can be early identified by appropriate sensor equipment and partially or completely removed before entering the road tunnel with the help of the action elements of telematics infrastructure by deploying appropriate management scenario can also be excessively wide vehicle moving on the highway or expressway while under the Slovak regulations it doesn't need to have permit for transport but regard to traffic safety in road tunnels may present a danger associated with the development of a traffic accident or congestion. And therefore, in the interest of maintain fluent traffic flow and safety of its participants, it is necessary to monitor (not only this) parameter of vehicles and apply appropriate control algorithm to the traffic process.

References

[1] PRIBYL, P., JANOTA, A., SPALEK, J. *Analýza a řízení rizík v deprave. Tunely na pozemních komunikacích a železnici*. BEN Praha, 2008 ISBN 978-80-7300-214-5

[2] PRIBYL, P., SVÍTEK, M. *Inteligentní dopravní systémy* BEN Praha, 2008 ISBN 80-7300-029-6 / 9788073000295

[3] METODICKÝ POKYN pre povoľovacie konanie na zvláštne užívanie pozemných komunikácií pri prepravách nadmerných a nadrozmerných nákladov (a niektoré súvisiace vybrané povinnosti správcov pozemných komunikácií) účinnosť od: 1.6.2008

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The Ways of Urban Traffic Management

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Abstract. This article is focused on traffic management in the cities. There are differences in traffic management among large European cities, smaller European and Slovak town. Many of bigger cities need the traffic control centre for traffic management, but central control can be also expedient in smaller towns. In this article you can find basic ways of controlling urban network and also analysis of traffic solution in 2 European cities and 1 Slovak town.

Keywords: Intelligent transport systems, Traffic Management, Traffic Control

1. Introduction

Because of large amount of traffic volume in large cities in present, there is no way how to effectively control the traffic without the support of information and communication technologies, the backbone of which are intelligent transport systems. These systems can be widely used for example for traffic management (both individual and public), for providing traffic information, charging for using infrastructure sections etc. Using of ITS in traffic management leads to reduction of negative traffic impacts and has a positive impact on increasing traffic safety and smoothness.

2. Urban Network Control

From the point of view of traffic control there are two ways of controlling the traffic network in the urban areas – control of traffic node and control of traffic network (area). For the control, the traffic controllers are used. The controllers are usually equipped with detectors, which monitor the presence of vehicles or pedestrians. Active items are traffic lights. Controllers can operate isolated, or they can be in coordination or they can be controlled by the urban control centre.

2.1. Traffic Nodes Control

Traffic node can be controlled using fixed programs (off-line), where each signal group is calculated on the basis of historical data, or they can be controlled using actuated programs (on-line/ traffic response), where signal groups are depended on current traffic situation. When using traffic response control, regulatory intervention is calculated for momentary traffic situation (phases on call, prolonged green phase, changed sequences of phases).

New methods of managing the traffic nodes are based on potential of modern traffic controllers, which are fitted with 32-bit processors, and often use principles of artificial intelligence (methods TRENDS/TRELAN, VS-Plus, FUZZY) [2]

2.2. Traffic Network Control

Single nodes are connected to urban control centre, which in the level of area controls and coordinates operation of nodes. For control of traffic area are used fixed programs (off-line), traffic response programs (on-line), on-line control with optimization, adaptive control method, and heuristics and expert methods. [1]

Off-line programs use historical traffic states of the area. On the basis of this (historical) data, fixed signal groups are calculated for each traffic controller. This signal groups are then used in traffic control and their change depends on the time of the day and on the day of the year. When calculating signal groups, there is taken into account optimization of various parameters such as length of green, cycle period and offset. As an example of such method is TRANSYT.

When using Traffic response programs (on-line), several sets of signal groups are calculate for various traffic states on network. The signal groups are saved in traffic controllers or in the urban control centre. When calculating maximum green, cycle and offset, TRANSYT is usually used. There are strategically located detectors, which monitor the traffic situation. On the basis of the data from these detectors, there is chosen the set of signal groups, which is the most convenient for the situation. This type of control we can define as on-line control without optimizing.

On-line control with optimization uses urban control centre, where all the intelligence of the system is concentrated. There are transmitted data about traffic and each second there are calculated with optimizing the lengths of green, cycles´ periods and offsets. Traffic lights are directly controlled by this centre. An example of such control methods are SCOOT or SCATS.

Adaptive control methods are a combination of the abovementioned methods. Traffic controllers have considerable intelligence, or the controllers operate in Traffic Response mode. Control centre every 10-15 minutes optimize regulated values (maximum length of green, cycle period and offset). There are several used methods such as OPAC, PRODYN, UTOPIA, and especially MOTION method.

Heuristic and expert methods are used in the case of very complicated situation. They work with the database of predefined conditions and try to simulate the behavior of an expert.

2.3. The Ways of Control when Using Modern Technologies

As an example of traffic control using modern technologies can be mentioned traffic solution of the company, which is engaged in the development, supply, installation and maintenance of technological equipment for road transport – CROSS Zlín, a.s.

Approximate size of the town	Number of traffic lights, intersections	Example of present situation	Possible solutions	CROSS technologies §solutions
0 - 5 000	2 - 3	Fixed time control	Vehicle-response isolated junctions	Controller CROSS RS 4 LED technology Traffic detectors (loops, video detection...)
5 000 - 15 -000	3 - 10	Low capacity	Vehicle-response isolated junctions Linear or area coordination	Controller CROSS RS 4 LED technology Traffic detectors (loops, video detection...)
15 000 - 30 000	10 -20	Limited options for traffic control at night	Vehicle-response isolated junctions Linear or area coordination Remote monitoring from a central dispatch center	Controller CROSS RS 4 LED technology Traffic detectors (loops, video detection...) Traffic management center for supervision
30 000 - 100 000	20 - 50	Often congestions in rush hour	Vehicle-response isolated junctions Linear or area coordination Remote monitoring from a central dispatch center Public transport preference	Controller CROSS RS 4 LED technology Traffic detectors (loops, video detection...) Traffic management center for supervision and fully adaptive control
More than 100 000	More than 50	Unbalanced control during special events	Vehicle-response isolated junctions Linear or area coordination Remote monitoring from a central dispatch center Public transport preference. The default path for the IRS	Controller CROSS RS 4 LED technology Traffic detectors (loops, video detection...) Traffic management center for supervision and fully adaptive control

Tab. 1. Example of proposed traffic solution [3]

3. London

London with its population of 7,57 million inhabitants is the Capital of England and also the biggest city in the European union. The modal split for London is 21% walking, 2% cycling, 19% bus, 1% light rail, 10% metor, 8% commuter rail, 37% car and 1% motorcycle/scooter. The length of the road network of London is 14,748, of which 60 km are urban motorway, 1720 km constitute the urban primary network (A and B Roads) and the remaining 13,003 km are the secondary network and minor roads. From the intersections with signal control, very few use fixed-time programs (some MOVA), 900 use fixed-time programs with control updates, approximately 2300 use a dynamic response UTC area and approximately 2800 are vehicle-response isolated junctions. . For the dynamic response UTC, the SCOOT system is used. For the detection in the dynamic UTC system, loops are used. London has a dedicated traffic control center that is operational 24/7, using more than 1200 CCTV cameras and for traffic control uses 120 variable message signs. The London Traffic Control Centre is unique among the world´s traffic control centers as it carries out both real-time traffic management, and provides up-to-date traffic information. [4] The traffic control centre does not have a command and control or a decision support system in place. The London Streets Traffic Control Centre (LSTCC) is collocated with the London Buses Control Centre in the Surface Transport Traffic Operations Centre (STTOC), which also housed the Co-ordination Centre for the Olympic and Paralympic Games in 2012. [4]

London uses the VISSIM, TRANSYT, LINSIG, VISUM and Legion tools to model traffic flow and pedestrian flows. [4]

4. Heerlen

Heerlen has a population more than 90,000, and the length of the road network is 418 km. The exact number of intersections is not known, although the number of traffic lights is 31 and the number of roundabouts is 59. All of the traffic lights react to the traffic-intensities by detectors in the road (for motor vehicle´s) and pushbuttons (for bicycles and pedestrians). The only information that is known of Traffic Control Centre is the data collection. The data are collected from:

- the traffic lights (malfunctions and occasionally for counting motor vehicle´s
- parking guidance system (malfunctions and occupation of the garages)

There are no variable message signs. The Parking guidance system is available in the centre of the city. All (9) public garages are connected to the system, showing the number of free parking lots of each garage. There is one red light running detector in the town of Heerlen, it is owned and operated by the police. And there are five locations for speed cameras in the region, which also are owned and operated by the police. Three of them are on a regional road, not owned by the city of Heerlen. The speed cameras circulate between the different locations in the region. [5]

5. Žilina

The number of inhabitants of the city of Žilina is 84,303 (31st July 2012) [7]. The length of the road network is 311,257 km. Road infrastructure of Žilina is characterized by a relative dense network of roads, but the proportion of the higher classes' roads is low. The basic communication system in Žilina is radial-circular. At present time, it is created of main radials and also of three circuits, and also fourth circuit is about to build.

In the Strategic Development Plan of the city of Žilina, there were identified streets that are of concern from the point of view of traffic solution. The mentioned streets are the Kragujevská, feeder motorway Žilina-Strážov, Priemyselná, Ľavobrežná, Veľká Okružná, Závodská, Rajecká, Kvačalova and Hôrecká. According to the Strategic Plan, from the point of view of urban structure, the most problematic part remains to link the western part of the city and the city center. [9]

Public transport is operated by Transport enterprise of the city of Žilina, Ltd. The operation of urban transport is covered by trolleybuses and diesel buses, which operate on 8 trolleybus lines and 13 bus lines. The length of trolleybuses lines is 128.3km and the length of bus lines is 270.3 km.

In the town of Žilina, there are 7 roundabouts, the three of which are located on Vysokoškolákov Street. There are 21 traffic lights, not all are in operation. 17 traffic lights are in operation, the 10 of which are at signal controlled intersections. Remaining 7 traffic lights ensure safe pedestrian crossing (green phase for pedestrian are on the basis of pushbuttons)

5.1. Traffic Lights at Streets Hričovská and Kragujevská

Kragujevská Street is continuation of Hričovská Street, it is part of the road I/18 and creates feeder in the direction of Bratislava. At this section, there is one pedestrian crossing that is secured with traffic lights (call by pressing the pushbutton). Except the pedestrian crossing, there are another 5 traffic lights (3 intersections + 2 pedestrian crossings), but they are due to traffic smoothness out of operation (blinking yellow or completely off)

5.2. Traffic Lights at Košická Street

There are three intersections controlled by traffic lights on this street. First of them is traffic signal ath the entrance to TESCO (controller VSF-12). The middle one is intersection at the TESCO Hypermarket, on the road I/18 (controller MTC 3000). This intersection is the only intersection of the third (speed) traffic circle of the town and is also the busiest intersection of the town. The third traffic light controls the intersection of the streets Košická - Pri Celulózke, where ensures left turn from the Košická Street and the right turn from the Street Pri Celulózke.

5.3. Traffic Lights at Veľká Okružná Street

In 2011, the driveways and intersection round the Shopping centre Aupark were reconstructed. It concerns the intersections Veľká Okružná – Hálková, V.Okružná – Komenského, V. Okružná – Aupark, V. Okružná – Vojtecha Spanyola and V. Okružná – Predmestská – 1. Mája and pedestrian crossing next to the “Dom odborov”. The traffic lights are fitted with camera detectors, pushbuttons and CROSS RS4 traffic controllers. Signal groups of the intersections were calculated on the bases of measuring the intensity by the camera detectors, which lasted approximately 1 month after reconstruction. Each intersection has four sets of signal groups, of which the length of cycles are 68s, 85s, 91s and 109s and in two different versions – signal programs without calls and signal programs with call. Tab. 2 shows timing of the mentioned signal groups. [8]

Mo- Fri		**Sa, Su, Holyday**	
time	**state**	**time**	**state**
0:00	yellow	0:00	yellow
6:00	68s	6:00	68s
7:00	91s	19:00	yellow
9:00	85s		
13:30	109s		
19:00	yellow		

Tab. 2. Timing of the signal groups of the Street Veľká Okružná

All of these traffic lights are in coordination (linear coordination). The coordination is ensured by receiving the exact time from satellites, but individual traffic controllers are not connected to each other. In practise it means, that in the case of malfunction of any traffic controller, remaining controllers don’t react on it and remain operate in the same programme.

5.4. Remaining Traffic Lights

There are two more intersection with traffic lights in Žilina. First of them is the intersection of streets Komenského and Fándlyho (traffic controller VSF -12) and intersection P.O. Hviezdoslava – Kálov – Kysucká – Sasinková (traffic controller BDE). Both traffic lights are controlled by fixed time programs. Remaining traffic lights ensure pedestrian crossings and are on call.

5.5. UNICAM Camera System

There are 2 modified camera systems in the area of Žilina [6]: *speed cameras* for detection of speed on a road section (UnicamVELOCITY), which are located on the Veľký diel street; and *red light running cameras* (Unicam REDLIGHT), which are located at the intersection of streets Predmestská, Veľká Okružná and 1. Mája. These systems are located there in the framework of the Transport Research Centre, specific objective 2 (Extension of planned research of advanced technologies in the field of law enforcement in road transport).

The principle of the system UnicamVELOCITY is based on the time data from detection of presence of vehicle at two different places, while distance between them is fixed (528,4m) Only one lane is monitored. The offence is recorded through photographs and details of the registration plate (+ processing of the special software for recognition of registration plate number)

The system UnicamREDLIGHT monitors only one direct lane at the mentioned intersection. The system uses surveillance and detail cameras. In the case, when surveillance camera detects motion of a vehicle during red signal, camera starts to take images of the vehicle at intervals, while detail camera takes a picture of registration plate. The registration plate is subsequently recognized automatically by special software for recognition of registration plate number)

6. Conclusion

This article provides an overview of the possibilities of urban traffic management. Single traffic management solutions are compromise of many factors. On the basis of the analysis of abovementioned three cities we can say, that traffic solutions depend mostly of the size of the city. But there are many other criteria which influence traffic solutions. One of the most decision criteria is initial and operational costs. Choosing the right solution can lead to reduction of negative traffic impacts and to increase of traffic safety and smoothness.

References

[1] PŘIBYL, P. – SVÍTEK, M.*: Inteligentní dopravní systémy*, Praha, 1. vyd. BEN – technická literatúra, 2001, 543s, ISBN 80-7300-029-6

[2] KALAŠOVÁ, A – ONDRUŠ, J. - PAĽO, J.: *Dopravné inžinierstvo:Križovatky*. 1.vyd. : EDIS – vydavateľstvo ŽU, 2011- 205 s., ISBN 978-80-554-0332-8

[3] CROSS, *Inteligentní řízení dopravy.* Online: http://www.cross.cz/download/brochure/CROSS_BRO_TRAFFIC_1009_CZ.pdf

[4] http://conduits.eu/documents/city-summaries/london.pdf

[5] Information provided by the city of Heerlen (contact: Ruud Schmeitz)

[6] VÝSKUMNÝ ÚSTAV DOPRAVNÝ: Charakteristika kamerového systému UNICAM, Základné informácie

[7] http://www.zilina.sk/userfiles/2012/Spravodajstvo/Oznamy/Stav_obyvatelov_k_0712.pdf

[8] Projects of the Street Veľká Okružná

[9] Strategic development plan of the city of Žilina up to 2025. Online: <http://www.zilina.sk/userfiles/2012/strategia/Strategicky_plan_rozvoja_mesta_Zilina_do_roku_2025(1).pdf>

VEGA Projekt č. 1/0159/13 – KALAŠOVÁ, A. a kol.: Základný výskum telematických systémov, ich podmienky rozvoja a potreba dlhodobej stratégie, ŽU v Žiline, FPEDAS, 2013-2015.

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The concept of mobile technical basis for City logistics

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Abstract. This article deals with City logistics of freight transport with a focus on technical basis with potential application to the Slovak cities. The main objective of the paper is an analysis of the mobile base which includes for example: small containers, cargo trams and waste collection in a city.

Keywords: City logistics, small containers, cargo-tram, trolley truck.

1. Introduction

In this article, we would like to suggest some possible solutions of supplying large cities of Slovakia, whose streetcar lines and trolley lines are developed. We think about the use or rather the formation terminal design near the Gateway of these cities and design of distribution / supply network using the existing lines. This system has a potential to achieve many synergies in terms of sustainable mobility. In this article, we focused on the mobile part of the City logistics.

1.1. Small containers in City logistics

The main problem of a road freight transport are high costs on loadings and joined consignments orders. Urban freight transport involves the supply transportation, which means that handling units are much smaller than for long driving distances. Larger handling units and corresponding intermodal loading units are not very suitable for collection or distribution along urban roads from customer to customer living near urban centers.

Therefore, is now the domain of the road freight transport the cargo transportation designated for centers allocated on the margin of urban areas and the transport among goods distribution centers is shifted to the capacity more favourable railage. This means that when separating consignment the costs are very high so the direct supply compared to combined transport of urban centers by semitrailer units for long distances is often the most favourable for the distribution companies.

Smaller containers that correspond to the usual volume of cargo in the supply transport, represent an opportunity to reduce the financial cost of joined consignments orders, or it would be better to remove the possibility of joined orders. Compared to today's containers, small containers meet the requirements for both short-distance journeys with small cargo units, as well as for long driving distances with large cargo units. Considering the requirements of urban freight transport (narrow roads, environmental aspects) is increase in price undesirable.

Fig.1. Example of small logistics box – on the right are small containers loaded at railway wagons in Japan and on the right proposed standardization of dimension lines in Europe; on the bottom from left to right – Australian taxibox and minibox – also known as mini container (ISO 10 ft. container).

Small containers are containers that generally correspond to the mid 7.45 m long standard swap body and are used in combined transport. The minimum size corresponds to ISO container pallets. Current standardized intermodal containers - ISO containers and swap bodies - have the loading capacity of approximately 40 to 90 m^3 or 15 to 30 tons.

We can assume that these containers are suitable for direct mail (from the supplier to the recipient - D2D technology - door to door) of size from about 20 m^3 or 10 tons. Smaller shipments require grouping of items in order to fill whole container, and then by distribution needed shipped directly to the recipient. This can be done while shipping from the supplier to the recipient or by consignment distribution centers. These activities are expensive and require a higher time consumption. At the design stage for standardization are two small containers sized as following: 1/2 or 1/4 of the 7.45 m long swap body, in accordance with CEN standard EN 284, with a loading capacity of 8 to 9 or 4 EUR – pellets (1200 x 800 x 144 mm). Non-standardized small containers similar to ¼-new containers were put into operation in Zürich (Switzerland). Medium-sized food distributive company supply small business recipients in the remote logistics center fifty kilometers far from Zürich. For these small containers was developed frame reloading equipment by which they can be manipulated onto a small container supply vehicle. Reloading equipment is highly automated. Vehicle of 3.5 tonnes weigh (lighter containers) was specially designed in order to lay the containers on the florr without additional assistance. The subframe would be possible to transport on a truck, but also on the standard railcar dedicated to transportation of swap bodies, even reloading itself would be possible to carry out using normal transhipment facilities.

Regarding special advantageous sliding containers with forklift head truck because they allow easier use of transhipment equipment (medium sized forklift truck), which are used by default. After designing and constructing demonstrations of handling options is only necessary to technically develop and to test individual components. Their suitability for practical use must be demonstrated by more extensive demonstrations and their future users need to be aware of the new system properly. [2,3]

1.2. Manufacturing company supply and waste collection by trams

In the most of the European and world cities, there is a complex of large-scale transport infrastructure, for example, where transport capacity in certain hours of a day (eg, night hours, traffic saddle, freight saddle) is not sufficiently utilized. Therefore, there is a possibility of its use to supply stores in the city center and shopping malls in the wider city center or also waste collection for example waste. The condition is that the specially modified cargo tram, trolleybus or bus must not be in car collision. It is necessary to optimize the use of infrastructure for both passenger and freight traffic. Investments made in the treatment of infrastructure and the introduction of the transport of goods system is set to return in term of several decades, hence this method still requires a constant traffic supply.

FIG. 2. Example of Tram Cargo (tram designed for freight transport) in Dresden

Trams supply VW car production with necessary parts at the time from 6:00 to 00:00 and from Monday to Saturday in 40 min. intervals, what is utilization of time spaces in the traffic order service that share the route. The distance among distribution center and manufacturer is 4.2 km and a tram pass the distance in18 minutes. Top speed tram is 50 km / h and therefore the rail transportation in the city is not limited. Other technical parameters are: gauge of 1450 mm, total length of vehicle is 59 400 mm, width of the vehicle is 2200 mm, max. loading volume of 214 m3, weight (tarra tram) 90 t, max. load carrying capacity 60 t, the total weight of the tram nákladom150 t. Goods are transported on pallets and a tram is possible to unload in 20 minutes.

A cargo tram in a daily operation replace about 65 trucks that would otherwise contribute to congestion in the city center. Freight tram operation is profitable for DVB. The Dresden freight tram represents a specific solution that was designed specifically for the needs of Volkswagen (VW). The main obstacle pose common tram infrastructure with passenger traffic. [1]

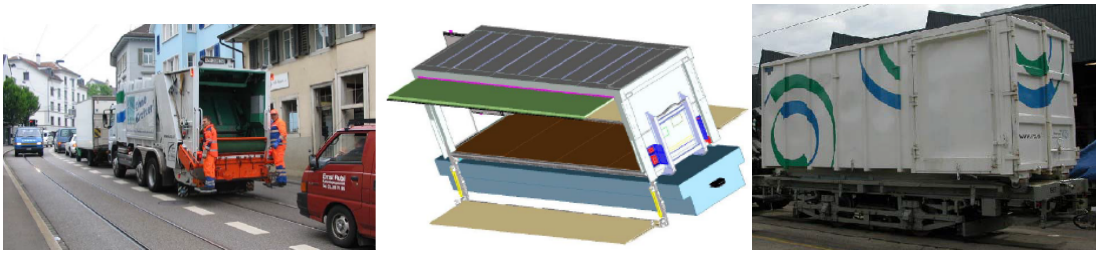

FIG. 3. Collection of waste in the streets of Zürich – (from right to left) constant congestion in city complicate collection of waste by road vehicles, the drawing of ACTS container with specially adjusted operable walls to facilitate emptying, to the far left ACTS container on a special wagon

Cargo Tram and E-tram, these two types of fright trams drive in Zurich. Cargo Tram established provider of local public transport company VBZ in collaboration with a local recycling company ERZ. Trams were introduced in 2003 and had to be used mainly for cohesionless garbage, glass waste and metallic waste. In 2006 was launched the E-tram project, which was primarily

designed to collect old and decommissioned electrical and electronic components. This step was favored after an experience with low efficient collection by garbage automobiles, due to the exclusion of the city's ring road during peak hour; they had to drive almost three runs more round the city than in different time period of the day. The Cargo Tram project appeared by the number of 364-thousand people, representing 100 thousand tons of waste a year as a solution that is cheap, fast, reliable, with low-emission load, without any delay or complication in their delivery services ordered by other companies.

The city is already 9 stops; in 2003 were there only 4 collection points with the total collection of 272 tons with the utilization of 35 rides. One year later, it was 94 rides and 785 tons of collected and removed waste. The cost of each trip is on an average of € 3,200. In 2005, a total savings represented 5,020 made by a vehicle, which has helped to reduce CO2 emissions by 4.9 tons. By now, there is newly created recycling point centre dedicated to the waste processing, collected only by the tram.

GüterBim launched the Austrian Ministry of Transport and innovation in cooperation with the Vienna transport company (Wiener Linien), the operator of light rail (Wiener Lokalbahnen), Vienna Consult and Tina Vienna. This project started in between 2004 and 2005, and right now is about to close up and passes further to the run test. This project is based on the principles of interoperability, intermodal transport units, telematics supply chain management of different companies with the target to optimize the resources used.

FIG. 4. The example of a tram and a universal tram wagon carrying swap-body in Vienna and specially modified Box in a trial operation in Amsterdam

City Cargo Amsterdam is oriented to the project of the first and or the last mile. The origins of the project date back to 2007, however the project after the money issue compilations was the project stopped.

Project - the cargo tram in Barcelona. This project started by the year 2012 and two variants has been planned. The first variant covers the distribution task and the second is dedicated to the waste collection service. Statistical findings suggest the solution as waste collection services in the city agglomeration of Barcelona where it is about 349.28 kg / inhabitant. While using 328 garbage cars - this project suppose to save up to 20.5 km by a garbage car, what represents 52,378 km by the garbage car. That would in total depict 40% cost savings. But it is necessary to note that this project is still at the beginning of the solution. [6,7]

2. Trams for freight in mixed traffic during a day

In the second half of November and December of 2011, Paris launched a pilot project called *the utilization of trams for freight*. In 2007 this feasibility study served as the base for the research (which has btw. been running 3 years) and was concluded by Monoprix. The aim of this pilot study was to schedule the transport of goods into the city center by rail and tramway from halle de Barca to the 90 selected stores in 26 different ways. By this action were the emissions reduced by 50 per cent. However it had to be realized under the condition that cargo trams have to be included into daily operation of the public passenger transport trams. And so they were incorporated into the T3 lines twice a day between stops Pont du Garigliano and Porte d'Ivry. The major initiator for the project was the Parisian company for planning, *Apure* (Atelier Parisien d'urbanisme), by this project they wanted to point out that the tram for freight would not have any negative impact on passenger services on T3 line. During the operation of the tram was concluded a survey among residents of the capital city and tourists who use public transport. 95% of respondents said they have not noticed almost any change, 20% of the tourist noticed a difference and stated that there is a change from the usual appearance of the ordinary trams. Up to 84% of people who participated in the survey considered such project as a very good idea and also stated that it would definitely help the city's freight transportation. The next stage of the trial run was scheduled to the beginning of this year. In addition to this, a possibility of usage the underground for the cargo trams for freight is also considered. [6]

FIG. 5. Example of freight tram in Paris

References

[1] Nákladní tramvaj [online]. 2009-01-12 [cit. 2011-11-06]. Dostupné http://www.enviweb.cz

[2] http://blogs.yahoo.co.jp/chihiro1890/42802814.html

[3] SVITEK, M. - STÁREK, T. – TVRZSKÝ, T. – MANDA, P. – ĎURIŠ, M. Metodika City logistiky. projekt č.cg732-108-520. Praha. 2008

[4] http://www.otosaigon.com/forum/m2837287-print.aspx

[6] http://www.umwelt.nrw.de/umwelt/pdf/pronet/factsheets/41.pdf

[7] http://tram-2.andreetjes-website.nl/cargo_tram_amsterdam/start_cargo_tram_amsterdam.htm

[8] VEGA Projekt č. 1/0159/13 – KALAŠOVÁ, A. a kol.: Základný výskum telematických systémov, ich podmienky rozvoja a potreba dlhodobej stratégie, ŽU v Žiline, FPEDAS, 2013-2015

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Assessment of change a noise and vibration of engine during start-up

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Abstract. The aim of the work is to determine changes of the diesel engine vibroactivity at the moment of starting. The vibroactivity in the period of a few rotations of engine crankshaft in a good condition and with one of fuel injectors damaged was analyzed. It was proved that the noise and vibration level of the internal combustion engine, increase in the range of a few first complete cycle of the engine work and after that it stabilizes. As a result of one of fuel injectors damage there is a slow growth of the rotational speed of the engine, the vibration level increases in the transverse direction to the axle of the piston movement, slightly decrease the vibrations accordant to the axle of the piston movement and the noise level increases.

Keywords: Combustion engine, nonstationary, noise, vibration, condition monitoring.

1. Introduction

The internal combustion engines are the units which work is connected with the cyclic repeating fast-changing mechanical and thermodynamical phenomena. In these working conditions, the estimation of the technical condition of the internal combustion engine is a difficult diagnostic problem.

Currently, the basic estimation of the technical condition of the engine assure the on-board diagnostics OBD [1-3]. These systems have limits as to diagnose the mechatronic units of the engine which operation consists mainly in adaptation of the steering unit of the engine in order to meet the norms of the fuel toxic elements emission. During the normal exploitation there are damages which detection is possible by looking for leaks, blows and by listening to the engine [1,2]. In the diagnosis of the engine technical condition there are new, more advanced methods of measure and data analysis. They use registration and the transformation of the vibroacoustic signals, which is presented in the works [3-12].

One important question connected with the operation of the internal combustion engine is the level change of its vibroactivity during the starting point, which is disturbed by the damages occurring in the engine. Non-stationary work of the engine, in this case may be examined in a few dimensions, as the processes of the vibroactivity changes connected with the rotational speed change, the injector damage and with both these processes occurring simultaneously.

In the work, the vibroactivity change of the diesel engine during the start up were estimated. Additionally, the trial of the estimation of the injection damage influence on the change of vibroactivity during operation was taken up.

2. Methods of research

The object of the study was the diesel engine of Renault Master 2.5 DCI with 88 kW and the mileage 102000 km, equipped with the Common Rail system.

On the test stand there were measures conducted connected with the vibration acceleration in the transverse direction to the axle of the piston movement and the direction accordant with the movement and the noise with the distance of about 0,5 m from the cover of the engine valve. During the experiments the referential signal position of the crankshaft was recorded. The measures

were conducted with the sampling frequency 25 kHz. The signal transformation was conducted in the Matlab-Simulink programme.

The scheme of the piezoelectric transducers lay-out and the place of condenser microphone are presented in figure 1.

a) b)

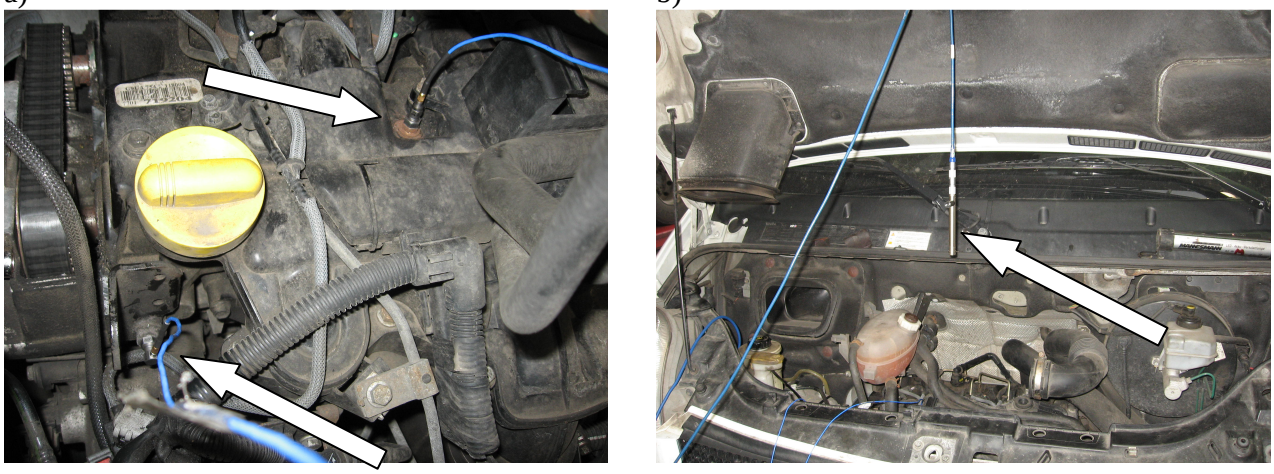


Fig. 1. The piezoelectric transducers lay-out and the place of condenser microphone

In the study it was assumed that the measures would be conducted for the engine in a good technical condition and with one fuel injector off which is simulated its damage.

3. The measure results and their analysis

In figure 2, there are results of the measure of the vibration acceleration in the transverse and parallel to the axle of the piston movement and also the level of acoustic pressure in the period of its starter and a few first rotations of the crankshaft. Analysing the measures results a few characteristic phases of the engine work can be distinguished, which are accompanied with vibration and noise change:

- I phase – coupling starter with the flywheel toothing, significant increase of the vibration and noise,
- II phase – accelerate the engine to the normal rotational speed of the starter; the vibrations and noise caused only by occurring clearance and the charge exchange in the cylinders,
- III phase – rotation of the engine with the nominal speed of the starter together with the first symptoms of the burning process; vibrations and noise are caused by the clearance in the engine and the first initiation symptoms of the burning process,
- IV phase – the initiation of the full burning process, sudden increase of the rotation speed of the engine, the intensive emission of vibration and noise caused by clearance and the full burning process,
- V phase – the full burning process; the rotation speed, vibration and engine noise stabilization.

The presented phases of the engine work are accordant with the phases of the internal combustion engine starter presented in [13-14], in which the angular velocity of the crankshaft of the engine and the current intensity received though the starter.

In order to characterize the quantitative changes occurring in the rotation speed, noise and the vibration of the engine during the start, the average rotation velocity of the engine was calculated in the next cycles of its work and the average level of the signal noise (1) and the average power of the vibration signal (2) in these cycles, from the equation:

$$L_{p_i} = 10\log\frac{\frac{1}{T_i}\int_{t_i}^{t_i+T_i} p(t)^2 dt}{p_o^2}. \quad (1)$$

$$P_{a_{w(p)i}} = \frac{1}{T_i}\int_{t_i}^{t_i+T_i} \left|a_{w(p)i}\right|^2 dt \quad (2)$$

where:
p(t) – the level of the acoustic pressure signal, T_i – the length of analysis range, t_i – the beginning of the analysis range, $a_{w(p)i}$ – the vibration acceleration signal (w – lengthwise direction, p – transverse direction), i – the number of the analysis range.

The calculation results conducted for the first 16 cycles of the engine work are presented in picture 3.

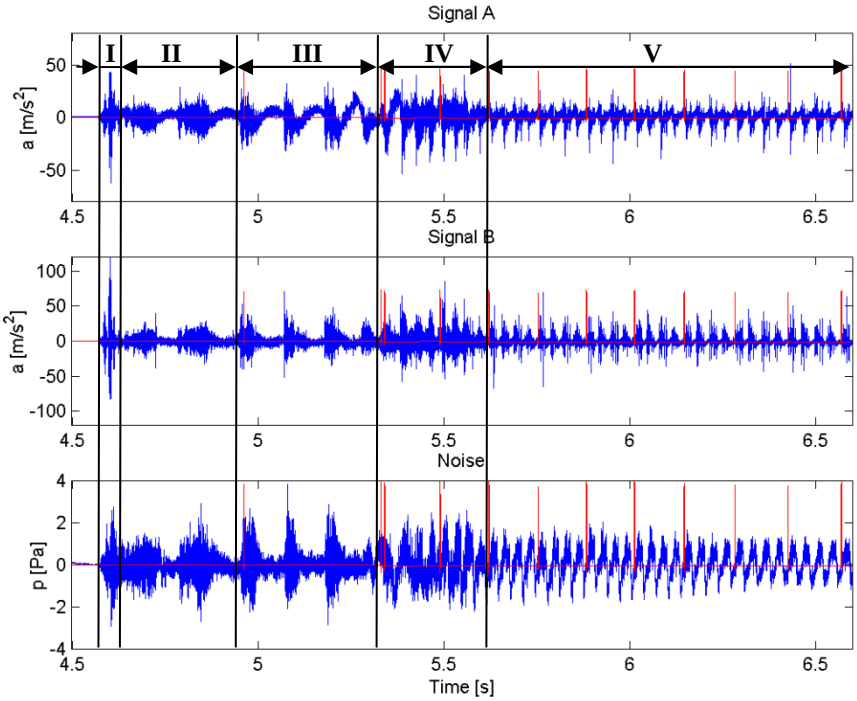
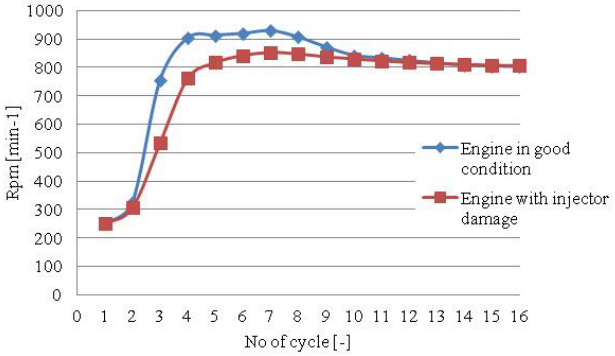
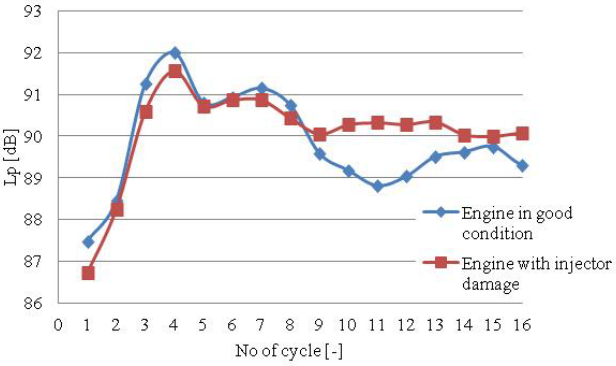


Fig. 2. The recorded vibration and noise signals of the engine in a good technical condition, during the measures, where: Signal A – signal of the vibration acceleration in the transverse direction to the piston movement, Signal B - signal of the vibration acceleration in the parallel direction to the piston movement, Noise – signal of the level of the acoustic pressure near the engine, I-V – next phases of the engine start; red colour – reference signal of the position of the crankshaft of the engine (the beginning and the end of the cycles of the engine work)

a)



b)



c) d)

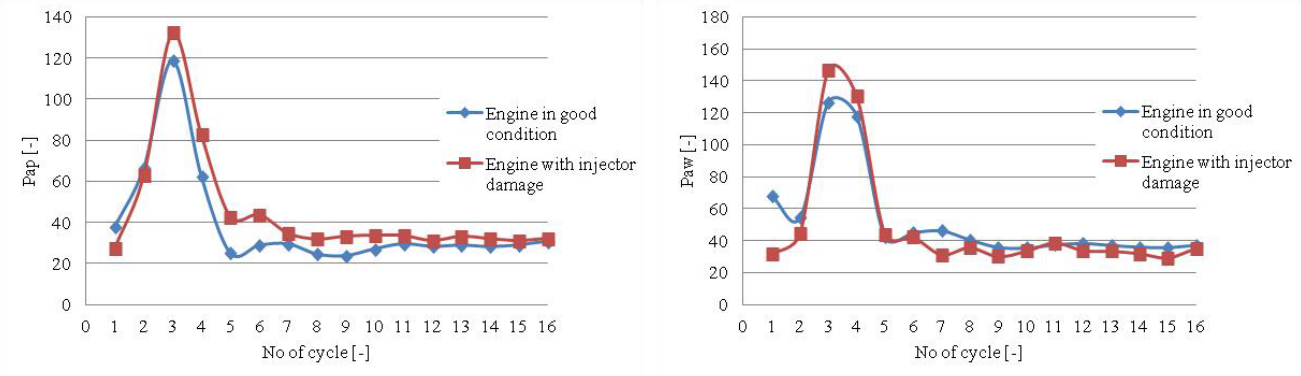


Fig. 3. The calculation results of the signals recorded for the engine in a good technical condition and with one injector damage, where: a) average rotation velocity, b) average level of the noise signal, c) average power of the vibration signal in the transverse direction to the piston movement, d) average power of the vibration signal in the parallel direction to the piston movement

The study results showed that the level of vibration and noise of the exemplary diesel engine increases in the range of a few full work cycles of the engine and then it stabilizes. As a result of one injector damage occurrence, there is a slower growth of the rotation velocity of the engine, there is increase in the level of the vibration in the transverse direction to the piston movement, and the vibrations accordant to the axle of the piston movement are smaller, and the noise level increases.

References

[1] LEHMANN W. *Reparatur - und Einstelltabelen. Kfz-betrieb*. Vogel Wurzburg Ausgabe 1998/99.

[2] BOCHEŃSKI C., JANISZEWSKI T. *Diagnostyka silników wysokoprężnych.* WKŁ Warszawa 1996.

[3] DĄBROWSKI, Z., ZAWISZA M. *Investigations of the Vibroacoustic Signals Sensitivity to Mechanical Defects Not Recognised by the OBD System in Diesel Engines.* Solid State Phenomena, Mechatronic Systems, Mechanic and Materials 2011, 194-199.

[4] PAKOWSKI R., ZAWISZA M. Symptomy wibroakustyczne jako miara uszkodzenia mechanicznego silnika ZS. XL Jubileuszowe Sympozjum Diagnostyka Maszyn, Wisła 2013.

[5] FIGLUS T., WILK A., KRAJZEL K. *Noise emission study of lawnmowers with SI engine*. Transactions of Universities of Košice, 3/2012, 45-50.

[6] BURDZIK R., KONIECZNY Ł. *Research into noise emissions by a car combustion engine exhaust system.* Zeszyty Naukowe Akademii Marynarki Wojennej rok LII NR 1 (184) 2011.

[7] FIGLUS T., WILK A. *Diagnozowanie stanu mechanizmu rozrządu silnika ZS metodą pomiaru i analizy hałasu.* Zeszyty Naukowe Instytutu Pojazdów 3(75)/2009, Politechnika Warszawska Wydział Samochodów i Maszyn Roboczych, 105-114.

[8] MADEJ H., CZECH P. *Discrete wavelet transform and probabilistic neural network in IC engine fault diagnosis.* Eksploatacja i Niezawodność – Maintenance And Reliability, 4(48)/2010, 47-54.

[9] MADEJ H., CZECH P. *Discrete wavelet transform and probabilistic neural network in IC engine fault diagnosis*. Eksploatacja i Niezawodność – Maintenance And Reliability, 4(48)/2010, 47-54.

[10] WANG Y., YANG J., JI Z. *Study on gasoline engine knock indicators based on wavelet transform and rough set.* Advanced Materials Research 2013, 651, 625-30.

[11] YANG C., FENG T. *Abnormal noise diagnosis of internal combustion engine using wavelet spatial correlation filter and symmetrized dot pattern*. Applied Mechanics and Materials 2012, 141(1), 168-73.

[12] CIOCH W. *Wibroakustyczna diagnostyka maszyn w zmiennych warunkach pracy*. WibroTech 2012.

[13] DROŹDZIEL P. *Nowa klasyfikacja etapów rozruchu silnika spalinowego o zapłonie samoczynnym*. Zagadnienia Eksploatacji Maszyn. Z. 4 (144), v. 40, 2005, 87-96.

[14] DROŹDZIEL P. I INNI. *Wybrane zagadnienia samochodowego silnika o zapłonie samoczynnym*. PNTTE, 2007.

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Sustainable Mobility in the City of Bratislava – Tram Priority

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Abstract. United Nations Development Programme (UNDP), acting as an implementing agency of the Global Environment Facility (GEF) has implemented the project "Sustainable Mobility in the City of Bratislava". One component of the project deals with a higher level of priority to Bratislava's trams.
Driving time information from the ITCS of Bratislava public transport operator has been evaluated with Hamburg-Consults software "planfahrt" in order to find obstacles responsible for slowing down tram operation. Thereafter measures based on best practice solutions have been introduced for a fast and reliable tram operation: "The tram stops at stations only".
Integral part has been the simulation of public transport priority at three signalized intersections using transport modeling software "ptv VISSIM". The results prove the effectiveness of the priority. Public transport waiting times are reduced; the reliability of public transport operations improves.

Keywords: Public Transport, Tram, Transport Planning, ITCS, Driving Times, Public Transport Priority

1. Introduction

The transport sector is the third largest polluting sector in the Slovak Republic with respect to the emissions of greenhouse gases, after Energy and Manufacturing. CO2 emissions from transport represent 17% of the total national GHG emissions in the Slovak Republic. United Nations Development Programme (UNDP), acting as an implementing agency of the Global Environment Facility (GEF), is implementing the project "Sustainable Mobility in the City of Bratislava" financed by GEF within the umbrella of its Operational Program 11 and Strategic Program 5 Promoting Sustainable Innovative Systems for Urban Transport.

This part of the project deals with a higher level of priority to Bratislava's trams at signalized intersection in order increase the service speeds. Additionally to the project title the focus has been extended to all components of a modern tram system.

Exemplarily two out of four tram branches have been surveyed in order to find obstacles responsible for slowing down tram operation. Both Račianska and Vajnorská branch have widely separated alignment from individual transport. Therefore priority measures can be realised comparatively easily. Multiple tram lines serve each corridor with headways up to 4 minutes together.

The project has been realized between June 2011 and February 2012. First has been evaluated whether the selected tram corridors comply with design principles and system parameters of modern tram operation. By detailed analyses of ITCS (Intermodal Transport Control System) data main bottlenecks have been located. Afterwards in-depth analyses of three intersections have been carried out. The effectiveness of priority measures have been checked by using a micro-simulation model.

Stakeholders in this project have been:

- UNDP as the implementing agency represented by UNDP Bratislava Regional Centre,
- Energy Centre Bratislava as central project manager,
- Hamburg-Consult (HC) providing international expertise together with VerkehrsConsult Dresden-Berlin responsible for the modeling and
- DIC Bratislava as local counterpart.

At all stages local municipality (namely the Main Transport Engineer of Bratislava) and local public transport operator Dopravny Podnik Bratislava (DPB) participated and supported the project.

2. Survey of current situation

Beside a comprehensive field survey, main bottlenecks and shortcomings should be assessed in a quantitative way. Therefore the realized driving times of Bratislava trams have been evaluated. Bratislava public transport company DPB provided us with performing data from their operation control system. Nearly 20,000 trips representing the traffic situation in March 2011 have been transferred to Hamburg-Consult´s software "planfahrt". This software used by more than 100 public transport operators and authorities in Europe is designed for analysing data from Automatic Passenger Counting systems as well as driving time surveys.

E.g. for Račianska branch an average journey time of 24.5 minutes has been calculated. As the timetable states a driving time of 20 minutes, an average delay of 4.5 minutes shows the unreliability of tram operations. Additionally a theoretical minimum driving time consisting of the vehicle performance and station spacing distance has been calculated with 12.6 minutes (+3.5 minutes total dwell time at the stations). The gap between the theoretical and realized driving times represents the potential for tram priority. A total utilization of this potential would increase the attractiveness of the tram system and would additional save 3 vehicles under the conditions of the current timetable. Following table show the results for Račianska branch.

Station	Distance (m)	Theoretical (shortest) driving time (s)	Realized average driving time (s)	Deviation (s)	Deviation (%)	Average dwell time (s)
Račianske mýto						
Ursínyho	502	49	69	21	42%	14
Pionierska	836	73	139	67	91%	15
Riazanská	552	52	84	32	61%	16
Mladá garda	396	41	63	21	52%	16
Nám. Biely kríž	548	52	77	25	48%	13
ŽST Vinohrady	456	45	113	68	150%	17
Vozovňa Krasňany	349	38	81	43	114%	13
Nový záhon	347	38	51	14	36%	11
Pekná cesta	639	59	91	32	54%	15
Černockého	529	51	67	17	33%	13
Hečkova	375	40	61	22	54%	17
Hybešova	567	53	80	26	50%	13
Detvianska	516	50	77	27	55%	16
Záhumenice	404	42	95	54	128%	13
Pri vinohradoch	530	51	77	26	52%	10
Komisárky	164	24	28	4	15%	
Total	**7.710**	**757**	**1.254**	**497**	**66%**	**213**

Tab. 1. Driving times on Racianska corridor.

Main bottlenecks are located at following sections

- Nám. Biely kríž – ŽST Vinohrady: 68 s / 150 %
- Ursíniyho – Pionierska: 67 s / 91 %
- Detvianska – Záhumenice: 54 s / 128 %

The combination of the driving time evaluation with the field survey demonstrates the bottlenecks in a very obvious way and allows creating applicable improvements. The following figure shows an extract of Račianska branch.

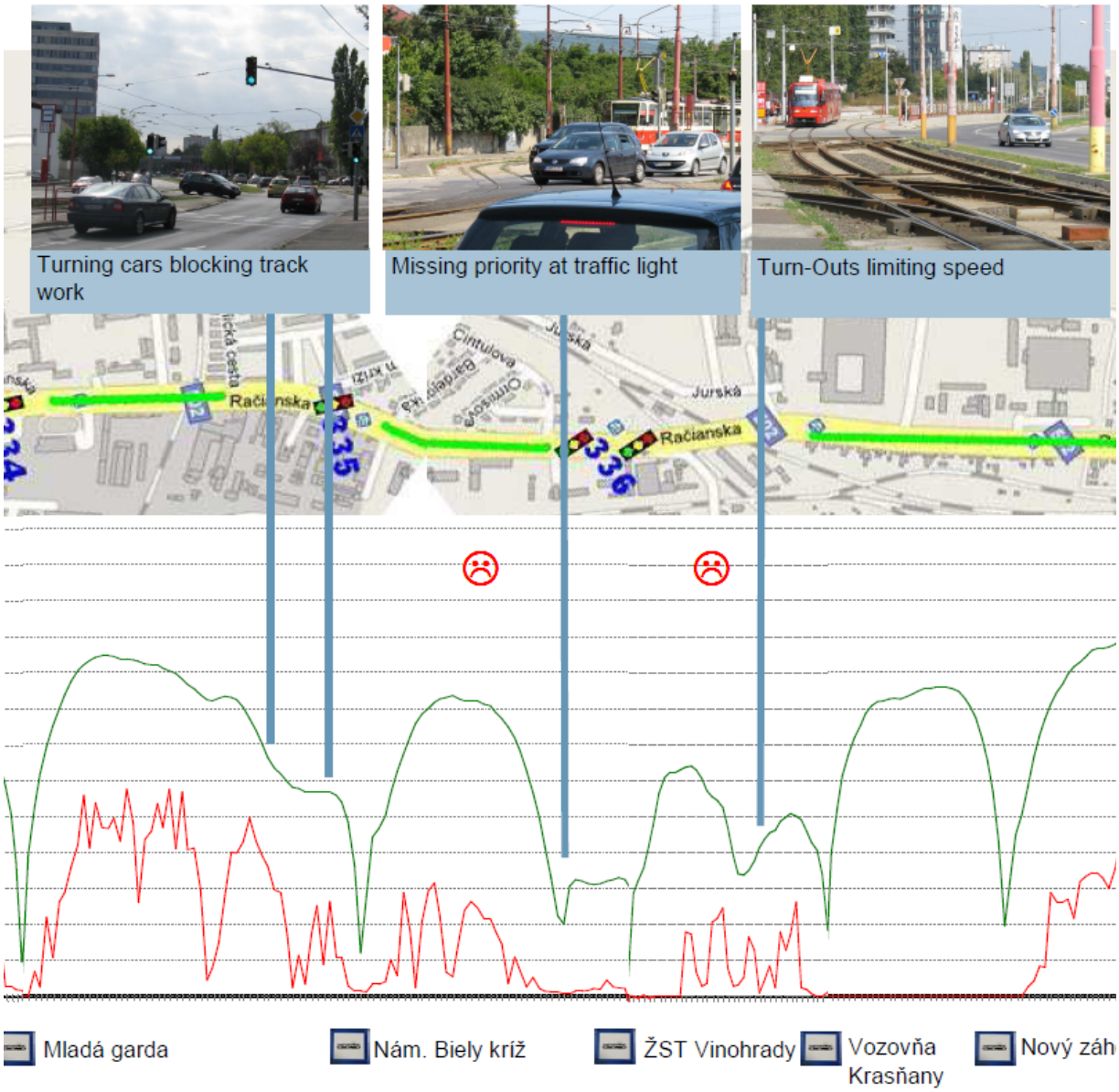

Fig. 1. Realized driving times on Račianska corridor and reasons for interferences and delays.

After the analyses of current situation, measures have been introduced in order to realize the mentioned potential and to ensure a fast and reliable tram operation: “The tram stops at stations only”. All recommendations are based on best practice solutions from state of the art tram systems consisting of following components:

- Alignment separated from other means of transport,
- Alignment with low level of constraints because of track conditions, curve radii or switches,
- Attractive station design with a focus on safe access and waiting areas,
- Attractive public transport transfer hubs,
- Priority at non-signalized intersections,
- Priority at pedestrian crossings and
- Priority at signalized intersections.

3. Priority at signalized intersections

Integral part of the project has been the simulation of public transport priority at three signalized intersections using transport modelling software “ptv VISSIM”. Beside the tram, busses

have been considered as well. This can be realised by the usage of TETRA radio communication between public transport vehicles and the priority equipment on-site instead of fixed way-side detectors. Two out of three intersections are relatively simple junctions with a high degree of freedom. The third one (Račianska / Jarošová) is more complicated as the traffic light system is coupled with another intersection and a railway crossing.

The results prove the effectiveness of the priority at intersections with a high level of freedom. The following table shows the results of the optimisation at the intersection Vajnorská / Bojnicka for peak hour traffic conditions.

Access from	Lines	Current Average Waiting Time (s)	Average Waiting Time (s) with Priority
East	Tram 2 and 4	19	0
South	Bus 65	16	4
West	Tram 2 and 4	24	1
West	Bus 57	43	4
North	Bus 65	11	3

Tab. 1. Average waiting times at intersection Vajnorská / Bojnicka

Not only public transport waiting times are reduced but also the range of waiting times. This is crucial for an improved reliability of public transport operations. The results show additionally that a sophisticated traffic light control does not have negative impact on individual transport or the overall capacity of the intersections. The results of the sample intersections can be easily adapted to other intersections in Bratislava and elsewhere.

4. Conclusions

Following key advises can be extracted from this study:

- Introduction of a priority program at intersections is highly recommended. The technical solution should be identical for tram and busses. The implementation strategy should start at smaller intersections which usually have more degrees of freedom. This ensures reasonable results with comparatively low investment costs.
- Reconstruction of track sections with poor conditions is necessary. Bratislava public transport company has to be provided with sufficient funding in order to maintain the infrastructure regularly before speed reductions appear.
- Introduction of tram priority at pedestrian crossings is highly recommended.
- Reduction of non-signalized intersections and crossings: Remaining intersections should be equipped with traffic lights ensuring a hard priority for trams – similar like trains on railway crossings.
- Reconstruction of stations in order to provide safe and comfortable waiting and access areas. An implementation strategy for the construction of interchanging hubs should be accompanied by a re-design of the public transport network. The parallel alignment of trams and busses – both local and regional – should be reduced to a minimum.
- Updating the track alignment on essential sections: Changing curve radii or the location of switches and stations in order to increase the allowed speed.

Within the framework of this UNDP GEF project a sample implementation of tram priority will be realised at two street crossings, namely Račianska / Pekná cesta and Vajnorská / Bojnicka. The project pushed the idea of public transport priority in Bratislava successfully. It is recommended to extend the project´s approach to main bus and trolleybus lines as well. A transfer to other Slovak and European cities can be realised easily.

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GIS in determination of mass evacuation routes: Three-step approach

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Abstract. Actually, commercial and noncommercial GIS (Geographic Information Systems) tools were employed to plan evacuation of people. By applying the **T**hree-**S**tep **A**pproach of GIS in determination of mass evacuation routes (TSA), determination of optimal evacuation routes and organizational issues, taking potential volunteered evacuation into consideration, were obtained. The main aim was to describe a holistic method for planning the mass evacuation of people, referring to a dynamics of crisis situation circumstances. TSA is an example of GIS application at the civil safety engineering field. It could constitute an appropriate solution for such evacuation transport and organizational problematic aspects as traffic jams on the main evacuation roads, necessity of changing evacuation directions, total evacuation time estimation and potential volunteered evacuation influence for all evacuation parameters. The approach application could increase effectiveness of crisis management owing to more optimal management of evacuation routes.

Keywords: evacuation roads, evacuation planning, GIS.

1. Introduction

In crisis situation, evacuation is conducted in order to displace people from a dangerous place to safer areas [1]. It is crucial to be done as fast as possible. It is necessary to prepare evacuation plans in order to have a satisfactory response time in such situation as e.g. floods, hurricanes and wildfires . The main challenge in developing the evacuation plan is the determination of effective distribution of evacuees into the safe areas, by deciding where and from which road each evacuee should go.

1.1. Mass evacuation of people modeling examples

Many optimization tools referring to mass evacuation of people have been worked out. Some of them base on node networks, where particular road crossings and other characteristic places (e.g. gather points, accommodation points) are tracked as nodes. The optimization process relies on shorten a traveling time between the nodes [2]. The other group of evacuation models connect evacuation route construction algorithms with traffic flow assignment algorithms. They constitute an attempt to create common evacuation-traffic management models [3]. As some threat characteristic elements to mathematical approaches are implemented, it is an opportunity to use models containing such elements. Referring to flood danger, there are following examples: The Life Safety Model, The Integrated Dynamic Traffic Assignment Model and The Evacuation Calculator [4]. Similar situation we will found in case of models designed for e.g. wildfires [5] and earthquakes [6].

Ones need to add, that GIS modules are integrated with many of previously mentioned models. Unfortunately, mathematical character of the models, necessity to gain scientific knowledge and purchase expensive GIS software are the main reasons, why are they not popular at local crisis management field.

As the GIS are implemented to everyday aspects (e.g. Google Earth®, Google Maps®, Targeo.pl®, www.geoportal.gov.pl), there is a chance to use noncommercial GIS solutions for evacuation planning needs. Connection of commercial and noncommercial GIS software could

increase usage of GIS tools in evacuation planning by local (provincial, district and communal) authorities, crisis management centers and rescue services representatives, in general.

1.2. GIS in mass evacuation planning

The GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. It allows users to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns and trends in the forms of maps, globes, reports and charts [7]. Foregoing definition is characteristic for such commercial solution as e.g. ArcGIS Desktop®. This GIS environment example incorporates all required evacuation plan elements. Taking spatial analysis for evacuation of people need into consideration, it is possible to use many different data layers. Among most useful ones, road infrastructure, area boundaries, buildings deployment, danger zone, address points, educational buildings, hospitals, police stations, fire brigade stations and accommodation places should be mentioned.

In accordance with the article subject, ArcGIS Desktop® is appropriate software tool for marking evacuation roads, distinguishing types of roads (national, provincial, district, others – assumption: national roads are more passable than provincial ones), estimating evacuation times, facilitating decision making referring to the determination of main evacuation directions, taking danger zones, safe areas, hospitals, schools, hostels etc. into consideration.

Not only commercial software could be useful during evacuation planning process. There are many pay-free computer tools, nowadays. Among the others, Google Earth® and Targeo.pl® are worth to be mention.

The first one is a powerful GIS tool, available online. In evacuation directions and roads appointment context, the following functions could be helpful [8]:

- Street View (all roads on a map are visible),
- Searching (searching for objects on the map is possible),
- Marking (objects important for evacuation might be marked),
- Customized Maps Sharing (prepared map might be easily shared with other users),
- Data Export (downloaded data can be edited),
- Importing GPS Data (GPS data are possible to be imported to Google Earth®).

The Targeo.pl® is a technological platform designed to implement digital maps and advanced geographical functions to any Internet or intranet applications [9]. In accordance with foregoing considerations, it allows to:

- search places, addresses, characteristic points,
- plan transportation routes (from point to point, address to address, point to address, address to point, with possible use of GPS data),
- visualize traffic situation on the roads (traffic jams, actual and previous speed of vehicles on the roads, road blocks),
- find information concerning public transportation system.

As economic aspect is very important, taking non-profit organizations (e.g. government offices, rescue services commands) functioning into account, it is not a truism, that the noncommercial GIS tools have the popularity advantage over their commercial equivalents. Nevertheless, local authority and public services representatives should take steps to connect both, commercial and noncommercial solutions, increasing the usage of GIS tools at the civil safety engineering field. The mass evacuation of people could be tracked as a one of the field dimensions.

2. Three-step approach of GIS in appointment of mass evacuation roads

TSA as a holistic method for planning the mass evacuation of people, referring to dynamism of crisis situation circumstances, is described. It consists of following elements:

- determination of main evacuation directions and roads (Appointment),
- optimization of the directions and roads (Optimization),
- verification of the routes basing on particular evacuation scenarios (Verification).

TSA and its relation with evacuation planning and usage of particular GIS tools is shown on Figure 1, below.

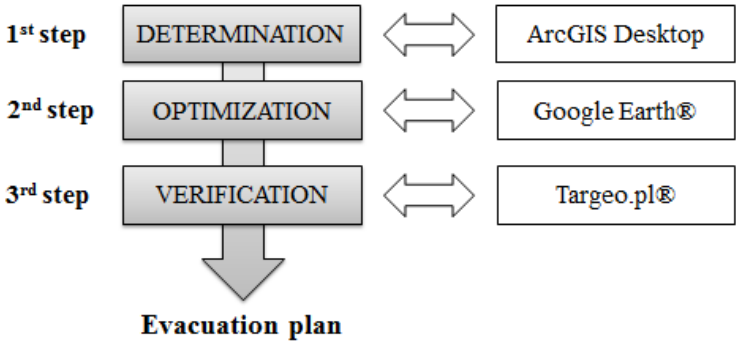

Fig. 1. TSA related to evacuation planning and the usage of particular GIS tools.

Example of application of particular GIS tools on Figure 2 is shown.

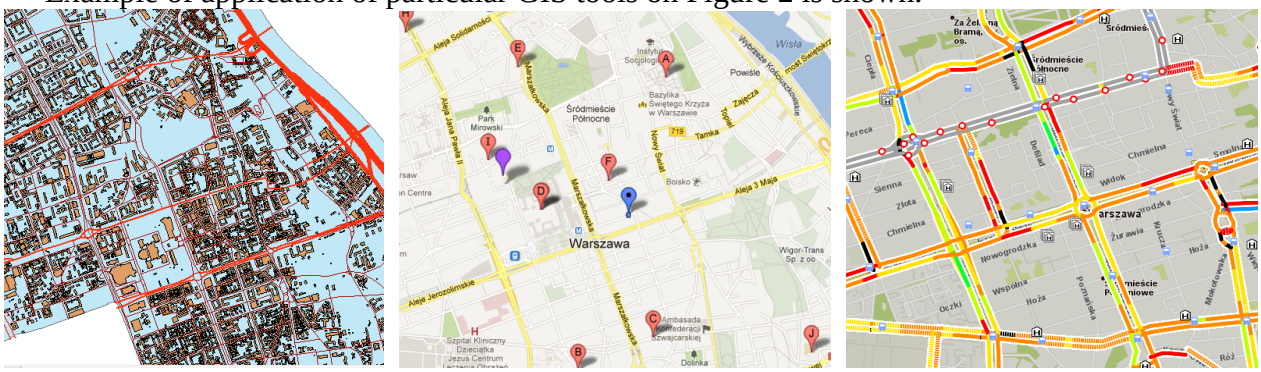

Fig. 2. Visualization of ArcGIS Desktop, Google Earth® and Targeo.pl® in evacuation roads determination.

2.1. Determination

The 1st step of TSA is the determination of the main evacuation directions and roads. Owing to a probability of the fact, that traffic conditions and vehicles' velocity at the main roads are better than in case of the others, it is crucial to mark which of them are national, provincial and local. Determination of evacuation roads should base on national and provincial ones. On the other hand, ones need to remember about an supporting role of other roads in evacuation planning process.

Particular types of roads are possible to be graphically distinguished by the use of ArcGIS Desktop software. The "roads" layer (with attributes referring to administration unit affiliation) is required.

2.2. Optimization

The next step with a necessity of taking into consideration critical places, that need to be evacuated (e.g. hospitals, schools, hostels) together with potential accommodation points (Fig. 2). For instance, a hospital evacuation is often a huge organizational venture. An involvement of many rescue resources is required. Moreover, many problematic aspects appears in case of school evacuation. All following elements could determine a change of main evacuation directions and roads. Complex safety analysis is required. It could be done by the use of the Google Earth®.

2.3. Verification

All previous considerations with potential evacuations scenarios in the verification step are compared. The volunteered evacuation aspect is taken into account. On the one hand, constant

increase of vehicles (cars, motor bikes, etc.) owners is observed. This is the main reason, why volunteered evacuation is known as the most common evacuation form. On the other point of view, unmanaged or incorrectly managed volunteered evacuation could cause traffic jams, decrease vehicles' velocity, that may lead to anxiety or even to panic.

In general, volunteered evacuation aspect constitutes a next potential cause of changing basic evacuation assumptions. The usage of Targeo.pl® could be noticed. The portal allows to check an actual, prognostic tomorrow and historical (2 days before) traffic situation in the city (e.g. average car speed on particular roads, traffic jams' places). In spite of the fact, that Targeo.pl® has nothing in common with computer simulation (it bases on conventional observation data only), it seems to be a very useful source of information for the evacuation planning proceeding needs.

3. Conclusion

This paper presents a simple but effective method to appoint evacuation roads, referring to dynamism of crisis situation circumstances. The contribution of this paper is description of comparison relating to the use of commercial and noncommercial GIS tools (ArcGIS Desktop, Google Earth® and Targeo.pl®) at the civil safety engineering field.

There are many mass evacuation optimization models. Its complexity and/or high economical cost of the software is the main reason why this computer environment is not widely used. The popularity of pay-free spatial data Internet portals seems to be a solution for this problem.

Google Earth® and Targeo.pl® are examples of widely available GIS tools. They can cooperate with commercial equivalents (e.g. ArcGIS Desktop), making all spatial analysis much more comprehensive. Evacuation routes determination is worth to discuss.

TSA focuses on determination, optimization and verification of evacuation routes, using basic functions of both commercial and noncommercial GIS tools. It is a small step in spatial data based evacuation planning. This direction seems to be appropriate in keeping abreast of the information and GIS technology development.

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References

[1] SAADATSERESHT, M., MANSOURIAN, A., TALEAI, M. *Evacuation planning using multiobjective evolutionary optimization approach*. European Journal of Operational Research 198 (2009).

[2] BRETSCHNEIDER, S., KIMMS, A. *A basic mathematical model for evacuation problems in urban areas*. Transportation Research Part A 45 (2011).

[3] YUEMING, CH., DEYUN, X. *Emergency Evacuation Model and Algorithms*. Journal of Transportation Systems Engineering and Information Technology 8(6) 2008.

[4] LUMBROSO, D., JOHNSTONE, W., DE BRUIJN, K., DI MAURO, M., LENCE, B., TAGG, A. Modelling Mass Evacuations To Improve The Emergency Planning For Floods In The UK, The Netherlands And North America. Birmingham: Aston University, 2010.

[5] VAKALIS, D., SARIMVEIS, H., KIRANOUDIS, C.T., ALEXANDRIDIS, A., BAFAS, G. *A GIS based operational system for wildland fire crisis management. II. System architecture and case studies*. Applied Mathematical Modelling 28 (2004).

[6] FENG, X., XUPING, CH., AIZHU, R., XINSHENG, L. *Earthquake Disaster Simulation for an Urban Area, with GIS, CAD, FEA, and VR Integration*. Tsinghua Science and Technology 13 (2008).

[7] *ArcGIS 9. What is ArcGIS?*, Redlands: ESRI, 2004.

[8] www.earth.google.com (17.02.13 r.).

[9] www.targeo.pl (17.02.13 r.).

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Carrying agents´ requirements for information systems in road freight transport

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Abstract. An article is focused on the requirements of carrying agents for information systems in a road freight transport. Based on their requirements for information and services, as well as the costs of various information systems, one recommended information system or a combination of information systems were proposed, which are the most convenient for carrying agents.

Keywords: Information System, Carrying Agent, Costs, Functions and Services.

1. Introduction

Individual information systems offer different functions and services to carrying agents for various costs. For carrying agent is therefore important that a concrete information system, which he buys, offers required features for the reasonable costs. It is important to avoid such situation that the purchased information system often connected with high costs, doesn't meet carrier's basic requirements and needed features.

2. Information systems that can be used by Slovak carrying agents

In Slovak republic carrying agents can use navigation systems and information systems, which are offered by individual vehicle manufacturers or, on the other hand, information systems which are independent from the vehicle mark and are focused on monitoring of transport and vehicles. There are also information systems that can't be used by Slovak carriers, because they are intended only for selected foreign carrying agents. An example for such information system is Frotcom, which is focused on monitoring of vehicles and transport.

2.1. Information systems offered by vehicle manufacturers

Information systems (Table n. 1) that are offered by individual vehicle manufacturers can be classified together with the subsystems for operational control and are designed to monitor operating parameters of vehicles. A part of such subsystem is, for example, a fuel management – management and control of the fuel consumption. These information systems also provide carrying agents different levels of services which provide a variety of information and can be focused on the vehicle, the driver or the transport management. At each level of service some hardware is needed. It may be a part of the new vehicle or not. Monthly fees are also different according to these levels.

Functions focused on the vehicle

These functions are included in the basic packages of informational systems. For their usage there is no need for the purchase of a new hardware for the carrying agent, because it is already a part of the vehicle. He pays only a monthly fee that is approximately 15 €/ month per each vehicle. Carrying agent therefore obtain following functions: recording of the vehicles journeys

(speed, braking, fuel consumption, travelled distance), remote data downloading, failures assistance, maintenance planning, log book.

Functions focused on the driver

Functions of this level of information systems are designed not only to monitor the operating parameters of vehicles, but also to control the work of individual drivers. For the usage of these functions, once again, is not necessary to purchase and procure hardware, because it is also the part of the vehicle. The carrying agent pays a monthly fee from 25 to 30 €/month per each vehicle. Besides previously mentioned features he also receives following functions: time records – all information about the working hours of drivers and the length of their drives, tacho-management – remote data downloading from the driver cards and mass memory tachograph.

Functions focused on the transport management

These functions aren't used by Slovak carrying agents so often as previous ones, because they require to purchase hardware – GPS module that isn't a part of the vehicles and its price including installation is around 2 500 €. The carrying agent pays for the usage of such functions a monthly fee, which is stated as 35 €/month per each vehicle. Carrier receives, in addition to previously mentioned features, following functions and services: processing of messages between the driver and the control centre, on tack – this function signalizes the dispatcher that the vehicle is close to its final destination, navigation, workflow – this feature integrates data about transport with the navigation, trailer&refeer – information about trailer – temperature, disconnection, connection, geofence – possibility of setting of geographical areas including reporting of exceptions.

2.2. Information technology for monitoring of transport and vehicles in road haulage

Information technologies for monitoring of transport and vehicles are designed mainly to monitor the vehicles movement, control the work of the drivers, record and monitor the operational status of vehicles. These information Technologies, however, don't allow navigation. In Slovak republic the carrying agents can use following information technologies: Commander, DeMoTech, GENETECH, INFOCAR, TAMEX, EMTEST. In road freight transport is system Commander the most widely used. For carriers it offers following functions and services: on-line monitoring of the vehicles, visualization of the vehicles on the map in the real time, automatic generation of the log book for tax purposes, unlimited storage of the drives history, automatic calculation of the fuel consumption according to data about refueling, automatic creation of transport orders with their accounting, monitoring of the operational status of the vehicles, the possibility to trace a vehicle after theft, car service management, the ability to track problems on the journey (f. ex. congestions, accidents, …) and to inform drivers about the impassable sections, communication with drivers, the possibility of setting alarm when entering in restricted areas – waypoint function, simple and accurate report about the service of the vehicle, the possibility to search for stolen vehicles.

In order to use individual levels of services and functions, carrying agent needs to have a GPS unit installed in his vehicle, which is connected to the bus. The price of this hardware equipment is 547.60 € for each vehicle. Its maturity is about 6 years. Besides one-time payment for the purchase, carrying agent also pays a monthly fee of 20 € per each vehicle.

2.3. Navigation systems

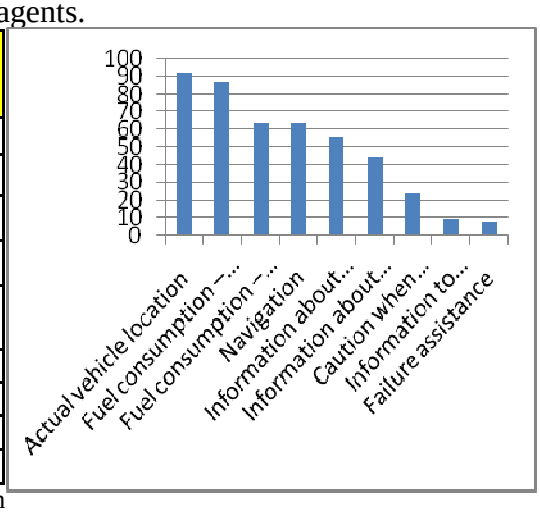
Information technologies for the navigation should be distinguished from the information technologies designed for monitoring vehicles and transport. Navigation systems are used to search for the shortest, fastest or the most economic journey of transport from the place of loading to the final destination. Its advantage is mainly a navigation of the driver in cities, because the driver can be fully focused on driving and the voice navigation guides him directly to the place of unloading in a concrete area. Navigation manufacturers developed special devices designed for trucks and their

price is around 400 €. Navigation systems also allow receiving actual information about the traffic conditions and in case of impassable sections they can suggest another journey in order to avoid long delays.

3. Transport companies´ requirements for various functions and information

Carrying agents have different requirements for information systems, their functions and services. If the carrying agent procures some information system, it should meet the most of his requirements for its functions and the costs shouldn't be higher than the savings achieved. For carriers is the most important to know about the location of their vehicles during its transport performance. They put on this feature even greater emphasis as on the fuel consumption, because in present time is the biggest importance given on the customer, delivery deadlines and reducing of empty runs. Important is also the fuel consumption, because this cost factor builds up to 40% of all costs. The problem is that the information systems that can be used by carrying agents in the Slovakia don't allow monitoring the fuel consumption on-line. Information system Frotcom enables to monitor the consumption on-line, but it can't be used in the Slovak republic. Other functions and services that are important for carrying agents: warning of the dispatcher when the vehicle is approaching its final destination, information about the drivers working hours, remote data downloading, navigation, which is important mainly to the driver, caution for the dispatcher if the vehicle is deflecting from the journey or approaching the final destination to a mobile phone (smart phone), information about the traffic density and congestions, failure assistance. Individual requirement according to their importance are shown in the following table "Tab. 1" and figure "Fig. 1". They are based on the requirement of 63 carrying agents.

Requirements of carrying agents	Amount	Percentage
Actual vehicle location	58	92,06
Fuel consumption – Online	55	87,3
Fuel consumption – Offline	40	63,49
Navigation	40	63,49
Information about the traffic density and congestions	35	55,56
Information about the drivers working hours	28	44,44
Caution when approaching final destination	15	23,81
Information to a mobile phone	6	9,52
Failure assistance	5	7,94



Tab. 1. and Fig. 1. Requirements of the carrying agents for information

4. Conclusion

Most of the carrying agents already use navigation and they have it procured before the individual vehicle manufacturers came out with the transport management function. Based on the analysis it can be concluded that in the Slovak republic there is no information system, which allows on-line monitoring of the fuel consumption. Carrying agents receive after the transport in certain periods if the journey was in the standard consumption level or above. Receiving information about vehicles by mobile phone (smart phone) allows just information system Fleet Board designed for Mercedes Benz trucks. Individual functions and services of information systems required by carriers are shown in the following table "Tab. 2". Based on the comparison of functions and costs "Fig. 2", information system Commander can be recommended to carrying agents to obtain in addition to their navigation, because it provides the best balance of functions for

carrier with lower costs as a complete package of managerial functions from different vehicle manufacturers.

Requirements of carrying agent	Blue& MeFleet	C 200	Fleet Board	Dyna fleet	Commander	Navigations	Frotcom
Actual vehicle location	X	X	X	X	**X**		X
Fuel consumption – online							X
Fuel consumption – offline	X	X	X	X	**X**		X
Navigation	X	X	X	X		**X**	
Information about the traffic density and congestions					**X**	**X**	X
Information about the drivers working hours	X	X	X	X	**X**		X
Caution when approaching final destination (area)	X	X	X	X	**X**		X
Information to a mobile phone			X				
Failure assistance	X	X	X	X			

Tab. 2. Comparison of the requirement of carrying agents with the information systems functions

To determine costs our calculations are derived from the average costs, which arise to the carriers during operating in road haulage. Costs €/km (basic rate – 0.8656 €/km without usage of any information system) were determined by calculation of variable and fixed costs. Individual rates may vary according to the amount of individual cost items and operational parameters of carriers. In the figure "Fig. 2" we can see the comparison of costs €/km, when the carrying agent use only a navigation, navigation and an information system commander, navigation and managerial vehicle and driver functions or complete service of transport management, which also includes navigation. Costs that are connected with the usage of navigation and commander system are comparable with costs of navigation and vehicle and driver managerial functions. In the case of the use of managerial vehicle and driver functions with navigation, the carrying agent receives failure assistance service, but he doesn't get the actual vehicle location function that is much more important.

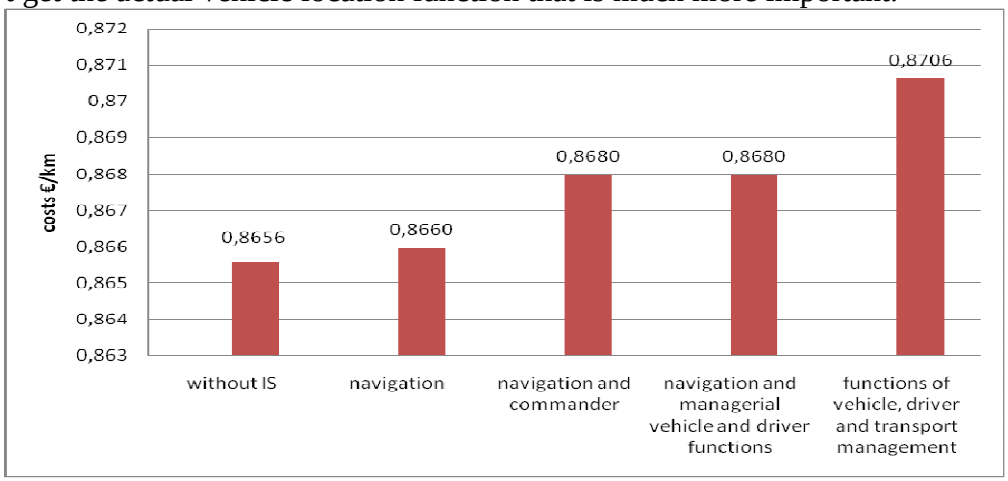


Fig. 2. Costs €/km when using individual information systems

References

Príspevok bol vypracovaný s podporou projektu:
MŠ SR VEGA č. 1/0144/11 POLIAK, M.: Vplyv zmeny kvality poskytovaných služieb verejnej hromadnej osobnej dopravy na zvyšovanie jej konkurencieschopnosti vo vzťahu k individuálnemu motorizmu

[1] GNAP, J.: Kalkulácia vlastných nákladov a tvorba ceny v cestnej doprave 3. vydanie; Žilinská univerzita v Žiline/EDIS - vydavateľstvo ŽU; Žilina; 2006

[2] GNAP, J. - KONEČNÝ, V. - POLIAK, M.: Aplikácia informačných systémov v cestnej doprave; Žilinská univerzita v Žiline/EDIS - vydavateľstvo ŽU; 2007

[3] POLIAK, M. - KONEČNÝ, V.: Ekonomika cestnej a mestskej dopravy, Návody na cvičenia, EDIS, Žilina 2008

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Proceeding in the railway infrastructure capacity research

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Abstract. The flexible response to the constantly evolving and changing customer requirements is one of the most important keys for competitive railway transport. To ensure the sustainability and development of market relations in the national and, of course, global scale is one of that aspects as well. In the market of services is right important aspect of supply responding to demand the infrastructure capacity. This contribution provides a new look at the issue of capacity, its identification and provision for railway transport undertakings. The article deals with a short presentment of selected methodologies for railway infrastructure capacity calculation and the modern common trends in this field as well as a preview of some ideas in a research of this scientific area.

Keywords: railway, infrastructure, capacity, research, proceeding

1. Introduction

The problematic of the time table construction and the railway infrastructure capacity estimation is very specific. The definition of a railway network capacity is one of the key issues of capacity management. The capacity expresses the infrastructure manager's business offered by the allocating of the train paths to the railway undertakings. The most frequently definition says that practical capacity is so quantum of allocated train paths on the track section until it is possible to manage the traffic on satisfactory qualitative level. [3]

2. Guiding principles in determining the capacity in Slovakia compared to Croatia

The methodology of the capacity estimation is introduced in the internal Regulation of Železnice Slovenskej republiky (D 24). [2].

2.1. The theoretical and practical capacity

The capacity can be in principle divided into:

- theoretical (maximum),
- practical.

When calculating the maximum capacity any loss of time is not considering and it is assumed that the device capacity we determine is used exclusively for activities, for which it is intended and necessary technological blocking times follow up tightly and immediately without any loss of time.

When calculating the practical capacity we consider not only the need for maintenance of equipment or the fact that the equipment is also used for other purposes than for which it is primarily designed and used, but also the buffer time.

2.2. The capacity of equipment

The capacity we determine at these railway equipment:

- track line,
- station gridiron (development of switches),
- station tracks.

For determining capacity of track lines can be used graphically methodology, analytically methodology as well as combination of both.

Maximum capacity can be expressed by a formula [2]:

$$N_{\max} = \frac{T}{t_{obs}} \quad \text{[technological operations / calculation period]} \quad (1)$$

where:

T calculated time (peak time or all the day) [min],

t_{obs} an average time for realization of the following technological operation (train drive, shunting operation etc.) [min].

If is there calculating a practical (effective) capacity, we could take in consideration the time for maintenance as well as the reserve time for elimination of delays, in which are primary traffic operations not possible. Practical capacity can be expressed by a formula [3]:

$$n = \frac{T - (T_{výl} + T_{stál})}{t_{obs} + t_{dod} + t_{ruš}} \quad \text{[technological operations / calculation period]} \quad (2)$$

where:

$T_{výl}$ total time, in which is the facility out of order because of maintenance, inspection or revision (time window) [min],

$T_{stál}$ total time, in which is the facility occupied by another operations, that are not primary intended for this facility [min],

t_{obs} technological time of facility occupation by one technological operation [min],

$t_{ruš}$ average time of probable mutual distortion of two operations (trains) in the places of potential threats (simultaneous drives impossible) accrued at one technical operation (train) [min],

The capacity is defined as a value of calculated trains of basic parallel graph (mostly represented by middle-distance freight trains or by the most frequent train category) or in an average trains (average value of time occupation per all of the trains according to the sequenced train layout). On the double track line is the capacity calculated separately for each track (direction).

To compare the analytical methodologies, the Faculty of Transport and Traffic Science of the University of Zagreb presented a quite similar methodology in its basic substance [4], that we can mention from this point of view. The main idea of capacity is the same, but for the calculation of particular capacity the coefficient of elimination is used. There are two different methods for capacity calculation used. The first method deals with the maximum capacity in the number of trains or train pairs (the difference), that are the most frequent on the line and these are used as a base. By using equivalents they transfer other train categories to this basic trains and the capacity is calculated such for parallel train diagram as for non-parallel train diagram. Other methods determine the capacity without isolating the category of trains and take into consideration the probability of the influence of mutual relations of certain types of trains [4].

For example, the capacity of the line section (both directional one track line) is presented in the following formula:

$$N = \frac{1440 - T_{pr}}{T_{pg}} \alpha_{ps} \quad \text{[train pairs / day]} \quad (3)$$

where:

T_{pr} time of technological downtime [min],

T_{pg} graph period (means for both directional train pair) [min],

α_{ps} coefficient of operation reliability [-].

That means, that capacity is detected for train pairs (supposition for only mutual trains) and the other circumstances that decrease the value of capacity are expressed by the coefficient in comparing with Slovak methodology that uses marginal amount of exact values in formula. But the whole issue is quite difficult and highly professional and slickly elaborated in detail [4].

3. Determination of the basic principles of capacity calculation in research

The world is currently using many methodologies for detection of railway infrastructure capacity. In the Europe, the International Union of Railways (UIC) draw up regulations for capacity, which aims to unify previously used national methodologies of each European railway networks, so that the results of the assessment of the individual parts of the corridors are mutually comparable. Leaflet UIC 406 is not mandatory but it has a recommendatory character that also allows infrastructure managers to use also the national methodology.

Tackling the issue of capacity of oven systems (infrastructure equipment, etc.) is a complex process in which basic rules of traffic operations must be followed while safeguarding the diversity that exists in this field in different countries. The basic premise is that practical capacity and required reliability of transport operations are consistent and as much as possible optimized.

The purpose of the new methodology proposal for capacity detection, respectively providing appropriate information, is the determination and the establishment of a procedure that can flexibly respond to immediate changes in traffic management and will be so full auxiliary tool for traffic planning that can be useful in relation to the railway infrastructure managers and railway undertakings. The basic scheme of the proposed methodology in which the undertaking enters into the process of selecting a suitable free train path is based on the following steps (Figure 1).

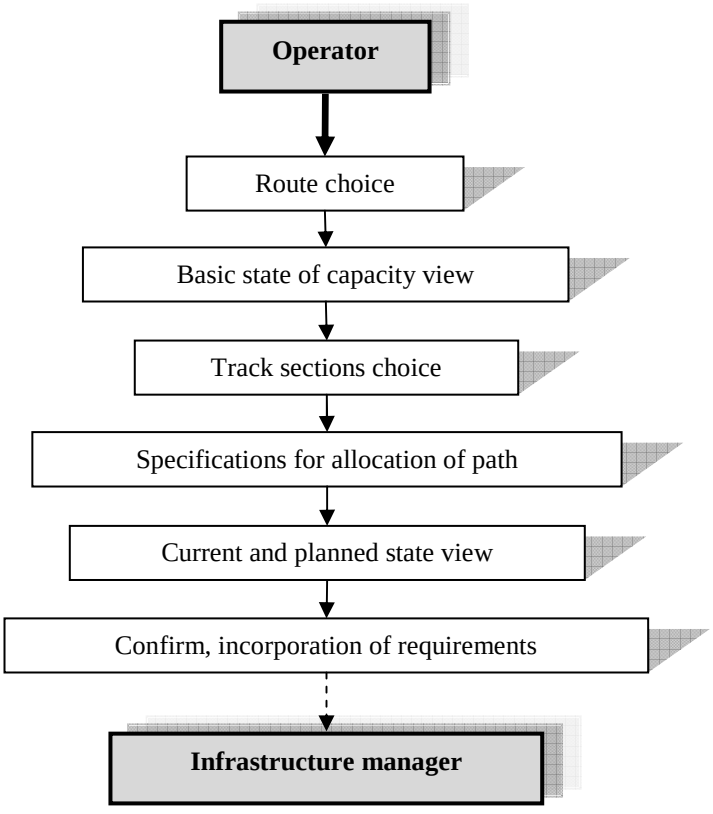

Figure 1. Flow diagram of selection of a suitable route for planning of shipment Source: [authors]

4. Conclusion

The problematic of the capacity estimation is high-actual all above in the connection with the liberalization of the infrastructure access. The capacity expresses the infrastructure manager's business offer by the allocating of the train paths to the railway undertakings. The pivotal moment by the capacity estimation is to define the required quality of the train traffic in the constructed time table.

However, to be fully maintained the principle of non-discriminatory access to the infrastructure for customers, the capacity (and its information) has to be properly identified and published by infrastructure manager, which is in its administration and for which is fully responsible. It is necessary to find a simple and transparent way to organize the resulting values into a usable format for marketing activities of infrastructure managers. This methodology may be used for a detailed determination of railway infrastructure capacity; accurate allocation bottlenecks that reduce the capacity of rail infrastructure; continuous calculation of available capacity in the allocation of "ad hoc" paths; operational management and decision making at operational incidents; educational and research purposes.

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References

[1] ARNE HANSEN, I., PACHL, J.: *Railway timetable and traffic.* University of Technology Delft, Technische Universität Braunschweig 2008, 1. vyd., 228 s., ISBN 978-3-7771-0371-6

[2] D 24 - *Predpisy pre zisťovanie priepustnosti železničných tratí. [Internal regulation for estimation of railway routes capacity]*, Praha: Nadas, 123 p

[3] GAŠPARÍK, J.; ZITRICKÝ, V.: *Manažment kapacity železničnej infraštruktúry*. EDIS, Žilinská univerzita v Žiline 2010, 1.vyd., 130 s., ISBN 978-80-5540-241-3

[4] ČIČAK, M., MLINARIČ, T. J., ABRAMOVIČ, B.: *Methods for determining throughput capacity of railway lines using coefficient of elimination.* In: PROMET – Traffic - Traffico, Vol. 16, No.2, 2004, pages 63-69, ISSN 0353-5320

[5] Leaflet UIC 406 - *Capacity*. International Union of Railways (UIC). Paris 2004, ISBN 2-7461-0802-X

[6] MOLKOVÁ, T. a kol.: *Kapacita železničních tratí*. University of Pardubice 2010, 1. ed., 150 s., ISBN 978-80-7395-317-1

[7] ŠOTEK, K., BACHRATÝ, H.: *Využitie simulačného modelu pre určovanie kvality dopravnej siete stability dopravného plánu.* In: Žel 2004 zborník prednášok z medzinárodnej vedeckej konferencie, EDIS, Žilinská univerzita v Žiline, Žilina 2004, ISBN 80-8070-249-7

[8] GAŠPARÍK, J., HALÁS, M., SCHÖBEL, A.: *The first experience with the tool OpenTRACK at the University of Žilina*. In: Euro-Žel 2012, Proccedings of The 20th International symposium, Tribun EU 2012, University of Žilina 2012, ISBN 978-80-263-0242-1

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The Forecasting of Passengers Public Transport Demand

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Abstract. Transport is fundamental in the development of national economy. The public transport of people forms an important part of the transportation system as whole, and is basically responsible for significant services for the society. The article deals with the issue of mathematical – statistical modelling of passengers demand for suburban bus transport. We presents some part of mathematical – statistical modelling of passengers demand using single-dimensional time sequences with the aim of the most accurate prediction possible for the future for the public transport. For practical reasons a specific for public transport operator has been selected to contribute necessary data in order to elaborate the study on the transport company.

Keywords: Modelling, Public transport, Transportation system.

1. Introduction

The public transport has a significant role in performing important functions for inhabited places and areas. It is important for the provision of large transport demands and at the same time it has no big demands for transport areas, it can provide better safety of travelling and has smaller negative impact on the environment as calculated per one transported person.

The role of the public transport itself is given by its properties in relation to the satisfaction of transport needs of the population living in the respective area, to environmental impacts and investment demands for the traffic infrastructure. In efforts to improve traffic safety, one of the most import ant elements is cooperation, Exchange of information and transfer of knowledge [1]. Especially today, in the time of significant growth of individual motorization, we should consider possibilities for improvement of the public transport quality. Slovakia has a ratio of the number of vehicles registered per 1 inhabitant equals to, 0.323, which means that for 1citizen of Slovakia there are about 0,3 cars [2]. Thus, public transport is a significant part in the movement of passengers who do not have own vehicles. The improvement of the public transport quality can be realized through, the technical equipment, technology and management organization, on the grounds of which we can expect beneficial division of transportation labour in favour of the public transport and increase of passenger demand for it.

The analysis of data associated with the intensity of vehicle use is applied in the evaluation of a given transport system [4]. The following contribution deals with the issue of mathematical – statistical modelling of passenger demand using single-dimensional time sequences with the aim of the most accurate prediction possible for the future. This prediction is important for transporters from the already mentioned point of view of quality.

To achieve this objective, which rests in the creation of a short-term prognosis of demand for the following period of one year with the subsequent examination of the impact of the non-systemic part in the proposed model, we have chosen a particular public transport operator. This operator works in the area of public transport, namely in the following cities:

- Liptovský Mikuláš,
- Ružomberok,
- Dolný Kubín.

Urban transport operator in the districts:

- Ružomberok,
- Dolný Kubín,
- Námestovo,
- Tvrdošín and public transport in cities Ružomberok and Dolny Kubin [7].

The transport company has 228 buses to transport people on a variety of routes, including international ones. Land transport infrastructure consist of engineering structures, enabling the movement of means of transport in an organized, possibly safe and comfortable way [2]. Figure 3 shows the Road Network in Slovakia.

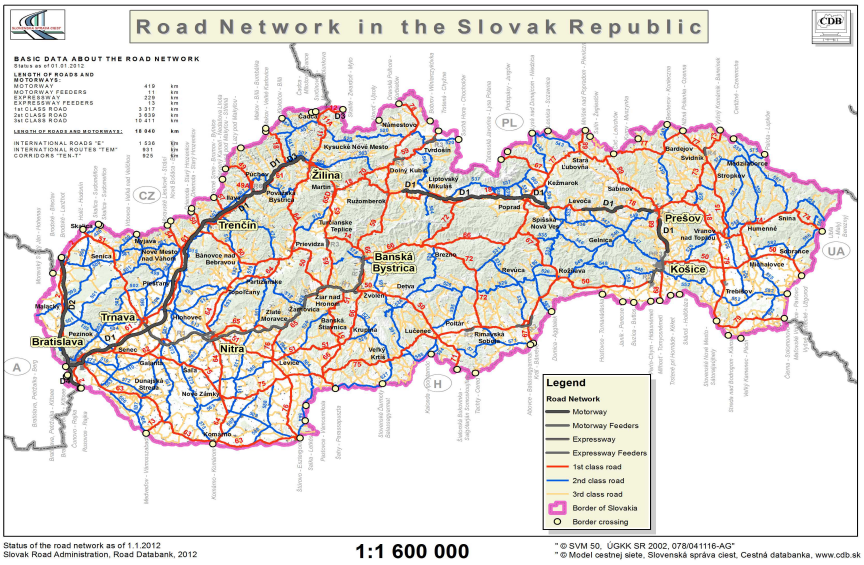

Fig. 1. The Road Network in Slovak Republic [8].

The total length of roads in Slovakia is 18015 km. They include:

- Highways with a length of 419 km,
- Expressways with a length of 229 km,
- Road's classes from I to III with a total length of 17367 km.

These last roads have the largest share in transporting people. Public transport users are mostly young learners, students and people who commute to work.

The paper focuses on the average journeys range lengths up to 250 km. This article is an introduction to issues related to forecasting demand for public transport passengers. The forecasting models are presented in details in the work [5], where authors based on the data of one of the transport companies.

2. Problem Definition

A method based on quantitative or mathematical - statistical point of view was chosen for the elaboration of the prognosis model. Usage of multi-criterion linear regressive model with artificial, (0-1) seasonability explaining variables, proved to be the most advantageous for the elaboration of the prognosis with regard to statistical significance of the whole model (determination coefficient), as well as individual parameters of the same.

Software program SAS 9.1.3 was used for mathematical expression of the model. Linear regression models for determination of point prognosis and interval estimate were created separately for time sequences of transported passenger travelling with student fares – (SF) and separately on full fares. Further models for both fare types were created so as including in addition to trend and seasonal component also random (residual) components. Based on such additional

modelling of the residual component and using decomposition approach, the total impact of such component in the model, as well as impact on original prognoses without it, could be assessed.

In order to choose a suitable type of regression task as specified in [3], it is necessary to know the given type of time sequence. Time sequences used in this contribution are additive time sequences with linear trend component with monthly seasonability. The chosen multi-criterion regression task using decomposition approach is based on the basic structure of short-term single-dimensional time sequences of additive type, where we subsequently transformed the model shape for our needs to:

$$\hat{y} = \hat{b}_0 + \hat{b}_1 . t_k + \hat{b}_2 x_{2t} + ... + \hat{b}_k x_{kt} + \varepsilon_t \qquad (1)$$

Where:

$\hat{y}$ – modelled value of examined indicator [persons / month],

$\hat{b}_0$ – estimate of initial variable (specifies value of $\hat{y}$ in time $t = 0$),

$\hat{b}_k$ – parameter expressing the constant change of dependent variable $\hat{y}$ induced by the increase of value of respective time variables $k = 1, 2, 3, ...12$,

ε_t – random (residual) component,

t_k – order number of time period,

x_{kt} – artificial variables taking into account seasonality of time sequences.

The Fig. 1 shows scheme of the possible division of regression model.

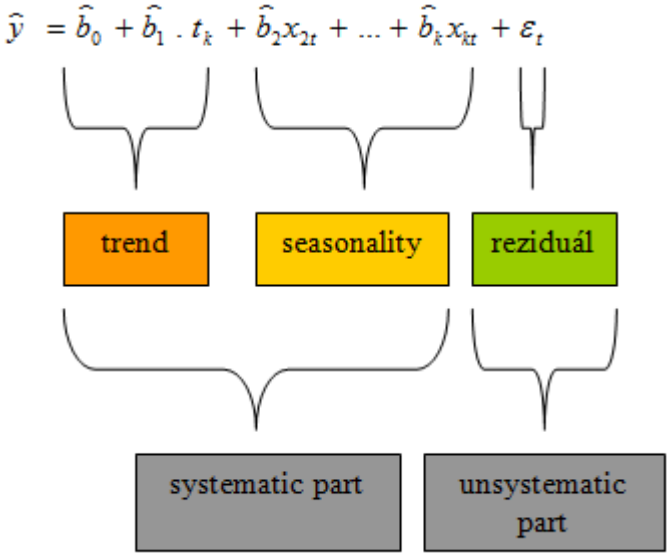

Fig. 2. The division of regression model [5].

The regression model can be mathematically divided in to a systemic and non-systemic part. To determine the number of coefficient of autocorrelation of residues, we applied the autoregression equation of residues for sequence p on the basis of the studies [3] and [6].

3. Conclusion and Recommendations for Practice

In developing the forecasts based on the theory of time sequence, it is very important to have a sufficiently long time sequence of values (at least 5 years of previous development in the case of the indicator). Nethertheless, we cannot forget that the information ability of prognosis decreases along with the increasing number of forecast periods.

If you use the software to create short-term forecasts or forecasts model, it is beneficial to check the accuracy of the model created by well-known forecasting available values (ex – post forecasts). And then make a prediction of the unknown future value.

In practice it is good if the transport company, which needs very accurate prognosis of demand of passengers for a longer period of time, uses for the creation of prognosis professional statistical software and experienced analysts, because analysts can complete the prognosis created on the grounds of mathematical – statistical methods also with their own qualified estimate [5].

The authors have pointed out that it is possible to forecast the passengers demand for public transport. This allows you to adjust the means of transport by the transport operator to the expectations of the population, improving the economics of use of vehicle and improves road safety.

References

[1] CABAN, J., OPIELAK, M., RYBICKA, I. *Przyczyny zdarzeń drogowych i stan bezpieczeństwa w miejskim ruchu drogowym na przykładzie MPK w Lublinie.* ZESZYTY NAUKOWE INSTYTUTU POJAZDÓW, nr 3 (89) 2012, Politechnika Warszawska, Wydział Samochodów i Maszyn Roboczych, Warszawa 2012, pp. 21-27.

[2] CABAN, J., VRÁBEL, J., DROŹDZIEL, P. *Stan bezpieczeństwa transportu drogowego w Polsce i na Słowacji w porównaniu z innymi krajami UE*. AUTOBUSY, Technika, Eksploatacja, Systemy transportowe, Nr 3/2013.

[3] CYPRICH, O., LIŠČÁK, Š. *Modelovanie reziduálnej zložky časového radu a jej vplyv na kvalitu viackriteriálneho regresného ukazovateľa počtu prepravených cestujúcich*. Doprava a spoje, 2010, roč. 6, č. 1, pp. 16-24.

[4] DROŹDZIEL, P., KOMSTA, H., KRZYWONOS, L. *Analiza intensywności użytkowania pojazdów (Część I)*. LOGISTYKA, 3/2012, Instytut Logistyki i Magazynowania, Poznań, 2012, pp. 487-492.

[5] LIŠČÁK, Š., HOLEŠA, L., CABAN, J. *Analysis of impact of residual component when forecasting the demand of passengers by means of unidimensional time sequences of additive type*. AUTOBUSY, Technika, Eksploatacja, Systemy transportowe, Nr 3/2013.

[6] TREVIN, D.A. *Guide to Interpreting Time Series – Monitoring Trends*. Canberra ABS, 2003.

[7] http://evidencia-dopravcov.eu/zobraz_dopravcu.php?id=73

[8] http://www.cdb.sk/files/img/zakladne-mapy-cs/2012/cestna-siet-sr_a3_zemepisna-siet.jpg

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Methodology of Treatment of Typified Threats in Railway Transport

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Abstract. The paper describes present results of the KISDIS project that are unique in the field of the crisis management of transport in the middle European area. In the first stage of the solution of this project a methodology was created that has ambition to become a certified methodology for the railway transport for municipalities with extended competence.

Keywords: Methodology, typified threats, crisis information system, rail transport, Czech Republic.

1. Introduction

In 2012 the solution of the project "Automated Complex Information System for Remote Management of Crisis Situations in Rail Transport with Emphasis on the Crisis Infrastructure" with the acronym KISDIS was started. In the first year a large analysis of available information from foreign sources was made. Its goal was to find similar projects or methods in relevant European countries. The result was the final statement that these problems are not being solved in any of the researched countries.

The overall goal of the KISDIS project is the creation of an expert information system that would efficiently interconnect the crisis management of the Railway Infrastructure Administration and that of municipalities with extended competence. The existing systems are entirely autonomous and do not allow efficient and fast sharing of information about an incurred extraordinary situation.

The goal of solution in 2012 was the creation of a methodology that will apply defined typified threats to the rail transport of the Czech Republic. With regard to the overall goal of the project, it was necessary to define a real functioning data set that will be the base for a future expert information system.

2. Analysis results for the methodology of typified threats in rail transport

The basic approach to the work with the methodology for the choice of typified threats lies in the fact that the railway is considered as an integrated system. For the purpose of the research we divide the system to particular railway lines and stations. The lines must be preferably marked by the number of the line or partial section. By the obtaining of the appropriate parameters the lines (their sections) can be considered typified and one can elaborate a unified documentation that differs in a particular situation only by the number and coordinates. Similarly, if there are 5 typified stations on a typified line, it is enough to elaborate the documentation for one railway station and to differentiate them by different names.

The work according to the methodology represents the first step in the process of the planning of the measures for the management of crisis situations and it demands a good knowledge of the assessed line, terms of traffic, signalling and build directives of the Railway Infrastructure Administration. Methodological processes enable not only to choose the typified threats from the menu available by the dispatcher crisis information system KISDIS. The methodology is lined

logically consistent with the definition of a threat as a description of one risk source. Before the final determination of the name of the particular typified threat it unifies the sooner made analyses into a unified table in the succession that is used in the KISDIS software.

2.1. Formulation of basic multipurpose criteria

The assessment of the impacts on the rail subsector of the critical infrastructure will be made by the comparison of the chosen place and expected consequences. Thus we assess a particular place of the critical infrastructure and the possibilities of the effect of a particular event on the function of an element of the critical infrastructure.

In case that the place is the same or the effects influence the function of the critical infrastructure element, its mark will change (e.g. by another colour) and this typified place is considered as preferred in the area of treatment. The multipurposeness of the criteria is researched in this order of importance:

1. The place where a threat can occur.
2. Risk source (what is the possible risk carrier).
3. Activation (mechanism that activates the risk source).
4. Cause (why the risk source activation can occur).
5. Event (what can occur after the risk source activation).
6. Expected effects (what can be caused by the risk source activation).

Risk source are always connected with a particular place and risk cause. A very often activation mechanism is the crossing of railway with other line infrastructure objects. Relative often causes are unintentional errors of transport participants, extreme weather influences or technical faults. In the Fig. 1 a potential risk source is shown – a road bridge.

Fig. 1. A crossing of a rail track and a road – an important source of risks (photo R. Soušek).

2.2. A general form of the name of typified threats

In general, with effect for the state administration and business sphere, process (set up) the threat into the name of typified threat in the form of the sole sentence consisting of four parts – EVENT – RISK SOURCE ACTIVATION – PLACE – CAUSE in the following shape:

1. „The name of the EVENT “ due to (in case of the unique event name the point one may be omitted),
2. „the name RISK SOURCE ACTIVATION“,
3. in „the name of the PLACE“,
4. caused by „the name of the CAUSE“.

The extent of the proper analytic-synthetic research activity is apparent from the gradual change of the generated threat names, see Tab. 1. They are an important part of the proposed methodology.

	No. of elements		No. of name variants		Name of typified names	
	original	new	original	new	original	new
Event	4	1	12.032	2.800	2.620	615
Risk source activation	47	50				
Place	4	4				
Cause	16	14				

Tab. 1. Gradual changes in the number of identified threat terms.

For the naming of all EVENTS in railway use the unified (typified) name "change of operation conditions". For a more detailed determination of the typified event it can be divided with respect to its characteristics as a process that affected the substance of railway operation as follows:

- operation closure – a threat can exert so that the railway transport can not be operated,
- timetable change - a threat can exert so that albeit the railway transport can be operated, however in a limited extent,
- technology change - a threat can exert so that it impacts the work system,
- change of service extent - a threat can exert so that the infrastructure is not disturbed, but due to identified causes it comes to a change of the extent of supplied services.

The second important step is the determination of the name of the RISK SOURCE ACTIOVATION that starts from the identification of risk sources. In rail transport they are rail infrastructure objects, rail constructions, rail vehicles, operating staff, customers and devices in the railway neighbourhood. During a several months running expert activity, overall 35 activation mechanisms were defined (e.g. fire, flood, explosion, collision etc.).

The third step is the exploring of the proper PLACE of the TYPIFIED THREAT. It proceeds by the linking of activation mechanisms with risk sources. During an extensive professional discussion overall 50 possible combinations were defined that are relevant and relatively probable in the rail traffic.

The CAUSES were divided into two basic groups (natural and human). Another procedure consisted in their matching to the risk source activation. It had been related to a place (line, station, construction or train) in the preceding step. The facticity of such originated combinations must always be assessed. Unrealistic combinations had been omitted and not used any more. For the name of a typified threat many causes were considered. By their assessment and the consecutive ordering 14 groups of causes were created according to their common characteristics that are shown in the Tab. 2. They are used in the name of a typified threat under the name specified in the column "Cause name".

No.	Cause name	Content
1	Atmospheric and cosmic interferences	storm, other electric phenomena in the atmosphere, cosmic radiation, magnetic anomalies, meteorite fall
2	Biological extraordinary event	overpopulation of infectious insect, overpopulation of weeds, virus overpopulation, bacteria overpopulation, overpopulation of animal pest, overpopulation of free living infected game
3	Mass population frustration	ethnic conflicts, racial conflicts, religious conflicts, breach of social reconciliation (4)
4	Mass unrests	mass revolts and escapes of prisoners, rioting, disallowed demonstrations (3)
5	Human factor error	fatigue, lapse, inattention, communication error,

No.	Cause name	Content
		organizational shortcomings, inappropriate repair or maintenance, deviation from determined operational conditions, operator error, incompliance with work operation, incompliance with principles of work safety and health protection, shut off safety system, mistake of dangerous materials (12)

Tab. 2. A fragment of the table of particular causes related to the cause name.

2.3. Determination of names of typified threats in the railway

In the research framework it was decided to insert the name of typified threat into a predefined template, see Tab. 3. The determination of the names of typified threats was a synthesis of general criteria that involves all possible combinations created from EVENT, RISK SOURCE ACTIVATION, PLACE and CAUSE. The names were set to sentences in this form and sequence:

- The name of an EVENT followed by the word "due to",
- the name of the RISK SOURCE ACTIVATION,
- „in" and the name of the PLACE,
- „caused by" the name of the CAUSE.

EVENT	RISK SOURCE ACTIVATION	PLACE	CAUSE
Change of operation conditions due to	rail vehicle bombing	on the track	caused by atmospheric and cosmic interferences
Change of operation conditions due to	immobility of tractive vehicle	in the train	caused by human factor error

Tab. 3. A Fragment of the syntax of threat name generation according to a created template

By the defining of the names of typified threats, their testing and verification in the cooperation with rail transport experts and crisis management experts on the regional level a summary table of 615 typified names of relevant and relatively probable typified names. They will become the database for the prepared expert information system.

3. Conclusion

In this paper the results of the first year of solution of the KISDIS project were published for the first time. The versatility of the use of the proposed expert information system enables the expectation of its future formation and use also in other EU countries. The authors of the project believe that other activities of the project will lead to the certification of the created methodology at the national level. The basic goal of the project is the improvement of the information support of the crisis management in two different areas – in the rail transport and in the crisis management of municipalities.

Acknowledgement

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References

[1] DVOŘÁK, Z., LEITNER, B., SVENTEKOVÁ, E., SOUŠEK, R.: *Managing of risks in railway transport*, Institut J.Pernera, University of Pardubice, 2011

[2] DVOŘÁK, Z., SOUŠEK, R. ENGLICH, J., *Preparation for solution of crisis situatons in railway transport in Czech Republic*. Logistyka i transport 2007., Issue 1, pp. 23-26.

[3] DVOŘÁK, Z., SVENTEKOVÁ, E., *Evaluation of the resistance critical infrastructure in Slovak Republic.* Zrenjanin, Technical Faculty Mihajlo Pupin. 2012.

[4] DVOŘÁK, Z., LEITNER, B., MILATA, I., NOVÁK, L., SOUŠEK, R.: *Theoretical background and software support for creation of railway transport model in crisis situations* in WMSCI 2010: the 14th world multi-conference on systemics, cybernetics and informatics.

[5] *Krizový plán Ministerstva dopravy*, Č.: 32/2005-CNP ze dne 15.března 2005. Praha, Ministerstvo dopravy, odbor 030.

[6] *Nařízení vlády č. 432/2010 Sb., o kriteriích pro určení prvku kritické infrastruktury*. In: *Krizové zákony, Hasičský záchranný sbor, Požární ochrana, podle stavu k 19. 3. 2012*. Ostrava: Nakladatelství Sagit, a.s., 2012, s. 43-49. Edice ÚZ – úplná znění předpisů, číslo 898. ISBN 978-80-7208-919-2.

[7] OBJECT MANAGEMENT GROUP. *Documents associated with UML Version 2.1.1*. [online]. Release date: August 2007. [cit. 2012-07-23]. Dostupné na Internetu: http://www.omg.org/spec/UML/2.1.1/>.

[8] SOUŠEK, R., DVOŘÁK, Z., *Risk identification in critical transport infrastructure in case of central Europe with focus on transport of dangerous shipments*. Orlando, Florida, WMSCI 2009.

[9] SOUŠEK, R. et al., *Methodology of critical transport infrastructure object identification*. Pardubice, Czech Republic, University of Pardubice. 2010.

[10] SVENTEKOVÁ, E., DVOŘÁK, Z., 2012. *Performance testing of cricical transport infrastructure elements*. Zrenjanin, Serbia, Mihailo Pupin Technical Faculty.

[11] *Typový plán Narušení funkčnosti dopravní soustavy velkého rozsahu*, Ministerstvo dopravy ČR, Praha 1.11. 2010, č. j.: 116/2010-030-CRS.

[12] VIDRÍKOVÁ, D., DVOŘÁK, Z., KAPLAN, V.: *The current state of protection of critical infrastructure elements of riad transport in conditions of the Slovak Republic.* Kaunas, Lithunia, Kaunas University of Technology. 2011.

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New approach of railway infrastructure development based on the regular interval timetable system

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Abstract: A new approach seems to be outlined in the field of the railway infrastructure development. The new system is principally based on the elimination of bottlenecks, paying particular attention to the speed restrictions and sections with limited capacity. A modern, regular interval timetable structure relies on three basic factors: the periodicity, the symmetry and the everywhere-to-everywhere connection system. In the first part, the paper presents the principles of the system; afterwards it defines the role of these factors in the identification process of bottlenecks; at the end of the paper will be defined the expected results of the new method.
Public transport in the Central Eastern region of Europe currently faces a situation very similar to Western European experiences from the 1970ies onwards. Yet this current "curse" can be viewed as a "blessing" as we are now in a position to select, as a point of depart towards progress, the most suitable, tried and tested method from amongst a number of approaches.

Keywords: railway infrastructure development, economic public service, regular interval timetable.

1. Introduction

Some decades ago most railway companies in Western Europe – due to the dramatic shift towards car use – had to face with formidable decrease in the passenger transport. The development of transport infrastructures concentrated on motorways while the rail network has remained more or less unchanged. As the number of cars increased and the motorways spread, public transport regressed or – in some places – even ceased. Due to the lack of competitive innovations and investments, most state railway companies were inert, not being able to cope up with individual transport.

Some railway companies developed several solutions for this problem. However, these solutions required such expensive infrastructure and rolling stock investments, that not every country could afford them, even in Western Europe. Some others came up with the idea of a revolutionary new public transport system, which is based on a symmetric, regular interval timetable structure. The greatest advantage of the new system was that it was able to provide new, attractive passenger services, without requiring expensive investments.

In the first part of the article I introduce the main attributions and the Hungarian experiences concerning the regular interval timetable. In the following part of the article I describe the principles and the mathematical background of the timetable based infrastructure development, and I will present some examples as well as from Hungary and from other countries.

2. Possible approaches

The French Model

Main characteristics:

- Operating only "fully" trains
- Keeping passengers by expensive rolling stock and infrastructure developments
- Preferential approach – market segmentation
- Using high speed networks (TGV)
- Procreating hyper-modern suburban system (RER)

The Swiss Model

Main characteristics:

- Since 1982 a regular timetable designed to meet peak period demand is maintained all day and all week long.
- In 1982 to begin with, the Swiss had some of the oldest (but well maintained) rolling stock in Western Europe.
- Relatively low speed on main lines (80-140 km/h).
- Between 1982 and 1992 only isolated infrastructure developments took place with minimal costs, geared to service needs in harmony with the timetable.
- A national transport scheme with broad inter-modal cooperation based on the regular interval timetable which includes bus and city transports.

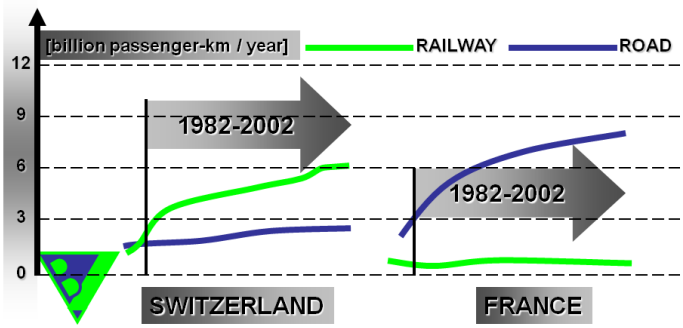

Fig.1. Transalpine traffic

3. The suggested approach

Being efficient is essential in all fields of life. The infrastructure investments are one of the most expensive issues of the national and EU budget. Naturally it is an essential requirement to spend the limited sources in the most effected way. From my point of view the best way to plan and prioritize the infrastructure investments is taking into consideration the bottlenecks in the line capacity and the timetable.

The suggested procedure is called timetable based infrastructure development thus the Swiss model. It means that we should focus on those parts of infrastructure where it is essential to reduce some minutes in the running time of the trains. Anyway we should continue the “big projects”, when a relative long line section going to be fully upgraded, but in this case we also have to take into consideration the needs of the timetable, and increase the allowed speed, or plan second or third track where it is required form the timetable point of view.

3.1. Short description of the regular interval timetable system

There are three basic requirements which have to meet the regular interval timetable:

- It has to be symmetric;
- It has to be periodic;
- It is based on connections;

The fourth main rule is that the running time between the junctions has to be less than 30 or multiple of 30 minutes. This rule is obtainable from the symmetrisation as the arrival to the junction has to be just before xx:00 or xx:30. When a train cannot fulfill this essential requirement than it will impossible to ensure the quick connections for the passengers.

From my point of view the regular interval timetable and the timetable based infrastructure development are the only one chance to reverse the unfavourable trend of the modal split. Unfortunately today the tariff of the passenger transport is constantly increasing and the quality of the service is stagnant or decreasing. For this reason more and more people use the car instead of the public transport. The main objective of this article is to describe one approach solving this problem, and ensure a quality service by using the available sources.

The introduction of the regular interval timetable does not need a significant extra cost as the percentage of the fix cost at the railway industry is almost 90%, so 10% increasing of the traffic volume costs only 1% more.

From operational point of view there are also many advantages. As the timetable is symmetric, we do not need to run empty "ghost" trains on the network. The "spiders"[1] can be only at xx:00 or xx:30, so the staff in the intermediate time are not very busy.

From user point of view it is also very comfortable that the trains depart in every hour in the same minute and the average changing time is less than 10 minutes, so the whole journey time can be reduced significantly.

4. The main objectives of the regular interval timetable

The most important aim is to ensure the shortest journey time for the passengers in the public transport. That means not only the railway traffic but all of the public transport modes. It is needed to construct several intermodal junctions throughout the country and it is also essential to harmonize the timetables of all transport modes. By these arrangements there will be surely a competitive public transport.

In a current Hungarian setting even the most carefully prepared and executed reduction of train services will typically result in a loss of passengers, though one might suspect an improved efficiency resulting in a cut in costs to a greater extent than causing increased costs elsewhere. A further loss in passengers is detrimental to EU transport policy and principles of sustainability. In the French Model, in order to gain passengers the attraction of those services which are maintained must be significantly increased by means of extremely costly development of infrastructure and rolling stock. The results:

- Rising passenger numbers in the preferred segments – partly to the detriment of traditional segments (cannibalization)
- Further decrease of the share of the entire rail transport within the sector
- Ever more costly railway systems next to an increasing measure of state budget commitments.

It is interesting to compare transalpine traffic in Switzerland and France (Fig.1) despites, the model called French here is no longer consistently applied on the French railway market, and

[1] The spider means the encounter of the trains at a station. This name comes from the graphic timetable as the train paths stand out a picture like a spider in the junctions. The detailed description is given chapter 4.1.

naturally we meet such demand driven service models elsewhere. SNCF have adopted a regular interval timetable structure on some of their partial networks.

The principles

Let we see what is this Regular Interval Timetable (ITF) anyway? Not more but not even less than a standard, for organizing effectiveness transportation system. In this section, we will go through the most important rules and definitions needed to build up a modern ITF-system. The regular interval timetable relies on three main factors: the periodicity, the symmetry and the optimized connection-system at the network nodes.

Periodicity

First of all, let's see the explanation of the periodic timetable from the aspect of technology. In case a *T* term can be found wherein each adjacent $s_i(t)$ and $s_j(t)$[2] path-pairs of the same path type mask each other by shifting the same □ü value, the paths are periodic.

$$\frac{d\mathbf{s}_i(t)}{dt} = \frac{d\mathbf{s}_j(t)}{dt}; t \in T; \exists \tau_{ü}, j, \forall i \Rightarrow \mathbf{s}_i(t) = \mathbf{s}_j(t \pm \tau_{ü}) \qquad (1)$$

where:

T – *the validity-term of period-structure*

$\tau_{ü}$ – *the value of periodicity*

In case there is a homogeneous line (with only one train path type), and the headway is identical between any arbitrary chosen adjacent path-pairs, the line has a periodic timetable, irrespectively of the value of periodicity. In this context, the value of $\tau_{ü}$ could be as well 37 minutes, 24 hours or any other extremity.

The same principle can be applied to a line with heterogeneous train services, but there have to be equal $\tau_{ü}$ for each train types.

Symmetry

Connections, travelling times and station stop times can be symmetrically built up for the outward and homeward journey of any connection. This means that if an optimal connection has been set up for the outward journey, the corresponding timetable slot can also be filled with a train path in the reverse direction, as a matter of principle.

This means that in case the system is symmetric, we can find a t_s symmetry-axis for each path-pair, which can be calculated as the average of the departure time pairs at any station:

$$\forall i \exists j; \frac{d\mathbf{s}_i(t)}{dt} + \frac{d\mathbf{s}_j(t)}{dt} \equiv 0 \Leftrightarrow \mathbf{s}_i(t+\tau) = \mathbf{s}_j(t-\tau) = t_s \qquad (2)$$

where:

t_s – *the symmetry-axis*

τ – *the duration from/to the symmetry-axis, along the time axis*

When the complete daily timetable chart is symmetric to a common axis, there is the global symmetry-axis (typically at about early afternoon). Moreover, there can be several local symmetry-axes within every basic period.

[2] *i* := *1* to *n-1* and *j* := *2* to *n*

Spiders

The optimal connections at interchange-stations are crucial for an ITF, since keeping the connection times low is the cheapest way to significantly reduce journey times. This requires that in a connecting terminal all trains meet always at the same time to enable the passengers to change between all lines. The name "spider" of such sophisticated connection system comes from its typical graphical representation: if we plot the traffic diagram at an interchange-station, the diagram resembles the contours of a spider. (Fig.2)

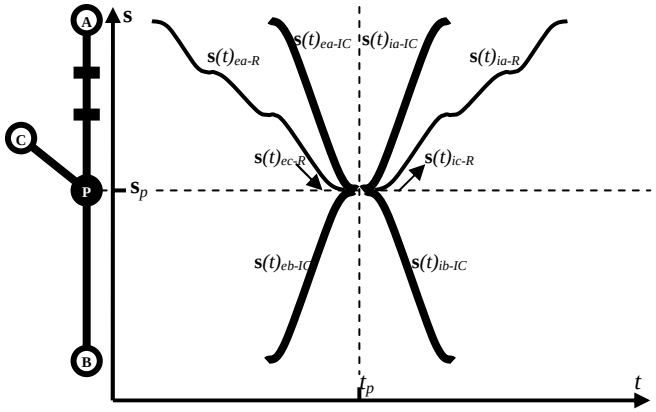

Fig. 2: Classic interchange-spider with arriving (index: e) and departing (index: i) trains from/to station A (index: a), station B (index: b) or station C (index: c) as type InterCity (index: IC) or regional (index: R)

In a station with interchange-spiders at every period, trains arrive and depart in the sequence of their gradient from/to each direction.

For example, before the "spider-time" the slowest (*Regional*) train-types arrive first, which are followed by *InterRegio* and *InterCity* trains (3).

<u>*Direction A:*</u>

$$\frac{d\mathbf{s}(t)_{ea-R}}{dt} \le \frac{d\mathbf{s}(t)_{ea-IC}}{dt};\ \max\{Ran[s(t)_{ea-R}]\} \le \max\{Ran[s(t)_{ea-IC}]\} \qquad (3)$$

furthermore

$$\frac{d\mathbf{s}(t)_{ea-IC}}{dt} + \frac{d\mathbf{s}(t)_{ia-IC}}{dt} \equiv 0;\quad \mathbf{s}(t-\tau)_{ea-IC} = \mathbf{s}(t+\tau)_{ia-IC} = t_p \qquad (4)$$

where:

t_p *– the spider-time axis*

Similarly to B and C

It's obvious that at the interchange-station, periodicity of the t_p spider-time axis is τ_r or $n\tau_r$, depending on the interconnected periodic schedules' basic periodicity.

In case the timetable is not just periodic but symmetric as well, the t_p spider-time axis has a definitive position (5), which makes the planning of an ITF system easier.

$$t_p = \begin{cases} t_s + n\tau_r \\ t_s \pm \dfrac{\tau_r}{2} + n\tau_r \end{cases} \qquad (5)$$

5. Regular interval timetable in Hungary: experiences and potential

The Hungarian regular interval timetable pilot project was established in 2004 in the Danube Bend region north of Budapest, a system of regional and so-called zonal trains running to a regular schedule. A 30% performance increase of the existing rolling stock was realized next to a cost increase of a mere 0,4%.

Due to the great success of the pilot project, in 2006 ITF system was (slightly diluted by the Ministry of Transportation but at least) adopted (only) for the north-eastern part of the country as a first step for extends a regular timetable to the entire country.

Results	Other (not itf) lines	ITF lines
Number of passengers	**-11%**	**-2%**
Income	**+15%**	**+31%**

Tab 1. First year results. There was a price rising (in 3 steps, together on average 30% rise) during the year

It was planned the extension for the whole network the next year, but unfortunately this step was adjourned sine die due to political exigencies restricting performance. In 2008 and 2009 on some additional lines have been introduced the new timetable system (as a part of the yearly timetable-change procedure), but the needed exhaustive reorganization (like in the north-eastern part of the network) is still waited for. The network's partly developed statement and other external and internal factors dimmed the positive effects of the Hungarian regular interval railway timetable, such as a severe rise in ticket prices, a lack of regional transport schemes and truly integral inter-modal timetables etc. Even so, summarized we found the prosperous way for future by integrating our public transportation system by the rules of regular interval timetable in Hungary like in Switzerland or the Czech Republic.

Presently on a national network level contradictory tendencies prevail. While in the Danube Bend and in other areas a timetable with regular intervals is in force this has not been extended to the entire network and some hourly services e.g. in late morning were suspended because of the constraints of cost limitations which is still believed by some to be basically achieved by performance restraints. Meanwhile even the available poor statistical data clearly shows the results of several attempts at a performance cutback.

Summing up the aggregated performance function of costs and revenues in a manner true to measure we will get the business result (profit/loss) of the activity of passenger transport. Except for a few operators working with a regular integrated timetable passenger railway companies operate with losses throughout Europe, it is therefore reasonable to first and above all look at the performance function of business losses (Fig.4).

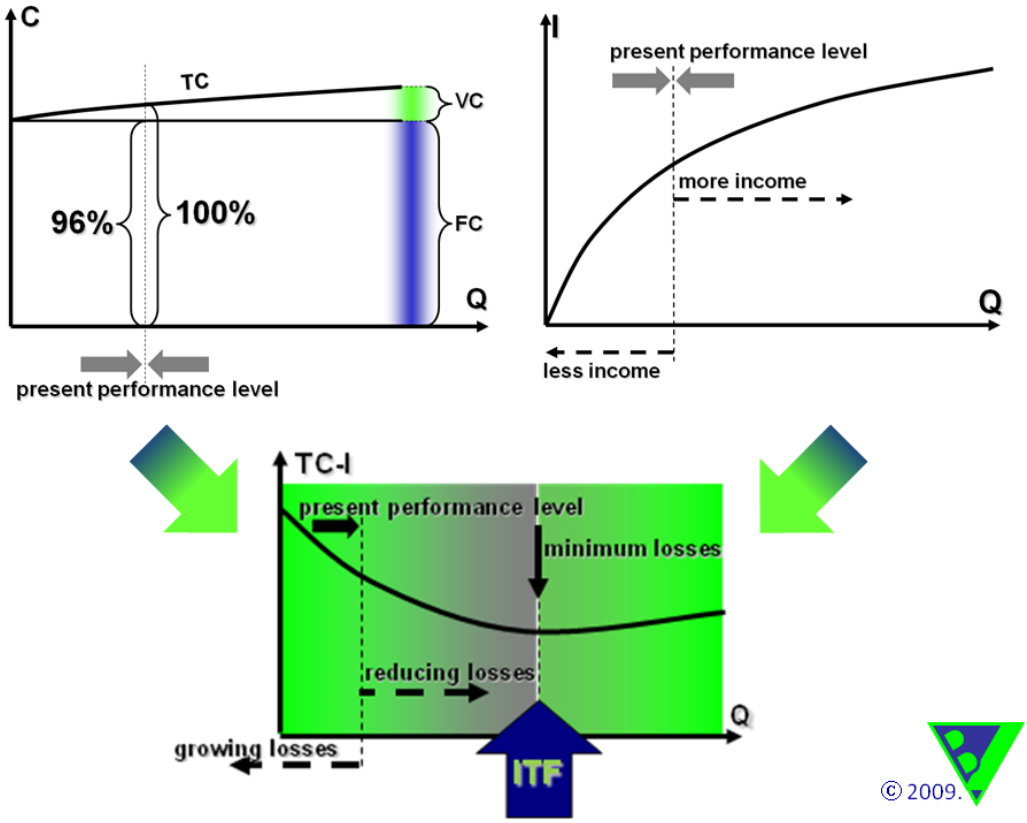

Fig. 3. Total costs (TC) in railway transportation include mainly fix costs (FC) and a marginal part of various costs (VC). On the other side it is always much more difficult to find new passengers (by increasing performance level) than lost them (by decreasing performance level). Aggregating costs and incomes (I) we could find the minimum point of deficit by developing regular interval timetable system. (Source: Viktor Borza)

At their present level of service a further performance reduction appears to threaten the very raison d'être of basic MÁV activities. It is a candid task to gain back passengers that railways have lost or are about to lose, let alone to become attractive to new potential passengers. The goal of a railway company operating in a rational manner should be to establish the point of minimal losses and attain it by reaching an optimal level of services. Regular interval timetable if consequently applied as “software” for operations appears to warrant such a level of service, it allows operators to maintain a level where the value of marginal revenues is in excess of marginal costs.

If looking at the local potential of regular interval timetable, companies must take care to operate the regular interval timetable system in a reasonable way given the local infrastructure situation, as well as mentalities, traditions and organizational structures which it is not always possible or appropriate to change. Nevertheless we put up the questions which transport policy and corporate measures (legal and institutional background, integral tariff system) would be suitable and necessary in order for regular interval timetable to exert all its benefits in view of an optimal cost and size proportionality.

6. Principles of the timetable based infrastructure development

Take into consideration the spiders, it is essential to ensure the required journey time between the hubs. When the running time is more than it would be necessary, than the trains have to wait in the station until the next spider, which is 30 or 60 minutes later. In this case the regular interval timetable would cause disapproval from the travelers as the whole journey time would be not less moreover sometimes longer than earlier. To avoid this social tension we have to create an absolutely clear and transparent system and generally quicker service than before.

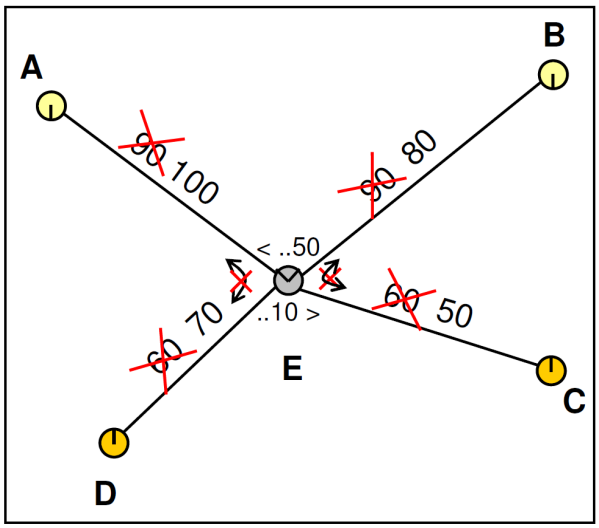

Fig. 4. Adequate and ineligible running time between the hubs

Not only the quality of the service can be improved by the described method, but the following issues can be also enhanced:

- capacity allocation;
- traffic management;
- track and vehicle maintenance;
- rolling stock and staff circulation;

As the first step we should work out a long-term development strategy using the experiences of the regular interval timetable. After that the network should only gradually improved, only where it is crucial, in a very cost-effective way. In Switzerland for example an extremely rational infrastructural investment was conducted at low cost between 1982 and 1992. More than a decade later, in 2004, using the synergy of mainly local improvements, a radical change was implemented in the basic structure of the timetable. Keeping the rules of regular interval timetable, service quality has been significantly improved. Connection times have been reduced, more stations could be accessible without significant increase of the journey time.

In Switzerland the second included capacity increase of high-speed railway traffic, and railway infrastructure. The goal is to provide an infrastructural network that will be uniquely able to enhance the competitiveness of railway transportation. The long term planning stage, lasting until 2030, allows the government to implement the necessary funds into the budget.

6.1. Main steps of the new method

Analysis based on operational considerations

- We’ve made an infrastructure analysis covering the whole railway network from operational point of view.
- The base of the analysis was the regular timetable system, as it defines the main bottlenecks of the network.
- The bottleneck analysis absolutely correlated with the real operational needs.
- The operational consideration focuses on the whole territory of Hungary, not only on the core network.

- This new business driven approach takes into account the expectations of the freight and the passenger transport as well.
- It leads to a functional reorganisation of the network.

Based on the timetable conception we are able to locate the most crucial bottlenecks. The aim of the process is to evolve a homogeny network and maintain the cadenced timetable on the whole network to ensure an attractive passenger transport by the flexible connections and shortest journey time. Till now we've maintain less than 100 km/year. Continuing this performance the level of service would be rapidly decreased. It gives a clear picture with the most crucial bottlenecks.

Main goals:

- Raising the level of service, elimination of bottlenecks
- Ensuring the sustainability and operation efficiency
- The same level of technical parameters covered the whole network
- Development plans from the point of view of operation
- Maintain at least 200 km/year line section

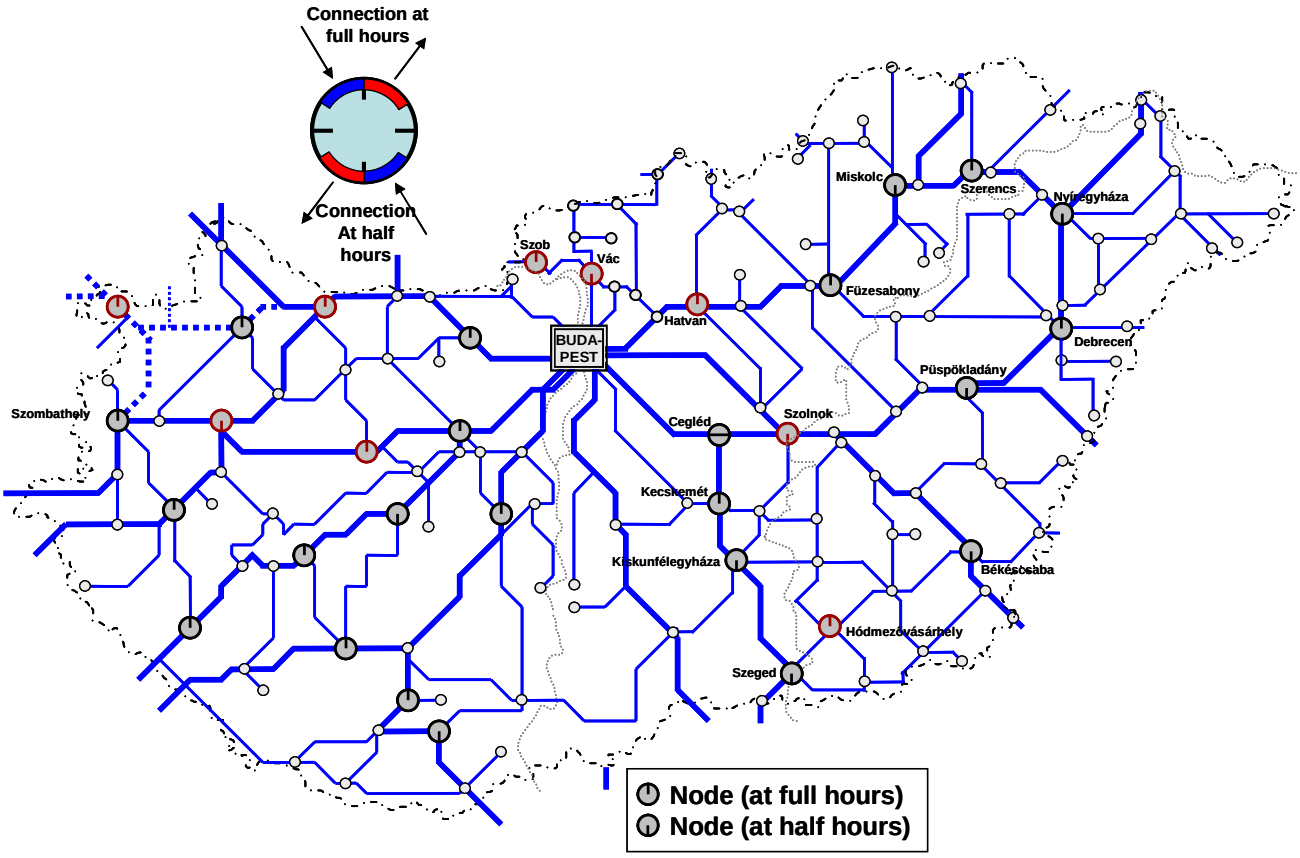

Fig. 5. Map of the main nodes in Hungary

Requirement: functional reorganisation of the network.

- Related to operational consideration
- Limited actions under the frame of operation
- Intervene in every places where in case of „do nothing" scenario the timetable structure would collapse.
- Pilot project: renewal of Vác – Szob railway line

In Hungary there are several nice examples. The first "pilot project" was established in 2004 the in the northern suburb of Budapest (described in chapter 5). There are two lines, one of them is Budapest – Vác – Szob, and the other van is Budapest – Veresegyház – Vác.

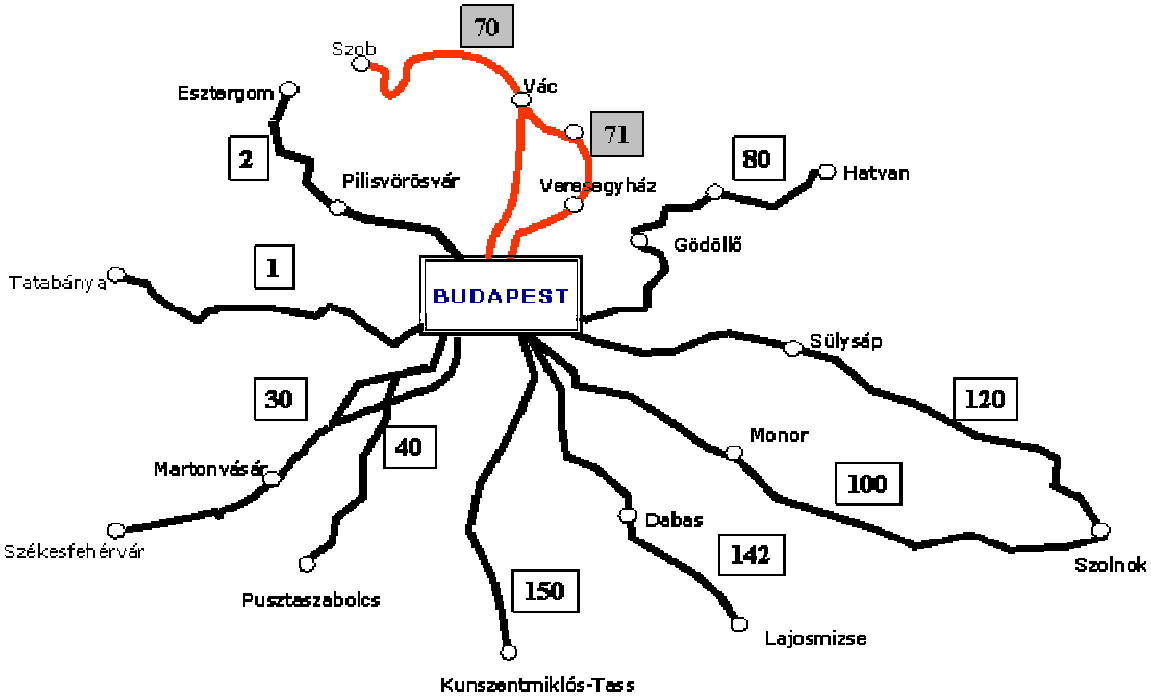

Fig. 6. Suburban network, pilot project-lines no. 70 and 71

With reference to the success of the project above, value analysis should also be necessary for the further developments in order to achieve quick and resourceful improvement. As the first step the new system was peaceable using the existing rolling stock and staff.

During the described suburban pilot project many experiences were gained which supported the forthcoming timetable and infrastructure development plans. We used this knowledge not only in the suburb of Budapest but the new approach has covered the whole country.

Connected to the railway line development we have also worked out a strategy for the modernization of the hubs, which is called intermodal stations.

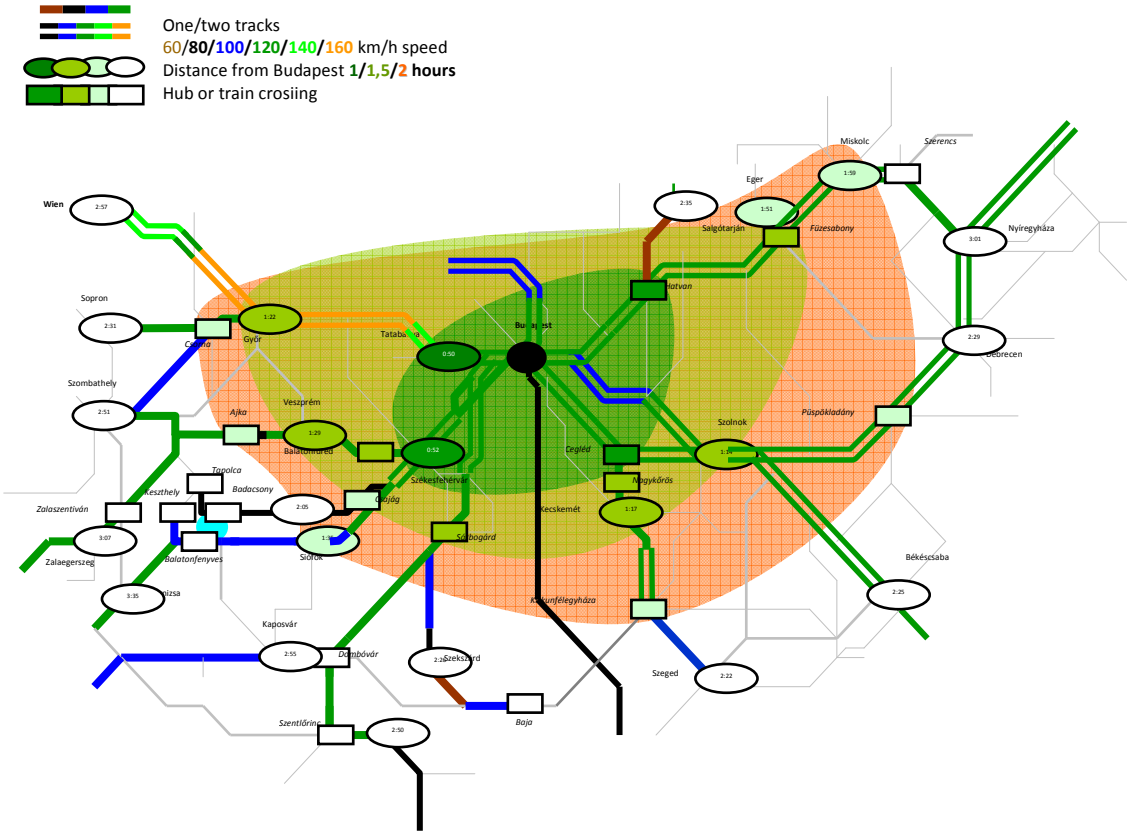

Fig. 8. Main infrastructure parameters

The figure No. 8 contains only the long distance lines including Budapest and the capitals of counties as well as the main centres of regions. (Sopron, Nagykanizsa and the area of Lake Balaton), such as the Trans-European network.

The basic parameters for the timetable based infrastructure development plans are the following:

- hourly cadenced service;
- symmetric regular interval timetable;
- based on the running times between the predetermined connection terminals;
- it is optimised not only on the travelling time between two particular hubs but between any terminals on the whole network due to the short connection time.
- the travel time is real, not calculated.

6. Conclusion

The crisis situation typical for this region today was faced in Western Europe some 30 years ago. From amongst the numerous approaches to cure the problems the Swiss Model appears the most effective given that regular interval timetable based operations proved to be the only system for passenger railway companies to operate without losses.

Looking at the present macroeconomic performance levels of the regional states an important aspect of the Swiss Model is that with its help an almost immediate rise in the level of service can be attained without the need for costly investments. Based on Swiss (and partly, Hungarian) experience, within 1 to 7 years and next to a 4% cost increase, a 10% to 40% rise in revenues can be attained, improving the situation of companies afflicted by losses amounting to billions and that have to be compensated from time to time by the state budget. Therefore regular interval timetable,

next to attaining a positive shift in the modal split, helps to decrease the external costs borne by society at large.

An regular interval timetable-based system of operations greatly contributes to creating a viable conception for efficient infrastructure development priorities. It also shows which possible developments is *not* a priority. It clearly favours efficient human resources management (this area still makes up for 45% of MÁV's cost structure) and due to its transparent, periodic nature the amount of planning work can be reduced to a fraction of the previous level, the remaining tasks not necessarily requiring in-depth railway related knowledge.

As the process of railway liberalization advances in line with EU transport policy, track access for all operators without discrimination is a critical expectation, in view of which a general requirement is an objective set of rules based on related standards. A regular interval timetable is a viable setting for that.

In case the system can be extended to the entire network and the other branches of public transport would be integrated, based on experience it does not appear an audacious claim that within a decade rail passenger transport can be made a profitable business in Central Eastern Europe.

Opening the argument I ask a question: Why should we maintain any more expensive and less efficient system of railway transportation, instead of adopting a regular interval timetable?

References

[1] BORZA, VIKTOR – KORMÁNYOS, LÁSZLÓ – VINCZE, BÉLA,
Periodic timetable-map for Hungarian railway system by an adaptation of the European structure ŽEL 2004, Žilina 2004, pp. 182-189.

[2] BORZA, VIKTOR – KORMÁNYOS, LÁSZLÓ – VINCZE, BÉLA,
New regular interval timetables in operation on the suburban line of the Hungarian State Railways ŽEL 2005, Žilina 2005, pp. 57-64.

[3] BORZA, VIKTOR – HORVÁTH, ZOLTÁN,
Regular interval timetable in Hungary
Periodica Politechnica Transportation Engineering 38/2 (2010) 1-7

[4] LEU, HANS-PETER,
Bahn2000 Project, conference presentation – Strategy of ŽSS,A.S. int he context of European Transport Policy. Bratislava, 18 October 2005

[5] UTTENTHALER, HELMUT,
Principles of railway infrastructure upgrading based on an integrated periodic timetable using the example of central Europe
Thesis in University of Graz
October 2010., Graz, Austria

[6] www.alptransit.ch

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Approach of Slovak Road Transport Operators to Proposal for New Smart Recording Equipment

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Abstract. The article named Approach of Slovak operators to proposal for new smart recording equipment deals with new EU proposals on recording equipment in road transport. Slovak road transport undertakings are required to comply with EU legislation. EU adopts many laws that are criticized by Slovak road transport undertakings. Article shows awareness of Slovak road transport undertakings about new provisions of recording equipment and also proposal for better dissemination of information on future legislation between road transport undertakings. The goal of early awareness of upcoming changes in legislative is to allow the road transport undertakings to comment EU proposals. The possibility of road transport undertakings expressing can help to adopt only changes that are useful for road transport.

Keywords: Smart recording equipment, weighting sensors, Regulation No 3821/85, tachograph

1. Introduction

Recording equipments - tachographs in road transport represent very important part of professional drivers work related to rules on driving time and rest periods. Tachographs are also very useful equipment for enforcement authorities because they can record information on driving time and rest periods. Tachographs help to improve road and driver safety as well as fair competition between road transport companies. Currently there are two types of tachographs used in road transport sector – analog and digital tachographs. These two types of tachograph are installed into 6 million vehicles operated in EU what is not a negligible quantity. Because of this reason and because the tachograph is very important for drivers profession and enforcement authorities, it is necessary to ensure high standard of their technical parameters. Rules of tachographs usage and their technical parameters in EU are regulated by Council Regulation (EEC) No 3821/85 on recording equipment in road transport. For ensuring high standard of tachographs the Regulation No 3821/85 has been adapted ten times to technological progress.

Despite continuous improvement of tachograph technical parameters, many infringements during roadside checks and checks at the premises of undertakings are found by enforcement officers. There are many cases when drivers drive vehicle equipped with a manipulated tachograph or a non-valid card on the trans-European network.

Imperfection in the system of tachoraphs using that caused breaching the social rules were a stimulus for adoption of new tachograph regulation amending Council Regulation (EEC) No 3821/85 on recording equipment in road transport. Article deals with main changes listed in new proposal of regulation that can influence business in road transport sector.

2. Proposal for New Regulation on Recording Equipment

2.1. New smart recording equipment

Last proposal for a Regulation amending Regulation No 3821/85 was adopted by Commission on 19 July 2011. Very important change related to recording equipment listed in proposal for new

regulation is that all vehicles shall be fitted with recording equipment connected to a global navigation satellite system (GNSS). Recording equipment shall be connected to GNSS for identification of starting and ending place of the daily work period and for control purposes through remote communication. Remote communication will ensure data transmission and possibility of enforcement officers to check vehicles remotely, without necessity to stop them.

According to the proposal recording equipment connected to GNSS must be installed in all vehicles put into service for the first time, after 48 months after the entry into force of the new regulation. Considering that the Regulation would enter into force in 2013, the new recording equipment could take place in 2018.[3] Proposal for a Regulation was transmitted to the European Parliament and to the Council and on 2 July 2012 the European Parliament adopted in Plenary its first reading position on the review of the Regulation No 3821/85/EC. [2]

Result of the first reading related to smart recording equipment is that European Parliament requests to equip all vehicles, not just new ones but also old ones with new smart recording equipment **by 2020**. This would mean that all transport operators are obligatory to retrofit their all vehicles with new tachographs. According to European Commission this retrofitting will represent too high costs for transport operators.

Other positions of European Parliament adopted in first reading that is not mentioned in Commission proposal but are:

- Including all vehicles over 2,8 t within the scope of Regulations No 3821/85 and 561/2006. According to this recording equipment will be mandatory not only for vehicles over 3,5 t but for vehicles weighting over 2,8 t.
- Fitting vehicles with new recording equipment with weighting sensors

2.2. Installation of recording equipment in vehicles over 2,8 t

According to results of the first reading of EP, all vehicles over 2,8 t must be fitted with recording equipment. These vehicles should be also included within the scope of regulation No 3821/85 and Regulation No 561/2006 on the harmonisation of certain social legislation relating to road transport. This change will mean that also drivers that carry out goods by vehicles over 2,8 t, not just over 3,5 t will be required to comply with the rules on driving time and rest periods. European Commission estimates that this establishment will affect more than 20 million vehicles and that it would have a substantial impact in EU countries.[1]

2.3. Weighting sensors

European Parliament calls for all vehicles to be equipped with weighting sensors for monitoring of vehicle loading and unloading. Monitoring of vehicle loading and unloading should prevent vehicle overloading. According to European Commission it is very important to assess the impact of such provision especially impact on costs of road transport operators.

These and other provisions listed in new regulation proposal will have and significant impact on professional drivers and road transport undertakings especially related to their costs. This regulation and its provisions will have impact also on Slovak road transport undertakings and their drivers due to the fact that Slovakia is regular EU Member State. Cause of this fact, it was realized a questionnaire survey on the awareness of the upcoming changes in recording equipment in road transport.

3. Awareness of the upcoming changes in recording equipment in Slovakia

Slovak road transport undertakings and their drivers are requested to comply with EU legislation as well as transport undertaking and drivers from other Member States. Because of this is new regulation on recording equipment applied also on Slovak drivers and transport undertakings. Based on this was realized questionnaire survey in Slovak transport undertakings performing road

transport with vehicles over 3,5 t focused on awareness of the upcoming changes in recording equipment. Questionnaire was realized by phone and by electronic form in February and March 2013. Transport undertakings were approached by the total number of road transport undertakings in Slovakia. According to Ministry of Transport, Construction and Regional Development of the Slovak Republic 4 083 road transport undertakings is registered in Register of Road Transport Undertakings. Minimal sample size in the case of confidence interval of 5 and 95 % confidence level is 351. Questionnaire was realized in 354 road transport undertakings performing road transport with vehicles over 3,5 t. From every region were chosen at least 5% of total number of road transport undertakings in the region. Total number of road transport undertakings and number of received questionnaires is listed in table 1.

Region	**Total number of road transport undertakings**	**Number of received answers**
Bratislava	639	48
Trnava	260	49
Nitra	1 190	63
Prešov	118	45
Banská Bystrica	354	25
Žilina	1 200	61
Košice	164	29
Trenčín	158	34
Total	4 083	354

Tab. 1. Number of total and received questionnaires on awareness of the upcoming changes in recording equipment

Source: Author

Questionnaire was focused on awareness of the new proposals and changes in the recording equipment in road transport. Representatives of road transport undertakings were asked on these questions:

- awareness of proposal to equip all vehicles with new smart recording equipment by 2020
- awareness of proposal to equip all vehicles over 2,8 t with recording equipment
- awareness of proposal to equip vehicles with weighting sensors
- interest in provision of information on upcoming legislation
- interest in comment on upcoming legislation

4. Results of Slovak road transport undertakings awareness of new recording equipment

Based on realized questionnaire it can be said that the most of Slovak road transport undertakings are not informed about upcoming changes in EU Regulation on recording equipment. From all received answers only 32% road transport undertakings were informed about proposal to equip all vehicles with new smart recording equipment by 2020. Level of awareness of proposal to equip all vehicles over 2,8 t with recording equipment is only 17% and of proposal to equip vehicles with weighting sensors only 12 %.

The most informed road transport undertakings about proposal to equip all vehicles with new smart recording equipment by 2020 are located in Žilina region, where up to 57 % of received answers from road transport undertakings were informed. The most informed road transport undertakings about proposal to equip all vehicles over 2,8 t with recording equipment are located in Žilina region where up to 33 % of received answers from road transport undertakings were informed. The most informed road transport undertakings about proposal to equip vehicles with weighting sensors are located in Žilina region, where up to 25 % of received answers from road transport undertakings were informed.

Comparison of awareness of upcoming changes in recording equipment in different Slovak regions is shown in figure 1.

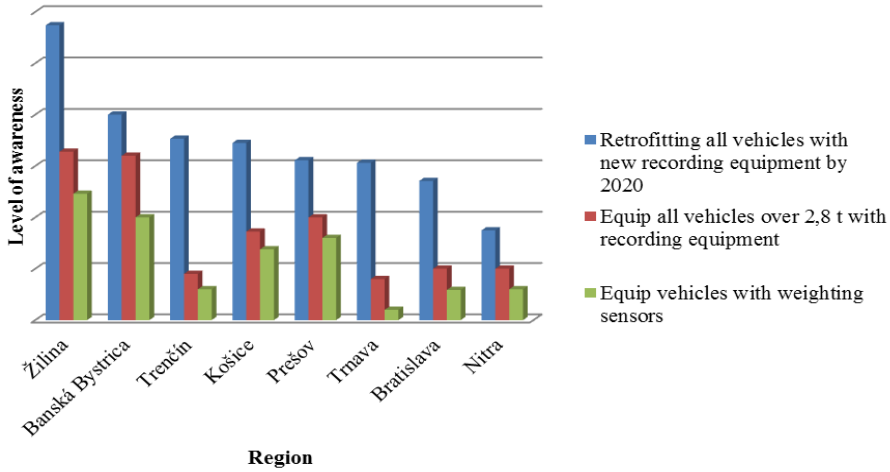

Fig. 1. Awareness of upcoming changes in recording equipment in Slovak regions

Source: Author

Most of Slovak road transport undertakings expressed negative opinion on the proposed amendments related to recording equipment. Related to retrofitting of all tachographs road transport undertakings are worried about increased costs. If they could they would like to comment proposed changes in legislation and contribute to road transport operation improving.

5. Conclusion

Awareness of legislation that is related to road transport sector is very important for all road transport undertakings and their drivers to ensure proper performing of road transport services. According to realized questionnaire survey, Slovak transport undertakings are not informed about legislation that is prepared. This information is usually available only in English or other foreign languages and that can represents barrier in getting information. Up to 81% of all road transport undertakings that were asked would like to get information on upcoming changes in legislation related to road transport. It is very important to find a way to inform road transport undertakings on upcoming changes in legislation and give them an opportunity to comment these changes. Proposal for method and way how to inform road transport undertakings, process comments and transfer of these comments to competent organs is one part of author`s dissertation thesis.

6. References

[1] Review of the digital tachograph regulation 3821/85/EC, CAS/BR1162/JNE, Item VI.1. on the provisional agenda of the Commission on Social Affairs (CAS) to be held in Brussels on 1 February 2013, Brussels, 18 January 2013

[2] Review of the digital tachograph regulation, No 3821/85/EC, CAS/B100944/DVI, Item VII. on the provisional agenda of the Commission on Social Affairs (CAS) to be held in Brussels on 2 October 2012, Brussels, 30 August 2012

[3] Report of Council the European Union, Interinstitutional File: 2011/0196 (COD), Brussels, 8 December 2011

[4] Road transport: new tachograph to tackle unfair competition, 7 March 2012. Available at: http://www.europarl.europa.eu/news/en/pressroom/content/20120703IPR48186/html/Road-transport-new-tachograph-to-tackle-unfair-competition

[5] Proposal for a Regulation of the European Parliament and of the Council amending Council Regulation (EEC) No 3821/85 on recording equipment in road transport and amending Regulation (EC) No 561/2006 of the European Parliament and the Council, COM(2011) 451 final, Brussels, 19 July 2011

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The Future Use of RFID Technology in the Postal Sector in the Czech Republic

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Abstract. This article deals with the question of practical use of RFID technology in the Czech Republic postal sector. After an introductory section, which is aimed at description of current situation, in further sections the theoretical basis discusses of RFID technology and its practical application in the postal sector. The final section outlines briefly some potential for the deployment of RFID technology.

Keywords: radio frequency technology, postal sector, postal services, postal item.

1. Introduction

Radio frequency identification (RFID) technology is used in different fields of activity, above all in various logistic processes. In the postal sector RFID technology improves the quality of classical postal services, during the last two decades a significant acceleration, improvement and modernization of the overall process of postal, express and courier consignments was observed.

The existence of alternative communication forms and data conduced to decrease postal services use especially by private users. Decrease in demand private users is compensated by large companies which use postal operators for the mass mailing of account statements, etc. For this reason, the postal operators have to continually invest in technological equipment with the aim to maintain, at high level continually improve the quality of postal services, because handling of large volumes of postal items would be unrealistic without proper automation and identification, besides the goods should be delivered in the shortest time and with the smallest error rate.

2. RFID technology

RFID technology is a form of automatic identification. RFID technology uses electrical or magnetic fields at specific frequencies, through which it secures transmission of information. RFID technology is able to record, store, and provide objective information about the objects in real time. RFID technology can be adapted to individual areas such as automotive, security, protection, access control systems, but also in tracking and delivery postal items. [1] [2]

The basic components of RFID system include:

- **Tag** – consists of chip, which itself consists of an electric memory circuit, and an antenna coil and in the case of active tag has its own power source.
    - Dividing tags:
        - **Active tag** - the main advantage of active tag is not only its greater reach, but it is also able to transmit own identification, so it can be used for active localization.
        - **Passive tag** - uses electromagnetic energy that is taken from the RFID reader. It is cheaper, smaller and lighter, but has a low power setting.

        - **Semi – active tag** - is an active tag, which stays in the sleeping mode unless it is called upon to communication by signal from RFID reader.
        - **Semi – passive tag** - a passive tag, which is used as the battery, but doesn´t return signal.
    - Tags can be also divided according to the type of memory:
        - **Read only (RO)** - tag is stored inside a serial number that has been encoded in its manufacture. It is similar to a bar code is read-only and can´t change it.
        - **Read Write (RW)** - can store large amounts of data such as active tag from 16KB to 2MB. Data written to the tag can be erased and rewritten up a thousand times.
        - **Write Once Read Many (WORM)** - are read-only. Tag is not already programmed during production, but only at the dealer.
- **RFID reader** - is formed by transmitting / receiving circuit with a decoder and antenna. In some cases, the reader may be also equipped with its own operating system.
- **Control sofware (middleware)** - is designed to manage, filtering, analysis of data retrieved from the RFID reader, RFID tag. Its task is to procure communication with individual readers and process the data. [3]

3. RFID technology in the postal sector

In the postal sector, RFID technology is applied increasingly because it provides important information for postal operators about the quality of postal services provided by them.

3.1. RFID technology used abroad

RFID technology has been used in the Swiss Post since 2008. For first time the RFID system was implemented for tracking of 45,000 containership cages intended for handling packages in the postal terminals. Swiss Post officers handle annually more than 2.3 billion letters. RFID technology will follow the movement of 70,000 containers transporting trays with letters on the area of each of the more than 50 postal hubs located throughout the country. RFID system includes EPC Gen 2 tags in a hard case, attached to each container, gate with RFID readers and software for tracking containers and their content and management of postal operations. [4]

Spanish Correos post office also uses a RFID technology with UHF EPC GEN 2. It transports annually around 5 billion postal items. By the instrumentality of RFID monitors the Spanish post office their movement within the chain to create 5,000 passive tags.

Finnish post office began to apply RFID technology to track containers, to be able to track them, because the transport companies were losing above 17,000 containers per year.

Postal operators (Saudi Arabia or the United Arab Emirates) tested their chains using RFID technology and specifically Saudi Arabia planned to create a network based on the principle of RFID installation of 10 million mailboxes.

Swedish post office began to use RFID technology in 2009 in order to reduce the number of thefts during transportation of packages.

The other post offices which have applied RFID technology are Korea Post and China Post. They use passive tags, UHF frequency and tested on parcels and transport units. [2]

3.2. RFID technology in Czech Post

RFID technology is used in the system of international performance measurement (quality) of postal operators in the UNEX project. The project aims to help national postal operators, especially in monitoring and improving the services they provide to their customers. UNEX system is based on a network composed of more than 3,000 volunteers in 43 participating countries, who are

selected by an independent organization TNS Research International. Activities and benefits of involved voluntary participants consist of sending and receiving of a "test consignments", according to a predetermined weekly schedule. The participants should record the time when they got the letters at packages in the central computer system. In this system over a half million international priority mails are dispatched and tracked annually. The main emphasis is put on aspects of quality of deliveries, then on quickness and reliability. In recent years, the objectives of the Czech Post met over the limit, which in case of quickness is 85 % and in case of reliabilities is 97 %.

Movement of test postal items is monitored using RFID technology. On each postal item is placed RFID tag, which allows to track the current location of goods, how quickly they were delivered or on which post offices were held up. Data are sent by information systems using RFID technology to the global IPC center, where the system describes and analyzes either progress or delay of trial postal items from the country of dispatch to the country of delivery. UNEX provides measures on both ends of the international postal network. [5]

Fig. 1. The string "end-to-end" in the measuring system UNEX
Source: UNEX™: Measuring International Letter Service Performance through UNEX™. *International Post Corporation* [online]. [cit. 2013-02-14]. Accessible from the: http://www.ipc.be/en/Services/Technical%20_Platforms/UNEX.aspx

Condition required for participation in the project was the installation of UNEX RFID technology, which was implemented in 2005 at selected sorting centers ensured foreign postal service. These were sorting centers Břeclav 120 and Praha 120 in 2012. The planned extension of the implementation of RFID technology began, namely at the sorting centers Praha 022, Brno 02 and Plzeň 02. While they were coming and going postal items through postal centers Praha 120 or Břeclav 120, yielded only the capture information about the postal item and time of takeover and clearance, so the introduction of RFID technology in the context of the other three centers of Czech Post gets an overview of the catchment area of collecting transport node (the longer sorting center) Prague 022, as well as 02 Brno and Plzen 02, through which the postal item will probably continue to carry. Extending the scope of monitoring allows to get detailed information about the served territory with subsequent quality improvement of the transportation process, the processing of postal items and services. The obtained information can also serve as background information for the further implementation of RFID technology within the major transportation network of the Czech Post, which represent a partial indicator when the total cost of a full RFID technology equipment is estimated.

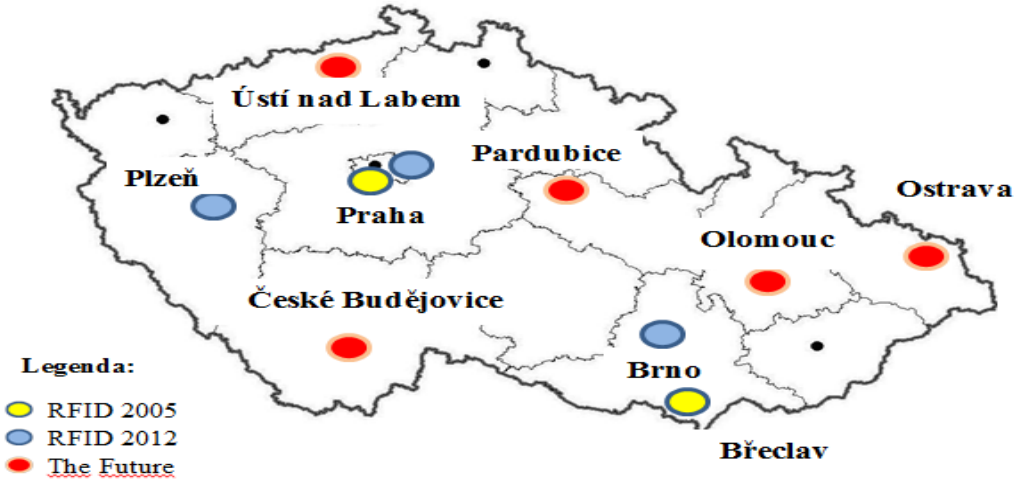

Fig. 2. Graphical representation of branches Czech Post with RFID technology
Modified source: *http://www.zemepis.com/smkrajem.php*

4. The future of RFID technology in Czech Post

Deployment of RFID technology to track postal items is not the last areas in the Czech Post, because the problem of precise records (current number, occupancy and the current location) of their transport units has been solved the longer time yet. Czech Post has about 131 thousand pieces mailbags, 37 thousand pieces of plastic boxes and 10 thousand pieces cages and containers. In most cases transported units are not marked at all or only marked with a bar code, consequently may occur the situation when due to lack of information about it is exact quantity and location, same sorting center has surplus of postal items and other vice versa solve the problem of scarcity. As a result same individual managers of sorting centers have to make phone search of missing goods. This leads of course to additional costs.

The implementation of RFID technology helps to prevent these negative situations and to find the effective tag for managing location and distribution of transported units between individual sorting centers. During the implementation of RFID tag, it is also important to consider the environment, where the transported unit will be moved and then decide which type of tag should be used where and how it should be attached to the transported unit, in order to prevent its removal and at he same time to keep readability at 100%. For example in case of containers it would be ideal place the tag in a plastic case.

The other, but not the least important effect of RFID technology is the possibility to control the transported unit delivery. It often happens, that employees are not careful enough during handling of goods. For that reason the costumer may receive a damaged postal item. RFID tag is able to control shocks and hits during handling of goods. The active tags can be used because they consist an integrated sensor which reacts to shocks, pressure etc. The Czech post can get an information which employees are not careful enough during the handling of transported units.

5. Conclusion

Suitable combination is undoubtedly the combination of RFID technology with GPS, where it would be possible to track postal items in real time. Into the vehicle of postal course would be placed a GPS fastened on a container RFID tag and the postal item would be marked by barcode or QR code. Can´t yet be expected that RFID technology in the near future will replace the bar codes in identification of postal items, because the economic costs of its implementation are still high. On the other hand, with a larger use of this technology the price of RFID tags also reduces, which

significantly facilitates the development and deployment of RFID technology in new application areas, such as the postal sector. Postal sector should have actual information about the location of postal items, their postal containers, boxes and courses.

References

[1] KOLAROVSZKI P., VACULÍK J. *RFID ako budúcnosť označovania prepravných jednotiek v poštovom a logistickom prostredí*, príspevok a prezentácia na workshope DoNT‘2009, Žilinska univerzita, 18.11.09

[2] ZELIK P. *Mobilné technológie v poštovej preprave*. Žilina, 2010. Dizertačná práca. Žilinská univerzita v Žiline.

[3] SOMMEROVÁ M. *Základy RFID technologií.* Výukový materiál pro Logistickou akademii.

[4] RFID-EPC.cz portál. *Švýcarskou poštu řídí RFID* [online]. 2013 [cit. 2013-03-21]. Source: http://www.rfid-epc.cz/clanky/reseni/svycarskou-postu-ridi-rfid-a2413630

[5] IPC. *UNEX*. In: *International Post Corporation* [online]. © 2012 [cit. 2012-04-17]. Dostupné z: http://www.ipc.be/en/Services/Technical%20_Platforms/UNEX.aspx.

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Simulating the transport department required for the transport of cars based on AHP method

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Abstract. Decision making method AHP delivers real results based on selected criteria analysis and solution variants. As a weighted sum of the output of decision analysis determines the order of significance compared variants. It represents "Base model" for simulation. Sensitive changes in input data for the decision-making process may result in a reordering output of AHP method. The simulation model makes it easy to simulate the desired conditions with increasing or reducing the importance of each criterion in relation to variants percentage change their addictions.

Keywords: multicriterial decision, AHP, transport modes, simulation.

1. Introduction

Analytical method for multi-level AHP provides a framework fro devising effective decisions in complex decision-making situations, helping to simplify and accelerate the natural process of decision making.

For the implementation of decision analysis, it is important to properly identify:

- objective of decision-making process,
- criteria,
- version of decision.

Objective decision consists of determining the transport department, which is the most suitable for the transportation of cars, depending on the selected criteria. For the application of the decision-making process, we chose five criteria decision-making (transportation cost, time of delivery, degree of building infrastructure, transport safety and environmental aspects).

Variants decisions represent transport unions involved in the transportation process cars. The process of decision analysis, we chose the road, rail and water transport, which is currently involved in the process of shipping cars. Air transport can be examined solely from the process as it related to the transport wheeled equipment is not used, or used only in specific cases (for the transportation of military equipment, which is not subject to review).

2. Multicriteria decision making method AHP

In determining the value of comparing various criteria based on the results obtained from statistical surveys from respondents in the investigation area (logistics, government and professionals). Based on the results to determine its own matrix vector "wi" according to the

horizontal structure of decision-making matrix. Normalized vector matrix "vi" is the weight of each criterion.

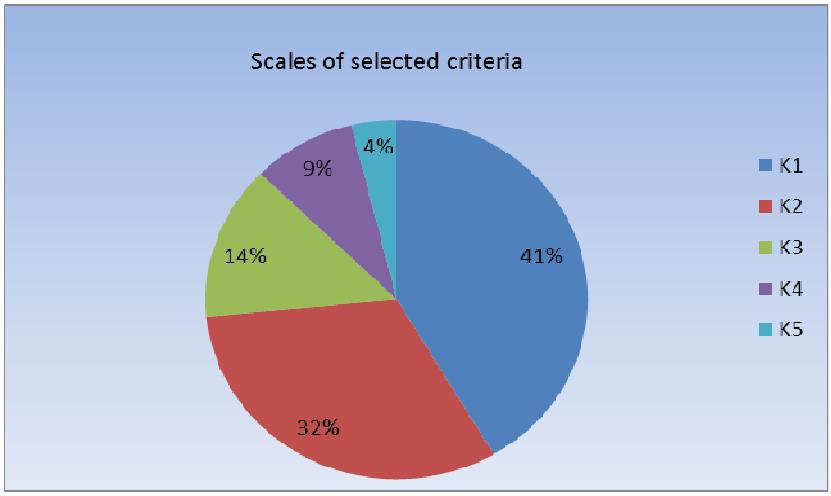


Fig.1. Evaluation criteria weights

s(i,j)	Criteria								
Criteria	**K1**	**K2**	**K3**	**K4**	**K5**	**Π S(i,j)**	**w(i)**	**V(i)**	**λ(i)**
K1	**1,00**	2,00	6,00	6,00	9,00	648,000	2,942	0,415	8,910
K2	0,50	**1,00**	5,00	6,00	9,00	135,000	2,265	0,320	8,265
K3	0,17	0,20	**1,00**	3,00	9,00	0,9000	0,983	0,139	6,713
K4	0,14	0,17	0,50	**1,00**	5,00	0,0595	0,625	0,088	6,216
K5	0,11	0,13	0,14	0,20	**1,00**	0,0004	0,271	0,038	5,577
Sum							7,086	1,00	35,681

Tab.1. determine the weights of criteria in the process of shipping cars

The weights of the criteria, and then comparing the investigated variants using AHP method may be made final assessment compared transport modes in relation to the choice of a suitable transport department for transport vehicles in Slovakia.

Criteria	Scale of criteria	Variants decisions		
		Road transport	Rail transport	Water transport
Transport costs	0,415	0,2138	0,2933	0,4929
Time of delivery	0,320	0,5117	0,3402	0,1481
Infrastructure	0,139	0,5095	0,3463	0,1481
Transport safety	0,088	0,1775	0,2770	0,5455
Enviromental aspects	0,038	0,1550	0,2928	0,5522
Sum		0,3446	0,3142	0,3418
Ranking		**1**	**3**	**2**

Tab. 2. The final evaluation of compared variants

For critical criteria that influenced the outcome of decision analysis can be time delivery rate and build infrastructures that are interdependent. Flexibility, speed and density of the road network features are compared, transport modes are not able to compete with the current conditions.

3. Methodological approach for simulation

The simulation consists of a sequence of steps, which are interlinked and depend on the method used by decision. Application of AHP method in determining the significance of selected variant t. j. most appropriate transportation department provides the basis for simulating the desired conditions. The basis for the simulation process is to determine the matrix that compares each individual criteria and the subsequent calculation of the normalized vector "vi", which is the weight of importance of the criteria. To calculate the weighted sum - order of importance of each variant is necessary to apply decision analysis for each criterion, particularly in relation to transport modes. Calculating a weighted sum of the sequence we get the significance of transport unions on the basis of criteria weights. The result of the analysis of decision-making is called 'base model'. It forms the basis for the desired simulation conditions. Process simulation is to increase or. reducing the significance of selected criteria in relation to the transport department. The rate of change is defined as a percentage. The rate of change in the significance criteria in relation to one transport department has an effect on the change in value of the standard vector "vi", which is the basis for the calculation of the weighted sum and for final order of the significance of transport modes. Percentage change in the significance of each criteria in relation to variants get "desired model".

4. Simulation of the transport department of the transport vehicles in Slovakia

Application of simulation model to a specific condition consists of a variant selection criteria decision analysis. As the “base model” is chosen outcome AHP multi-criteria analysis.

Simulation process can be devided into 2 phases of the project:

- Multicriterial decision making method AHP,
- Simulating conditions.

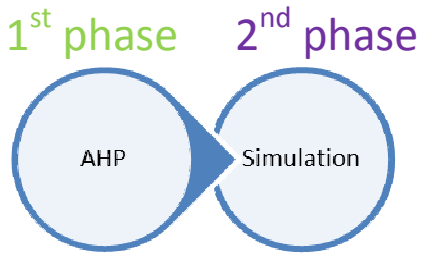


Fig.2. Phases of project

The importance of simulation lies in the easy access to information about it, what criteria need to be addressed to create the desired output of the model and how they impact on the overall change. First phase consists of multi-criteria decision making method AHP, resulting in the use of road transport to the most appropriate department for transport vehicles in Slovakia. The second

phase consists in simulating the significance criteria, resulting obtain the desired output - the transport department. Since waterways are not used to transport cars, it is necessary to simulate the conditions under which it would use to potential participants in the transportation process conveniently. For a starting model simulations (phase no. 2) use also called "zero state" i.e., desired model without changing the significance of individual criteria.

Variant	Road T.	Rail T.	Water T.	**Π S(i,j)**	w(i)	v(i)		Price increase	Price reduction
Road T.	1	0,6667	0,2	0,13333	0,7148	0,2238		0,00%	0,00%
Rail T.	1,5	1	0,286	0,42857	0,8683	0,2718		5,00%	0,00%
Water T.	5	3,5	1	17,5	1,6113	0,5044		0,00%	0,00%
					3,1943				

Tab. 3. Simulation of the changes of significance selected request – Transport costs

Variant	Road T.	Rail T.	Water T.	**Π S(i,j)**	w(i)	v(i)		Time reduction	Time increase
Road T.	1	3	7,5	22,5	1,6802	0,5054		0,00%	0,00%
Rail T.	0,33	1	5,5	1,83333	1,1063	0,3328		0,00%	0,00%
Water T.	0,13	0,1818	1	0,02424	0,538	0,1618		15,00%	0,00%
					3,3245				

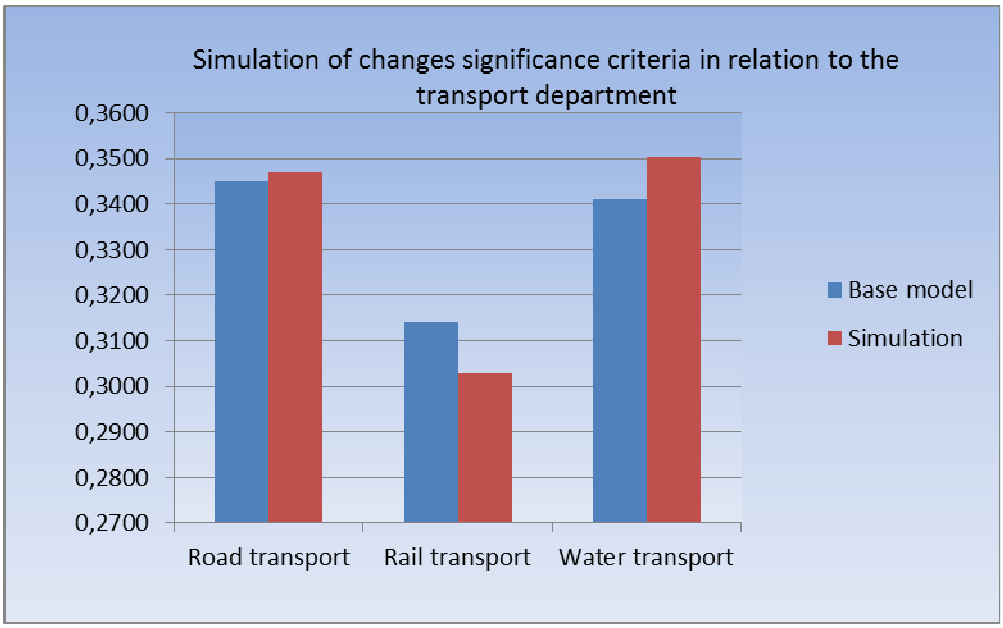
Tab. 4. Simulation of the changes of significance selected request – Time of delivery

Change of importance of each criteria is automatically converted and applied to the output of the model, which is a result of the simulation (excel version). Simulation results is the impact of changes to the original condition and the result of AHP method adjusted for the impact of the significance criteria.

As an example, the simulation can be determined that the timing of delivery of water transport and the change in the price of rail transport. Time of delivery in water transport will be reduced by 15% compared with other transport modes and rail transportation costs will increase by 5%. Other values weights remain unchanged. The impact of the changes can be seen in the table and shown graphically.

Criteria	**Scale of criteria**	**Variants decisions**		
		Road transport	**Rail transport**	**Water transport**
Transport costs	0,415	0,2238	0,2718	0,5044
Time of delivery	0,320	0,5054	0,3328	0,1618
Infrastructure	0,139	0,5094	0,3464	0,1442
Transport safety	0,088	0,1808	0,2759	0,5433
Enviromental aspecst	0,038	0,1552	0,2927	0,5521
Sum		0,3470	0,3028	0,3502
Ranking		**2**	**3**	**1**

Table 4: Final evaluation of transport modes



5. Conclusion

Information obtained from statistical surveys and assigning weights to each criterion represent the baseline examination. For credible simulation is necessary to work with current data, as the significance of individual criteria may change over time.

Process simulation requested conditions based on the percentage increase or reducing the significance criteria in relation to the transport department, under which there are changes in the results of decision analysis. Changes in the status of the significance of individual criteria in comparison with other transport departments can result in significant changes in the final evaluation and hence the choice of a suitable transport vehicle for the transportation department. Simulation of changes in the criteria in relation to the transport department can best simulate respectively "desired model".

References

[1] BANAS, J. a kol.: *Prepojenie Vážskej vodnej cesty na európsku vodnú sieť*. Príspevok na konferencii Dunaj tepna Európy, Bratislava 1995.

[2] KUBEC, J.: *Vodní cesty a přístavy*. Skriptum F – PEDaS VŠDS v spolupráci s a.s. Ekotrans Moravia, Praha 1993.

[3] DÁVID, A.: *Vážska vodná cesta*. Príspevok, 2003.

[4] ŽARNAY, P. Vodná doprava Slovenskej republiky 2002. In: Slovakia Transport – Alamanach dopravy, LUXUR v spolupráci s MDPT SR Bratislava 2002, 44-53 s.

[5] HAVIAR, V.: *Analýza vodnej dopravy a rozvoja vodných ciest v SR*. In: Zborník z medzinárodnej konferencie XXV Plavebné dni 2009.

[6] http://actamont.tuke.sk/pdf/2009/n1/15rohacova.pdf (2.4.2013)

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Grouping of Regions of Latvia Based on Indicators Influencing the Regional Passenger Transportation

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Abstract. The article considers the problem of grouping of Latvian regions taking in account a variety of social, economic and infrastructure indicators affecting the state and development of the regional passenger transportation. The authors propose the solution of the considered problem in applying the cluster analysis methods: Joining-tree clustering and K-means clustering. The classification of 26 regions of Latvia has been executed. For the solution of the examined task it is suggested using STATISTICA package. The results of the regions' grouping provide new opportunities for the research of passenger transportation processes between and within regions of the state.

Key words: passenger transportation, region, grouping, cluster analysis, clustering variable

1. Introduction

The regional passenger transportation status and development depends on a variety of social, economic and infrastructure indicators of provinces and regions of the state. Foremost among such indicators are: population density, labor activity of the population, average income per citizen, the number of companies and enterprises, the number of educational institutions, the density and quality of roads, the number of vehicles of different categories, etc. An analysis, conducted by the authors, shows that these parameters differ for 26 Latvian regions [2], and differentiated approaches to the development of transport region's infrastructure must be used. In consideration of the above-described problem the task of regions' grouping by the set of indicators (regions' characteristics), influencing a condition and development of regional passenger transportation, is quite actual. To perform such a grouping of regions the authors propose to use the methods of cluster analysis [3].

2. Steps of classification

The process of regions classification is divided into five stages considered below.

1. Selection of the clustering variables. When choosing the clustering variables defined by vector $\mathbf{x}_i = \{x_1^{(i)}, x_2^{(i)}, ..., x_n^{(i)}\}$, which are the indicators of *i*-th region affecting the regional passenger transportation, it is necessary to consider their probable interdependence by calculating the coefficients of a pair correlation. So, from two strongly correlating variables (indicators of regions) only one could be used for classification. Since regions' indicators have different physical nature and, as a consequence, different units of measurement and orders the process of classification starts with the standardization of data.

2. Selection of the distance measure. Let us consider the set of regions *S*. There exist several definitions of the distance between the *i*-th region and *j*-th region defined by the vectors of clustering variables $\mathbf{x}_i$ and $\mathbf{x}_j$, there included: Euclidean distance, City-block (Manhattan) distance, Chebychev distance and others [1, 3]. In the present research we have chosen Euclidean distance defined as:

$$\delta_{i,j} = \sqrt{(x_1^{(i)} - x_1^{(j)})^2 + (x_2^{(i)} - x_2^{(j)})^2 + ... + (x_n^{(i)} - x_n^{(j)})^2}\,, \qquad (1)$$

where $\delta_{i,j}$ is the distance between regions with numbers i and j, $i \in S$, $j \in S$;

$x_l^{(i)}$ is the value of the l-th characteristic of the i-th region, $l = 1,2,...,n$.

The selection of Euclidean distance is explained by the following reasons: observations are taken from the population of data described by the multidimensional normal law, the components of the observations vector $x_l^{(i)}, i \in S$ being mutually independent and having the same variance; these components are uniform in their physical meaning and according experts' assessments all of them are equally important for solving the problem of referring a region to either this or that class.

3. Selection of the method. The methods of cluster analysis form seven basic families: hierarchical agglomerative methods, hierarchical divisional methods, interactive grouping methods, methods of searching modal meanings of compactness, factor methods, methods of condensations, and methods using the theory of graphs. Each group of methods has its advantages and disadvantages. The authors have chosen the most popular methods, which can be used to solve the problem of the regions' grouping – hierarchical agglomerative method Joining-tree clustering and interactive grouping method K-means clustering.

4. Defining the* number *of clusters. To define the number of clusters it is suggested to apply the Joining tree clustering using Ward's minimum variance method [3]. According to the clusters' joining tree we should choose the number of clusters. In the example considered below we have determined that the number of clusters is equal to 4.

5. Defining the members of* each *group and evaluation of the quality of grouping. There exist different evaluation criteria of the clusterization quality. One of the most popular criteria of the clusterization quality is the ratio of the inner-cluster variance to the inter-cluster variance, which has been used in the present paper.

3. Grouping of Latvian regions using cluster analysis methods

Let us consider the classification of 26 regions of Latvia in accordance with the above-described process. For the examined task solution it is suggested using STATISTICA package [5]. According to a survey of experts 18 regions' attributes were included in the initial set of classification variables. Note that some of these attributes are defined per 1000 inhabitants, some per 1 square kilometer. Pair-correlation matrix was calculated to reduce the dimension of the vector of clustering variables. Taking in account the pair-correlation matrix 8 attributes of the initial set of classification variables, which have high coefficients of pair correlation with other variables, were excluded from the consideration. As a result, 10 indicators were included in a basic set of clustering variables used for regions' grouping, including: population density x_1; the unemployment rate x_2 and the number of working (active) population x_3 per 1000 inhabitants; the average level of income capital x_4 (LVL); the number of companies x_5 per 1000 inhabitants; the number of schools x_6 per 1 sq. km; length of paved roads x_7 per 1 sq. km; the number of railway stations x_8 per 1 sq. km; the number of buses x_9 and the number of cars x_{10} per 1000 inhabitants. Prior to the cluster analysis, all factors were standardized by the method of Z-Scores [4].

Two methods of grouping have been used: at first regions joining was performed on the basis of the Joining-tree clustering, and then the results were précised by K-means clustering. Fig. 1 presents the results of grouping of the initial set of regions by the Joining-tree clustering method. In determining the distance between clusters Ward's method was used. As can be seen from Fig. 1, the regions of Latvia can be grouped into four clusters.

So, K-means method of classification has been executed for four clusters. The obtained clusters together with their initial values of clustering variables (regions' indicators) are presented in Table

1. The numbers of clusters are shown in the last column of the table. Cluster # 1 includes 8 regions; cluster # 2 – 11 regions, cluster # 3 – 1 region and cluster # 4 – 6 regions. Note, that the region, which has the smallest geometrical distance from the centre of its cluster, is placed on the first position of the cluster.

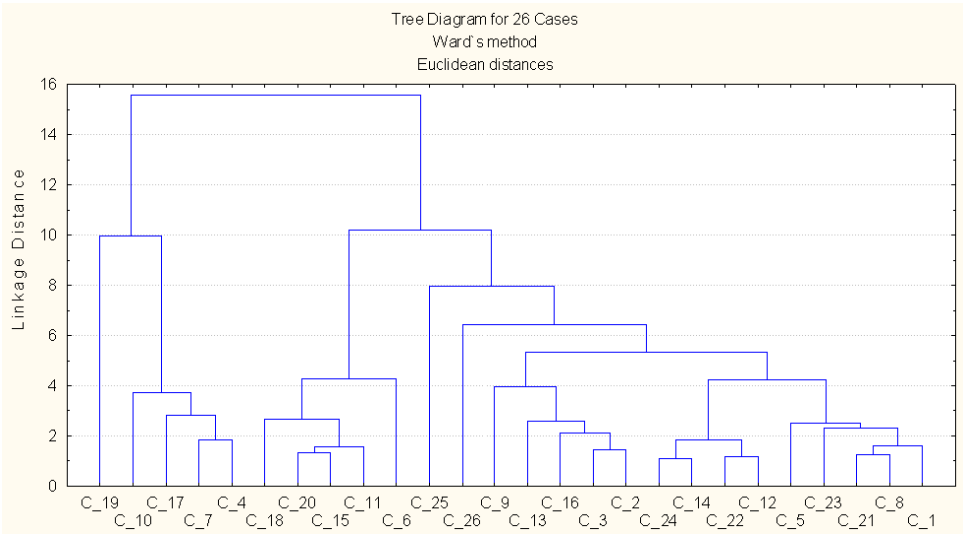

Fig. 1. Vertical joining tree of regions

Region	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	**Cluster**
Bauska district	25,10	65	462	290,25	72	0,049	0,137	0,0032	5,19	495,17	**1**
Cesis district	16,90	55	465	277,00	102	0,042	0,098	0,0024	7,54	551,34	**1**
Dobele district	20,42	81	470	299,33	62	0,046	0,125	0,0074	5,13	456,69	**1**
Gulbene district	12,19	72	466	257,00	58	0,033	0,107	0,0053	4,94	472,76	**1**
Jelgava district	21,49	73	469	333,50	191	0,040	0,218	0,0050	6,87	582,31	**1**
Ogre district	33,26	43	488	280,25	78	0,045	0,156	0,0092	4,46	482,27	**1**
Saldus district	14,63	71	459	261,50	86	0,038	0,104	0,0041	6,20	516,15	**1**
Tukums district	20,31	55	448	275,00	88	0,036	0,165	0,0037	5,22	507,85	**1**
Aizkraukle district	13,10	71	466	288,00	70	0,029	0,105	0,0031	5,06	508,69	**2**
Aluksne district	9,38	90	448	250,50	85	0,033	0,087	0,0018	5,65	494,83	**2**
Jekabpils district	7,40	88	426	271,80	144	0,031	0,072	0,0020	6,46	745,98	**2**
Kuldiga district	12,68	82	452	245,33	90	0,030	0,133	0,0008	6,21	506,45	**2**
Liepaja district	10,70	63	430	239,75	235	0,027	0,115	0,0019	5,38	478,79	**2**
Limbazi district	12,11	69	453	257,00	91	0,025	0,142	0,0004	4,41	542,90	**2**
Madona district	11,14	81	446	246,80	74	0,026	0,083	0,0030	8,12	495,90	**2**
Talsi district	14,98	63	457	239,25	82	0,029	0,171	0,0015	6,12	523,57	**2**
Valka district	10,78	75	466	267,00	77	0,028	0,142	0,0021	4,87	520,58	**2**
Valmiera district	12,29	64	433	262,67	155	0,039	0,162	0,0013	11,35	900,29	**2**
Ventspils district	4,94	64	447	368,00	304	0,016	0,126	0,0020	5,18	561,09	**2**
Riga district	57,04	42	528	338,24	640	0,049	0,263	0,0121	4,01	445,16	**3**
Balvi district	9,85	129	435	246,75	60	0,031	0,095	0,0025	6,27	491,49	**4**
Daugavpils district	13,17	91	408	241,00	173	0,030	0,156	0,0055	4,15	344,95	**4**
Kraslava district	11,31	138	444	234,00	44	0,034	0,122	0,0026	4,41	398,64	**4**
Ludza district	11,12	157	461	248,00	45	0,028	0,095	0,0025	4,66	425,60	**4**

Region	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	Cluster
Preili district	17,14	118	447	254,40	65	0,043	0,115	0,0034	3,41	414,28	**4**
Rezekne district	11,97	178	455	253,50	108	0,034	0,113	0,0034	4,98	382,34	**4**

Tab. 1. Initial statistical data source (year 2011) and results of regions clustering

Fig. 2 shows the plot of means for each cluster obtained in a 10-dimensional variables space for standardized data. Using the plot of means we can describe clusters of regions. It is easy to see, that cluster # 3 has the longest distance from the other clusters. This cluster consists of one region – Riga district, which is included in the metropolitan area of the capital city of Riga and has the highest socio-economic and infrastructure indicators. Riga district has the best regional passenger transportation indicators too. Cluster # 4, which includes Latgalian regions, has the worst performance. The authors note that the efforts of Latvian authorities should be made to improve the situation in the regions of the cluster # 4.

Fig. 2. Plots of means for 4 clusters (groups of regions)

4. Conclusions

In the paper the classification problem of Latvian regions has been considered taking in account a variety of indicators affecting the state and development of the regional passenger transportation. As a result of the research the distribution of regions into 4 groups (clusters) was carried out. The coordinates of centres of clusters identified for each group describe their features. Performed regions' grouping allows more differentiated approach to the strategic planning of the passenger transportation development, which takes into account specific features of regions' groups.

The results of the cluster analysis provide new opportunities for the research of passenger transportation processes between and within regions of the state.

References

[1] AFIFI A.H. and CLARK V. *Computer Aided Multivariate Analysis*. London: Chapman & Hall, 1996.

[2] Central Statistical Bureau of Latvia. *Statistical Yearbook of Latvia 2012*. Riga, 2013.

[3] Everitt, B. S., Landau, S. and Leese, M. *Cluster Analysis*, 4th Edition, Oxford University Press, Inc., New York., 2001.

[4] LARSEN R. J. and MARX M. L. *An Introduction to Mathematical Statistics and Its Applications, Third Edition*, 2000.
[5] NISBET R., ELDER J. and MINER G. *Handbook of Statistical Analysis and Data Mining Applications*. Elsevier, 2009.

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The Impact of Bus Priority on Bus Delays Reducing at Signal Controlled Junction

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Abstract. This article deals with the issue of bus priority at selected signal controlled junction in Žilina. By using the micro-simulation software two traffic situations were simulated. The first one presents the current situation at selected junction where an average indicators were calculated. The second one presents the situation by using bus priority which was implemented in the designed model. The results and the comparisons both of the simulations are mentioned in the last chapter of this article.

Keywords: bus priority model, signal controlled junction, delay reduction.

1. Introduction

The requirements of the citizens for transportation increase along with the rising living standards. Therefore individual passenger transport (IPT) is becoming much more attractive and more frequent mode of transport used for moving between the source and the aim of transportation. This is accompanied by many negative effects such as increasing the number of congestion in central areas of cities and the associated drivers nervousness, increasing the noise, making the exhaust gases, slowing traffic and especially decreasing safety. One of possible solutions to at least partially mitigate these negative effects is to create a system that would be able to transport large numbers of passengers, would be spatially and socially accessible to all categories of travelers, would provide comparable travel time between the source and aim against IPT, and would be reliable and also safe. All of these conditions meet the public transport systems. But nowadays, when city centers are crowded by passenger vehicles causing extensive congestion, public transport is not able to provide rapid movement between a source and an aim. Some foreign literatures indicate that it is the speed of the transfer that is the most important requirement for many travelers. Increasing travel speed of urban public transport doesn´t mean increasing the bus running speed but the goal is to reduce the number of stopping at places other than public transport stops. A key instrument, how to achieve noticeable results is the introduction of bus priority.

2. Traffic situation at junction Komenského- Surovová- J. Fandlyho

Communication network of the Žilina city consists of radial-circular system while junction of streets Komenského-Surovová-J. Fándlyho is placed at the radial (Fig. 1) which connects the city center with two large housing estates, Solinky[1] a Hliny[2]. The eight-hour junction survey that was conducted in April 2012 in time period between 6:00 to 10:00 and 14:00 to 18:00 showed that a total of 8 126 passenger cars passed the junction in this period. Junction is loaded mainly in main directions at the street Komenského whether in the direction to the city center or in the direction from the city center.

[1] Number of population 13 685, 31.12.2012
[2] Number of population 11 771, 31.12.2012

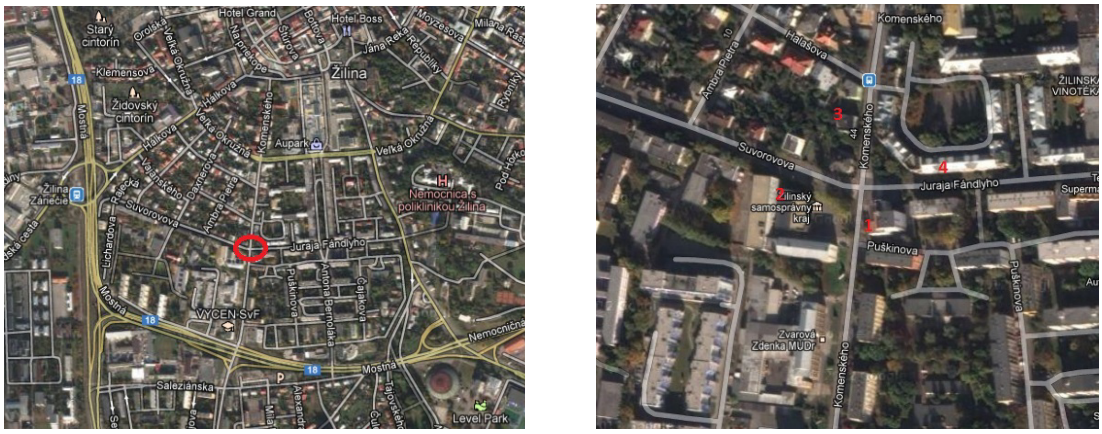

Fig. 1. Marking the junction of streets Komenského- Surovová- J. Fandlyho

Five public transport lines pass the junction in the main directions at the street Komenského (Tab.1). These ensure transport services not only between the center and the housing estates Solinky and Hliny but also between other urban areas.

Direction	To the center of city		Both directions		From the center of city
Line / Indicator	Line no.1	Line no.14	Line no.5	Line no.7	Line no. 4
Line interval during transport peak [min]	60	10	20	30	10
Capacity of vehicle [seats]	32 or 29	50 or 44	32 or 29	50 or 44	50 or 44

Tab. 1. Public transport lines pass the junction.

2.1. Model of current state at the junction

Two traffic situations were modeled by using microsimulation program Aimsun. The first one was situation- current state of the junction. There was modeled one hour during the traffic peak in time period 15:00 to 16:00. The traffic intensity for each junction approach entered into the model was used from junction survey mentioned above. Routes and timetables for each public transport line were created according to routes and timetables of public transport operator in Žilina (Dopravný podnik mesta Žilina s.r.o.).

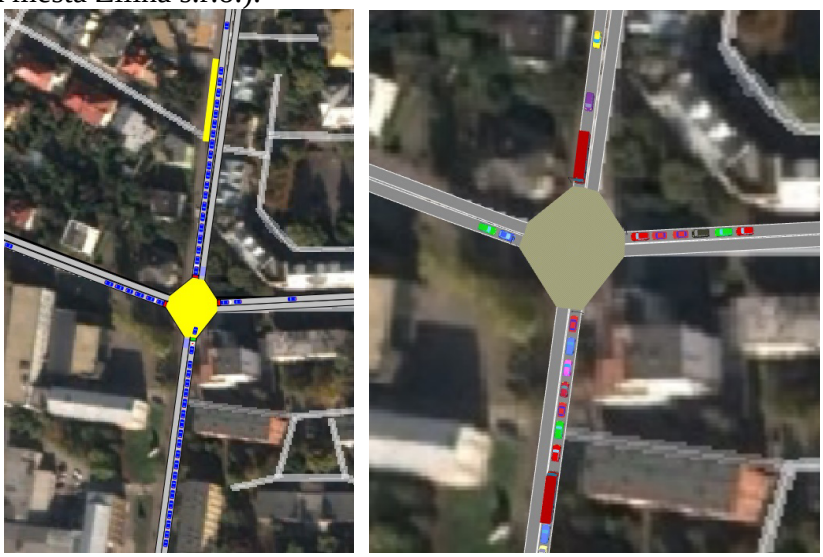

Fig. 2. Model of the current state at the junction created by the Aimsun.

Several indicators were evaluated for passenger cars as well as for public transport vehicles, which have been calculated as the average value of the previous ten simulations (Tab. 2).

Indicator / Direction	Komenského (approach 1)	Surovová (approach 2)	Komenského (approach 3)	J. Fandlyho (approach 4)
Simulated speed for cars [km/h]	15,8	16,1	11,3	24,6
Simulated speed for trolleybuses[3] [km/h]	11,4	-	8,5	-
Simulated speed for articulated trolleybus[4] [km/h]	9	-	7,6	-
Simulated travel time for cars [s]	82,0	75,6	107,9	82,1
Simulated travel time for trolleybuses [s]	115	-	128,4	-
Simulated travel time for articulated trolleybus [s]	130	-	125,8	-
Simulated delay time for cars [s]	64,2	31,4	91,5	53,1
Simulated delay time for trolleybuses [s]	96,1	-	110,5	-
Simulated delay time for articulated trolleybus [s]	109,9	-	107,4	-

Tab. 2. Evaluation of the current situation model.

2.2. Model with the introduction of bus priority

In the second case, there was modeled situation when bus priority was introduced. Log-on and log-off detectors used for send requests for bus priority were placed at the approaches to the junction from the street Komenského. The principle of requesting is as follows: at the time of passage of the vehicle the detector a request for allocation of signal "free" for the direction from which the vehicle comes is sent to the controller. Signal "free" is then assigned to the direction of a vehicle passing the intersection with minimum delay.

Fig. 3. Model with bus priority.

The same indicators were evaluated as in model of current state.

Indicator / Direction	Komenského (approach 1)	Surovová (approach 2)	Komenského (approach 3)	J. Fandlyho (approach 4)
Simulated speed for cars [km/h]	17,7	15,9	17,9	18,9
Simulated speed for trolleybuses [km/h]	17,3	-	15,4	-
Simulated speed for articulated trolleybus [km/h]	12,9	-	14,3	-
Simulated travel time for cars [s]	79,7	79,0	71,6	116,0
Simulated travel time for trolleybuses [s]	61,9	-	60,5	-
Simulated travel time for articulated trolleybus [s]	85,7	-	63,8	-
Simulated delay time for cars [s]	61,8	64,6	55,2	87,2
Simulated delay time for trolleybuses [s]	42,3	-	42,9	-
Simulated delay time for articulated trolleybus [s]	65,8	-	44,5	-

Tab. 3. Evaluation of the model with bus priority.

[3] Vehicle with capacity 32 or 29 seats.
[4] Vehicle with capacity 50 or 44 seats.

3. Conclusion

There were significantly delays reducing and the speed increasing of public transport vehicles after the introduction of bus priority at the streets Komenského. The delays were reduced by the value of 53.8 s in the direction to the center of the city and by the value of 60.6 s in the direction from the center for the trolleybuses. For articulated trolleybuses, the value of the delays was reduced by the value of 44.1 s in the direction to the center of the city and by the value of 62.9 s in the opposite direction. This fact is shown in figure 4 through the color change from the initial orange to yellow.

a)Trolleybuses b) Articulated trolleybus

Fig. 1. Comparison of public transport vehicles delays.

The introduction of bus priority at all signal controlled junctions would be achieved significant time savings for public transport vehicles and to ensure more competitive against the individual transport. Beneficial effects would not be only travel time savings but an energy savings, too. And also the noise and the exhaust gases reduction and in particular improving safety in case of passengers transfer from individual transport to public transport.

References

[1] *Aimsun 7 Dynamic Simulators User's Manual*, October 2012

[2] GOGOLA. M.: *Modelové riešenie preferencie MHD na vybranej časti mesta Žilina*. Doprava a spoje [elektronický zdroj] : internetový časopis. - ISSN 1336-7676. - 2012. - Č. 1 (2012), online, s. 94-103. dostupné na: http://fpedas.uniza.sk/dopravaaspoje/2012/1/gogola.pdf

[3] HORAL: *Dokumentácia skutočného vyhotovenia CSS na križovatke ulíc Komnského-Fandlyho*. Žilina 1998

[4] *Preference vozidel MHD na křižovatkách řízených SSZ*. [elektronický zdroj]. [jun 2012] dostupné na: http://www.svsmp.cz/Files/svs/dopravni_pruzkumy/ doprava_ 2008/07 _R8_06SSZ.pdf

[5] PŘIBIL, P.: *Inteligentní dopravní systémy a dopravní telematika*. 1st ed. Vydavatelství ČVUT. 182 st. 2005

[6] ŽELEZNÝ, R.: *Preference provozu veřejně dopravy je významnou funkcí zdravého rozvoje města*. From horse-drawn railway to high-speed transportation system. 17.-19.04.2007, Prague

VEGA Projekt č. 1/0159/13 – KALAŠOVÁ, A. a kol.: Základný výskum telematických systémov, ich podmienky rozvoja a potreba dlhodobej stratégie, ŽU v Žiline, FPEDAS, 2013-2015.

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Comparison of Relevance Based Approaches to the p-Median Problem

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Abstract. This paper is focused on the comparison of two basic methods of distance relevance estimation in approximate covering approach to large *p*-median problems. This approach pays for shorter computational time by a loss of solution accuracy. The accuracy depends on suitable determination of so called dividing points which are used for distance approximation. The selection of dividing points is based on a new concept which follows the idea that some network distances from the customers to possible service center locations can be considered relevant, and are expected to belong to the optimal solution. The outlined notion of relevance can be formalized in several ways. Hereby, we are studying the impact of various expressions of relevance on the effectiveness of presented approximate approach.

Keywords: Location, *p*-median problems, covering formulation, approximate approach, distance relevance

1. Introduction

This paper deals with the problem of designing the optimal structure of most public service systems [4], [5], [6], which is often formulated as the *p*-median problem. The particular location-allocation models are characterized by considerably big number of possible service center locations which can take the value of several thousand [1]. Concerning the problem size it is obvious that attempts at exact solving usually fail due to enormous computational time or memory demands.

The necessity of solving large instances of the *p*-median problem has led to the approximate approach based on a radial formulation [3], which can cause a loss of solution accuracy, but enables us to solve real-sized instances in admissible time using common optimizations software tools [4], [5]. The accuracy can be improved by a convenient determination of so called dividing points which are used in the objective function value approximation. Since the distances are approximated by the mentioned dividing points, their selection must be done very precisely. It is based on the idea that some distances are considered relevant and therefore they are expected to belong to the optimal solution. The main goal of this survey is to compare various expressions of relevance mainly from the viewpoint of solution accuracy.

2. Radial Formulation of the p-Median Problem

To formulate the *p*-median problem, we denote the set of serviced customers by J and the set of possible facility locations by I. It is necessary to determine at most p locations from I so that the sum of the network distances from each element of J to the nearest located facility is minimal. The network distance between the possible location i and the customer j from J is denoted as d_{ij}. The general radial model of the *p*-median problem can be formulated by further introduced decision variables. The variable $y_i \in \{0, 1\}$ models the decision about the facility location at the place $i \in I$. The variable takes the value of 1 if the facility is located at i, and it takes the value of 0 otherwise.

The keystone of the approximate approach consists of a relaxation of the assignment of a service center to a customer [4]. To this purpose, the range $\langle 0, max\{d_{ij}: i \in I, j \in J\}\rangle$ of all possible distances of the former location-allocation problem is partitioned into r+1 zones. The zones are separated by ascending sequence $D_0 \ldots D_r$, D_m where $0 = D_0$ and $D_m = max\{d_{ij}: i \in I, j \in J\}$. We

introduce a numbering of these zones so that the zone k corresponds to the interval $(D_k, D_{k+1}\rangle$, the first zone corresponds to the interval $(D_1, D_2\rangle$ and so on till the r-th zone which corresponds to the interval $(D_r, D_m\rangle$. The width of the k-th interval is denoted by e_k for $j \in J$ and $k = 0 \ldots r$. In addition to the variables y_i for $i \in I$ we introduce auxiliary zero-one variables x_{jk} for $k = 0 \ldots r$. This variable takes the value of 1 if the distance of the customer j from the nearest located center is greater than D_k and it takes the value of 0 otherwise. Then the expression $e_0x_{j0} + e_1x_{j1} + e_2x_{j2} + e_3x_{j3} + \ldots + e_rx_{jr}$ constitutes an upper approximation of d_{ij}. It means that if the distance d_{ij} falls to the interval $(D_k, D_{k+1}\rangle$, it is estimated by the upper bound D_{k+1}. Similarly to the covering model we introduce a zero-one constant a_{ij}^k for each triple $[i, j, k] \in I \times J \times \{0 \ldots r\}$. The constant a_{ij}^k is equal to 1 only if the distance $d_{ij} \leq D_k$. Otherwise this constant a_{ij}^k takes the value of 0. Then the associated covering model connected with the upper bound can be formulated as follows:

$$\textit{Minimize} \quad \sum_{j \in J} \sum_{k=0}^{r} e_k x_{jk} \tag{1}$$

$$\textit{Subject to:} \quad x_{jk} + \sum_{i \in I} a_{ij}^k y_i \geq 1 \quad \textit{for } j \in J \textit{ and } k = 0,..., r \tag{2}$$

$$\sum_{i \in I} y_i \leq p \tag{3}$$

$$x_{jk} \geq 0 \quad \textit{for } j \in J \textit{ and } k = 0,..., r \tag{4}$$

$$y_i \in \{0,1\} \quad \textit{for } i \in I \tag{5}$$

The objective function (1) gives the upper bound of the sum of the original distances. The constraints (2) ensure that the variables x_{jk} are allowed to take the value of 0 if there is at least one center located in radius D_k from the customer j. The constraint (3) limits the number of located facilities by p. This covering approach is reported in more details in [4].

3. Selection of Dividing Points

Optimal dividing points $D_1, D_2 \ldots D_r$ are selected in an exact way - by solving mathematical model (6) – (10). Basic idea is very simple: The elements of the distance matrix $\{d_{ij}\}$ form a finite ordered set of values $d_0 < d_1 < \ldots < d_m$ where $D_0 = d_0$ and $D_m = d_m$. If there are only r different values between d_0 and d_m, we could determine the dividing points $D_1, D_2 \ldots D_r$ so that they would be equal to these values. Then we can obtain the exact solution by solving the covering problem described by the model (1) - (5). Otherwise the distance between a customer and the nearest located center can be only estimated knowing that it belongs to the interval $(D_k, D_{k+1}\rangle$ given by a pair of dividing points. If we were able to anticipate the frequency n_h of each d_h in the optimal solution, we could minimize the deviation using dividing points obtained by solving the following model:

$$\textit{Minimize} \quad \sum_{t=1}^{m} \sum_{h=1}^{t} (d_t - d_h) n_h z_{ht} \tag{6}$$

$$\textit{Subject to:} \quad z_{(h-1)t} \leq z_{ht} \quad \textit{for } t = 2,..., m \textit{ and } h = 2,..., t \tag{7}$$

$$\sum_{t=h}^{m} z_{ht} = 1 \quad \textit{for } h = 1, 2, \ldots, m \tag{8}$$

$$\sum_{t=1}^{m-1} z_{tt} = r \tag{9}$$

$$z_{ht} \geq 0 \quad \textit{for } t = 1,..., m \textit{ and } h = 1,..., t \tag{10}$$

The decision variable z_{ht} takes the value of 1 if the distance d_h belongs to the interval which ends by the dividing point d_t. The link-up constraints (7) ensure that the distance d_{h-1} can belong to the interval ending with d_t only if each distance between d_{h-1} and d_t belongs to this interval. Constraints (8) assure that each distance d_h belongs to some interval and constraint (9) enables only r dividing points to be chosen. After the problem (6) - (10) is solved, the nonzero values of z_{tt} indicate the distances d_t which correspond with the optimal dividing points.

4. Distance Relevance Estimation

Selection of dividing points is related to estimated frequency n_h of each distance d_h in the resulting solution. Distance relevance expresses here the measure of our expectation that the value d_h will be included in the unknown optimal solution. Estimation of each n_h can be computed in several ways. Within this contribution we deal only with two basic approaches.

4.1. Exponential Approach

The basic idea of exponential computing of n_h comes from [4]. The main principle consists in the fact that each distance d_h is connected with a frequency N_h of its occurrence in the matrix $\{d_{ij}\}$. Consider, if $p > 2$, then the biggest value from the j-th column will be never included in the optimal solution of the p-median problem and therefore we can consider only $|I| - p + 1$ smallest distances of each matrix column. Estimation of n_h follows the hypothesis that the frequency n_h of d_h may be proportional to N_h and to some weight which decreases with increasing value of d_h. It means that smaller distances are expected more than the higher ones. This suggestion can be formalized by the following expression (11), where the symbol T represents a positive parameter.

$$n_h = N_h e^{\frac{-d_h}{T}} \tag{11}$$

Obviously, estimated value of n_h does not have to depend only on the size of $|d_h|$. Therefore we suggested a new ranking approach.

4.2. Ranking method

The ranking method was presented in [5]. In this method, we introduce a column ranking evaluation $L^{ts}_j(d_{ij})$ of the distance d_{ij} to define the relevance n_h according to

$$n_h = L^{tsh} = \sum_{j \in J} \sum_{\substack{i \in I \\ d_h = d_{ij}}} L^{ts}_j(d_{ij}) \tag{12}$$

The linear column ranking function $L^{ts}_j(d_{ij})$ is defined as follows: Let $P_j(d_{ij})$ be the position of d_{ij} in the ascending sequence of the j-th column items of the matrix $\{d_{ij}\}$ and let a denote the cardinality of I. Then $L^{ts}_j(d_{ij}) = a+s*(1-P_j(d_{ij}))$ for $P_j(d_{ij}) < a+1-t$ and $L^{ts}_j(d_{ij}) = 0$ otherwise. The threshold t influences the number of t-1 largest distances of the *j-th* column, which are not taken into account, and the step s gives the difference between the contributions of k-th and k-1th item of the ascending sequence of the j-th column items. The ranking relevance estimation can be also exponenciály reduced. In that case the mathematical expression takes the form of (13).

$$n_h = L^{tsh} e^{\frac{-d_h}{T}} \tag{13}$$

5. Computational study

Presented approaches to the distance relevance were compared on the pool of benchmarks from the *OR-Lib* set [2] enlarged by some problems generated from the road network of Slovakia. The cardinality of J is the same as the cardinality of I in all solved instances. The number of dividing

points r was set to 20 and $T = 1$. Since the covering model provides only the upper approximation of the original objective function, its real value must be computed in accordance to (14).

$$\sum_{j \in J} \min\{d_{ij} : i \in I,\ y_i = 1\} \tag{14}$$

All experiments were performed using the optimization software FICO Xpress 7.2 (64-bit, release 2011). The associated code was run on a PC equipped with the Intel® Core™ i7 2630 QM processor with the parameters: 2.0 GHz and 8 GB RAM. The experiments were performed for $s=a/(a-t)$. The threshold t was set at one quarter and three quarters of its possible range, i.e. at values $t_1 = (3p+a-1)\ div\ 4$ and $t_2 = (p+3a-3)\ div\ 4$. Obtained results for the relevance computed according to (11), (12) and (13) are reported in Table 1. Quality of the solution is evaluated by *gap* which expresses the difference between the objective function value (14) and the exact one in percentage of the exact solution. The exact solution of particular problems was obtained from our previous research. The computational times vary from 1 to 56 seconds for the largest instance.

	Distance	**|I|**	**100**	**200**	**300**	**400**	**500**	**800**	**1100**	**1400**	**1700**
	relevance	***p***	**25**	**50**	**75**	**100**	**125**	**200**	**275**	**350**	**425**
***Gap* [%]**	(12)	*Threshold t_1*	1.40	2.12	3.79	5.13	5.02	12.52	84.06	112.41	133.35
		Threshold t_2	0.16	0.34	1.45	1.23	2.21	2.29	32.37	31.74	31.47
	(13)	*Threshold t_1*	9.80	6.98	0.60	0.29	0.12	0.00	0.00	0.00	0.00
		Threshold t_2	12.22	6.98	0.60	0.16	0.12	0.00	0.00	0.00	0.00
	(11)		14.11	8.41	2.08	0.29	0.12	0.00	0.00	0.00	0.00

Tab. 1. Results of numerical experiments – comparison of various approaches to the distance relevance

6. Conclusion

The main goal of this contribution was to compare various approaches to the distance relevance which plays a very important role in the selection of dividing points. The performed numerical experiments show that the ranking method constitutes a promising way of solving large instances of the *p*-median problem, especially when combined with the former exponential reduction.

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References

[1] AVELLA, P., SASSANO, A., VASSIL´EV, I.: *Computational study of large scale p-median problems.* In Mathematical Programming 109, 2007, pp. 89-114

[2] BEASLEY J. E.: *OR Library: Distributing Test Problems by Electronic Mail*, Journal of the Operational Research Society, 41(11), 1069-1072

[3] GARCÍA, S., LABBÉ, M., MARÍN, A.: *Solving large p-median problems with a radius formulation*. IN-FORMS Journal on Computing 23 (4) 546-556, 2011

[4] JANÁČEK, J., KVET, M.: *Approximate solving of large p-median problems.* In Operational research peripatetic post-graduate programme: Cádiz, Spain. September 13-17, 2011, Cádiz: Servicio de Publicaciones de la Universidad de Cádiz, 2011, ISBN 978-84-9828-348-8, pp. 221-225

[5] JANÁČEK, J., KVET, M.: *Relevant network distances for approximate approach to the p-median problem.* In Operations Research Proceedings 2012, September 4-7 2012, Leibniz Univesität Hannover, to be published

[6] JÁNOŠÍKOVÁ, L.: *Emergency Medical Service Planning*. Communications –Scientific Letters of the University of Žilina, Vol. 9, No 2, pp 64-68, 2007

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Analysis of Road Transport Emissions

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Abstract. The article is focused on environmental problems related to specific types of transport and points out why it is important to search for possible solutions of emissions reduction in the atmosphere, because of its continually increasing values. Emissions produced from road transport have a negative impact on the deepening problem of the greenhouse effect.

Keywords: Emissions, greenhouse effect, exhaust gases, environment.

1. Introduction

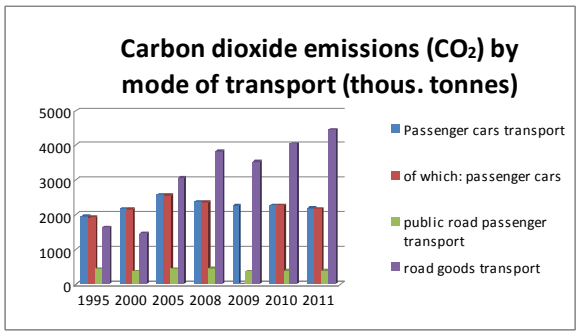
It is undisputed that people are largely responsible for the increasing value of emissions in the atmosphere. Massive use of motor vehicles, which are concentrated near the residences of the population, is a reason for developing a greater pressure to reduce emissions exactly for this group of vehicles. In spite of ongoing efforts to reduce emissions from road transport, the results are not satisfactory because the transportation needs of society are still increasing. Emissions produced from road transport have a negative impact on the deepening problem of the greenhouse effect. The greenhouse effect is responsible for average value of atmospheric temperature which is constantly increasing. The increase in temperature causes the melting of glaciers and so associated increase in world sea levels, which can lead to disastrous changes of climate and weather on the planet.

1.1. Emissions of Vehicles

The article is focused on the clarification of the issue of vehicle emissions production. Exhaust gases are composed by a mixture of chemicals, which composition depends on kind of used fuel, the technical conditions of the engine and the use of equipment to reduce emissions. World production of exhaust gases emissions is estimated on 10 milliard m2 every year. In addition, the exhaust gases adversely affect human health and they also have a negative impact on global climate changes. All mentioned aspects of exhaust gases are the reason for highlighting issue analyzed in presented article.

1.2. Carbon Dioxide (CO_2)

Carbon dioxide has the largest influence on global climate changes. This gas is the most harmful gas of greenhouse effect. Its participation on the creation of the greenhouse effect is estimated up to 55 %. Average changes in atmospheric CO_2 were about 22 molecules of carbon dioxide per million molecules of air during the last 610 000 years. This amount increased by 100 molecules per million molecules of air since the beginning of industrial revolution dated to the end of the seventeenth century, however. The combustion of one liter of gasoline causes formation of about 2,5 kg of CO_2. Society currently produces about fourteen thousand times more atmospheric CO_2 than the air is able to purify. If we would like to stabilize actual global temperature, we should reduce emissions by 60%. Actual values of CO_2 in Slovakia are listed in Graph 1.

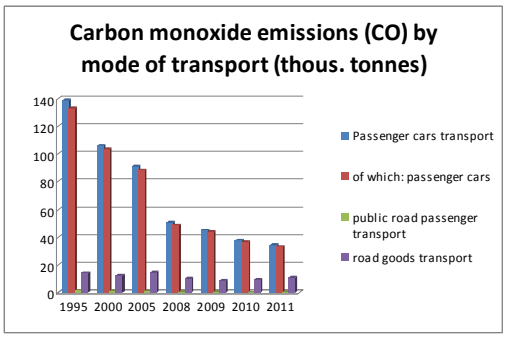


Graph. 1. Carbon dioxide emissions by mode of transport

Source: author

1.3. Carbon Monoxide (CO)

Carbon monoxide is a colourless and odorless gas which is lighter than air. The main reason of increased level of carbon dioxide emissions is the imperfect gasoline combustion in the engine. The negative effect of this process consists in avoidance of supply of oxygen to tissues in living organisms. High concentrations of this substance may cause death. Catalysts are used to reduce high values of CO in the exhaust gases. Their influence is negligible if the engine is running cold and low engine revs. Actual values of emissions of CO during last few years are listed in Graph 2.

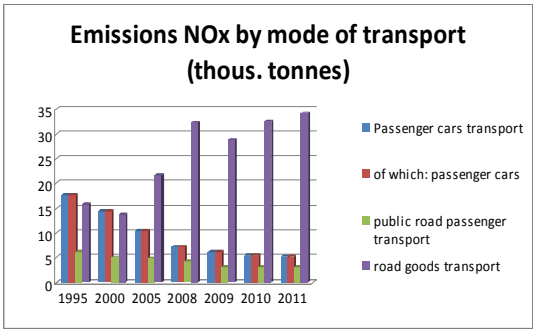


Graph. 2. Carbon monoxide emissions by mode of transport

Source: author

1.4. Oxides of Nitrogen (NO_2)

Nitrogen is a gas which is the most frequently located among all gases at the atmosphere. Nitrogen oxides are always formed during air heating or fuel combustion. They are created by vehicles due to high pressure and temperature in the engine, where the nitrogen reacts with oxygen. Nitrogen dioxide - NO_2 is the most important gas of the nitrogen oxides class. This gas is characterized as an irritant gas. The emissions of NO_2 are greenhouse gas which is responsible for reduction of the ozone layer. Actual values of emissions of NO_x are listed in Graph 3.



Graph. 3. Emissions NO_x by mode of transport

Source: author

1.5. Ozone (O_3)

This gas usually forms part of stratosphere and troposphere. Ozone has a protective function and protects us from the adverse effects of ultraviolet radiation. However, as the exhaust gas is undesirable because it is located just above the earth's surface and adversely affects living organisms. This phenomenon is called dry smog. The concentration of ozone at ground level is increasing annually by 2%.

1.6. Hydrocarcbons and Organic Substances

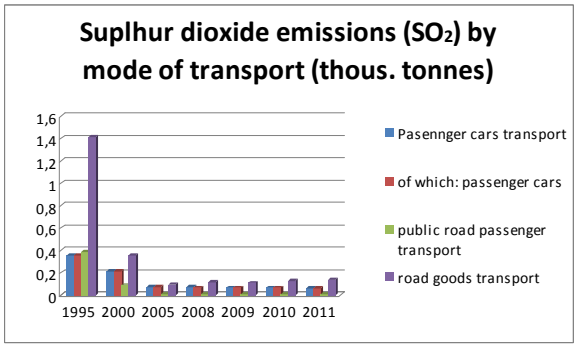
About one third of global emissions of hydrocarbons and organic substances is produced by traffic. Benzene as a significant organic substance is a volatile organic substance that has a carcinogenic effect. Hydrocarbons are usually created by incomplete combustion but their liberation to the atmosphere is possible by the leak from the tank of car during warm summer days.

1.7. Lead (Plumbum) and Heavy Metals

Heavy metals such as cadmium, arsenic, mercury, lead and zinc, are released to the atmosphere during combustion. According to the comparison between members of this group of substances, the emissions of plumb invoke the most serious consequences for the human body. These emissions have been reduced by the use of unleaded gasoline and mainly by the existence of catalytic converter in vehicles.

1.8. Solid Particles and Sulfur Oxides

Solid particles and sulfur oxides are produced exclusively by diesel engines. Their size varies from dust particles up to the particle having a size of 0.1 micron to 1 micron. They contain organic carbon, primary carbon, small amounts of sulfates, nitrogen, water and other unidentified compounds. As mentioned above, particles and the sulfur oxides are particularly produced by the compression-ignition engines. Production of sulfur emissions is negligible in terms of total production of emissions. The content of sulfur in diesel fuel is continually declining. Sulfur emissions produced by vehicles in Slovakia are listed in Graph 4.



Graph. 4. Suplhur dioxide emissions by mode of transport

Source: author

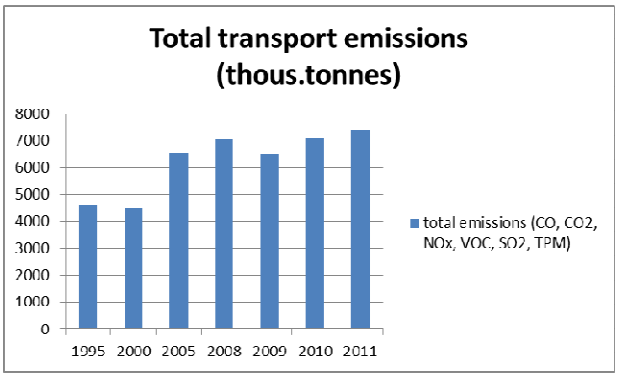
2. The Greenhouse Gases Emissions Produced by Transport

According to the information listed above, it is necessary to constantly deal with the issue of environmental aspects of transport. Potential problem can arise in developing countries where trend of cars which are nowadays produced without catalysts and with low efficiency of combustion is increasing. The biggest problem is in countries like India and China, where the price of newly bought cars is usually no more than € 3 000. This is the reason for the massive sales of vehicles in developing countries. There is this type of inexpensive cars dominating over the sales of environmental friendly hybrid cars which are considerably more expensive.

Transport emissions are influenced by several factors such as:
• unfavorable development of individual car transport,
• increasing number of kilometers travelled and associated increase of fuel consumption,
• use of older vehicles without catalytic converters.

3. The Greenhouse Gases Emissions Produced by Transport in the Slovak Republic

Road transport has a significant impact on the overall emission production of transport. Individual automobile transport and cargo transport produce together up to 87% of total transport emissions. The degree of motorization and automobilization, that still have a growing trend are also important indicators of the current status quo. Total emissions produced by transport in Slovakia are listed in Graph 5.



Graph. 5. Total transport emissions

Source: author

4. Conclusion

To preserve the Earth for future generations of humankind, at least in so far as we know now, it is necessary not only to reduce and note the threat of the greenhouse gases production of large companies in the transport sector, but also of individual users vehicles. Because of this, the portfolio of vehicles should be renewed by modern vehicles that utilize environmentally friendly engine design, exhaust gas recirculation, and the three-way catalyst.

References

[1] PILÁRIK, M., PABST, J., *Automobily II.* Praha: Informatorium, 2006. 163 s. ISBN 80-7333-038-5.

[2] HROMÁDKO, J., HROMÁDKO, J., HÖNIG, V., MILER, P. *Spalovací motory.* Praha: Grada Publishing, 2011. 296 s. ISBN 978-80-247-3475-0.

[3] *Emisie skleníkových plynov z dopravy* [online]. Posledná revízia 2012 [cit. 2012-10-11] Dostupné z : <http://www1.enviroportal.sk/indikatory/detail.php?kategoria=99&id_indikator=601>.

[4] *Emisie z dopravy* [online]. Posledná revízia 2012 [cit. 2013-05-02] Dostupné z : < http://www.telecom.gov.sk/files/statistika_vud/ziv_prostredie.htm>.

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Use of Electronic Product Code in the postal services

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Abstract. The article briefly deals with improving process of postal operators. Specifically we discuss possibilities of replacement of the existing one dimensional barcode labels by smart labels with RFID. The article deals with the lowest layer of the system: the hardware part, which is primarily consisting of RFID tags as information carriers. And last but not least the format in which the information will be coded on the tag and label. One possibility is to use the format of the Electronic Product Code, which is assigns by a non-profit organization GS1. Replacing the current status would have open new possibilities for the higher layers of the system and the processes in the post.

Keywords: RFID, GS1, smart label, EPC, post

1. Introduction

Postal process can be improved by new technologies. New technologies can offers new possibilities and advancement into progress of postal services. It is needed improve current state of package labeling to new type of labeling, which can be more sophisticated. We need to select most suitable solution for hardware and for type/format of data which we will store on the carrier.

2. EPC-Eletronic Product Code

This code uniquely identifies a product, item, room, place or any object.
It was created in the center of the MIT Auto-Id. Acronym EPC itself means electronic product code. And whole identification is based on electronic form. The identification number is coded and stored to RFID tag for example. EPC code itself is possible to store not only on RFID tags but it can be stored on various carriers (2 dimensional codes). With this unique code, we can identify any one item or product individually and uniquely. The granting of the identificiations numbers is in charge of the EPC global. EPC global is under non-profit organization GS1. In Slovakia is EPC organization represents GS1 Slovakia organization. Without authorization from the organizations mentioned above is not possible gain and use EPC code.[1]

This ensures uniqueness of the numbers. The number itself is meaningless without connection to database. And EPC as a unique key allows to access data on a particular product, which are stored in databases.

EPC structure:

- Head- defines type of EPC code. For each type of EPC is different 8 bit combination.

- EPC manager number. Prefix of company and assigned number from GS1 – GS1 company prefix
- Type of item- Type of product, not unique product but group of products (yogurt, milk)
- Serial number- This number refers to certain product, you may find additional information about the product[1]

Company can gain GS1 prefix only from GS1 organization and this number contain info about this organization. GS1 prefix is followed by prefix of company and together are creating GS1 company prefix.

3. Current status in Slovak post

Slovak postal is using one dimensional bar CODE 128 for pack labeling. This code can contain alphanumeric characters. This barcode consisting of 13 alphanumeric characters including control number. First two characters are reserved for code of service (table 2). This two characters are followed by 8 character string. This string contains number and this number is growing in range that was granted by Slovak postal. Bar CODE128 has three variants. Basic variant can support alphanumeric characters. CODE128B support alphanumeric characters as well but it can obtain small alphabet characters, too. The third variant can support longer string up to 19 characters, but only support numbers. Slovak postal need only large alphabet characters and numbers(table 1), therefore CODE 128 is sufficient. [2]

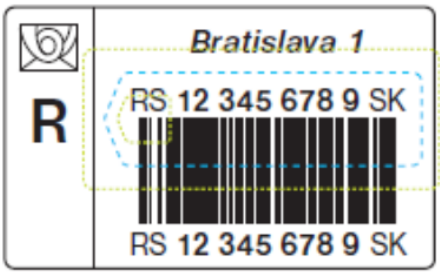

Fig. 1. Current label [3]

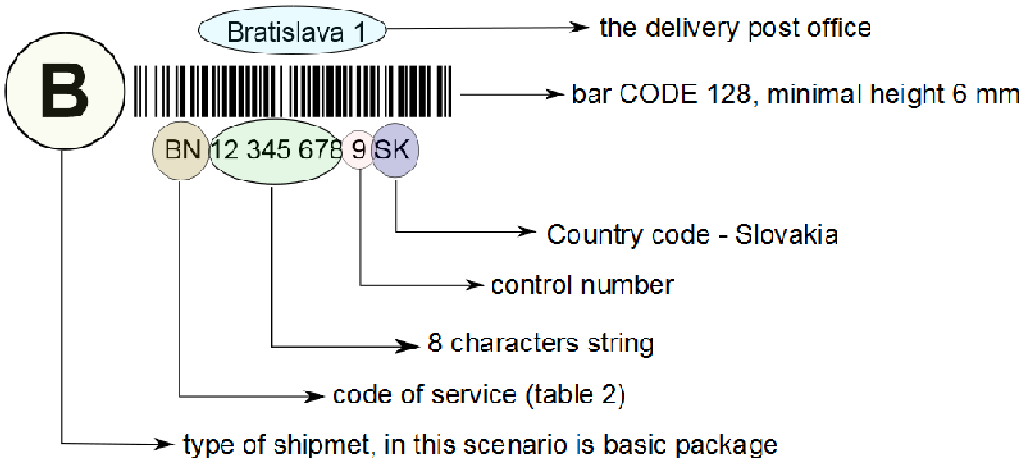

Fig. 2. Current label decomposition[4]

Type of packs (Consignments)	Prefix granted from Slovak Postal for labeling			
	domestic service		International service	
package	B	N,O,P,R,S,T	-	-
Contract package	Z	A-N	Z	O-Z
Contract package (sub type)	X	A-N	X	O-Z
Insurance letter	V	N,O,P	V	N,O,P
Official Consignment	U	N,O,P	-	-
Express Consignment	E	A-C,I,L,P	-	-
Express Consignment (sub type)	C	B,Y	-	-

Table 1. Type of consignments [3]

4. Possibilities of passive RFID technology in the post

RFID (radio frequency identification): RFID technology is using electromagnetic field for communication between terminal and electronic tag. The tag is attached to the object, goods or room about which carriers identification data. This identification data can be easily read by reading device and store or send for further data processing by system. [5]

Binary representation	Hexadecimal form	Size in bits	name
1111 1111	FF	undefined	Reserved for heads longer than 8 bits
0011 0011	33	96	GRAI-96
0011 0010	32	96	SGLN-96
0011 0100	34	96	GIAI-96
0011 0110	36	198	SGTIN-198
0011 0111	37	170	GRAI-170
0011 1000	38	202	GIAI-202
0011 1001	39	195	SGLN-195

Table 2. Selected types of heads and its interpretation[6]

Combinatorics give us 256 possible combinations of head (2^8). This value is relatively high but we can not forget it is limited. Some of combinations are reserved, undefined or already in use.

EPC code is code that exists in various forms and can be stored on various types of medias. It is not necessary that the EPC code is stored on the RFID tag only. Databases can work with EPC code and it does not matter form where EPC code was read. EPC stand alone above hardware solution and RFID tag is one of possibilities to store it. [7]

Elementary forms of EPC code:

- EPC in exact form of GS1 key,
- EPC Pure Identity,
- EPC TAG URI (only in RFID environment),
- EPC Raw URI (usually in case when tag does not contain valid EPC code),
- EPC binary form (only in RFID environment). [8]

4.1. RFID variants

Passive RFID **tags** are currently the most widely used type. It does not contain its own power supply which reduces the production cost at a minimum. The communication uses a power capacitor that is charging upon request by the transmitter. The transmitter periodically sends a signal to charge a capacitor tag corresponds by feedback, if the tag is in signal range. If we assume about RFID in post the most suitable solution will be use of passive RFID technology (due cost and variability). We can use RFID tag with combination of optical visible layer for packs labeling. This combination is called smart label.[5]

4.2. RFID Smart labels

One of the options to replace current postal system based on one-dimensional bar code is the use of smart labels. This is elegant combination of the bar code and identification using RFID. The advantage could be the use of two-dimensional bar code with additional information readable for humans or optical readers on top layer. Smart labels are basically a two-layer tags. The top layer is a layer of printed information for people or barcode readers. The bottom layer contains an electronic circuit and antenna-chip RFID tag. The label is typically located on the silicon substrate, which sticks to the labeled item. Whole smart tag is very thin, flexible and behaves like an ordinary stickers and can be delivered and stored in rolls. In the current system is information printed in CODE 128. This status can stay and be expand by system solution based on RFID tags. Or it may be to review the existing system and we can change information on the visible part of the smart label. For easy visual identification by human he can just uses the top of the label and he can read information(printed text). Not always we have available optical or RFID reader, but system has 3 level backup(one is text for humans, second one is information for optical readers and third one is information coded in RFID tag) and chance that we will not be able read any of this forms are zero. [9]

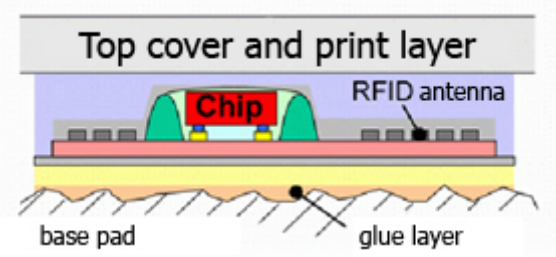

Fig. 1. Smart label [9]

5. Conclusion

One way to improve the postal business processes is replacement of the existing one dimensional barcode labeling by smart labels with RFID. Add value of new system is also main characteristic feature of RFID system: no need to optical reading of RFID tag content. By using RFID tags we naturally achieve more than a simplified reading. Into RFID tag can be coded much more information than to the existing one-dimensional bar codes CODE128 which can hold to 13 characters. If we used the EPC code it would be able uniquely identify the shipment in a central database, or we can use the structure of EPC code to code data as required. GS1, as authority for the allocation of EPC codes, does not allocate code with head for “pack” or “shipment” or for “post services”. Therefore, we had to go through a difficult approval process of creating standards for

postal operators. This process would require wider agreement of postal operators. Promising way would be to use the existing EPC standards and code the structure as we needed.

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References

[1] *EPC* [online]. [Cit. 2012-03-09]. Available on internet: http://www.gs1sk.org/elektronicky-produktovy-kod

[2] [online]. [Cit. 2013-03-04]. Available on internet: http://bartech.sk/blog/technologia/ciarove-kody/

[3] [online]. [Cit. 2013-03-04]. Available on internet: http://www.posta.sk/subory/36947/technicke-parametre-oznacovanie-zasielok.pdf

[4] [online]. [Cit. 2013-03-04]. Own source. Available on internet: http://www.posta.sk/subory/36947/technicke-parametre-oznacovanie-zasielok.pdf

[5] GLOVER, B., BHATT, H.: *RFID Essentials*, O'Reilly Media, USA, 2006. ISBN 978-0596009441.

[6] GS1 EPC Tag Data Standard 1.6. 2011. [online]. [Cit. 2012-20-03]. Available on internet: <http://www.gs1.org/gsmp/kc/epcglobal/tds/tds_1_6-RatifiedStd-20110922.pdf>.

[7] *GS1 EPC Tag Data Standard 1.6.* 2011. [online]. 2011. [Cit. 2012-02-03]. Available on internet: <http://www.gs1.org/gsmp/kc/epcglobal/tds/tds_1_6-RatifiedStd-20110922.pdf>.

[8] *General Questions about the Electronic Product Code (EPC).* [online]. [Cit. 2012-01-06]. Available on internet:<http://www.kentraub.net/tools/tagxlate/FAQ.html>.

[9] Antonín Vojáček. *RFID Smart Label a RFID vs. Čárový kód*. 2007. [online]. [Cit. 2012-20-03]. Available on internet: <http://automatizace.hw.cz/rfid-smart-label-rfid-vs-carkovy-kod>.

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The Possibility Reduction of Fuel Consumption and Toxic Emission on the Example Hybrid City Buses

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Abstract. In the case of city buses, on-going operating costs are critical to the overall cost of purchase and use of the vehicle. That's why researchers from the Institute for Combustion Engines and Transport was taken in the subject economic balance on the example of urban public transport enterprises. For an objective assessment of fuel consumption it is necessary to determine all variables. Therefore, developing a driving test, having the real use of buses and fixed the implementation of stringent procedures testing and measurement. The article presents the results of tests carried out to test fuel consumption by public transport buses SORT (Standardised On-Road Tests Cycles).

Keywords: Emission, city bus, combustion engine CI DI, hybrid bus.

1. Introduction

Ecological drivetrains are currently used in both heavy-duty trucks and buses. The latter utilize this technology mainly in the city municipal transport (city buses). This is related to the fact that the operating conditions of the vehicles in large agglomerations are characterized by frequent stops. The acceleration and braking phase is realized on short distances. Very often the acceleration and the braking phase are separated by a stop phase. The frequency of these phases is high and it depends on the factors related to the traffic. These can be: time of day, route throughput, traffic congestions, etc. Under such conditions, with the conventional drivetrain the combustion engine operates within a large range of power output, engine speed and efficiency. The overall energy efficiency of the conventional drivetrain is additionally reduced by the irreversible change of the kinetic energy into heat during frequent braking.

In order to comply with the new technology trends, MPK in Poznan (local bus operator) was the first to purchase a hybrid bus. The benefits from the use of such an innovative technology are clearly visible, which is confirmed mainly by the comparison of this new purchase with the ones already used in MPK.

ON-ROAD emission tests were performed under actual operating conditions in the SORT driving tests on the runway of the Bednary airstrip. In order to measure the energy consumption and the exhaust emissions by a given vehicle or the influence of individual vehicle accessories on the total energy balance it is necessary to determine all the variable factors such as: vehicle speed, engine load, acceleration, distance covered etc. To this end driving tests are developed that characterize the actual vehicle operation and procedures are constructed of the realization of these tests and of the performance of the measurements. The SORT driving tests have been developed by *International Association of Public Transport (UITP)* to evaluate the gas mileage of the city buses compliant with the standard of Euro IV and higher (Fig. 1). Three tests reflecting the following operating conditions have been distinguished (table 1):

a) Heavy Urban SORT 1 – exact downtown area of the city,
b) Easy Urban SORT 2 – within the city limits,
c) Suburban SORT 3 – suburban routes.

Due to the nature of city bus operation during the energy consumption tests of the individual accessories SORT 1 driving tests have been carried out (exact downtown area of the city).

	SORT 1	SORT 2	SORT 3
Average speed [km/h]	12,6	18,6	26,3
Share of vehicle standstill in the tests [%]	39,7	33,4	20,1
Constant speed in profile 1 [km/h]/[m]	20/100	20/100	30/200
Acceleration in profile 1 [m/s^2]	1,03	1,03	0,77
Constant speed in profile 2 [km/h]/[m]	20/200	40/220	50/600
Acceleration in profile 2 [m/s^2]	0,77	0,62	0,57
Constant speed in profile 3 [km/h]/[m]	40/220	50/600	60/650
Acceleration in profile 3 [m/s^2]	0,62	0,57	0,46
Stoppage after each profile [s]	20/20/20	20/20/20	20/10/10
Distance covered in the test [m]	520	920	1450
Deceleration in the speed profiles [m/s^2]	0,8	0,8	0,8

Tab. 1. SORT driving tests characteristics.

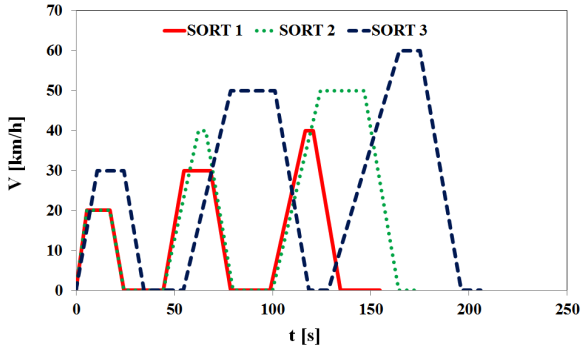

Fig. 1. The course of the SORT test (as a function of time); V = f(*t*).

2. Equipment used in the tests

For the tests the authors used a portable exhaust emission analyzer SEMTECH DS (fig. 2 - 3) manufactured by Sensors Inc. The exhaust sample is taken through a probe and supplied by a heated line maintaining the temperature of 191oC. Subsequently, the exhaust gases are filtered out of the particulate matter (diesel engine only). Then the measurement of the concentration of hydrocarbons is carried out in the FID (Flame Ionization Detector). The sample is cooled down to the temperature of 4^{o}C and in the NDUV (Non-Dispersive Ultraviolet) analyzer the measurement of the nitric monoxides and nitric dioxides is performed and in the NDIR (Non-Dispersive Infrared) the concentration of carbon monoxide is measured. The measurement of oxygen is carried out through an electrochemical sensor. Semtech also records parameters taken from the vehicle OBD and GPS (Global Positioning System). The analyzer can be controlled by a personal computer and through a wired or wireless connection.

Fig. 2. SEMTECH DS measurement device.

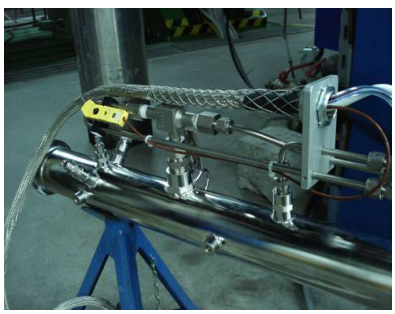

Fig. 3. Mass flow meter measuring the exhaust mass flow

3. Test results

The tests were performed in standardized conditions for the hybrid bus and for the conventional bus with a regular diesel engine (9,2 dm3 DAF PR 265) were carried out.

The tests were divided into 3 groups [3]:

- SORT1 – Heavy Urban – city center traffic (average speed 12 km/h),
- SORT2 − Easy Urban – city– combined urban and suburban traffic (average speed 17 km/h),
- SORT3 – Suburban – suburban traffic (average speed 27 km/h).

The tests results have been presented in figure 4.

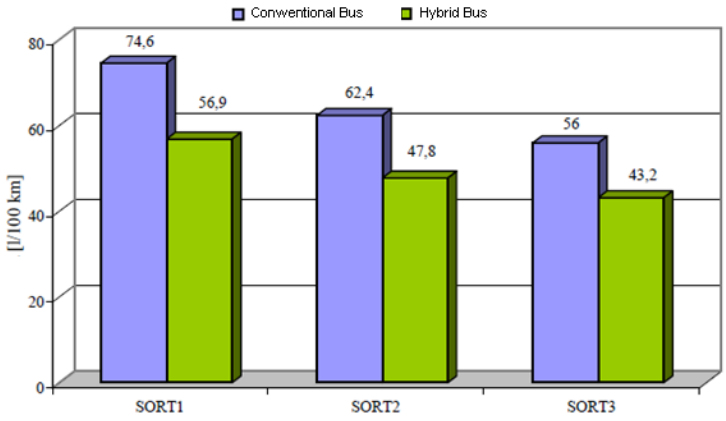

Fig. 4. Fuel consumption in the SORT tests.

During the tests in Poznan a test drive on the same route was realized by the hybrid and the conventional bus (fitted with a diesel engine). The vehicles covered a distance of 61,50 km and 61,42 km respectively. The average and unit fuel consumption have been shown in figures 5 and 6.

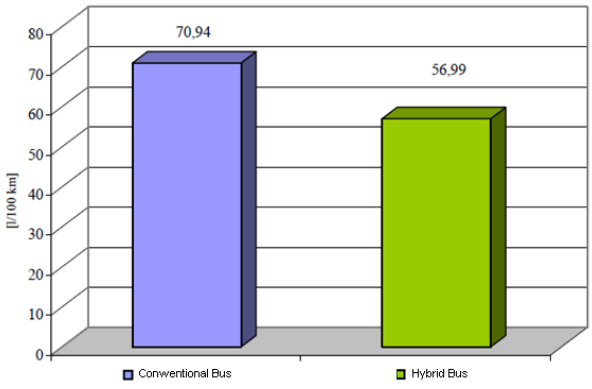

Fig. 5. Average fuel consumption in the urban traffic in Poznan

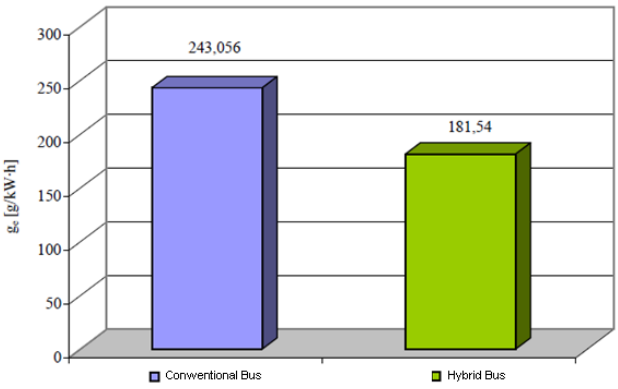

Fig. 6. Unit fuel consumption in the urban traffic in Poznan

4. The exhaust emissions from the hybrid bus

Another argument for the application of hybrid technology in vehicles is lower exhaust emissions. This is confirmed by the results of the tests carried out in bus on-road tests by the Institute of Combustion Engines at Poznan University of Technology. The comparative test was performed on a pre-selected route in Poznan.

The on-road exhaust emissions and unit exhaust emissions have been shown in figures 7 and 8.

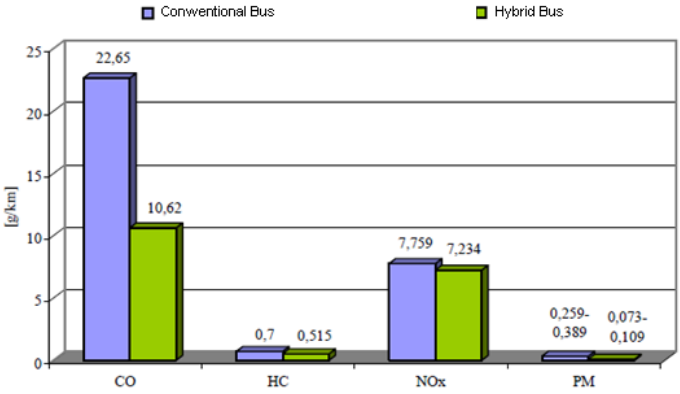

Fig. 7. The on-road exhaust emissions from the buses

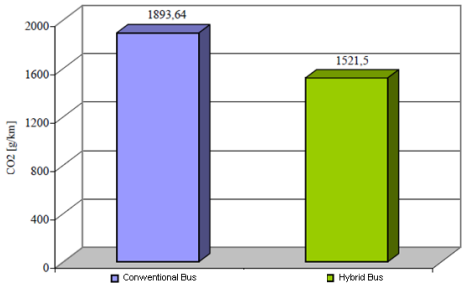

Fig. 8. The on-road emission of CO_2 from the buses

5. Conclusion

A contemporary hybrid bus is a technologically advanced vehicle utilizing modern mechanical and electronic systems.

The application of hybrid technology in city buses is extremely advantageous because in the city the buses move in a frequent stop and go manner. Frequent drive-offs and stoppages create perfect conditions for energy accumulation that comes from the energy surplus from the engine and kinetic energy recuperation. Thanks to this feature of the system we can use the accumulated energy when the vehicle drives off. The hybrid system enables the operation of combustion engines at optimum parameters in the energy-related and ecological aspects. This, in turn, contributes to a significant reduction of the fuel consumption and exhaust emissions, PM in particular, which is confirmed by the performed comparative tests in the city traffic. It is noteworthy that the benefits are heavily dependent on the local conditions and on how the vehicle is operated. In order to obtain maximum benefits in both areas it is necessary to precisely adjust the control systems to the conditions of operation and train the drivers to properly operate such sophisticated vehicles.

The hybrid bus also has a much lower noise emission. At the speed of 50 km/h the noise emissions is 61,2 dB(A) in the vicinity of the driver's compartment and 73,2 dB(A) in the vicinity of the rear axle. The vehicle, thus, complies with the very stringent EU standards set forth in directive 70/157/EEC [4].

It should also be noted that additional elements stabilizing the power of the initial source, irrespective of the type and value of the external load, enable the application in the electromechanical systems of engines of lower power output as compared to the ones with the mechanical drive.

References

[1] AVL, *Current and Future Exhaust Emission Legislation*. AVL List GmbH, Graz 2007.

[2] CHŁOPEK, Z. *Ocena zużycia paliwa przez autobusy komunikacji miejskiej*. Polish Scientific Society of Combustion Engines (2010-SS6-480)

[3] GAO, Y., CHECKEL, M. D. *Experimental measurement of on-road co2 emission and fuel consumption functions*, SAE Technical Paper Series 2007-01-1610.

[4] YANG, W.C., TOBLER, W.E. *Dynamic modeling and analysis of electronically controlled power steering system*" 1993, American Society of Mechanical Engineers, Dynamic Systems and Control Division (Publication) DSC 52 , pp. 267-278

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The analysis of the design of innovative drivetrains in ecological city buses

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Abstract. Rapid technological advancement, a fresh look on the ecology-related issues and ever-stringent exhaust emission limits lead to dramatic changes of the image of public transport. One of the very prominent changes is the search for more efficient technologies and fuels used in public transport. Municipal bus operators are thus forced to adapt to the changing requirements. The paper discusses the benefits from the new drivetrain technologies and the differences between the old and the new technologies are shown as a comparison between new buses and the already existing ones.

Keywords: Air quality, health impact.

1. Introduction

Ecological drivetrains are currently used in both heavy-duty trucks and buses. The latter utilize this technology mainly in the city municipal transport (city buses). This is related to the fact that the operating conditions of the vehicles in large agglomerations are characterized by frequent stops. The acceleration and braking phase is realized on short distances. Very often the acceleration and the braking phase are separated by a stop phase. The frequency of these phases is high and it depends on the factors related to the traffic. These can be: time of day, route throughput, traffic congestions, etc. Under such conditions, with the conventional drivetrain the combustion engine operates within a large range of power output, engine speed and efficiency. The overall energy efficiency of the conventional drivetrain is additionally reduced by the irreversible change of the kinetic energy into heat during frequent braking. For this reason a city bus is a type of vehicle in which the advantages of a hybrid system stand a chance of being used to the greatest extent. The application of such an innovative solution ensures both economic and ecological benefits.

In order to comply with the new technology trends, Miejskie Przedsiębiorstwo Komunikacyjne w Poznaniu (local bus operator) was the first to purchase a hybrid bus. The benefits from the use of such an innovative technology are clearly visible, which is confirmed mainly by the comparison of this new purchase with the ones already used in MPK..

2. Helpful Hints

The drivetrain of the hybrid city bus utilizes a diesel engine manufactured by Cummins. The other element of the hybrid drivetrain at the same time its basic component is the Ep50 system (Fig. 4.2) by General Motors. The hybrid drivetrain fills a gap between the conventional drivetrain using a combustion engine and the latest zero emission technologies. Buses fitted with this system have much lower fuel consumption and reduced exhaust emissions. They also have better acceleration than the conventional vehicles fitted with diesel engines and they drive off in a much quieter manner.

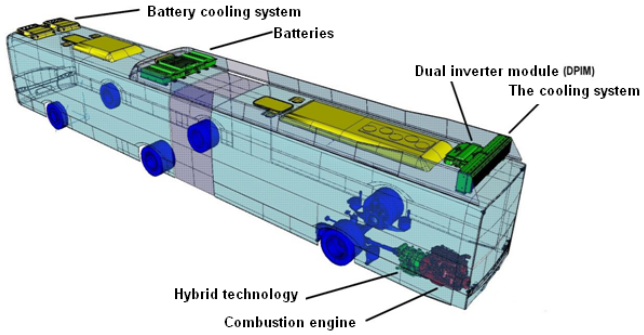

Fig. 1. Schematics showing the drivetrain components of Hybrid bus [2].

The components of the drivetrain are located in the rear part of the bus, similarly to the conventional vehicles. The engine is fitted vertically in the rear part of the bus and the power is transferred to the third axle of the bus. The other parts of the hybrid system such as the batteries and two inverter modules have been installed on the roof, which helped obtain optimum axle loads.

The bus operators are thus free to arrange the interior of the bus and the passengers do not see any difference compared to the conventional buses. Only the roof design and the much more quiet bus operation tell that this is an ecological vehicle.

3. The drivetrain

The basic elements of the hybrid system (Ep50 System™) (Fig. 3) used in the hybrid bus are - as the manufacturer assures – a true study of functional simplicity". The whole system, beside the engine, is composed of five elements:

- EV Drive™ (drive unit),
- dual power inverter module (DPIM),
- energy storage system (ESS),
- two electronic modules controlling the hybrid drive (HCM),
- pushbutton shift selector (PBSS).

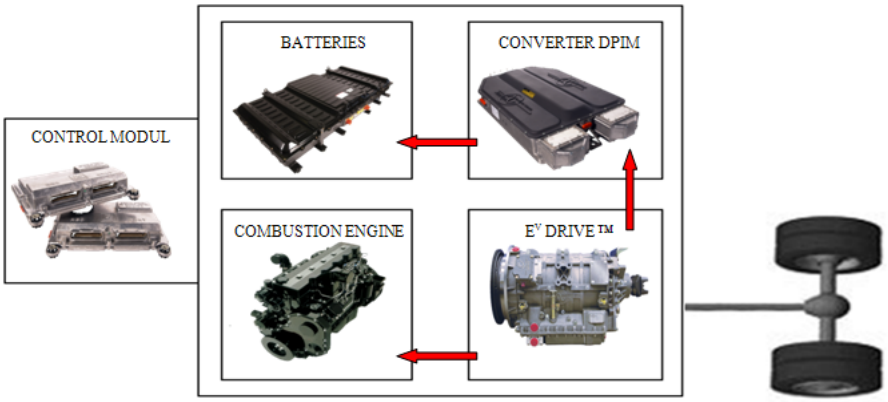

Fig. 2. The Ep50 System™ hybrid system used in the analyzed bus.

The individual system components are located in the bus in the following configuration: the cooling system is above the driver's compartment, the batteries are on the roof of the A section just before the articulation, DPIM and the cooling are above the engine tower and the engine, typically for the Urbino family is fitted askew on the left side of the body in the B section. The E^V drive is located in the place where a transmission is usually located.

The most important element of the system is the E^V Drive™ module (Fig. 3) where blending of the torque of the combustion engine and the electric motors takes place (Fig. 4).

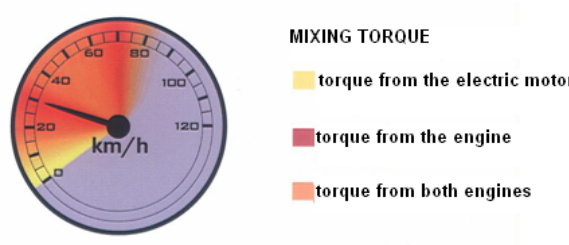

Fig. 3. The Ep50 System™ hybrid system used in the analyzed bus.

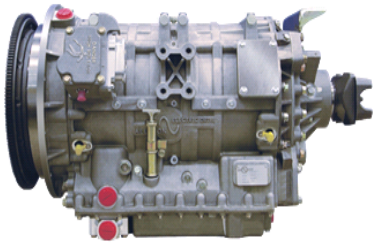

Fig. 4. The EV Drive™ module [1]

All the elements of the system co-operate with one another. The electric generator motors work as clutches of variable characteristics controlling the engine speed acceleration and deceleration and blocking of the gears of the planetary gearsets. All these mechanisms are located concentrically.

The Dual Power Inverter Module (Fig. 5.) is the main electric part of the hybrid system. It is composed of two AC/DC - DC/AC inverter modules operating in the range of 430-900 V.

Fig. 5. Dual power inverter module DPIM [2]

The energy storage system of the mass of 437 kg contains 6 battery packs each of which contains 40 NiMH batteries. This totals with the number of 240 gel technology batteries in the ESS system. The batteries are located on both sides of the ESS along with other components: control modules, fuses, and relays inside the system. The whole system is air-cooled and the rated voltage is 600V. The system is equipped with appropriate fire protection system. The high voltage circuit is not connected to the vehicle ground and each of the battery packs is insulated to protect it from components operating at low voltage.

The period of operation of the 2183mm x 1116mm x 283mm, 410 kg NiMH batteries is approximately 6 years depending on the driving characteristics of the bus.

The whole ESS system is cooled through a radiator that is located directly near the storage system and through an air-conditioner of the hybrid drive battery located in the front of the vehicle.

The Hybrid Control Module HCM (Fig. 6.) is the brain of the hybrid drive that processes signals and data from the sensors in the system subcomponents providing information related to the driver activity.

Fig. 6. The hybrid control modules HCM [2]

Fig. 7. The actual view of the PBSS selector fitted in the bus [2]

The HCM is composed of two control modules by Allison 1000/2000. The role of the first unit is the control and management of the operation of the hybrid drive while the other unit controls the cooperation of the system with the vehicle subcomponents. These two controllers process information from the system subcomponents, send commands to the actuators and control the drive to ensure the precision of the drive operation and energy production. The controllers can also realize diagnostic functions and be reprogrammed.

The Pushbutton Shift Selector PBSS (Fig. 7) controls the driving direction (forward, idle, reverse). PBSS is also used to control the operation of the oil level sensor, flash the error codes and control the recuperation brake.

4. Conclusion

The exhaust emission limits that become more and more stringent as well as the skyrocketing prices of crude oil forced the engineers to seek alternative powertrains to adapt to the existing situation. A purchase of a hybrid bus aims at a reduction of the fuel consumption and meeting of the ever-growing ecological requirements.

Based on the performed analysis of the operating conditions, the results of the performed bus fuel consumption tests and the discussions on the obtained results we may formulate the following conclusions:

1. The performed fuel consumption tests have shown that use of the hybrid bus in the period from 2008.11.08 through 2009.02.10 as compared to conventional vehicles (fitted with diesel engines) resulted in a reduction of the fuel consumption on the level of 7,75%. The operation of a hybrid bus thus brings measurable economical benefits (fuel consumption).
2. The operation of the hybrid bus on regular Poznań bus routes within the testing period resulted in a reduction of the fuel consumption of 11,03% and during the Poznań Climate Change Conference this value was only 2,11 %. Hybrid buses are very efficient when operating on regular routes and when the routes are irregular (frequent and long stops, longer distances between the bus stops, low daily mileage) their use is not economically justified.
3. The average reduction of the fuel consumption on the level of 11% during the operation on the bus routes is not as large as that specified by the vehicle manufacturer (15-25%). This could be the result of:
   * the season of the year when the bus was operated (winter);
   * insufficient driver experience in driving hybrid buses requiring a different driving style.
4. The fuel economy of the hybrid bus is mostly dependent on the type of route on which it is operated as well as the daily mileage it covers.

References

[1] CHŁOPEK, Z. *The methods of synthetic assessment of emissions from engines*. Polish Scientific Society of Combustion Engines (2009-SS4-407).

[2] PAWELSKI, Z. *Napęd hybrydowy dla autobusu miejskiego*. Wydawnictwo Politechniki Łódzkiej, Łódź 1996.

[3] SERDECKI, W. *Badanie silników spalinowych – laboratorium*. Wydawnictwo Politechniki Poznańskiej, Poznań 1998.

[4] WAJAND, J.A., WAJAND, J.T. *Tłokowe silniki spalinowe średnio- i szybkoobrotowe*. Wydawnictwo Naukowo – Techniczne, Warszawa 2005.

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Basic principles of new recursive 3D reconstruction algorithm

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Abstract. This paper proposes a new algorithm for 3D model reconstruction from two images. At beginning of the paper there is a brief introduction to the issues of 3D reconstruction and speed problems in real-time applications. The main part of paper describes and discusses our proposed algorithm.

Keywords: 3D reconstruction, computer vision, 3D vision.

1. Introduction

In the intelligent transport systems (ITS) there are devices used as input, such as sensors or cameras. It is possible to gain a 3D model of space, if two cameras are used. They allow us to get an approximate distance, direction, speed and size of detected objects.

The 3D reconstruction algorithm is the most used for navigation of mobile robots. In most cases, it is about using dense geometric approximation[1]. Rossi and Savatier [1] implemented this approach to mobile robot using GPU in real-time.

The common first step of 3D reconstruction is to identity *feature points* which are candidates for corresponding ones (same place of real point on one image has to be corresponded to the same real point on another image). So they must be founded on multiple images regardless of the noise, rotation, translation or other transformations between images. Finding of these points is the most computationally demanding operation and it is called as *feature finding*.

Finding of feature points is not easy. It can be used such algorithms as edge detectors, adaptive window, corner detectors, etc. The main difficulty is caused by need of processing all input images per pixel with focus on neighborhood pixels for all input images. This must be proceeding, because each algorithm tries to finding as much feature points as is possible (the more detected points mean the more overall quality of reconstructed model is). In addition this operation has huge computational complexity.

The 3D reconstruction process itself is based on *epipolar geometry*. It describes geometrical relations between multiple projections of the same points on them. For example multiple cameras can see common scene using different angle. One point of real world is reflected on surface of each camera in different places. These reflected points of one real point are called corresponding points (feature points are candidates for them). The 3D reconstruction is projection processing, so it is necessary to have at least two projection surfaces using known corresponding point on them. Steps of each 3D reconstruction algorithm can be as follows:

1. *Image filtering* – removal of noise, highlighting of weak areas, brightness correction, color adjusting, etc.
2. *Feature points detections* on all images – it can be carried out by edge detector, corner detector, combination of detectors, etc.

[1] Dense geometric approximation means that every pixel of input images is processed for real point depth approximation [2].

3. *Finding of the corresponding points* – matching of feature point candidates in all images.
4. *Reconstruction of the real detected points.*

One of things that extends computing time is homogeneous texture area (or area with poor texture variation). These areas force algorithm to search in wider neighborhood for more accurate feature information of each pixel.

2. Basic principles of proposed algorithm

The most computation time is taken by finding feature points. Some reduction time can be done by skipping homogeneous texture areas. Segmentation and dynamic depth of details, and load balancing to multiple CPU cores can reduce calculation time too.

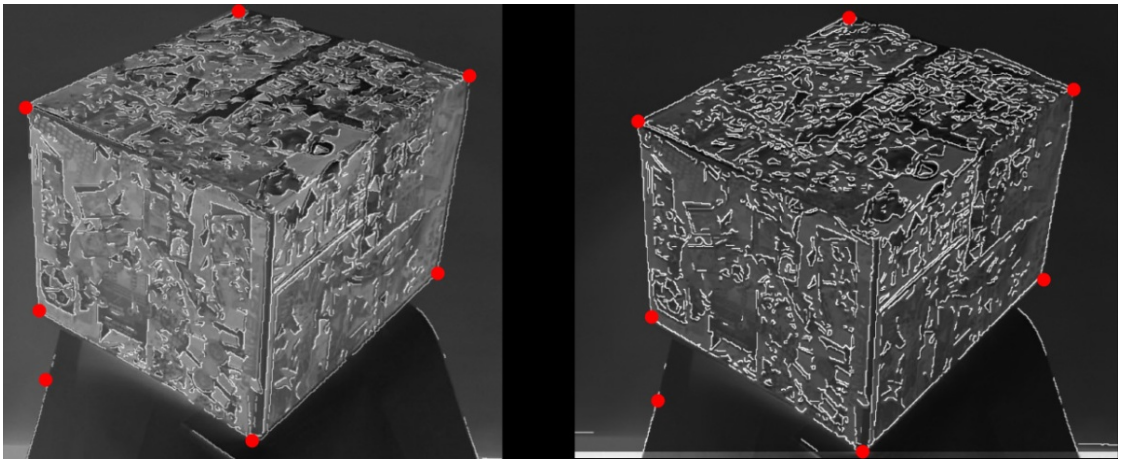

Fig. 1. The box of non-homogenous texture, white lines present edges, red dots present founded of first points after first iteration of algorithm.

The main core of the algorithm is method for extraction of feature points from one image segment using given number (algorithm does not fit into the dense algorithm group [2]). At beginning the whole image will be as starting segment. The result of the first iteration is demanded number of feature points, which can be the easiest detected (fig. 1). These points split segment into *triangle subsegments* and will be merged to the global mesh structure.

Each triangle of mesh represents separate image and can be analyzed again so we will get level of details. Triangle segmentation can be used for computing on multiple CPU or GPU (like Ruigang Yang and Marc Pollefeys does in [3]). For every triangle a describe vector will be created. This vector obtains information about texture intensity (homogenous or heterogeneous texture) in created subtriangle area. Homogeneous texture triangles will be skipped, if the describe vector will be under specified threshold. In next iteration it can be created new subtriangles with vector description, again and again, until is reached demanded level of detail (fig. 2).

The 3D reconstruction can run on low resolution input. Output 3D mesh can be applied on high resolution image. The main benefits of this algorithm will be:

1. Reduce of computing power and time by its distribution on multiple CPU, CPU cores or GPU for some computations.
2. Ability of the influence quality of final 3D model with level detail for reduces of computing power.
3. Skipping of texture-less areas.
4. Ability to use low quality cameras.

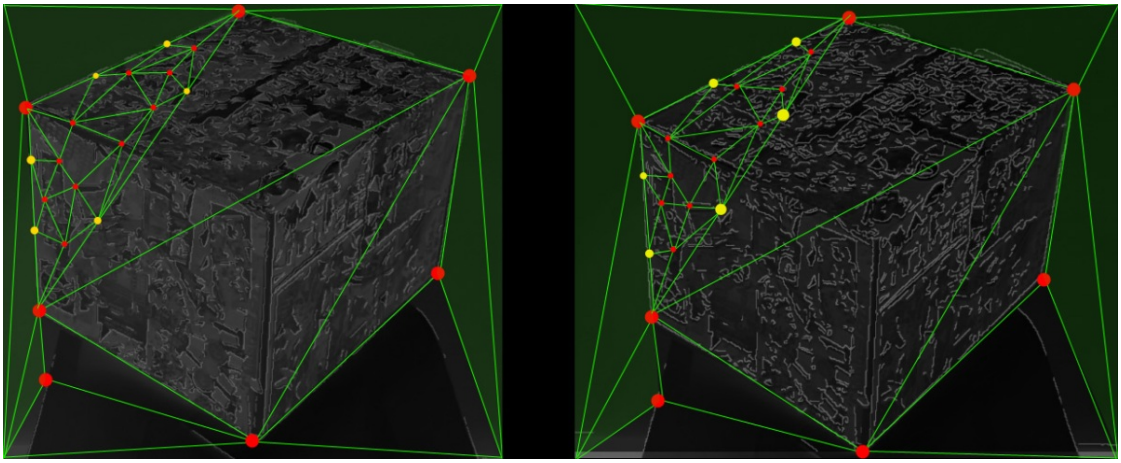

Fig. 2. The red dots are known points from past iterations. Light green lines presents edges of triangles or image areas, and yellow points are auxiliary points for easier creating of subtriangles.

3. Conclusion

The paper briefly describes our idea of 3D reconstruction algorithm. The next step in further research will be developing a method for quick detection of demanded number of points from selected image segment and use of the knowledge of the point position from first image in second image. It will be also interesting a test algorithm using multiple cameras and its comparison to existing algorithm.

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"Podporujeme výskumné aktivity na Slovensku/Projekt je spolufinancovaný zo zdrojov EÚ"

References

[1] ROSSI, R., SAVATIER, X., ERTAUD, J.Y., MAZARI, B.: *Real-time 3d reconstruction for mobile robot using catadioptric cameras*. In: Robotic and Sensors Environments, 2009. IEEE International Workshop on ROSE 2009, pp. 104 –109, Nov 2009.

[2] SCHARSTEIN, D., SZELISKI, R.: *A taxonomy and evaluation of dense two-frame stereo correspondence algorithms*. International Journal of Computer Vision, vol 47, issue 1-3, pp 7–42, Apr 2002.

[3] YANG, R., POLLEFEYS, M.: *Multi-resolution real-time stereo on commodity graphics hardware*. IEEE Computer Society Conference on Computer Vision and Pattern Recognition, pp I–211 – I–217, vol.1, June 2003.

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Automatic Incident Detection Based on Historical Model Created Using PCA Method

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Abstract. Automatic Incident Detection (AID) in road networks serves as an input for traffic control systems and systems informing the drivers. The paper describes global traffic state model approach based on processing of traffic sensors data from particular area. The dimension of multidimensional traffic states is reduced using Principal Component Analysis (PCA). Comparing field data with a historical model (typical traffic behavior in the area), it is possible to automatically detect non-standard traffic situations (accidents).

Keywords: AID, road traffic, global traffic model, state space, PCA, dimension reduction

1. Introduction

Traffic incidents (congestions and accidents) have negative impact on level of road traffic service. The Automatic Incident Detection (AID) algorithms like California algorithm, McMaster's algorithm, MEX (Tokyo Metropolitan Expressway) or ARIMA (Autoregressive Integrated Moving Average) can help to reduce their negative impact [1]. The existing traffic detectors can be effectively utilized as a data source for implemented control or telematics systems.

This article describes an innovative method how to create a global model of road traffic in the observed area (highway section in rural zones or road network in urban zones). The conventional methods are based on evaluation of traffic parameters in a single profile of communication. The idea of the global model is a description of traffic state behavior based on historically measured elementary traffic parameters (flow rate, speed and density) at level of the whole observed area.

The preprocessed traffic parameters are converted to traffic states of a state space in a discrete time intervals. However, with respect to the count of detectors, the state space may have too many possible states. Therefore the proposed method considers dimension reduction using Principal Component Analysis (PCA). The state space having significantly reduced dimension performs better from statistical evaluation point of view, but it is also more suitable for computer processing.

2. Input Data Description And Preprocessing

The basic measures characterizing the traffic are flow rate, speed and density. Flow rate q is defined as a number of vehicles n_t passing through a communication profile in time t. Time mean speed u_t is an arithmetical average of instant speeds $u(t_i)$ of all vehicles i passing through the profile in time unit t. Density k stands for a number of vehicles n_s observed in a unit of length s in one moment and as such it is defined as a section parameter, which is impossible to be measured in a particular profile [2]. Information about presence of vehicles on a communication section is represented also by time occupancy κ of a detector (hereinafter considered instead of the density). It is a ratio of total time when the detector is occupied by vehicles and the total measurement period t.

The data may come from various traffic sensors like inductive loops, laser sensors or video detection. The authors used inductive loops data provided by Road and Motorway Directorate of the Czech Republic. The data came from 8 detection profiles on Czech D1 highway and this set of data covers almost half a year 2009. The samples represented q, u and κ with 5 minutes aggregation.

The traffic characteristic database has been supplemented with database of accidents registered on D1 by police. Based on it, the days with an accident have been excluded from the input data and not considered in the historical model but they were used for verification of the algorithm.

3. State Space Modeling Approach

State space as a representation of all possible states of a dynamic system is convenient for a traffic description. Traffic modeling and prediction has been discussed in many studies. Crucial basics and outputs illustration of the usability of its application for urban or freeway stretch data are shown in text Multivariate state space approach [3]. Authors of similar studies described formation of method of vectors based on traffic stream model data and studied chronological time series and trajectory of vectors in state space [4]. Different researches were based on implementation into STARIMA models, based on detector location and relationships between sites in city areas [5].

State space can represent a base algorithm for Kalman filter traffic state estimator [6] or it can be for adaptive freeway traffic state estimator [7] utilized. Finally, state space has been presented as part of highly sophisticated application of origin-destination estimation [8]. Authors used state-space model because of its complexity of using all necessary variables, such as historical demand parameters. Investigation of the state space problematic shows, that state space is a modern and convenient method to transform traffic data from more detectors into "state" which will represent a qualitative parameter for further traffic examination. To transform considered discrete slices into a better evaluable form, it is necessary to use convenient reduction approach.

In terms of this article, the traffic state is theoretically expressed as current traffic parameters values in the observed road network. However, in practice the data are available only at measuring points (detectors) and for a given aggregation period (e.g. 5 minutes). That means the traffic state is both space and time discrete. Formally, the traffic state is defined as a 3-tuple

$$\vec{s} = \left(\vec{q}_t, \vec{u}_t, \vec{k}_t\right), \tag{1}$$

where $\vec{q}_t$ is a vector of values of flow rate q from all detectors in the area in time t; vectors of speed $\vec{u}_t$ and density $\vec{k}_t$ are defined by analogy. The state space (SS) is defined as a 2-tuple

$$SS = (S, \Theta), \tag{2}$$

where $S = \{s_i\}_{i=1}^{n}$ is a set of admissible states, n denotes a total count of admissible states of the system; $\Theta = \{\theta\}$ is a set of transitions, while $s_q = \theta_{p,q}(s_p)$ express transition from state s_p to s_q.

Dimension of the state space follows from a number of the variables describing a single state as

$$dim(SS) = |\vec{q}| + |\vec{u}| + |\vec{k}|. \tag{3}$$

In case of one detector recording three variable q, u and k, the state space dimension is $dim(SS) = 3$ (regular 3D space). For area monitored by n detectors, the dimension $dim(SS) = 3n$ (so called hyperspace). For instance, 7 detectors pose a dimension of 21 with hundreds of possible values on each axis, which means unacceptable computation complexity.

The historical model is a set of measured parameters and it can be depicted graphically as traffic parameters space distribution, which is changing in time. The model thus bears information about visit rate of the states, their corresponding time of day and probability of transition into subsequent states. The Fig. 1 (left chart) shows five states in non-reduced state space in particular time. As the traffic behavior depends on a day of the week, a different historical model has to be created for each week day (e.g. traffic situation course is different on typical Monday and Sunday).

4. Principal Component Analysis and Incident detection algorithm

For a huge amount of traffic data, PCA allows transformation of inputs into a smaller spatial dimension, while preserving the original variability. It creates new vectors, where each of them is a

linear combination of the original inputs. Outputs of this reduction algorithm are particularly principal components, secondarily component scores and variances (latent variables). First few principal components cover the largest variability part of the original data. The correlation values of traffic data can be projected in a new dimension in the 2D views (main component of flow rate, occupancy or speeds of several detectors), or in 3D dimension. There are several ways how to implement PCA and calculate principal components. Most frequently used are Singular Value Decomposition (SVD) or conversions through covariance or correlation matrices [9].

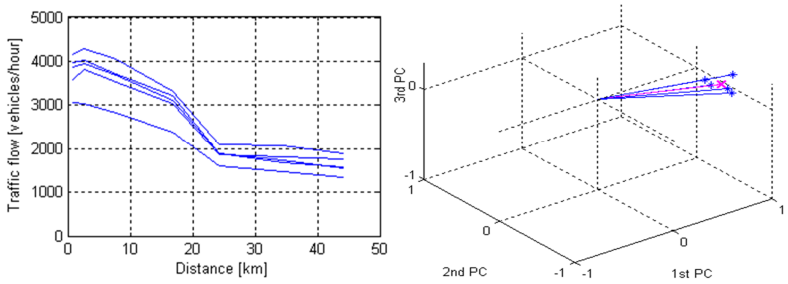

Fig. 1. In the left chart, there is a spatial distribution of flow rate q in time t (at 9:35) measured in different days d (5 successive Saturdays). The curves are linear interpolations of preprocessed traffic characteristic between detection profiles and represent the traffic states. The right chart depicts traffic states transformed into reduced dimension state space using PCA. The three first most significant principal components correspond to the axis of the new 3D space. Coordinates of the blue points * (highlighted by the vector from the origin) refer to the traffic situation (nearby positions mean similar traffic conditions). The violet point X is a cluster centroid (i.e. cluster representative) [authors].

The multidimensional state space historical model is converted using PCA method into 3D orthogonal state space. It allows an evaluation of the states and searching of the differences between signal of particular day and the average normal traffic behavior. The proposed approach utilizes simple clustering methods to detect sudden global traffic state deviations caused by traffic incidents.

The algorithm has two phases: at first it transforms all the historical progresses into reduced state space using PCA and store the transformed historical model back into the database. Afterwards, the analyzed day (data collected in real time) is processed in the same manner and it is evaluated against the historical model using clustering algorithm [10].

During the day, the area traffic assumes different states gradually. The algorithm processes all these states in a loop and transforms them into a new state space with reduced dimension. All the input vectors are centered by their mean value $\hat{x}$ and normalized into <-1; 1> interval (although the original values have been from <0; x_{max}> interval, because centering has shifted some values to negative numbers). It is important to normalize the vectors using single joint constant max($|x_d(t)|$) for all detectors in order to obtain comparable results across the whole analyzed area.

The final matrix **X** entering the PCA reduction algorithm at time t has a form

$$\mathbf{X}(t) = \begin{pmatrix} q_{d_1,t} & u_{d_1,t} & k_{d_1,t} \\ \vdots & \vdots & \vdots \\ q_{d_D,t} & u_{d_D,t} & k_{d_D,t} \end{pmatrix}, \qquad (4)$$

where $x_{d_i,t}$ means value of parameter x at detector i in time t; D is a total number of detectors.

The demanded outcome of the PCA transformation is a matrix containing principal components. If we select the three most significant components we obtain coordinates in the state space with reduced dimension. The five traffic states from the left part of Fig. 1 (only flow rate is displayed) are transformed into 3D state space as shown in Fig. 1 (in the right-hand chart).

When processing the whole day step-by-step, the changes of traffic conditions correlates with the movement of the transformed state and the trajectory of the point characterizes daily progress of the traffic situation. If the input data contains a sudden change of traffic conditions due to an incident, it raises a rapid deviation of the transformed state. Fig. 2 (left-hand diagram) depicts a daily course of speed u at a particular detector. The right-hand chart in Fig. 2 shows the trajectory of the transformed state, which correlates with a daily progress of the global traffic state. The state deviation corresponding to the incident can be observed there.

The key idea of the automatic incident detection is based on a comparison of the transformed current state (created from the on-line collected data) and the typical daily trajectories of the historical model. As the historical model does not contain days with accidents, clustering methods [10] can be used for recognition of the distinct states representing irregular traffic conditions. The algorithm calculates geometrical center of the typical states (so called centroid) and compares all states Euclidian distances from it. If the distance of particular state is greater than preset threshold (120% of average distance), the conditions are considered as an incident. The further research will concentrate on application of advanced clustering methods; especially it will focus on optimization of detection rate and minimization of false alarm rate.

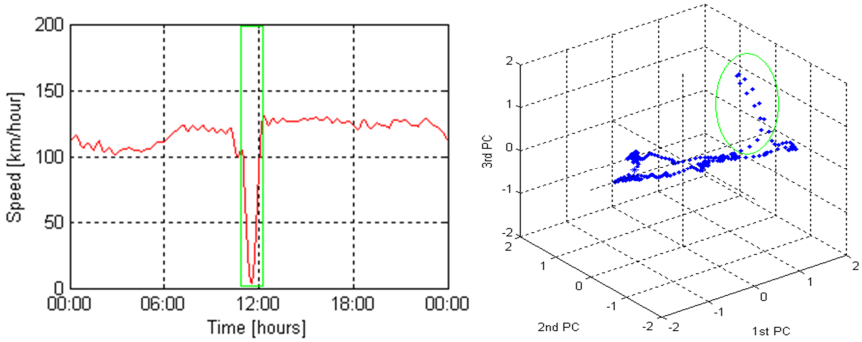

Fig. 2. On the left, time progress of mean time speed at particular detector is shown. A rapid decrease in speed due to an incident can be observed between 11:00 and 12:15 (highlighted by the green rectangle). The right chart shows a daily trajectory of the transformed state in the 3D state space with PCA reduced dimension. The gradual movement from left to right and back again is causally related to daily development of the area traffic situation. The rapid deviation (highlighted by green ellipse) is a result of changed conditions due to a traffic incident between 11:00 and 12:15 .

5. Conclusion

The paper describes a method for transformation of the global traffic state into new state space with reduced dimension using PCA. It allows composing of a historical model describing the typical traffic behavior in the whole area. Comparison of the on-line collected and transformed data with historical model can serve to detection of traffic congestions and accidents, using clustering methods. The advantage of the proposed approach is its potential to be generalized from application at line highways also for urban road networks. Such approach can be efficiently used as an input for telematics systems. The approach is designed in order to utilize existing traffic detectors and its implementation may help to increase safety and comfort of the drivers, with reasonable cost.

References

[1] PARKANY, E., XIE, Ch. *A complete review of incident detection algorithms & their deployment*. Amherst, 2005.

[2] PŘIBYL, P., MACH, R. *Řídicí Systémy Silniční Dopravy*. 1st ed. Prague: Vydavatelství ČVUT, 2003.

[3] STATHOPOULOS, A., KARLAFTIS, M. G. *A multivariate state space approach for urban traffic flow modeling and prediction*. Athens, 2002.

[4] LAN, L.W., SHEU, J.-B., HUANG, Y.-S. *Investigation of temporal freeway traffic patterns in reconstructed state spaces*. Taipei, 2007.

[5] KAMARIANAKIS Y., PRASTACOS P. *Space-time modeling of traffic flow*. Heraklion, 2002.

[6] WANG Y., PAPAGEORGIOU M. *Real-time freeway traffic state estimation based on extended Kalman filter*. Chania, 2004.

[7] WANG Y., PAPAGEORGIOU M., MESSMER A., COPOLLA P., TZIMITSI A. NUZULLO A. *An adaptive freeway traffic state estimator*. Chania, 2008.

[8] ZHOU X., MAHMASSANI H. *A structural state space model for real-time traffic origin-destination demand estimation and prediction in a day-to-day learning framework*. 2007.

[9] SHLENS J. *A tutorial on principal component analysis*. San Diego, 2005.

[10] KELBEL, J., ŠILHÁN D. Shluková analýza. Prague, 2002.

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Tasks of Sustainable Logistics and Socially Responsible Business as Part of Business Strategy

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Abstract: The environmental aspect of sustainable logistics focuses on the Elimination of the adverse effects on the environment, arising from the supply of raw materials, materials, semi-finished products, in the production process, the distribution to the final customer and the subsequent recycling, disposal and reuse.

Keywords: Environmental aspect of sustainable logistics, sustainable logistics, the economic aspect of sustainable logistics, reverse and green logistics.

The paper is also a part of KEGA project No. 037STU-4/2012 “Implementation of the subject “Corporate Social Responsibility Entrepreneurship” into the study programme Industrial management in the second degree at MTF STU Trnava”.

1. Sustainable logistics

The resolution of the European Parliament September 5, 2007 about freight on transport logistics in Europe - the key to sustainable mobility says: “Effective and efficient logistics costs as an integral part of the transport system in the EU is essential for the economic performance and competitiveness, for optimum use of resources, creation of jobs and opportunities, protecting the environment, combating climate change and improving the safety and security.“[1]

1.1 The field of logistics

Logistics is the science concerned with the planning, organizing, managing and coordinating material, money, and information flow and activities associated with them, the aim is to meet the needs of the customer with the smallest cost. Council of Logistics Management (formerly National Council of Physical Distribution Management) [2] defines logistics as:
"*The process of planning, implementation and management of an effective flow and storage of goods, services and related information from the point of the place to consumption, whose goal is to satisfy customer´s requirements*."Similarly, they understand and define the logistics and the European Logistics Association (ELA) [3] and others. On the basis of this it can be concluded that logistics is viewed mainly as an implementer of material flows, including material and information flows within the logistics processes from the point of developing to the point of consumption in order to save material resources. At the same time, it can be noted that the logistics as a comprehensive discipline is responsible for processes of recycling, disposal and reuse of products and it is therefore necessary to deal with the reverse logistics under which these processes are falling. [4] Corporate logistics structure falls to the following basic areas:• Security Logistics - provides the necessary amount of production items, raw materials, auxiliary materials, directly in the production or for other activities.• Manufacturing logistics - directs and controls the material

flows of raw materials and semi-finished products during the entire production process up to the storage of finished products.• Sales logistics - includes building a distribution network, the management of the distribution activities, planning and deployment of distribution warehouses, order fulfillment, and packaging of goods, goods storage and transport of products to the final consumer.

1.2 The definition and characteristics of sustainable logistics

Sustainable logistics can be understood as a concept composed by three aspects of sustainable development:

- environmental,
- economic ,
- ergonomic.

Its aim is in addition to the optimization of logistics processes in economic terms, the focus is on eliminating the impact of these processes on the environment and human beings and, therefore, the application of ergonomics, increasing work efficiency.

1.3 The environmental aspect of sustainable logistics

The environmental aspect of sustainable logistics focuses on the Elimination of the adverse effects on the environment, arising from the supply of raw materials, materials, semi-finished products, in the production process, the distribution to the final customer and the subsequent recycling, disposal and reuse. Environmental objectives, therefore, applied in all logistics processes of the company, including reverse logistics, which provides the final stage of the logistics chain [2]. The external influences that act on industrial enterprises are classified into two basic categories [4]:

1. Factors affecting by the effect of pressure-push:
• environmental disasters,
• currently occurring environmental problems,
• the tightening of legislation in the field of environmental protection,
• awareness of environmental needs, not only professionals but also by the general public.
2. Factors affecting by the effect of stroke-pull:
• expansion of consumer requirements for environmentally friendly products,
• growth in demand for such products,
• the impact of customers, who have more stringent environmental requirements on delivery of the request, for example. certification from suppliers, etc.

On the basis of the above external influences businesses generate their own environmental-oriented strategy in the field of logistics, thereby fulfilling the environmental aspect of sustainable logistics company.

Implementation of environmental requirements are divided into three levels [4]:

1. Defensive measures are implemented only under the pressure of laws, authorities, nd if appropriate, to the public.
2. Offensive - there is a substitution of inputs, the segregation of waste and implement smaller changes in logistics processes with a short return on investment in the long term planning.
3. Preventive - characterized by a constant search and implementation of more effective and environmentally better processes, preventing pollution in the transportation, transport and production, training of staff and the promotion of organic products. This level of implementation is characterized by the principle of prevention, care and integration.

1.4 The economic aspect of sustainable logistics

The economic aspect of the logistics deals since its beginning, because one of the fundamental objectives of logistics is to minimize costs in various areas from security through production to logistics sales.

For the reduction of logistics costsit it is necessary to optimize not only partial but also complex logistics activities. Due to the fact that logistics costs are not negligible component of the total cost of the undertaking, optimization techniques are the center of attention. Of the entire group of formalized approaches are quite often used in logistics, in particular:

- optimization techniques (linear programming, integer programming, dynamic programming, network analysis, models of inventory theory, etc.),
- analytical models (models of theory, models of the economic reach of services, etc.),
- simulation methods (simulation of the supply processes),
- heuristic techniques (location, move, search, distribution networks, storage options, organization of production, etc.). [4]

1.5 The ergonomic aspect of sustainable logistics

The ergonomic aspect is characterized by the application of ergonomic principles in all areas of logistics in order to enhance the efficiency, effectiveness and safety of work. International ergonomic Association [3] defines ergonomics as follows: „*Ergonomics is a scientific discipline that focuses on the definition and understanding of the interactions among humans and other parts of the system and also a profession that uses the theory, principles, data and methods focused on proposals to optimize human well-being and overall system setup*. „ As parameters to the evaluation of the performance of staff in the implementation of ergonomic solutions, you can choose [5]:

- health,
- the safety,
- hygiene of work,
- the performance of the employee.

The use of ergonomic principles aimed at minimising the impact of operating factors of the work and the working environment has a positive impact on economic indicators. These are directly influenced by the reduction of the cost of absenteeism, by reducing the costs associated with the judicial expenses caused by the actions of employees for injuries, reducing the costs associated with the recruitment, intake, an internship, training new employees, reducing the costs associated with the production of scrap in production, deterioration of materials during handling operations, increasing efficiency and labour productivity growth. On this basis, he finds that achieved economic effect is directly linked to the health of workers. [5]

2. Reverse and green logistics

If we are talking about the fact that logistics is the process of planning, implementation and management of an effective Executive, the flow and storage of goods, services and related information from the point of the place of consumption, whose goal is to satisfy customer requirements, then the definition of reverse logistics includes all activities that are referred to in the definition of logistics, the only difference is that the reverse logistics includes the following activities retroactively. "It is a process of planning, implementing and controlling the efficient, cost effective flow of raw materials, intermediates, finished goods and related information from the point of consumption on the place of origin for the purposes of recovery or disposal." More specifically, the reverse logistics is the process of moving goods from the typical final distillation

for the purpose of rehabilitation or liquidation. In some areas of the business, reverse logistics can be critical for the company. As a general rule in business, where the value of the product is high, or where the ratio of returned products is high, a much greater effort develops to improve the return processes. The best example is the automotive industry. The market for car spare parts recovered by Automotive Parts Rebuilders Association is to estimated 36 billion dollars. For example, 90-95% of the total quantity sold starters and alternators for compensation has been restored. It is important to distinguish a reverse logistics and related with it green logistics. Reverse logistics covers all efforts to move products from their typical place of loading in order to obtain the value again. Green logistics or environmental logistics refers to the understanding and minimising the environmental impact of logistics. Green logistics activities include measuring the impact on the environment of individual types of transport, the ISO 14000 certificate, reducing the use of energy, the activities of the logistics and the reduction of the materials used. [6] Figure 1 shows the loading of containers from road to rail cars in the area Želechovice container terminal in the town itself. Containers carrying goods from Hamburg bringing along the road and then are transferred in railway wagons, which are distributed to destinations in Europe. This form of transport is more environmentally friendly. Some of the activities of the Green logistics can be classified as a reverse logistics activities. For example, the use of recyclable packaging and the restart sale are problems as of reverse as green logistics. There are, however, many of the activities of the Green logistics, which are not related to reverse logistics. For example, the reduction of energy consumption, or a proposal for non-returnable containers, they need less material, it is not a matter of reverse logistics.

2.1 Reverse logistics and environment

Many companies first focused on the problems of reverse logistics due to matters relating to the environment. Today, some are only interested in reverse logistics, which refers to the return of the product to suppliers. But in future the environmental aspect will have a greater impact on a few logistical decisions. For Example:

- The costs of the landfills will raise in the past and is expected to increase in the future.
- Many products will be able to give to the landfill because of environmental restrictions.
- Economic and environmental circumstances are forcing companies to make use of reusable packaging and other materials.
- Ecologically motivated constraints are forcing companies to take back packaging materials.
- Many companies are forced by law to take back their products at the end of their life.[6]

2.2 Future trends of reverse logistics

It is clear that in the future there will be more firms to devote considerable attention to reverse logistics. Many companies have realized the importance of the reverse logistics and now they still must recognize its strategic importance. With the aim of reducing the cost of reverse logistics in the future, the company will have to concentrate on improving many aspects of its flows within reverse logistics :

- Improved technology monitoring of inputs.
- Improved data communication.
- Faster processing/shorter terms of cycles.
- Faster determined.

One of the easiest ways to reduce the cost of the flow of the reverse logistics, is the reduction of the volume of transported goods. There are two ways how to to do it:

- Products that do not belong to the flow, must be protected from the entry.
- When the product was put into circulation, it must be deleted away as quickly as possible. [6]

Fig. 1: The container docks in Zlín municipality

References

[1] EURÓPSKÝ PARLAMENT. Logistika prepravy nákladov v Európe – kľúč k udržateľnej mobilite. Uznesenie Európskeho parlamentu z 5. septembra 2007 o logistike prepravy nákladov v Európe – kľúč k udržateľnej mobilite (2006/2228(INI). [online]. [cit. 2013-03-04]. Dostupné na www: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:187E:0154:0158:SK:PDF>

[2] SUPPLY CHAIN MANAGEMENT TERMS and GLOSSARY. [online]. [cit. 2013-03-04]. Dostupné na www: <http://cscmp.org/digital/glossary/document.pdf>

[3] ELA STANDARTS. [online]. [cit. 2013-03-04]. Dostupné na www: <http://www.elalog.org/download/ELAstandards.pdf >

[4] SAKÁL, P. a kolektív autorov. Logistika výkonného podniku. 1. vyd. SP SYNERGIA Trnava, 2009, 633 s. ISBN 978-80-254-5754-2.

[5] BEŇO. R., Návrh postupu uplatňovania ergonómie v podnikovej logistike. [doktorandská dizertačná práca] – Slovenská technická univerzita v Bratislave. Materiálovotechnologická fakulta so sídlom v Trnave, Ústav priemyselného inžinierstva, manažmentu a kvality. Trnava, 2011. 138 s.

[6] REVERZNÁ LOGISTIKA, EU Bratislava. 2009. [online]. [cit. 2013-03-05]. Dostupné na www: <http://www.scribd.com/doc/41903194/20/Zelena-logistika-a-reverzna-logistika>

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Competition in the Polish passenger transport market

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Abstract. The article discusses the use of the instruments of competition on the Polish market of passenger transport. Market analysis shows that the most significant instruments of competition are price, accessibility, immediacy and time of travel.

Keywords: competition, transport, passenger transport market.

1. Introduction

Polish accession to the European Union had the key influence on the type and intensity of competition in the transport services' market. Market opening has resulted in an increased competition and changes in structure of its space and tools. Adjustment of many economic sectors, including transport, to the requirements of the European Union and the gradual process of unification of the rules for actors in the market have led to significant changes in perception of competitiveness of various modes of transport. In the passenger transport market oversupply of services is additionally caused by the development of individual automotive, which reduces demand for transport reported in the market.

Observation and analysis on the market show that competition in passenger transport includes mainly the following modes of transport:

- Road and rail transport,
- Rail over long distances (between agglomerations), a high-speed transport and air transport, including interregional transportation,
- Direct car transport and air transport for medium distances, including interregional transportation.

2. Polish passenger transport market

Passenger transport in Poland has been developing differently during the analyzed period for each mode. In general the downward trend can be observed. The decline in rail transport was slightly lower in nominal terms than in road transport, but proportionally just as large in relation to the total traffic of the branch. In the road transport decrease was caused primarily by a huge increase in the ownership of personal automobile. Although the advantage of car over rail transport is still significant, the observed decrease tends to increase. The importance of air transport has been growing. This is mainly a consequence of dissemination of the "budget airlines" and the increase in the number of Poles traveling abroad (almost doubled in 2010 compared to 2005, ie shortly after the Polish accession to the European Union). Tab. 1 presents passenger volume during the analyzed period. It reflects both declining changes in traffic volume changes and changes in traffic structure - a rapid decrease in road transport and much slower in rail transport.

Specification	1995	2000	2005	2010
transport of passengers [in thousands. persons]	1601089	1319972	1046930	838024
including:				
rail transport [k]	465901	360687	258110	261314
road transport[n]	1131593	954515	782025	569652
air transport	1847	2880	4637	4990

[k] Until 2001, freight carried by the Polish State Railways, since 2002 also by other entities that have received licenses to railway transport.
[n] Enterprises employing more than 9 persons; without freight carried out by the public transport enterprises.

Tab. 1. Passenger transport by type of transport [in thousands. persons]

Source: Statistical Yearbook of the Polish Central Statistical Office, Warsaw 2011

Tab. 2 presents changes in transport performance in passenger transport in Poland.

Specification	1995	2000	2005	2010
Transport performance [in passenger-kilometre]	65483	62055	56183	47986
including:				
rail transport	26635	24093	18157	17921
road transport	34024	31735	29314	21600
air transport	4633	6034	8504	8273

Tab. 2. Transport performance by the mean of transport in passenger-kilometre

Source: Statistical Yearbook of the Polish Central Statistical Office, Warsaw 2011

The downward trend in in the transport activity also reflects a decrease the number of transported passengers. This decline has a slightly lower rate, which may be due to longer travel distances. This is particularly evident in air transport. However, there is an inverse relationship in the rail transport - increased number of passengers and reduced transport performance. It means that more travelers move on shorter distances, especially to school and work. The choice of mean of transport is influenced by the prices of tickets, the economic availability and physical accessibility.

3. Assessment of the use of competition instruments in passenger transport

Competition in the passenger transport mainly includes the following instruments of competition: price and product (travel time and number of connections). The scope and way of use of competition instruments enable to distinguish price competition (including freight rates and prices of passes) and non-price competition (qualitative for properties of the services, personnel, distribution, process and material effect of transport services, and information, including how to communicate with the surrounding transport operators).

Means of transport are successively renewed by both motor and rail carriers (with the participation of state and local governments). Furthermore, customer service improves. A new approach to the perception of competition instruments can be observed in the air transport using as an example the low-cost airlines OLT Expres. The transformations taking place in the market has shown that redefining the product category (for example, air transport) appeared as an instrument of competition. Consumers' behavior has shown that core of the product is the most important, while the remaining parts are much less significant. What matters is the essence of the problem - the flight and low price. Perhaps this approach is an effect of a relatively high price of air transport in comparison to other modes of transport for passengers. This information is important for service providers operating in different modes of transport.

Market analysis shows that in the passenger segment the main competition instruments are price, accessibility, immediacy and time. However, a comprehensive price comparison on the basis

of available statistics is impossible, due to the fact that the individual transport is not taken into account there.

Tab. 3 shows the number of connections in the various modes of transport between Warsaw and big cities (mostly capitals of the provinces) in Poland. Regarded as a transport connection were only these connections which enable reaching the specified city directly by the analyzed mean of transport. The analysis showed that the majority of aviable connections has been offered by the road transport, as it offers widest range of options of both the time of departure, destination, and transit time.

Lp.	**Route**	**Minimum travel time**			**Number of connections**			**Travel price - the minimum**		
	Warsaw/selected city	Rail transport	Road transport	Air transport	Rail transport	Road transport	Air transport	Rail transport*	Road transport	Air transport
1	Białystok	02:44	03:30	x	10	17	x	37,0	32,5	x
2	Bydgoszcz	02:59	04:30	01:00	10	24	2	40,5	49,0	197,6
3	Gdańsk	04:53	05:30	00:55	9	29	10	58,0	55,0	219,2
4	Gorzów Wielkopolski	05:38	07:15	x	1	1	x	63,0	75,0	x
5	Katowice	02:39	05:20	01:00	22	11	2	49,5	45,0	197,6
6	Kielce	03:15	03:05	x	6	23	x	36,7	25,5	x
7	Kraków	02:48	05:00	00:55	20	12	5	49,5	48,0	197,5
8	Lublin	02:15	02:30	x	11	28	x	34,0	29,3	x
9	Łódź	01:41	02:15	x	26	11	x	28,0	27,0	x
10	Olsztyn	03:28	03:03	x	4	18	x	15,0	25,0	x
11	Opole	04:55	06:05	x	7	1	x	55,0	50,0	x
12	Poznań	02:29	05:10	00:45	20	6	6	49,5	60,0	99,0
13	Rzeszów	05:56	04:00	01:00	2	34	2	55,5	52,0	208,4
14	Szczecin	05:12	09:15	01:00	7	2	5	63,0	85,0	219,2
15	Toruń	02:37	03:35	x	8	23	x	40,5	43,0	x
16	Wrocław	05:13	06:05	00:55	14	11	10	60,0	50,0	219,2
17	Zielona Góra	05:16	10:09	x	2	2	x	63,0	75,0	x

Tab. 3. Comparison of the time, the number of connections and travel prices by each mean of transport on selected domestic routes. In air transport - only direct connection between the cities of the day 11.09.2012, prices of connections a week before departure. Road transport - without cars, included were only coaches, buses and vans. Prices of railway transport were given by the "information point" at the station.

Source: own

Tab. 3 compares the travel time variant minimum, medium and maximum between Warsaw and selected cities in Poland. Since the analyzed distances are large, definitely the fastest means of transportation is plane. The fastest option in land transport over long distances is traveling by train. Bus transport is slower at basically all analyzed routes. The main reason for that are the speed limits on the roads, the need for pit stops, and more bus stops. This is an important factor in competition for customers. The analysis showed that considering this instrument of competition, the most competitive is the rail transport [1].

Tab. 3 compares the prices by various means of transport on selected routes. The analysis of this instrument of competition shows that the price is an important criterion for decision-making. Price competition for a short distance focuses mainly on passenger road and rail transport. Costs of journey over a similar distance is often on the same level and show differences in selected relationships in favor of one or the other mode of transport. Apart from this, various promotional activities can be seen which differ prices especially in rail and air transport (which is not cost competitive to other modes of transport).

4. Conclusion

The rationality of the decision made by the customers is an effect of the comprehensive evaluation of the offer in terms of number of connections, travel time, prices, as well as other such as security, reliability, availability, and more.

The used instruments of competition, strategies and directions of development of intermodal competition are influenced by the regulations of the market and submarkets (it's segments). It can be expected that the model of competition in the market of transport services will be evolving in the following directions [2].

1. Competition model will change from "price war" into the qualitative competition combined with the need to maintain cost discipline.
2. More significant will be the ability to innovate, determined by the level of staff education and access to the finance.
3. New environmental requirements will became important, particularly reduced emissions of exhaust into the atmosphere.
4. Providing the necessary social conditions for staff working in the various modes of transport will become even more important (eg car drivers, train drivers, railway workers, airports workers, etc.).

References

[1] taken into account were direct connections, from *www.e-podroznik.pl*.

[2] PAPROCKI, W. *Fair competition - model and reality in the EU market*. Translog 2007, chances of development of transport ..., p 432.

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Comparison of the causes of road excident in urban traffic in selected polish cities and slovakia

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Abstract. The article discusses the causes of road accidents in city traffic. It also presents a comparative analysis with the number of public transport vehicles - buses on the example of the city of Lublin in Poland and the city of Žilina in Slovakia. Interval of the period analyzed in both cases is 2008 - 2012 year.
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Keywords: buses, public transport, road accidents

1. Analysis of the the number of road accidents involving buses in the cities of Lublin and Žilina

In road accidents have become almost daily events to which we are accustomed to the extent that they do not have on our experience [4]. The state of road safety information provides detailed analysis of past accidents, their causes, effects and consequences of the risk [3]. Assessment of the number of occurrence of road accidents can determine in a direct way the security situation in urban traffic. The authors of this article conducted the analysis for public transport vehicles which are trolleybuses. The analysis of data associated with the intensity of vehicle use is applied in the evaluation of a given transport system [6]. Data acquired it from the Municipal Transport Company in Lublin and Urban Transport Enterprises in Žilina. Study the relationship between the development of number and structure of vehicles in Slovakia and the development of infrastructure and partly the impact on the environment and other factors [7].

Public Transport in Lublin uses 246 buses, of which there are 64 vehicles Jelcz art, modern bus Solaris Urbino, and newest Mercedes autos. There currently are 50 lines of Lublin. Transport Company (DPMŽ) supports public transport lines in Zilina, including 10 daily bus lines with a length of routes of about 8 km. Tabor Karosa brand buses are most frequently produced in the years 1986-2006, and the type Irisbus buses were manufactured after 2006.

Figure 1 shows the graph of the number of road accidents involving vehicles MPK in 2008-2012. It may be noted that for the whole period the number of incidents of road is on the same level. Where at least 393 events took place in 2008. In 2009, the number of events increased by 54 (2009-447). Most road accidents occurred in 2010 (551), with the next year in 2011 amounted to 431 incidents in 2012 and a slight decrease of 10 events (2012-421).

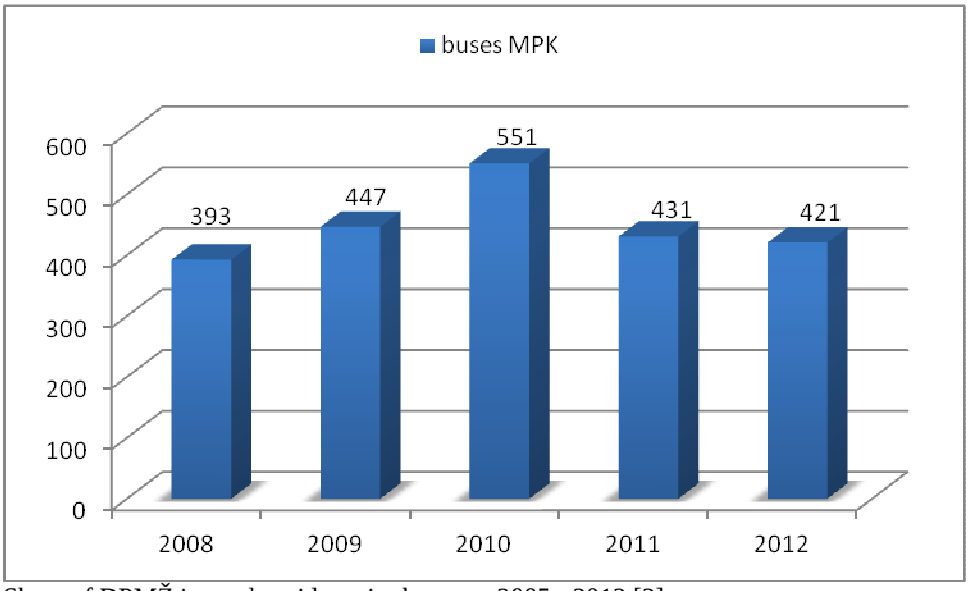

Figure 2 Share of DPMŽ in road accidents in the years 2005 - 2012 [2]

In Figure 2 is a graph of the number of road accidents involving trolley in Zilina in the period from 2008 to 2012. In comparison with the number of events MPK Lublin road vehicles can be seen that the number is much lower. The largest number of road accidents accounted for in 2010, where he was 64th respectively During the period in question it is worth noting that the number of road accidents has an irregular character. There are, in pewym period (2008) the number of events is 44, then increases (2009 - 52), where in 2010 the number of events increases again (2010 - 64), after falling slightly as in 2011 and 2012.

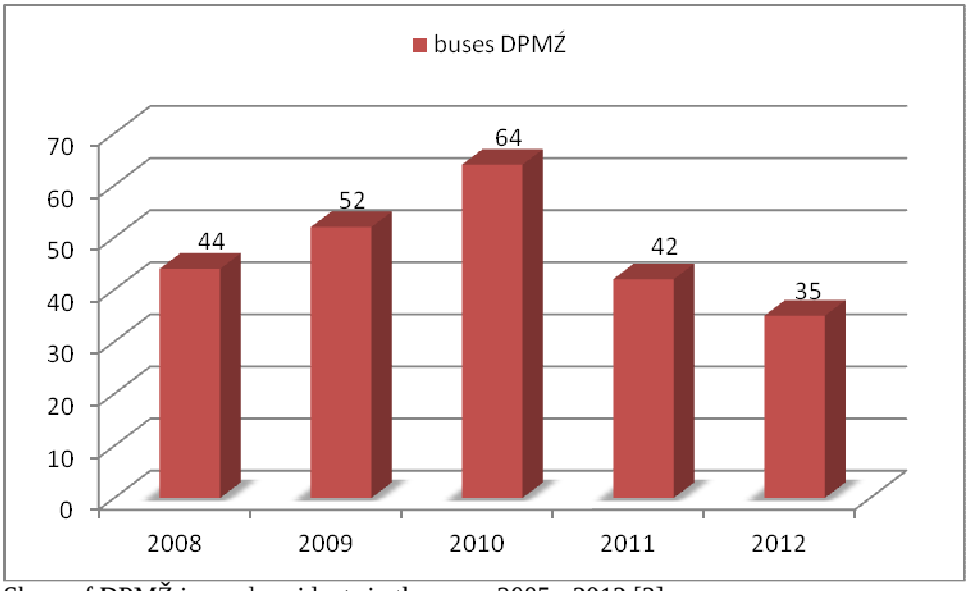

Figure 2 Share of DPMŽ in road accidents in the years 2005 - 2012 [2]

Because of the different number of used vehicles converted the number of road accidents per one bus. Figure 3 shows the rate of participation in the event on the road an average of one bus, with a separate service for each year (2008-2012) for both analyzed transport companies. It is worth noting that the participation rate throughout the period under consideration is the highest in the case of MPK Lublin. MPK Lublin for the smallest value of the index falls in 2008 (1.59), followed by two years of 2009 and 2010 respectively increased ratio was 1.82 and 2.24. In 2010, Next drank the biggest indication. In the last two years of the time period decreased value amounting to 1.75 and 1.71. If DPMŽ in Žilina character incidence rates did not show significant variations. The lowest

level of the indicator falls in 2008 (1.04), then in the next two years there was an increase to 1.23 and 1.52. In 2011 and 2012 the value of the index falls.

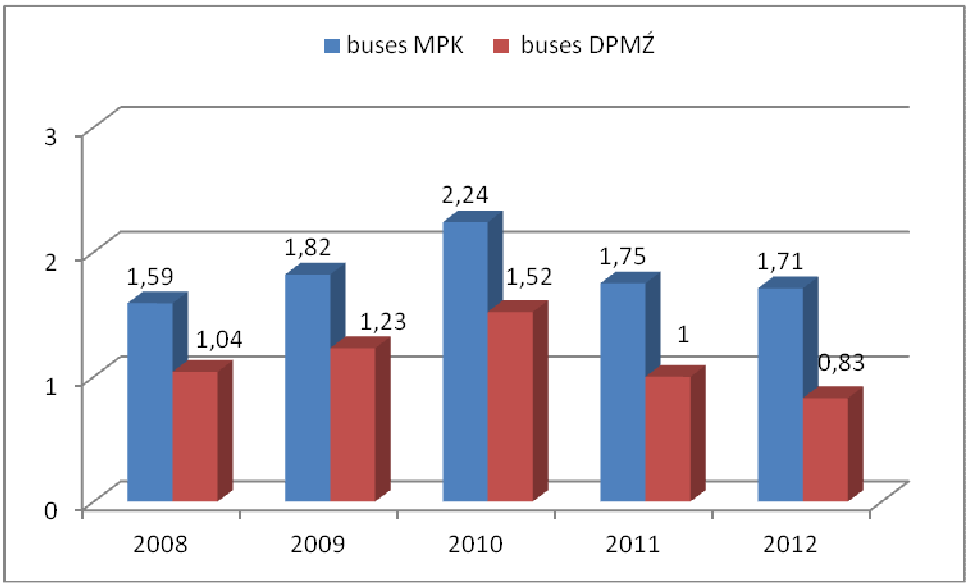

Figure 3 Summary of participation in the event traffic per one bus [1, 2].

2. Conclusion

The presented the safety analysis shows that public transport compared to private vehicles safer and it occurs in fewer road accidents and above all fewer casualties. This paper presents a statistical analysis of road accidents in the City Bus Transport Company in Lublin and Enterprise Transport in Žilina. The analysis includes the years 2008-2012.

The analysis shows that the least number of accidents throughout the relevant period falls on DPMŽ in Žilina. Significantly lower rate of the number of vehicles registered per 1 inhabitant in Slovakia (0.323) than in Poland (0.469) and fewer roads have a major impact on the level of security [5]. This may explain the smaller number of road accidents involving public transport vehicles in the city Žilina.

The analysis also includes the participation rate in the event the road an average of one bus for both analyzed transport companies. The share of the tested interval is the highest in the case of MPK Lublin.

Acknowledgement

The acknowledgement heading is of the same style as the heading references ”Reference” and it is not numbered. The text of acknowledgements is of the style “Text”.

The authors are asked to pay special attention to the form of references. The NAMES OF AUTHORS should be typed in capitals, the Titles of Journals, Books or Proceedings in italics with the first capital letter in all significant words. The titles of articles are typed similarly as the basic text without the first capital letter in all words. When referenced in the text, enclose the citation number in square brackets, for example [1].

References

[1] Materials MPK Lublin

[2] Materials DPMŽ Žilina

[3] CABAN, J., DROŹDZIEL, P., LIŠČÁK, Š., *Selected aspects of road safety*. Vehicle Institute of Scientific Papers, 2012, No. 3 (89), University of Warsaw, Faculty of Automotive and Construction Machinery Engineering, Warsaw 2012, pp. 13-19.

[4] CABAN, J., OPIELAK, M., RYBICKA, I., *The causes of road accidents and the security situation in the city traffic on the example of MPK Lublin.* Vehicle Institute of Scientific Papers, 2012, No. 3 (89), University of Warsaw, Faculty of Automotive and Construction Machinery Engineering, Warsaw 2012, pp. 21-27.

[5] CABAN, J., VRÁBEL, J., DROŹDZIEL, P., *State of road safety in Poland and Slovakia in comparison with other EU countries.* BUSES, Technology, Operation, Transport systems.Nr 3/2013, ISSN 1509-5878.

[6] DROŹDZIEL, P., KOMSTA, H., KRZYWONOS, L., *Analysis of the intensity of use of a vehicle (Part I).* Logistics, 3/2012, Institute of Logistics and Warehousing, Poznan, 2012, pp. 487-492, ISSN 1231-5478.

[7] GNAP J., KONEČNÝ V., ŠIMKOVÁ I., *The development of numbers and structures of vehicles in slovak republic.* Doprava a spoje: internetový časopis Žilinska Univerzita, 2012, nr 2, s. 89-98

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The problem of limited visibility through the windshield

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Abstract. The paper presents the problem of limited visibility caused by not wiped off part of the windshield in the aspect of road safety. Discusses disadvantages of the windshield wiping system and shows road situations in which this problem has the greatest importance.

Keywords: road safety, wipers, visibility through the windshield

1. Introduction

In order to improve road safety it is more often required an installation of intelligent driver assistance systems. The driver should have a high ability to observe the surroundings and the construction of the vehicle should provide the best possible visibility from the inside. Bad weather conditions such as snow or rain reduce road safety and driving the vehicle becomes more difficult. A major problem is the window wiping system, which does not completely wipe the windshield, resulting in the formation of visibility limitations.

2. Description of the problem

Cars must have a windshield wiping system. It is required that wipers cleans at least 80% of the windscreen [1]. Unfortunately, the remaining 20% may include a critical part of the windshield next to the A-pillar of a car. When on the road are very poor weather conditions limiting visibility, such as heavy snow, the wipers are not able to work in full swing due to the lingering snow. Remaining snow limits the field of vision and driving becomes less secure. The most commonly used solutions are two wipers working concurrently Fig. 1a or working in opposite directions Fig. 1b performing the movement along part of the circle. While you can adjust the maximum swing of the wipers, it's very often found cars with wipers so set, that they does not reach a critical part of windshield next to the A-pillar. One of the improvements of the windshield wiping system is the reversible engine, ensuring full working area. In order to protect wipers drive mechanism from damage, an additional system of automatic position adjustment of the wiper arm was developed. It task is to detect obstacles located in the windshield, for example in the form of lingering snow or ice, and automatically narrow down the area of work, which unfortunately also reduces the driver's field of vision [2]. In some vehicles a single wiper performing the movement along part of the circle is used Fig. 1c. The advantage of this design is simplicity, but the optimal cleaning is when the width is twice of the height of the windshield and even in this case, there will be large areas of the upper corners uncleaned. One of the most complicated system is one wiper with eccentric mechanism Fig. 1d. This mechanism is complicated and mostly used in expensive cars. Areas, where the blade of the wiper of this type does not reach, are very small and for these reason it is one of the most excellent wiper cleaning system, in terms of cleaning effectiveness. Another wiper system used in buses is the mechanism which maintain wiper blades vertical Fig. 1e. The use of such wiper system minimizes uncleaned

areas, especially in the case of windshield similar to the shape of a rectangle. For large windshields it is sometimes necessary to use system with three wipers Figure 1f.

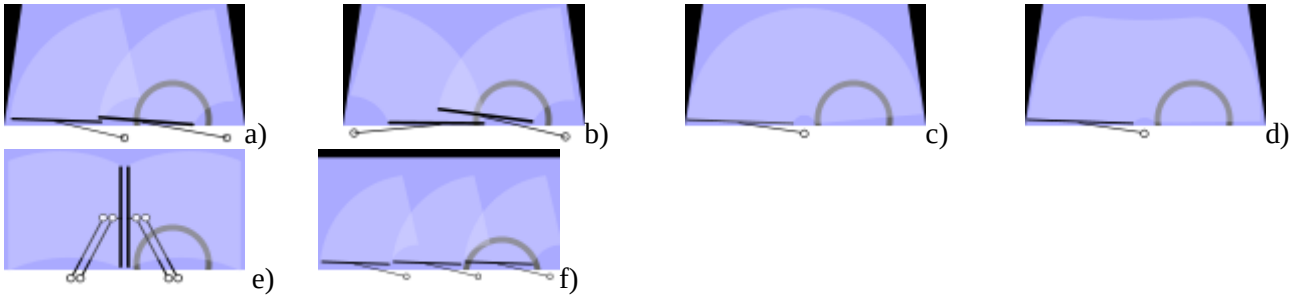

Fig. 1. Examples of wiper systems. a) two wipers working concurrently, b) two wipers working in opposite directions, c) one wiper moving along a part of a circle, d) one wiper with an eccentric mechanism, e) two wipers mechanism maintaining wiper blades vertically, f) three wipers [3].

The driver with limited field of vision should reduce speed of the vehicle. Thanks to this will gain more time to react in case of an emergency [4]. Different matter is, when you consider a rally car that moves with significant speed. Routes for rally cars often take place in mountainous areas, where there is a large number of turns, climbs and downhill rides. In this area it is preferable not to have dirty windshield. Rally driver while crossing such a route is often forced to analyze further driving line looking only through the part of the windscreen cleaned by wipers. The remaining part covers view, what in many cases, such as when climbing hills, greatly reduces the possibility of identifying terrain and gives less time for the driver to assess the situation.

Another big problem is the possibility of not detecting of oncoming vehicle from the left side. In Figure 2 is presented T-shaped road where can be seen, how much area is invisible because of lingering snow on windshield and the A-pillar from position of the driver.

Fig. 2. The view from the car cab with the area not reached by a wiper blade.

Even worse is the situation with the cyclist. During bad weather conditions it is difficult to see the cyclist, which is often unlit and takes up a lot less space on the road than a car. It may happen

such a situation, that the driver approaching to a major road would not see moving on this road cyclist, because he would be covered by lingering snow on the windshield and the A-pillar of a car. Application of the system, which would wipe the entire windshield would reduce the area invisible to the driver and therefore road safety would increase.

3. Conclusion

This paper presents drawbacks of the windshield wiping system. The road traffic safety is composed of a man, the vehicle and the surrounding environment. By increasing the vehicle's active safety, by providing better visibility, the overall safety on the road increases. The considerations shows that there is a need for a new mechanism wiping the windshield entirety.

References

[1] Norma PN ISO 9619:1998. *Układy wycierania szyby przedniej*.

[2] Olejnik K.: *Bezpieczeństwo w transporcie samochodowym. Wybrane problemy*. Wydawnictwo ITS. 2009.

[3] http://pl.wikipedia.org/wiki/Wycieraczka

[4] Olejnik K.: *Ergonomiczne aspekty zapewnienia widoczności kierującemu pojazdem mechanicznym w świetle wymagań obowiązujących w Polsce. Ergonomia Transportu*, Komitet Ergonomii przy PAN, Kraków 2001.

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Conception of Compressed Air Transportation System

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Abstract. Penumatic solar-powered motors ensure extremely low costs, wide availability, and care for the natural environment. The idea is to create a compressed air station system powered by solar energy, able to meet the needs of vehicles with pneumatic motors. The aim is to demonstrate the advantages of this system over existing solutions, while maintaining the economy of such solution. Advantages of vehicles powered by compressed air, this lightweight design, no batteries and no emissions and silent operation. This article is merely an indication of the direction of development of urban transport systems using simple methods combined with innovative solutions.

Keywords: Copressed air, Stirling engine, PowerDish module, supercapacitors.

1. Introduction

The idea starts with the invention of the prior 143 years prepared by the Polish engineer - Ludwik Mękarski, who was the founder of experimental tram lines. Pole in 1870, constructed in France tram powered by compressed air. It was one stroke engine - the air before reaching the cylinder was passed through a hot water tank in order to increase the strength of gas expansion, and, after the work escaping directly to the atmosphere. Air tanks filled with compressors installed at bus stops. The largest tram Mękarski network system functioned in Nantes in 1879 - total 39 km of tram lines - during the 34 years of its operation it carried about 12 million passengers. A similar line was also built in Paris and New York operate like trams, but driven by a motor built in 1882 by Robert Hardy and operating under the same conditions as the engine of a Polish engineer. As air motors they never gets warm and will not produce sparks, the slightly modified locomotives were used in the U.S. HK Porter Company, we have successfully sold in mines susceptible to firedamp example. Pneumatic locomotives and trams disappeared in the 30's of the twentieth century superseded by improved internal combustion engines and electric. For several years, the idea of vehicles powered by compressed air returns. The company MDI of Luxembourg has developed a few years ago, a prototype of such a car, and now it is already placed on the market, and the price does not exceed 10.000 USD. Of course, in addition to the standard system, only compressed air supply company also offers a hybrid power Hybrid Air, which this year also demonstrated min. PSA (Peugeot-Citroen group), which may indicate the potential and future of such a solution.

When there is information about the vehicles on compressed air, journalists often put allegations that, while not burn fuel, but still the energy needed to drive the compressor comes from power plants burning fossil fuels, as if they have not heard about solar panels, windmills and other unconventional sources energy. Firms, markets, which will use these types of vehicles can be mounted on the roofs of their buildings, solar panels or put a windmill. The air so collected in stationary pressure tanks can also be used at a time when there is no wind or sun, that in calm weather or at night. Such a solution could be used in public transport using buses powered by compressed air. So the prevalence of this type of vehicle will foster the development of power plants based on alternative sources of energy. Compared to electric cars (and gas), these vehicles are lighter (weight of batteries). have a longer range than most produced electric cars, refueling the station takes only three minutes, and using an electrical outlet 4 hours, which is also less than half

the electric vehicle (but is not silent). Reached the end of the car does not have to worry about disposal of batteries, in which there are a variety of dangerous lead compounds, electrolytes, etc., which, with the mass production of electric vehicles could become a big problem. The disadvantage is, high pressure air tanks, which in the case of an accident such as a truck would have ended their explosive, but the same defect may vehicles on gasoline or hydrogen, which are also flammable substances. However, these vehicles can have well future, especially in a urban solution. Research shows that compressed air solution or a hybrid-pneumatic are currently the best choice economically and environmentally. However, the problem is always to power of these vehicles. We always need the electricity, diesel or petrol. For cars with compressed air to produce a voltage there is necessary to compress the air. The proposed solution is based on the compressed air powered by solar energy. While the prototype air vehicle models are already available, the solar air station does not have a solution at the moment. Such station would be independent of the existing energy infrastructure, and completely self-sufficient. The main components of the station are as belows.

2. Solar Disk Focusing Sun Beam

One of the first solutions of this kind is the American system PowerDish provided by Inifinia company, combining energy generation with solar power with a solution based on a Stirling engine. Infinia's PowerDish is an innovative grid interconnected solar power-generating module That converts the sun's heat into electricity. The PowerDish couples, low-cost and maintenance-free Stirling generator with a dish-style solar concentrator to create electric grid-ready solar power. The PowerDish is an automatic, self-contained system That produces clean, AC power without the use of water. PowerDish generates more electricity in high solar insolation conditions, for less capital and installed within a smaller footprint than competing technologies. The PowerDish is the world's first solar power generation system suitable for automotive-scale manufacturing and deployment ranging from small-scale arrays distribution to thousands of units deployed in utility-scale solar power plants.

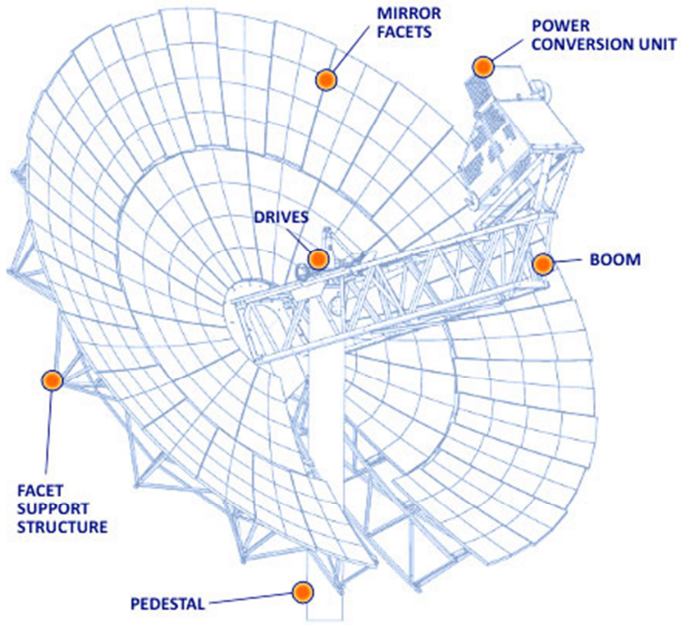

Fig. 1. Shield for solar energy conversion PowerDish.

3. Solar Energy Conversion Module

The module is a modern design based on a Stirling engine patented by Infinia. One of the most important parts of the system, because it is responsible for energy requirements. The efficiency of

conversion of the engine in a such configuration, exceeds 40%, i.a. by using hydrogen as the working gas warming to a temperature 720 Celcius degrees. The core of Infinia's success lies in its proprietary free-piston Stirling generator technology. These generators have been Demonstrated in critical power applications That require quiet operation, High Reliability, and very long, low-maintenance service lives. Engines are distinct from more widely publicized That kinematic Stirling engines have inherent life and more reliability limitations Imposed by Their lubricated mechanical system and sliding seals. Infinia's technology has Demonstrated a collective total of more than 2,000,000 hours of engine operation, Including 100,000 hours free of maintenance, degradation free operation on a single engine. From solar power applications to remote installations, Infinia's Stirling generators are designed to deliver energy in a way that is quiet, long-lasting, economical, environmentally-friendly and exceptionally low-maintenance.

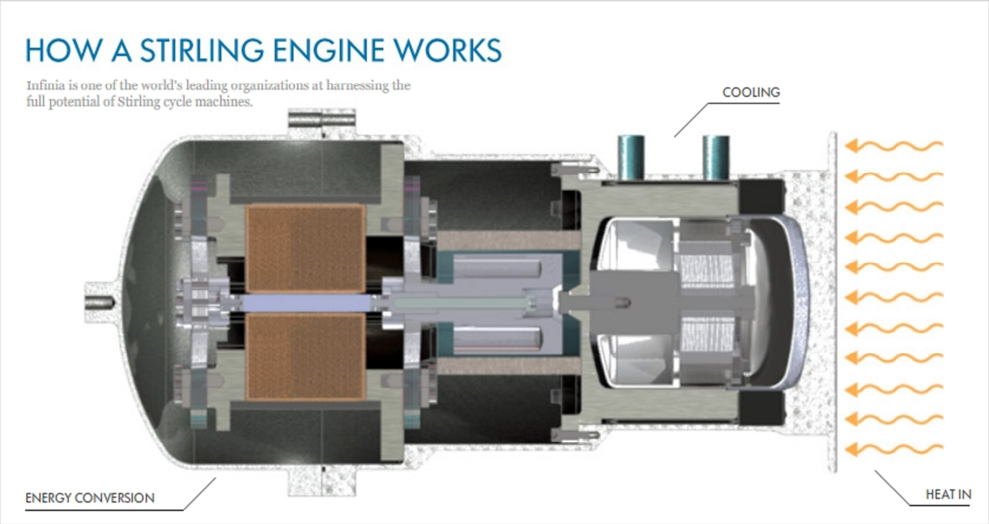

Fig. 2. Breakthrough Stirling engine as a power conversion module.

4. High Capacity Supercapacitors

An important element of the system is a set of supercapacitors that are able to accumulate surplus of unused energy, giving back if it's necessary. The advantage of supercapacitors is their relatively low price, ease of production, high capacity and efficiency, also no need for utilization. Supercapacitors have the highest available capacitance values per unit volume and the greatest energy density of all capacitors. Supercapacitors bridges the gap between capacitors and rechargeable batteries. In terms of specific energy, as well as in terms of specific power, this gap covers several orders of magnitude. However, batteries still have advantage in the capacity. While existing supercapacitors that have energy densities are approximately 10% of a conventional battery, their power density is generally 10 to 100 times as great. Combines power density energy density with the speed at which the energy can be delivered to the load. This makes charge and discharge cycles of supercapacitors conducts much faster than in batteries. Additionally, they will tolerate many more charge and discharge cycles than batteries. The use of additional energy sources is important during cloudy days and at night, when there is no sunlight.

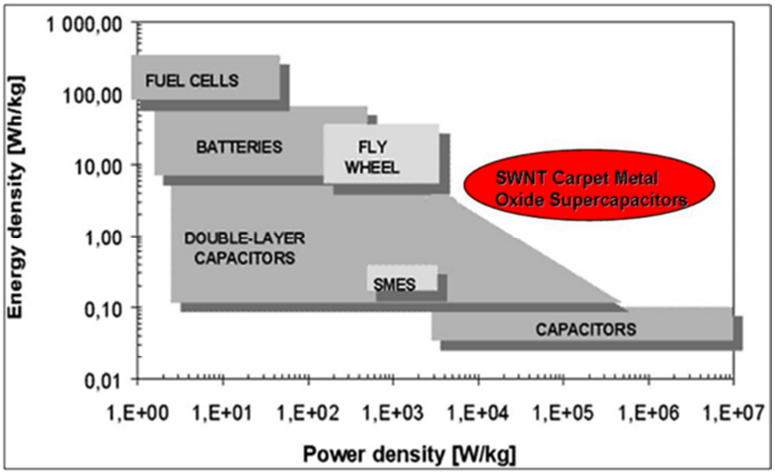

Fig. 3. Supercapacitors advantage over other energy sources.

5. Compressor Tank Pressure with the User Interface

Obtained in the previous step energy would serve to drive the air compressor to the subsequent high pressure into custody. The best solution seems to be the use of a rotary vane compressor, which has a simple design, maintenance-free operation, low noise and high efficiency. Some existing structures such as Hydrovane achieve reliability row 100.000 hours., which with reduced energy demand by about 50% is of extreme importance. Air Vehicles would be refueled as in a normal gas station, of course, with appropriate safety standards.

6. Conclusion

Summing up, the transportation system based on compressed air and solar energy as a power source, it can be an interesting solution to the fuel crisis and environmental protection. Through the use of simple but innovative connections of many technologies we can build a cheap, quiet, economical and environmentally friendly transportation system. After all it works perfectly both in urban as well as inside and outside, because availability of solar energy is everywhere. The only drawback there may be the safety considerations related with air tank transporting on a car board under extreme pressure over 300 bar. However, so far there has been no case of a major failure of any vehicle with pneumatic drive. Same vehicles are simple in its design and cheap to operate. The solution in the form of a Stirling engine and vane compressors are also reliable, after all, guaranteed reliability goes back 12 years. It therefore remains to be hoped that the invention from several decades will be rediscovered once again, with a benefits for all.

References

[1] W. ZALEWSKI, *Compressor heat pumps, absorption and thermoelectric*, MASTA, Gdańsk, 2001.
[2] TYTKO R., *Renewable Energy Sources*, OWG, Warsaw 2009.
[3] J. KUCOWSKI, D. LAUDYN, M. PRZEKWAN, *Energy and the Environment*, ed. Scientific and Technical, Warsaw, 1997.
[4] SZUMANOWSKI A.: *Fundamentals of hybrid drive*, ITEE, Radom, 2001.
[5] SZUMANOWSKI A.: *Hybrid Electric Vehicle Drive Design*, ITEE, Radom, 2006.
[6] GRAŻYNA JASTRZĘBSKA: *Renewable energy sources and environmentally friendly vehicles*, WNT, Warsaw, 2007.
[7] AUNGIER, RONALD H., *Centrifugal Compressors A Strategy for Aerodynamic Design and Analysis*, ASME Press, 2000.
[8] PARK, CHULSUNG; WELL, KEUNSIK; CHOU, PAI H. TURBOCAP: *A batteryless supercapacitor-based power supply*. University of California, USA and National Tsing Hua University, Taiwan, 2006.
[9] www.infiniacorp.com
[10] www.mdi.lu

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A Discussion of Automotive Rear-View Camera for Obstacle Detection

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Abstract. These paper discussion of automotive rear-view camera for obstacle detection in ADAS systems. Briefly characteristics and compare the detection sensors of information perception module. Defines the basic properties of ADAS systems. This paper discussion of methods for rear-view cameras and their advantages. The conclusions suggest further potential use for rear-view camera.

Keywords: rear-view camera, stereo camera, ADAS, obstacle detection, sensor, LIDAR, RADAR

1. Introduction

Road traffic accidents are one of the main health risk problems. Globally, as the number of vehicles of the vehicles on the road increases so too does the number of fatalities and injuries. As a consequence of road accidents, every year approximately 1,3 million people are killed and the almost 50 million disabled or injured. Injury assessment data from the World Health Organization (WHO) has shown that in the year 2000, 23 percents of all deaths in the world have resulted from road traffic accident related injuries making in the main cause of mortality amongst other death related injuries „Fig. 1“. Future predictions show that the number of deaths and casualties due to traffic accidents will increase to 65 percents by the year 2030 worldwide [1]. According to the statistics (NFTSA), in U.S., 31 percents of vehicle accidents are due to rear-end collision. Vehicle accident statistic disclose that the main threats a driver is facing from other vehicles. Consequently, developing on-board automotive driver assistance systems aiming to alert a driver about driving environments and possible collision with other vehicles is attracted.

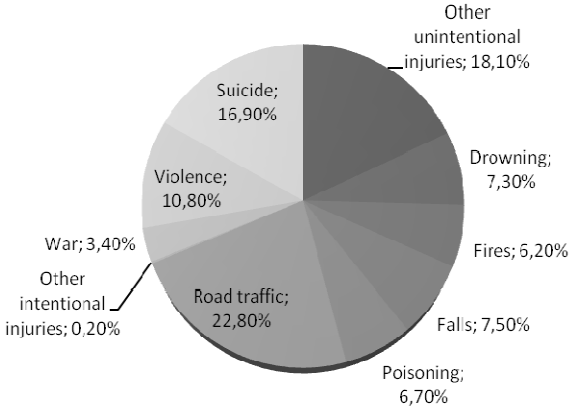

Fig. 1. Distribution of global injury mortality by cause

2. Obstacles and Objects Detection Sensors

With respect to various driving situations, the sensors should be capable of evaluating driver commands (steer angle, blacking, lane changing, turning an overtaking a vehicle) and relative vehicle´s velocity and traffic flow (low or dense). The combination of these parameters will used to reflect a proper driving situation encountered by the driver. So we need an optimal sensor selection to monitor all these three factors [3].

	Infrared	LIDAR	RADAR	Ultrasonic	Camera vision
Cost	Low	High	Medium	Low	Medium
Computation overhead	Low	High	Medium	Low	High
Range	30 m	1,5-80 m	1-150 m	3 m	Line of sight
Detection capabilities	Distance, presence	Distance, speed, geometry	Distance, speed, cross section	Distance	Distance, speed, geometry, object class data
Operating Conditions	Clear visibility	Clear visibility for 80 m, 55m in fog	Normal to heavy rain or snow	Clear visibility	Clear visibility

Tab. 1. Sensors comparison.

Image sensors as cameras have some drawbacks, such as low ability of sensing depth and advantage of higher ability of discrimination than LIDAR and RADAR. Besides, the data may be corrupted by noise and distortions. Such corruptions come from variations such as weather, shading, lighting, magnetic fields and electric noise, movements, bad calibrations, motion blur and compression artifacts after image capture. Given these daunting challenges, we need to utilize some complementary sensors to obtain additional contextual knowledge to cope with limitations imposed on visual sensors. RADAR shows limited lateral spatial information because it is not available at all, the field of view is narrow, or the resolution is reduced at large distances. Prior to sensor fusion decision on selecting a proper set of object-detecting sensors should be made based on the capability of available sensors and real-time driving condition [4].

RADAR and LIDAR sensors are ideal to measure distance from any moving and static object around the vehicle. The RADAR sensors are available in two types according to its frequency (long and short range radar). Laser scanner has a wider viewing angle. But they are highly degraded by weather conditions such as dirt, snow or mud on the back of target vehicle.

Infrared Laser (IR) is used for large distance measurement. For automotive systems are applicable only sensors based on refractive effect [3].

3. Adaptive Driving Assistance Systems (ADAS)

Information from a single sensor is not enough for a driver assistance and safety system to manage high level tasks in dense traffic environments. ADAS systems use a combination of previous mentioned sensors.

Adaptive driving assistance systems (ADAS) is a on-board vehicle device focused on the driving process. One of the main objectives of this technology has been to increases driver awareness by providing useful information. Tradditional adaptive driving assistance systems (ADAS) is composed of three parts. The information perception module, the decision strategy module and the display and control mechanism module. The relationship between three parts is shown „Fig. 2“. With information perception module, the information such as the motion

characteristics of car, the lane and traffic signs and other traffic objects surrounding the car can be collected and then be processed fast and efficiently [5]. Information perception module is composite from sensors. The results will be transferred to decision strategy module. This module simulate the program to control vehicle in human brain.

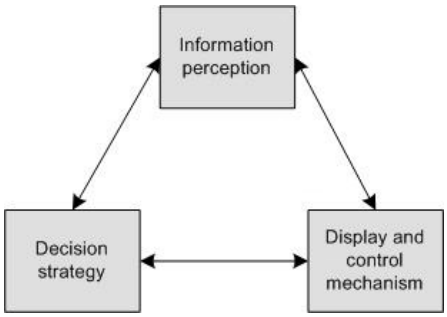

Fig. 1. General structure of Adaptive Driving Assistance Systems (ADAS)

4. Comparison of Monocular and Stereo Camera of Rear-View System

4.1. Stereo Camera System

Stereo methods make use of the disparity field to infer the depth of image features. This allow for detection of the ground plane and the detection of obstacles as any feature off the ground plane. Stereo-vision systems have the advantage that no motion is required between the vehicle and the scene in order to recover 3D structure. Also, they do not require strict constraints on the ground surface and are preferred for autonomous navigation on undulated terrain. Well calibrated stereo systems can achieve impressive results, but at a sever cost both financially, which is problem the adoption of these systems to market products.

4.2. Monocular Camera System

Monocular systems operate at a reduced cost and require little maintenance, but lack the depth perception of stereo systems.
Monocular systems form three broad classes:

Appearance-based methods use color and shape cues to differentiate image regions belonging to the ground from regions belonging to obstacles. The advantage of appearance-based methods is speed, simplicity and ability to detect very small obstacles. However, they suffer from underlying assumptions.

- Obstacle detection can only occur if obstacles differ in appearance from the ground
- Obstacles can`t occupy the area near the vehicle assumed to be ground, otherwise their appearance gets incorporated into the ground model
- Obstacle distance can only be estimated if the obstacle is detected at its base.

All of these assumptions are often violated in a parking scenario.

Motion-based methods are complimentary to appearance-based methods in that they largely ignore colour and shape but rely heavily on the motion of image features. Some rely on external sensors to measure vehicle motion while others estimate vehicle motion directly from the image. The ground, assumed to be planar, is expected to move a certain way on the image. A parametric model is constructed to capture the essence of this motion. The ground motion is observed, with or without the help of external sensors, and parameters of the motion model are estimated. Regions of the image that agree with this model are considered ground,, and the rest are considered obstacles. The strength of motion- based methods is the ability to detect obstacles based on scene structure without an explicit 3D recovery of the scene. This methods do not provide a direct estimate of the obstacle distance.

Structure-based methods detect obstacles by an explicit 3D reconstruction of the scene. For this to be possible with a single camera. The camera must be in motion. The images of the scene may be taken from different poses. Obstacles are detected from image features that lie above ground plane in the 3D model. Reconstruction-based methods are more complex and computationally expensive, but offer a direct estimate of the obstacles location in space [6].

Stereo vision based methods achieve good performance. But they need two cameras, which require extra costs and space. Monocular systems use wide camera. Then its need use distortion correction. For parking assistant applications, the speed of moving car is usually less than 20 km/h. The basic systems used rear-view cameras are:

- Rear-end collision warning system
- Rear-view obstacle detection

5. Conclusion

There are more and more car, which have parking cameras as standard equipment of vehicle. This cameras are mounted only as monitoring rear- end cameras. We assume that it is advantageous to develop monocular rear-view camera system. These camera systems can play a functional part of ADAS systems to become more mature.

Acknowledgement

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References

[1] WHO *Global status report on road safety*. 2009.

[2] CHE-TSUNG, L. – YU-CHEN, L., WEI-CHENG, L. – CHI-WEI, L.: *A real-time obstacle detection system based on a fish-eye camera*, IEEE Signal & Information Processing Association Summit and Conference, 2012, ISBN: 978-1-2673-4863-8.

[3] SOSA, R. –VELAZQUEZ, G.: *Obstacles detection and collision avoidance system developed with virtual model*, IEEE International Conference on Vehicular Electronics and Safety, Beijing, 2007, ISBN: 978-1-4244-1266-5.

[4] M. Rezaei, M. Sarshar, M. M. Sanaatiyan, *"Toward next generation of driver assistance systems: A multimodal sensor-based platform,"* ICCAE Computer and Automation Engineering International Conference, vol.4, pp. 62-67, 2010.

[5] XIN, J. – ZHENCHENG, H. – HSIN, G.: *A new multi-sensor platform for adaptive driving assistance system (ADAS)*, IEEE World Congress on Intelligent Control and Automation, Taipei, pp. 1224-1230, 2011, ISBN: 978-1-61284-698-9.

[6] LALONDE, J. – LAGANIERE, R. – MARTEL, L.: *Single-view obstacle detection for smart back-up camera systems*, IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, 2012, ISSN: 2160-7508.

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Poka-yoke and JIS Checking Implementation in Automotive Plant

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Abstract. The aim of this contribution is to describe the implementation of Poka-yoke and JIS (Just-In-Sequence) checking project in modern automotive plant in Slovakia. It outlines basic requirements from customer, simplified solution design, and description and overview of basic project functions. The implementation took place in early 2013, therefore there are no valid statistical data to analyze project success rate.

Keywords: Automation, Automotive, JIS, Poka-yoke, ZQC

1. Introduction

Poka-yoke is fool proofing technique for avoiding and eliminating mistakes. It is the basis of the ZQC (Zero Quality Control) approach. Generally this technique is used in manufacturing processes, but has much wider uses. Common implementations are in offices - order and invoice processing, hospitals - drug dispensing, aircraft maintenance - particularly with processes having the potential of inducing catastrophic in-service scenarios. The technique is often understood as part of an organization's Value Stream Analysis or Root Cause Analysis program.

The term Poka-yoke is Japanese. It can be roughly translated as a mistake or fool proofing. It is derived from word 'Poka' - inadvertent mistake, and a word 'yoke' meaning avoidance. The concept of fool proofing processes has been around for many years, but it was the Japanese Matsushita Industrial Engineer Dr. Shigeo Shingo who was probably the most prominent and influential person in developing it into a technique. He turned an idea into an approach – approach for eliminating mistakes and achieving zero defects. Dr. Shingo in his works used the phrase "error avoidance". He recognized that people, specifically Japanese workers, may take offence at the term fool, particularly when associated with mistakes. This approach is especially important when considering that the technique requires the worker's active participation in the error cause avoidance.

Dr. Shingo is the author of the book "Zero Quality Control: Source Inspection and the Poka-yoke system" published in late 1986. This publication is defined as the basic approach definition and idea description. However, the technique has been extensively developed since that time. Dr. Shingo suggested that the statistical process of Poka-yoke is fool-proofing.

Poka-yoke can be used wherever something can possibly go wrong or a mistake can be made. It is a technique, a tool that can be applied to any type of process in manufacturing or the service industry. There are several types of errors that can possibly occur. Processing error means an operation missed or being not performed during standard operating procedure/cycle. Setup error is caused by using wrong tooling or setting machine adjustments incorrectly. Missing part error occurs whenever not all parts are included in the assembly, welding, or any other manufacturing

process. Improper part/item error is caused by wrong part being used in the manufacturing process. Operations error carries out an operation done incorrectly; having supplied the incorrect version of the specification. Measurement error occurs due to inappropriate machine adjustment, test measurement or dimensions of a part coming in from a supplier.

1.1. Customer Requirements

As based on requests from Automotive Plant Assembly team, there was a solution supplied to address issues in JIS parts delivery to the assembly line, and to address issue of wrong part specification installation as a result of human fault in part selection phase.

The project addressed the issues of

- Mixed or shifted JIS delivery to the Assembly line,
- Wrong part specification assembly into the vehicle.

Simple analysis shown that these issues were basically caused by

- Wrong JIS delivery from supplier as a result of human failure or communication issue,
- Confusion in line operator working procedure during part assembly process.

The aim of the project was to:

- Decrease the likelihood of wrong part installation in case of confused sequence,
- Avoid wrong part specification being installed into the vehicle,
- Improve working conditions of operators on Assembly line by addressing ergonomic issues of working process.

1.2. The project idea

The project was based on ideas of man-in-the-middle architecture. Its functionalities added additional working comfort to Assembly line operators without special need to change their working procedures or specific habits. In other words, the system adapted to working procedures of line operators, it helped them to avoid mistakes and to make their work more comfortable.

2. Project description

The system from the hardware point of view consists of one server, one dedicated automation controller and one application specific rack. The server is located in MES (Manufacturing Execution System) CCR (Computer Control Room) and its actual physical location and actual network configuration is in responsibility of company IT (Information Technologies) team. The automation controller is located under Assembly line in dedicated 18U (Unit) rack. The application specific rack equipped with a bunch of sensors and light/sound indicators is located directly in the Assembly line in working area of line operators.

The server is standard 1U HP ProLiant DL server with Windows Server 2008 OS (Operating System). Its network configuration is in responsibility of company IT team. The software necessary for this project consist of

- Interfacer application responsible for database access, bar code scanners access and communication with Presenter application,
- Presenter application - the decision making core of this project, communicates with Interfacer application on one side and automation core hardware on the other side,
- Web interface based on XAMP open source freeware distribution with its application specific content,
- OCR (Optical Character Recognition) module for label data recognition, BAR-Code module for bar code recognition,
- Sick SOPAS software - needed only for configuration changes in bar code readers configurations.

2.1. The Poka-yoke implementation

Reliable detection of operator's hands inside the part feeding rack is very important for overall project behavior. This issue is addressed by combination of PIR (Passive Infra-Red) detectors with integrated MW (Micro Wave) Radars and standalone Seenergy NVR (Network Video Recorder) detection engine installed inside of the HouseMar Automation Core. For motion detection, proprietary Panasonic VMD (Video Motion Detection) motion detection engine is used.

Diffusion light sensors are used to detect the presence of part feed stack inside the feeding rack. There is one diffusion sensor per each of three rack positions. These devices are standard Lanbao light diffusion detectors with simple PNP output logic.

Bar-Code scanners are used to read specification bar-code for each JIS supplied part. Due to variable location of code label sticker, there are two scanners with oscillating mirrors used to improve reading reliability. Scanner laser beam is triggered wisely (with specific delay for each reader) using ultrasonic detector sensing JIS part passing over bar-code scanners.

The HouseMar PLC (Programmable Logical Controller) is located in dedicated rack under line conveyor system. The PLC runs application specific firmware for Poka-yoke project what concerns its I/O (Input Output) operations filtering and its Round-Robin communication stacks. In general, this PLC runs in dummy mode and all decisions are done in dedicated software running on server. The PLC accessed through serial interface is equipped with CPU (Central Processing Unit) board, Digital Input board (40xDI), Digital Output board (40xDO), Connection board and chassis.

There are three independent power sources used in this project with common ground. The sources labeled „Alpha" and „Beta" are standard Industrial Grade DIN (Deutsches Institut für Normung) power sources 12V/4A. The „Gamma" power source is standard Industrial Grade DIN power source 24V/2A.

The Relay Rail is equipped with 32 standard relays RS-12 Tracon for switching currents up to 8A with both - electrical and mechanical lifetime over 1.000.000 cycles.

There are two dummy Ethernet switches inside the rack. One of them is standard L2 Cisco 8-port 10/100mbps FastEthernet switch. The other is Zyxell 8-port GbE (Giga-bit Ethernet) switch with PoE (Power over Ethernet) on first four ports – supplying power to IP cameras.

There is a dedicated Fuse-box inside the roof space of the rack for each 12V low voltage circuit. Fuses are standard Car-type fuses for 2A and 5A currents.

3. Poka-yoke system and JIS checking system behavior

The system functionality can be roughly divided into two separate function parts – indicative part for Poka-yoke implementation and checking/warning functionalities for JIS checking.

3.1. Poka-yoke indication and system parameterization

The system functionality can be roughly divided into two separate function parts – indicative part for Poka-yoke implementation and checking/warning functionalities for JIS checking.

The indicative part of the system consists of blue and green indication lights based on LED (Light Emitting Diode) stripes around parts feeding racks. Green color navigates the operator to pick specific part based on current car specifications. Blinking blue color indicates empty rack after 20 correct picks without re-filling. Steady blue light indicates rack with no feeding box inside.

System checks the JIS part specification comparing bar-codes to MES specifications. The result is indicated on lighthouse on the top of part feeding rack – steady green light means correct JIS part.

The checking/warning part of the system shows steady red light on the lighthouse indicator with audible sound alert if current JIS part is out of specification. Red LED stripe around specific rack lights in case of operator's pick part from incorrect part feeding rack. Blue indication on lighthouse indicates possible sequence shift in JIS delivery.

The system administrator can log on to Poka-yoke server and set system firmware parameters to fit specific needs. Such changes alter overall system behavior. When accessing the server, the area of JIS part frame allows the administrator to modify system behavior in case of wrong JIS part specification situation. The checkbox “JIS part Siren” enables/disables the audible sound alert in case of wrong JIS part specification situation is being detected. Attached numeric value represents the timer of siren activity in seconds. The checkbox “Wrong JIS Pick Light” enables audible warning in cases when operator’s hand is detected inside of any rack while/after wrong JIS specification situation is indicated. Attached timer value sets the time-out of this feature measured in seconds from the moment of wrong JIS specification has been detected. The checkbox “System Ignored indication” sets the system protection against ignorance from line operators. In case of successive no-pick-ups are detected (specified amount to be set in attached text box), large green flashing LED indication around upper part of the rack will activate. The checkbox “High Sensitivity Pick Detect” allows system to combine signals from PIR/Radar detectors and Motion Detection cameras to recognize operator’s hands. If this selection is unchecked, camera motion detection engine won’t be used.

There are several energy consumption optimization daemons running in system background. Depending on system activity, processor utilization and communication frequency with MES network and PLC is reduced. There is also an automatic shutdown feature that turns off all lights in the rack in case of there is no activity detected MES network.

3.2. JIS checking system behavior

Wrong JIS part Specification detection is indicated in case when the bar-code sticker on the top of the JIS part does not meet the specification from MES data. The indication is performed based on system administrator settings described above, but as a standard – lighthouse indicates red light and rack perimeter LED stripe indicates red. Audible sound alarm sounds for two seconds. In cases when operator puts his hands into the tray while Wrong JIS Specification is indicated, audible sound alarm sounds and the tray perimeter signalizes red. In such cases, it is necessary to visually check the JIS part specification and compare it to displayed MES data. Common issues are – switched JIS trolleys, wrong stickers on JIS parts or wrong JIS part specification in the trolley. In any case, the line supervisor should be informed. System returns to normal state after correct JIS part is detected or after indication times out.

Correct JIS Specification detected is indicated in any of the bar-code readers reads a bar code that is valid when compared to MES specs. The situation is indicated as “Good JIS Specification”. In such cases, the signal lighthouse indicates green. In cases when none of bar code scanners is able to read JIS part bar-code, part is treated as correct, but the signal lighthouse does not show any indication. In such cases, the position and orientation of bar-code stickers should be checked.

4. Conclusion

The implementation of Poka-yoke and JIS checking project in an automotive plant is an important step in achieving Zero Quality Control standards. The improvements are noticeable from the first moments mainly in work procedure ergonomics on the Assembly line, however there are no valid statistical data to analyze project success rate yet. Anyhow measureable improvements in assembly quality are expected from customer point of view.

References

[1] SHINGO, S.: *Zero quality control: source inspection and the poka-yoke system.*, Productivity Press, 1986.

[2] ČERNÁ, L. – MAŠEK, J.: *Meranie kvality logistických služieb*. In: Logistika - ekonomika - prax 2012: Zborník medzinárodnej vedeckej konferencie. Žilina: EDIS, 27. november 2012:. s. 18-26.ISSN 1336-5878.

[3] MAŠEK, J.: *Possibilities optimalization of store economy in business logistics*. In: LOGI 2010 : 11th international scientific conference. Brno: Tribun EU, 2010. s. 128-134. - ISBN 978-80-7399-205-7.

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Artificial neural networks applied to the modeling of aircraft landing phase

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Abstract. This article presents an application of artificial neural networks in modeling aircraft landing. To determine the network were used data recorded by on-board flight recorders. For each of the flight created a separate network, which was due to the variable parameters and duration of flight operations. The results obtained, the accuracy of mapping flights through the network, are presented in tables. Examined the impact of network structure on the accuracy of mapping aircraft landing. This will provide a simulation model and an assessment of the flight course.

Keywords: mathematical modeling, artificial neural networks, aircraft landing.

1. Introduction

In recent years, the world can be seen increased interest in air transport. This clearly connects with the growing number of pilots, which in turn leads to an increase in air traffic. In addition, growing technology air forces to meet the safety requirements and the economics of transportation. This is why it becomes important problem of mathematical modeling of the high degree of precision mapping of the actual flight by a mathematical model for this in the form of artificial neural networks. In this study, in order to obtain very good accuracy of the mapping actual flight, have been used to study the results of the actual data, which originated in the on-board flight recorder.

2. Data on board flight recorder

The data used for modeling came from the records of "black boxes" Embrear 170th aircraft It is a passenger plane, jet manufactured by Brazilian company Empresa Brasileira de Aeronautica SA from 19 February 2002.

Based on the analysis could determine the flight segments. Examples of segment boundaries are shown in Table 1.

Segment number	**Segment borders**
I	– hide the chassis; – flaps in position "0"; – significant changes in the angle of inclination; – large increase in real speed;
II	– stabilization of the magnetic course; – the angle in the range 0; – a significant reduction in the value of the inclination angle;
III	– the angle in the range 0; – stabilized magnetic course;

	– constant value of growth rate real speed;
IV	– angle reaches its lowest value; – real speed value falls slightly; – vertical speed stability; – reaching cruising altitude constant.

Tab. 1. The boundaries of segments determined on the basis of data from on-board data recorders.

3. Artificial neural network

The prototype of all neural networks is of course the human brain. A neural network is a very simplified model of the brain. It consists of a large number (several hundred to tens of thousands) information processing elements. These elements are referred to as neurons, although in relation to the actual function of the nerve cells are extremely simplified, not to say - primitive. Neurons are connected to the network via connections with parameters (so-called weights) modified during the so-called learning process. The topology of connections and their parameters are the program of the network, and the signals that appear on its output in response to specific signals are output solutions against her tasks.

Most recently built and used in a neural network has a layered structure, wherein, due to availability during the learning process the layers are distinguished: input, output, and so-called hidden layer [4-5].

In the present paper input signals are stored in a vector:

$$X^T = [t, s, V_{i-2}, V_{i-1}]$$

where:
t - time [s]
s - segment [-]
V_{i-2} - the speed at i-2 [kt]
V_{i-1} - the speed at i-1 [kt]

The output of the speed of flight while at the time (i) (vi). Before the neural network will be built to the data from the on-board recorders be standardization, which includes N data. In this particular neuron neural network is used as in Figure 1.

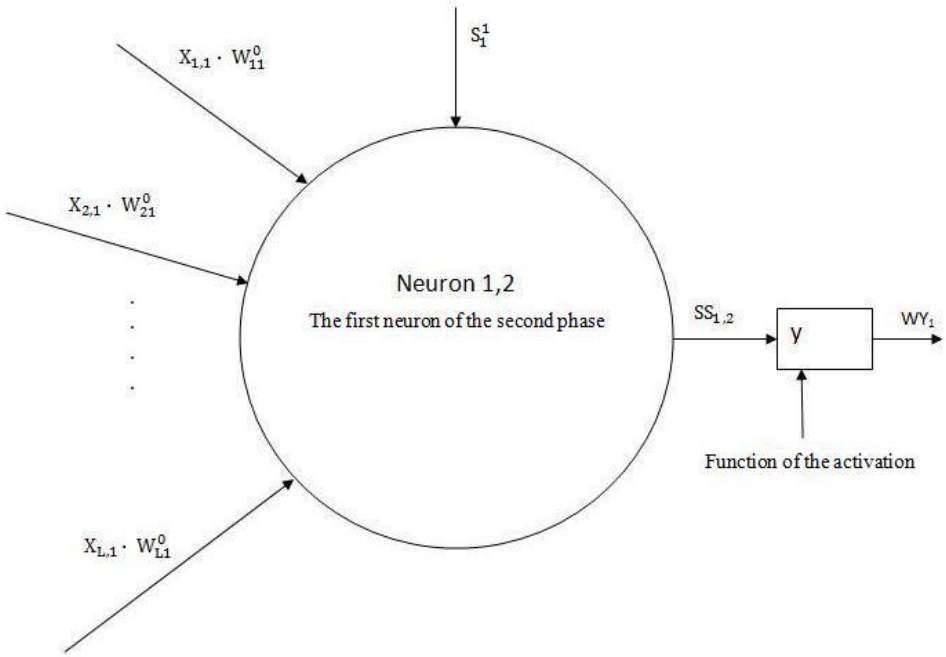

Fig. 1. Neuron used in the modeling of neural networks. Function of the activation

The output neuron used with one input neuron is the sum of x_{11}, x_{21}, ..., x_{l1}, multiplied by the weight w^o_{11}, w^o_{21}, ..., w^o_{L1} and constant s^1_1.
The output signal of the neuron in question $ss_{1,2}$ is as follows:

$$ss_{1,2} = x_1(1,1) \cdot w_1(1,1) + s_1^1$$

where:
$x_1 = [x_{1l}, ..., x_{ll}]$;
$w_1 = [w^0_{11}, ..., w^0_{L1}]$.
In addition to the development of aircraft landing phase was used as the activation function:

$$y=\frac{1}{1+\exp(-2\,y_W)}$$

The essence of the development of the network is to set fixed weights and using the results of the registration board flights. Its algorithm is used to create moments backpropagation method, in which the variables are constant learning α and η momentum.

Assessment of the accuracy of the mapping is determined by the sum of squared differences between the model and the real object and the number of positive events. The next step is to test the accuracy of the determination of the network that is compared to the input and output signals of the [2].

4. Conclusion

This section presents the results of mathematical modeling using artificial neural network. Table 2 shows the results obtained landing phase includes an assessment of the accuracy of the mapping of the model in the form of imitation of the actual network speed during the landing phase of flight.

The results are shown for different neural network structures such as the number of neurons in the input layer and the output is always the same, respectively, 4 and 1, and the change in the number of hidden layers, and one occurring in the number of neurons.

Structure of the neural network					
Number of inputs	Number of neurons in the hidden layers		Number of outputs	Number of positive events [%]	χ^2_{AV}
1	*2*	*3*	*4*	*5*	*6*
4	2	0	1	100	$0{,}51060 \cdot 10^{-3}$
4	3	0	1	100	$0{,}41722 \cdot 10^{-3}$
4	**4**	**0**	**1**	**100**	$\mathbf{0{,}29450 \cdot 10^{-3}}$
4	5	0	1	100	$0{,}41122 \cdot 10^{-3}$
4	6	0	1	100	$0{,}44352 \cdot 10^{-3}$
4	2	2	1	100	$0{,}53347 \cdot 10^{-3}$
4	3	2	1	100	$0{,}52562 \cdot 10^{-3}$
4	4	2	1	100	$0{,}51354 \cdot 10^{-3}$
4	5	2	1	100	$0{,}51225 \cdot 10^{-3}$
4	2	4	1	100	$0{,}49822 \cdot 10^{-3}$
4	3	4	1	100	$0{,}40185 \cdot 10^{-3}$
4	4	4	1	100	$0{,}39590 \cdot 10^{-3}$
4	5	4	1	100	$0{,}39959 \cdot 10^{-3}$

Table 2 Accuracy of mapping the actual landing phase of the ANN with different structures.

The network structure presented shows 100% of the number of positive events. Network structure 441 (4 inputs, 1 hidden layer with 4 neurons and 1 output) χ^2_{AV} gives the lowest value, which means that the selected structures is this best replicates the real flight.

During the study, the influence of constant learning and the accuracy of the momentum mapping landing speed over the network. Figure 2 compares the velocity waveforms of the registration board aircraft and artificial neural network with the best and worst of the structure.

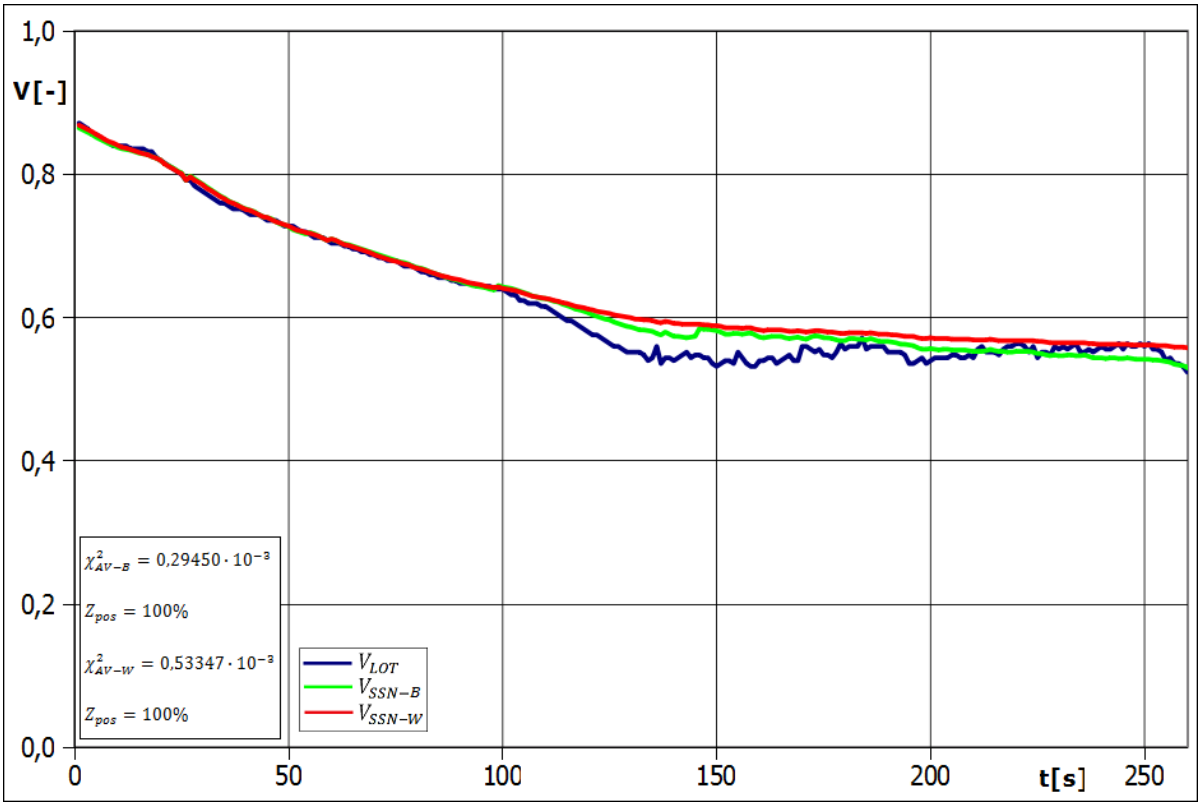

Fig. 2. Comparing the speed of the aircraft passes the registration board and the artificial neural network with the best and worst of the structure.

Landing phase lasted 190 s, of course χ^2_{AV} shows that the artificial neural network in the initial phase of the landing stage very well reproduces the construction of the aircraft. In the final phase of the landing stage, or at times when the airplane is cruising altitude, we get worse representation; however, the average deviation between the speed χ_{AV} is negligible. It can be said that the resulting network of well-mapped landing phase of flight.

The results of mapping the actual landing by the neural model can be considered satisfactory, which confirms that the neural network can be used for mathematical modeling of an aircraft. So developed model can be used to create a simulation model used to study air traffic, as well as training simulators. Unfortunately the drawback of this method is very time-consuming, high data associated with the preparation and testing of the network.

References

[1] strona internetowa Urzędu Lotnictwa Cywilnego –statystyki.
[2] Stelmach A., Manerowski J.: Identyfikacja modelu matematycznego operacji lądowania samolotu. Czasopismo Logistyka, nr 4/2011, Poznań 2011.
[3] Malarski M.: Inżynieria Ruchu Lotniczego, OWPW, Warszawa 2006.
[4] Stelmach A.; Stańczyk P.: Sztuczne sieci neuronowe w zastosowaniu do modelowania fazy wznoszenia samolotu, Czasopismo Logistyka 4/2012, Poznań 2012, płyta CD.
[5] Tadeusiewicz R.: Sieci neuronowe, Akademicka Oficyna Wydawnicza, Kraków 1993.

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Possibilities of Using Roller Performance Dynamometer to Measurement of Fuel Consumption

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Abstract. Roller performance dynamometer is not only designed to measure the actual performance of vehicles. It is a useful tool for measuring fuel consumption in different operating conditions. During these measurements, we can simulate the different states of vehicle (e.g.: engine failure, environmental influences, the effects of the driver). These types of measurements have many advantages including especially quick reproducibility and stable ambient conditions.

Keywords: performance of the vehicle, roller performance dynamometer, fuel consumption.

1. Introduction

Consumption is quite extensive concept. The issue of road vehicles represents the amount of the used (consumed) fuel for their operations. Energy released by the combustion of the fuel is used to ensure the operation of main and support functions of the vehicle necessary to perform the tasks for which the vehicle is used.

The fuel consumption can be expressed in different units. It is not strictly defined a unit expressing fuel consumption, because the variety and usability of performance vehicles is great. Therefore, the several units are used, depending on the type of vehicle performance or the measurement methods. We can use the absolute expression of fuel consumption in volume and mass units (dm^3, m^3, l, g, kg), but the higher informative value have the relative statements related to vehicle performance.

It is therefore a fraction, the numerator represents the amount of the consumed fuel. It can be given in units of volume or weight, according to the method of measurement.

$$Fuel\ consumption = \frac{dm^3, l, g, kg}{km, t, tkm}. \qquad (1)$$

The denominator is a unit expressing the vehicle's performance, depending on the type of vehicle, current use, meaningful, suitability for calculation and similar. In transport, it is most often the traveled distance, time of operation, the amount of goods transported (km, mth, t, ks, pkm, tkm) and the like.

In conditions of our laboratories we express consumption in the two most widely used relative terms. The first is the fuel consumption in free-running expressed in l/h. During operation of the vehicle we express the fuel consumption in l/100 km. In the next two parts of the article there are explained two most important technical features for measuring fuel consumption in conditions laboratories of the Department of road and urban transport.

2. Roller Performance Dynamometer Maha LPS 2000

Roller test performance is generally a device whose purpose is to identify key performance parameters of examined vehicle (especially motor power, motor torque, acceleration of the vehicle).

This type of workplace must be equipped with:

• roller performance dynamometer (test cylinders, communication desk to operate the equipment, printer)

• Cooling fan

• Exhaust gas equipment

• Fixing straps

Options for measuring on the roller performance dynamometer Maha LPS 2000 can be divided into the following parts:

• Performance measurement of the vehicle

• Performance simulation

• Measurement of acceleration

• Check the tachometer

Measuring the performance of the vehicle can be considered as the main type of measurement on the roller performance dynamometer. The task of this measurement is to detect the external speed characteristics of the engine. Measuring the performance of the vehicle can be considered as the main type of measurement roller test performance. Task of this measurement is to detect the external characteristics of the engine speed. Roller performance dynamometer also defines the level of losses, which is the difference of performance vehicle on wheels and performance of the engine itself.

Simulation performance is a kind of measurement, in which the roller performance dynamometer allows to measure performance parameters under various operating conditions. Examples of these types of measurements are to simulate driving of the vehicle in a defined gradient, or driving at a constant speed, or at a constant fastness.

Measurement of acceleration of the vehicle is a tool in which you can measure the length of time set the initial and final speed.

The aim of the control tachometer is to determine difference between the given and the measured speed values. The purpose is to determine deviations of actual vehicle speed from the vehicle speed indicator.

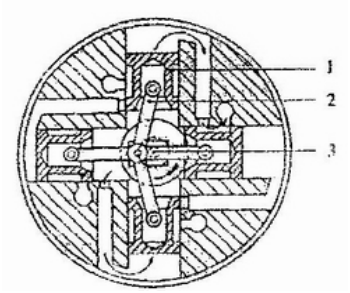
Fig. 1. Roller performance dynamometer Maha LPS 2000

3. Volume Flowmeter Flowtronic 205

For the accurate measurement of fuel consumption of vehicles in operation are most commonly used the **volume flowmeters**. In this method of measurement is necessary the fuel flow sensor mounted in the fuel system of the study vehicle.

Volume flowmeter Flowtronic 205 is a device that consists of:

1. **The sensor** works on the principle of extrusion fuel and it consists of 4 radially mounted pistons, crank mechanism and the body with the connecting and transfer channels. Pistons are set in movement by the fuel pressure. Fuel is the entrance pipe brought into the space of the crank mechanism. Fuel also provides lubrication of the crank mechanism. Fuel which is in the area of the crank mechanism does pressure on the piston, which is at the moment at the top dead center, pushing it to the bottom dead center and overprint the fuel that is in the space above the piston opposite. The speed of crankshaft is sensing with the contactless magnetic sensor and the signal is transmitted to the evaluation unit.



1. piston
2. connecting rod
3. crankshaft

Fig. 2. Volume flowmeter Flowtronic 205

2. **The evaluation member** is the electronic calculator, which processes the impulses transmitted from the sensor. Each pulse represents one rotation crank mechanism. The amount of fuel that flows through the sensor during one rotation of crank mechanism is called the "unit measurement" and it is the sum of swept volume of the all piston sensor.

4. Methods of Measuring Fuel Consumption in Laboratory Conditions

Consumption measurement in laboratory conditions is currently performed mainly by calculation from the amount of produced gas of the vehicle under defined conditions.

Directive 70/220/EU describes the procedure according to which are approved vehicles with regard to emission profile. This is identical with the regulation „EHK OSN 83" for approval of a vehicle with regard to emissions. Driving cycle in accordance with this regulation consists of urban cycle, which is also known as ECE-15, and the extra-urban cycle marked EUDC (European Urban Driving Cycle). The composition of the driving cycle, which consists of four ECE-15 and then one EUDC is called the NEDC (New European Driving Cycle).

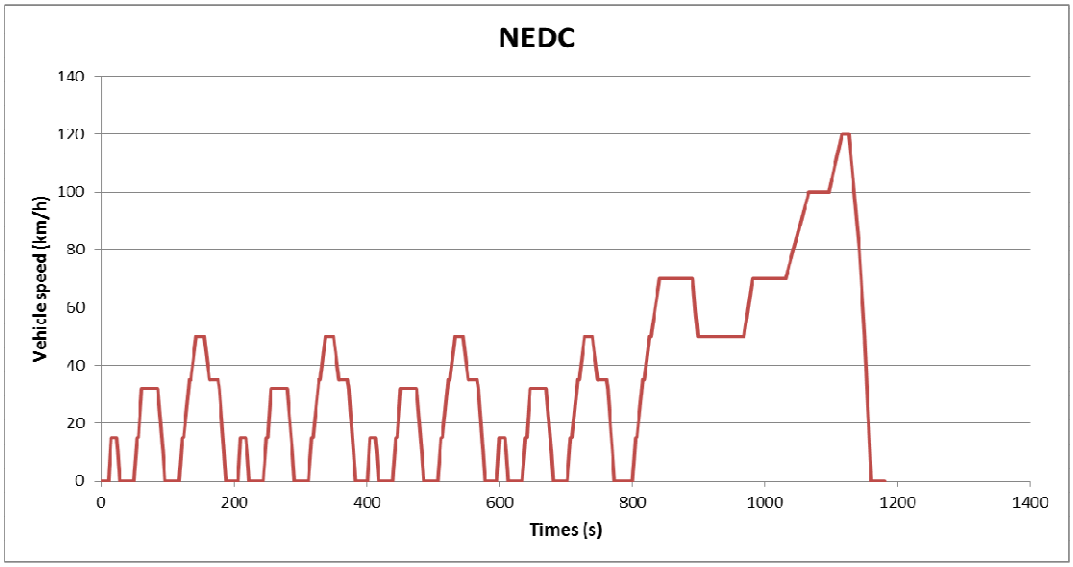


Fig. 3. New European Driving Cycle

In laboratory conditions of the Department of road and urban transport can be carried out only consumption measurements in the steady speeds. Examples of output from these measurements are given below.

5. Examples of Measurement of Fuel Consumption

In the mentioned workplace there is measured the fuel consumption at constant speed. There are examined particularly the following effects on the fuel consumption of vehicles:

- impact of settings the engine control unit
- impact of selected engine components (fault simulation)
- impact of the operating conditions
- impact of the driver
- impact of vehicle technical condition
- impact of the type of fuel

Methodology of measurement is the measurement of the fuel and the distance of the vehicle and subsequent calculation

Example 1

Fuel consumption of Kia Ceed 1.6 CVVT in the simulation of speed 90 km/h and ignition failure on one cylinder.

t = 60 [s]	Flowtronic	Volume	Distance	Fuel consumption
Number of measurement	[cm^3/min]	[l/min]	[m]	[l/100km]
1	134,792	0,134792	1 500	8,986
2	138,784	0,138784	1 500	9,252
3	136,784	0,136784	1 500	9,119

Tab. 1. Fuel consumption at steady speed 90 $km.h^{-1}$

Example 2

There was examined the effect of setting the vehicle's engine control unit Skoda Fabia 1.4 MPI. On the vehicle, there were realized four modifications of the program of the engine control unit. Fuel consumption was measured at engine idling as well as at 4 steady speeds. Summary results are listed in the Tab. 2.

	Idle speed ($l.h^{-1}$)	Steady speed			
		30 $km.h^{-1}$ ($l.100km^{-1}$)	50 $km.h^{-1}$ ($l.100km^{-1}$)	90 $km.h^{-1}$ ($l.100km^{-1}$)	120 $km.h^{-1}$ ($l.100km^{-1}$)
Original software	1,0080	8,5390	5,7927	6,0778	7,6526
1. modification	0,9801	8,2070	5,5776	6,0114	7,6038
2. modification	0,9601	8,1008	5,5537	5,9981	7,6038
3. modification	0,9362	7,9680	5,5378	5,9671	7,6038
4. modification	0,9442	7,9946	5,5298	6,0070	7,6038

Tab. 2. Fuel consumption

6. Conclusion

Measuring of fuel consumption is one of the most important operating characteristics of road vehicles. Its measurement is essential in determining the impact of affecting fuel consumption. Measuring of fuel consumption in laboratory conditions with the use volumetric flow meter is suitable for this purpose method ensuring accuracy, speed and accuracy.

References

[1] GONDŽÁR, A.- GONDŽÁR, K.: Automobily a spotreba paliva. Nakladatelství dopravy a spoju, Praha, 1989. ISBN 80-7030-085-X.

[2] DENTON, T. Advance automotive fault diagnosis, Elsevier, Oxford, 2006, ISBN-10: 0-75-066991-8

[3] KAMBLE, H.S.- MATHEW, V.T.- SHARMA, G.K.: Development of real- world driving cycle. Central institute of road transport. Pune, 2005.

[4] GONCALVES, G.A.- FARIAS, T.L.: On-road measurements of emissions and fuel consumption of gasoline fuelled light duty vehicles. Instituto Superior Tecnico, Lisbon.

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The Evaluation of Services Quality in Road Freight Transport and Forwarding

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Abstract. This paper deals with transport and forwarding quality assessment. First of all, we need to know what the quality exactly means and then we are able to define the quality in transport and forwarding field. There are two different conditions of quality: quality for public urban transport and freight transport. These kinds of transport have different type of quality characters. It is important to evaluate these characters for future of organizations, and also to know how to improve their services and products and have a stable position in the transport and forwarding business.

Keywords: Quality, Transport, Forwarding, Services, Evaluation

1. Introduction

The meaning of the word "Quality" is used like marks of excellence of services and goods in community without knowledge in this field. It is evaluation of the services or goods. The quality is a sum of subjective opinions at the object. The quality is expressed in quality characteristics and her level is expressed through a measured or assigned value.

There are a lot of definitions of the word "quality". Every sector or department understands something different under the term.

In the norm STN EN ISO 9000: 2009 Quality management systems- Fundamentals and vocabulary, the quality is defined like "degree with which a set of own characteristics fulfills requirements"

2. The Quality in Road Freight Transport and Forwarding

Requirements are not much different in freight and forwarding services. The differences may be caused by different defining priorities with respect to final destination. This priority can be transformed to the mathematical formulation of quality evaluation.

The external quality is the quality what a customer sees. This quality is mainly in places of contact with a customer.

In **the internal quality**, from a transport operator perspective, the price is important for provision of services quality or higher level of services quality. From a technological perspective, the emphasis is mainly on the operation of the organization and ensuring the economical, safety and environmentally friendly method of the transportation process technology. The suitability of technological process may be shown also in the external quality of services.

The most important quality criteria in forwarding are:

- reliability,
- accuracy,
- safety,
- speed,
- protection of shipments,
- delivery time,
- politeness of employees,
- qualification of employees,
- technical condition and appearance of the vehicle,

- communication,
- credibility,
- flexibility
- planning.

The most important quality criteria in freight transport are:

- reliability of carrier - compliance with delivery times, places of loading and unloading,
- transportation of intact shipment from door to door,
- minimal time from the order of the transport till the realization,
- speed of delivery,
- price corresponding of customers´ ideas and services quality,
- suitable capacity (chance to select vehicle)
- exact information about the services offered,
- adaptation activities of carrier to the customer needs.

The perception of the quality movement is characterized by two views: external and internal quality.

3. The Importance of Measurement and Quality Assessment

The quality evaluation and measurement represents tool for objectification and quantification of quality services level, which are provided. The most important economic reason for measurement and evaluation of quality is checking of the requirements at quality of transport services.

The organization can establish its own methods of evaluation, adopt or edit method that was adopted by importance of selected requirements. There are two methods for measurement and evaluation of quality criteria: one-criteria and multi-criteria.

In the one-criteria evaluation of quality, the result is a quality value based on monitoring and measurement of one from the selected quality characteristics.

The advantage of this method is simplicity in monitoring only one characteristic, which was selected.

The disadvantages are:

- showing a lower meaning of quality service character,
- possibility of obtaining positive results of the evaluation also for non-compliance certain quality requirements (hidden poor quality).

The result of the multi-criteria evaluation of quality is a value based on monitoring and measurement of a group of quality characteristics, which are characteristic for freight transport quality.

This method shows us more clearly characteristics of transport quality. Monitoring of criteria group allows complex view at the transport services provided. It respects interrelationships among selected characteristics.

Each of importance values must respect priorities of individual criterion. The total evaluation of importance is measured based on arranged pairs, which are importance value of the specific criterion and level of requirements fulfillment for the specific criterion.

$$HK = \sum_{i=1}^{n} v_i . s_i \qquad (1)$$

Where: HK is total value of quality,
v_i is value of importance; i- quality criterion,
s_i is level of requirements fulfillment; i- quality criterion from supplier perspective.

Evaluator sets the importance value of criteria. It is possible to specify those values by many ways, which are defined in publication [1]. The fulfillment level of the specific quality criteria is measured based on real measured a fulfillment or not fulfillment of criteria directly in services provision process. Evaluator determinates the level of fulfillment. Technical resources or measurement by a supervisor can be used for measurement of level fulfillment. Because of objectification of supplier quality assessment, where the suppliers provide services in different range, it is appropriate to calculate the level of fulfillment by relative way for positive quality criteria.

$$s_i = \frac{X_m}{X_n} \tag{2}$$

For negative quality criteria (failure to comply with the delivery time, damage shipments etc.):
Where X_m is number of shipments, which were done positively in i quality criteria during the evaluation period,
X_n is total number of shipments during the evaluation period.

$$s_i = \frac{1 - X_m}{X_n} \tag{3}$$

Where X_m is number of shipments, which were done negatively in i quality criteria during the evaluation period.

For designing methods of measuring and evaluating the quality, it needs to be solve also issues as:

- time interval realization of measurement and evaluation quality,
- the number of quality criteria included in the method,
- the ways of measuring,
- persons trained and responsible for the measurement and evaluation,
- purpose of the use of the results and its distribution by the rated entity.

The goal of the methods is to ensure the required service quality, selection of quality suppliers and elimination of low-quality suppliers of transport services. The unified methods and their results can be used in future by associations of carriers and shippers to compile objectively supplier charts of transport services in terms of services quality.

4. Conclusion

The service quality in transport and forwarding is also significant determinant of demand. In the competitive environment, it is an important tool for customer retention and also it has affects on the performance and economic results of the organization. When you have a competitive advantage, it means to satisfy customer requirements but also to overcome their expectations. Dissatisfied customers are able to say their bad experience, which can affect the attitude of other customers. Dissatisfied customer means a loss of revenue, loss of missed opportunity and in the end loss of customers.

The future of each organization depends on customer behavior. Increasing the level of satisfaction must be one of the main objectives of each organization.

Acknowledgement

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References

[1] MOJŽIŠ, V., *Kvalita dopravních a přepravních procesu*, Institut Jana Pernera, o.p.s.: Pardubice, 2003

[2] KONEČNÝ, V., *Nástroje a metódy manažérstva kvality*, Žilinská univerzita v Žiline/EDIS- vydavateľstvo ŽU: Žilina, 2012

[3] STN EN ISO 9001: 2005, *Systém manažérstva kvality- Základné princípy a slovník*

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The process of establishing Functional Airspace Blocks

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Abstract. This paper deals with the implementation of Functional Airspace Blocks (FABs) in Europe. It focuses on the main activities of stakeholders to achieve objectives of Single European Sky's Framework Regulation. The current status indicates that the European airspace requires increased capacity, higher, flexibility and improved efficiency. For achievement of these objectives FABs were defined. The paper is structured into three main parts. First, the introduction contains background of scoped area. Next, it describes individual requirements and phases of development and finally, conclusions. The aim of the paper is to introduce the key issues associated with the processes of establishing sustainable European airspace.

Keywords: Functional Airspace Block, Single European Sky, EUROCONTROL.

1. Introduction

European airspace is characterized by high fragmentation, which is divided into 60 control centers in 27 national air traffic control systems. Currently aircraft fly 42km longer than necessary due to configuration of airspace, causing longer flight time, delays, extra fuel burn and emissions, estimated to cost users an additional €5 billion each year, according to the Performance Review Body analysis of en route and terminal air navigation services costs published in 2010. [1] Every time when an aircraft enters into the airspace of a Member State is controlled by different Air Navigation Services Provider (ANSP) under different rules and operational requirements. Each ANSP operates tailored equipment and most maintain their own training organizations and all other support functions. This fragmentation impacts on safety, limits capacity, and above all, adds to cost. If this does not change, it can significantly results in an increasing congestion, given by the expected growth of air traffic. The key to improved capacity and efficiency, increased safety and lower costs of air traffic control is through enhanced collaboration and integration across borders. It represents the establishment of Functional Airspace Blocks (FABs) which is crucial mechanism for the Single European Sky (SES). The framework ensuring increased cooperation and integration leading to a more rational organization of airspace regardless of state boundaries in the European Union. It also means that civil-military coordination in air traffic control. The provision of air navigation services must be performance-driven and optimized. FABs will be drivers for change and the power of the national ATM services and it will be an invaluable tool in achieving ANSP binding performance targets.

2. The process of establishing FABs

2.1. Background

The main strategy to increase European airspace capacity is to reorganize the airspace from sixty fragmented areas according to national borders into nine FABs designed for better utilization of air traffic flow management (see Fig. 1). This reconfiguration aims at achieving more integrated management of the airspace. It is based on operational requirements, regardless of existing boundaries. This means, in particular, that the design of routes and the service provision should not be constrained by the national boundaries. Establishing effective partnerships among ANSPs is key

to improving the efficiency of the European ATM system. The full list of FABs are: UK-Ireland FAB, Danish-Swedish FAB, Baltic FAB, BLUE MED FAB, Danube FAB, FAB CE, FABEC and South West FAB.

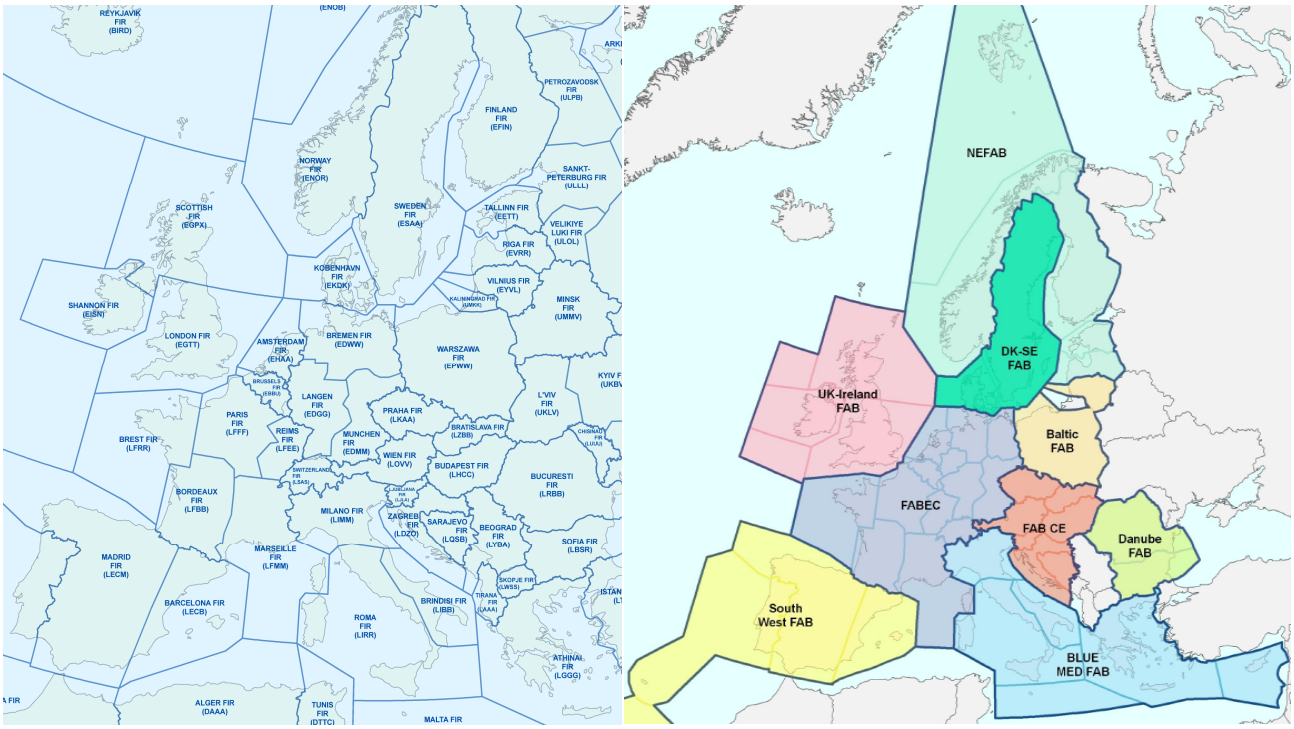

Fig. 1. Fragmentation of European airspace and Functional Airspace Blocks [4]

2.2. Regulatory requirements

Building on the achievements of the internal market and the need to cope with air transport growth and congestion, the European Commission (EC) launched in 1999 the Single European Sky (SES) initiative. The 1999 Communication underlined in particular that the European Union (EU) could not maintain frontiers in the sky where they had been removed on the ground. The SES objective is to reform the architecture of air traffic control in the EU in order to meet future capacity and safety needs. It would do this through improving the overall performance of air traffic management (ATM) and air navigation services (ANS), with the aim of:

- increasing airspace capacity threefold, so reducing delays;
- improving safety performance tenfold;
- reducing environmental impact by 10%; and
- reducing ATM costs by 50% [2]

2.3. Framework regulations

The requirements for the establishment of Functional Airspace Blocks (FAB) are defined in the EUROCONTROL Report on the European Commission's Mandate on the subject. It identifies improvements in flight-efficiency within each FAB which provides significant opportunities for savings to operators and benefits for the environment. According to EUROCONTROL, one quarter of European route extension issues can only be solved across FABs and Europe-wide, a strong and effective network management and design function at European level is necessary.

The concept of FABs was defined in the 1st legislative package (2004) of the SES and further developed in the 2nd legislative package (2009). The creation of FABs is one of the cornerstones of the SES. [3]

2.4. FAB initiatives

The service provision Regulation (EC) 550/2004 as amended by Regulation (EU) 1070/2009 requires that FABs shall respect the following standards:

- be supported by a safety case
- enable optimum use of airspace, taking into account air traffic flows
- be justified by their overall added value, including optimal use of technical and human resources, on the basis of cost-benefit analyses
- ensure a fluent and flexible transfer of responsibility for air traffic control between air traffic service units
- ensure compatibility between the configurations of upper and lower airspace
- comply with conditions stemming from regional agreements concluded within the ICAO
- respect regional agreements in existence on the date of entry into force of this Regulation, in particular those involving European third countries
- facilitate consistency with EU-wide performance targets [4]

2.5. Development of FABs

The European Commission (EC) appointed EUROCONTROL as network manager, supported by a Network Management Board (NMB), in 2011 tasked with improving the European ATM performance and developing an efficient and safe route network design, the aim is to promote cooperation and defragmentation among Europe's ANSPs. Board members comprise representatives of ANSPs, airspace users, airport operators, civil and military operational stakeholders.

Massimo Garbini (Chairman of NMB) explains representatives on the Board are limited to only one per FAB in order to encourage ANSPs to work collectively. "In addition to that, only four voting rights, out of the total number 12 distributed to the operational stakeholders, are recognised to the ANSPs. this arrangement further pushes ANSPs to cooperate not only within the FAB but also between the FABs and more in general to seek partnership with other stakeholders, to ensure decisions at Board level can be built with large consensus." the governance of the network function is designed around the concept of cooperative decision making. The working model has to ensure that all interested parties are involved and decisions are taken based on the active contribution of those parties. It is a two-way process in which the stakeholders have to ensure the measures implemented at local level are compatible with those adopted at network level. Sultana says there has been no disagreement on the Board yet, and while the network Manager has no power to impose a network solution, there is now a direct pathway via the NMB to the European Commission, that has entrusted EUROCONTROL. [4]

2.6. Current phase

Many European Union Member States are lagging behind and not yet fully comply with the requirements. Signatories failed to meet a December 4 deadline to establish operating FABs as required by SES regulations dating to March 2004. It ascribed this delay in accordance to lengthy upon completion institutional issues and inadequate protection of national interests. European Commission also served notification that it will begin infringement proceedings against the Member States whose not comply requirements. Some countries are still working at SES from the first period. Their debt remains in the second, for which target setting will be decisive. European Commission responded and sent a strong political message on the feelings of frustration at the slow

pace of implementation FABs. It can resulted into infringement procedures against the Member States to reflect on ideas for an EU legislative.

2.7. Future airspace design

European Commission anticipated a network comprising FABs responsible for European airspace, in place of multiple ANSPs. Next year will be critical for the credibility of SES by raising capacity of European airspace, improving safety and cutting costs. Another Goal is to reach less than 0.4 minute average delay per flight. This is what EC wants and the Performance review Board is overseeing to achieve this. The Board has also been actively engaged in setting the framework for more stringent targets. The network Strategy Plan for 2013-2019 includes the Network Performance Plan, while the European network improvement Plan identifies some of the issues to be addressed including far wider use of collaborative decision making. The issues are not really operational. There are examples of improvements, FABEC States have identified and run real-time simulations on important projects which have yet to be implemented as they are very complex. But no FAB will operate successfully should the participating States and ANSPs continue to focus on national interests. This is why EC welcomes initiatives of possibly going for FAB targets in the future as a means of overcoming this national focus. [5]

3. Conclusion

The fact is that at present there is little guidance in the legislation that describes the process that must be followed by Member States to establish or change FAB. Although the Regulations designate general principles for the modification of FABs, these have not yet been prepared. It should be noted that Member States want to maintain maximum flexibility in the development. The SES study identified that the introduction of FABs was an ambitious project, and would be as a political commitment. The Single European Sky Provision Regulation requires that Member States shall take all necessary measures to achieve the desired capacity and efficiency of Air Traffic Management network and maintaining a high level of safety and reduce the impact on the environment.

Despite continuing problems with implementation, this project is one of the crucial in the SES, which is increasingly recognized by stakeholders. The biggest barrier to this activity are national requirements, but the initiative of the European Commission should significantly speed up the process and to solve implications mentioned in this paper.

References

[1] STATFOR, Bulletin *on air transport trends.* 2013. EUROCONTROL. Available from: http://www.eurocontrol.int /sites/default/files/content/documents/official-documents/industry-monitor/eurocontrol-industry-monitor-149.pdf

[2] REGULATION (EC) N° 1070/2009. *Single European Sky*. 2nd ed. 2009. Available from: http://ec.europa.eu/ transport /modes/air/single_european_sky

[3] GARBINI M. *Skyway magazine.* EUROCONROL. 2013 Available from: http://www.eurocontrol.int/ sites/default/files/content/documents/official-documents/skyway/2013-skyway-spring-59-singles.pdf

[4] CAREY B. *EU States Miss FABs Deadline.* 2012. Available from: http://www.ainonline.com/aviation-news/ain-air-transport-perspective/2012-12-10/eu-states-miss-deadline-functional-airspace-blocks

[5] THANOS C. *"Nash equilibrium" situations among FABs.* 2011. Available from: http://www.garsonline.de/ Downloads/090910/Papers/Paper_Papavramides_Nash-ATM.pdf

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The Use of the Genetic Algorithm for the Evacuation Plan Design

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Abstract. Evacuation can be performed effectively only under a good evacuation plan. The evacuation plan design requires solving the vehicle assignment problem (VAP). This problem is hard to solve but has to be solved in a short computational time in order to the evacuation plan can be completed promptly. In this paper, the min-max approach is shown for solving this problem where reduced VAP is solved in the each iteration. We propose to use the genetic algorithm to solve the reduced problem. Moreover, we propose to improve efficiency of the algorithm by using the appropriate selection and crossover operators. Hereby, we study the impact of the proposed algorithm on the quality of results.

Keywords: evacuation plan, vehicle assignment, combinatorial problem, genetic algorithm.

1. Introduction

Evacuation is an activity which serves for protection of human life and health. When some natural disasters or other emergencies occur the evacuation allows minimising the consequences of such emergencies. The evacuation can be done efficiently only under a good evacuation plan which allows evacuating people from the endangered dwelling places to the safety places in minimal time. Such plan has to contain the route for each vehicle which will be used during the evacuation. The vehicle assignment problem [5] (VAP) has to be solved in order to these routes can be determined.

2. Vehicle Assignment Problem

In the transportation network, there are two sets I and J. The set J is the set of the endangered municipalities where each municipality $j \in J$ is characterised by a number b_j of inhabitants who have to be moved to the pre-assigned refuge. In the set I, there are the fleets where each fleet $i \in I$ contains N_i vehicles with the same capacity. The objective of VAP is to assign an appropriate number of vehicles from the fleets to the municipalities so that the evacuation can be done in minimal time. Because of a presumption that each vehicle can be assigned to one municipality at most, the route of a vehicle is given when the vehicle is assigned to a municipality [2].

2.1. Iterative Method

VAP leads to nonlinear mathematical model. The nonlinearity was successfully mastered in [1] using the special iterative method where the separate reduced VAP is solved in the particular iterations for the fixed time (T^{max}). Although, the reduced vehicle assignment problem is linear it still represents a hard combinatorial problem.

2.2. Reduced Vehicle Assignment Problem

The objective of the reduced vehicle assignment problem (RVAP) is to assign an appropriate number of vehicles from the fleets to the municipalities so that the evacuation can be performed in the *predetermined* time T^{max}. If the following values are known (the vehicle capacities, the time T^{max} and the travelling times between the fleets, municipalities and refuges) then the coefficients a_{ij} for $i \in I$, $j \in J$ can be determined. The coefficient a_{ij} represents the number of people who can be

evacuated from the municipality j by one vehicle from the fleet i up to the time T^{max}. Let us define the following sets to make the problem model smaller. The set $I(j)$ is the set of the fleets $i \in I$ where $a_{ij} > 0$ and the set $J(i)$ is the set of the municipalities $j \in J$ where $a_{ij} > 0$. We introduce the variables $q_{ij} \in Z_0^+$ for $i \in I$, $j \in J(i)$ which denote the number of vehicles from the fleet i which are assigned to the municipality j. The objective of RVAP is to find a feasible solution which satisfies the constraints (1)-(3) or to prove that such solution does not exist.

$$\sum_{j \in J(i)} q_{ij} \leq N_i \qquad for\ i \in I \tag{1}$$

$$\sum_{i \in I(j)} a_{ij} q_{ij} \geq b_j \qquad for\ j \in J \tag{2}$$

$$q_{ij} \in Z_0^+ \quad for\ i \in I,\ j \in J(i) \tag{3}$$

The set of constraints (1) ensures that only vehicles which are in the fleets will be used for evacuation. The constraints (2) ensure that every inhabitant from every municipality is evacuated.

3. Genetic Algorithm

We used the genetic algorithm (GA) to solve RVAP in the previous research in [5], where we focused on appropriate setting of these control parameters: number of populations (*NoP*) and number of individuals (*NoI*) in each population. The analysis of experiment results showed that it is convenient to set the parameters *NoP* and *NoI* rather to values lower than 300 than to higher values. Although we lose some accuracy, we achieved considerable computational time saving. In this paper we focus on an improvement of the efficiency of GA for these lower values. We propose to test selected operators of selection and crossover and then to choose the best combinations of them.

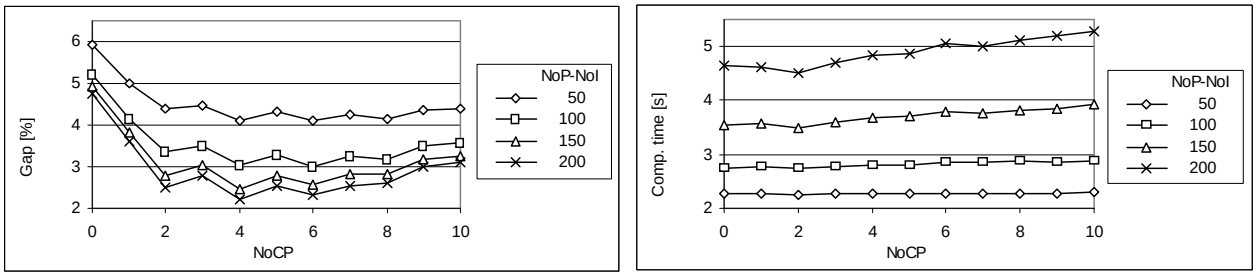
We suggest using these two selection operators: the roulette wheel selection with linear ranking (RWS+R) as in [6] and the tournament selection (TS). The advantage of RWS+R selection scheme is that it can be done in $O(1)$ time [3]. In TS, τ individuals attend the tournament and the best one is chosen (the value of the parameter τ is adjustable).

Further, we propose using the following crossover operators: the partially mapped crossover (PMX) and the adapted uniform crossover (UX). Both of them are used for non-linear crossover, because we use non-linear encoding of individuals, specifically the individual is represented by a permutation of numbers [5]. The operator PMX operates as follows: number of crossover points (*NoCP*) is chosen uniformly and the sections between couples of these points define an interchange mapping which is applied on the respective individuals. At UX, the 0-1 mask is generated, where the genes corresponding to 1 are copied from one individual and those that corresponds to 0 are taken in the order they appear from the second individual in order to fill the gaps [3]. We set the probability that the mask element has the value 1 to the value 0.5 according to [4].

4. Numerical Experiments

We performed numerical experiments on a personal computer which is equipped with Intel Pentium D with parameters 3 GHz CPU and 1 GB RAM to study the suggested approach. We solved twenty benchmarks of the vehicle assignment problem which are created on the transportation network of Slovakia. In the previous research in [5] the following selection and crossover operators were used: PMX(2) and RWS+R (according to [3] *NoCP* was set to the value two). In this paper, we experimentally tested all combinations of the suggested selection operators RWS+R and TS(τ) and crossover operators PMX(*NoCP*) and UX. Based on the results in [5], we tested this approach for the following (low) couples of *NoP*-*NoI*: *NoP* = *NoI* = 50, 100, 150, and 200.

First, we tested the couple PMX and RWS+R. We set the parameter *NoCP* in PMX to the values 0, 1, 2, … , 10 successively. We solved the benchmarks for several times (in order to suppress the impact of a random process) and computed the average values of the cost function and the computational time. Based on the average values of the cost function and best known lower bounds we computed the gaps between these values. The average values of the gaps (a) and the average values of the computational time (b) for each value of *NoCP* are shown on the charts on the **Fig. 1**.



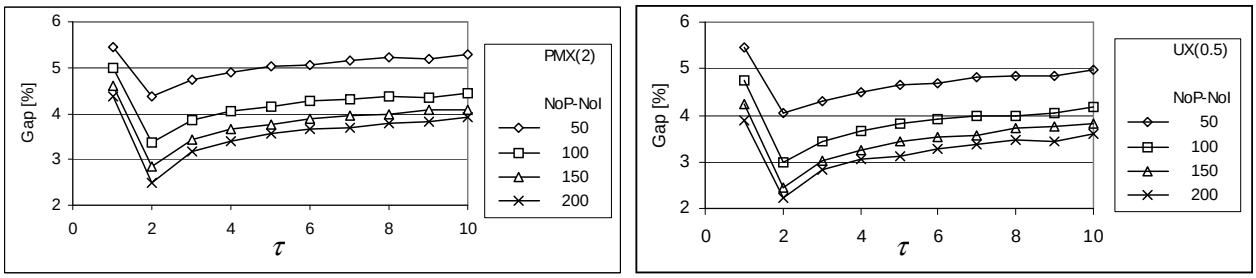
(a) (b)

Fig. 1 Relation between the parameter *NoCP* and quality of results (a) and computational time (b)

The experiments showed that the even values of *NoCP* from the interval $\langle 2; 8 \rangle$ are good and they give similar good results. The even value of *NoCP* always closes the section which defines an interchange mapping in PMX. The computational time is lowest for the value two so this value is the best one for *NoCP* in PMX.

In the next experiments we tested also the UX(0.5) with the RWS+R operator for the selected *NoP-NoI* couples. No additional parameters were set in these experiments.

In the next two experiments we tested the selection operator TS(τ) with the crossover operators PMX(2) and UX(0.5) successively. We tested several values of the parameter τ (τ represents the number of individuals which attend the tournament) for chosen *NoP-NoI* couples. We set τ to the values 1, 2, 3, … , 10 successively and again computed the average values of the gaps. The charts on the **Fig. 2** show relations between the values of the parameter τ and the average values of the gaps when TS(τ) was used with PMX(2) (a) and with UX(0.5) (b).



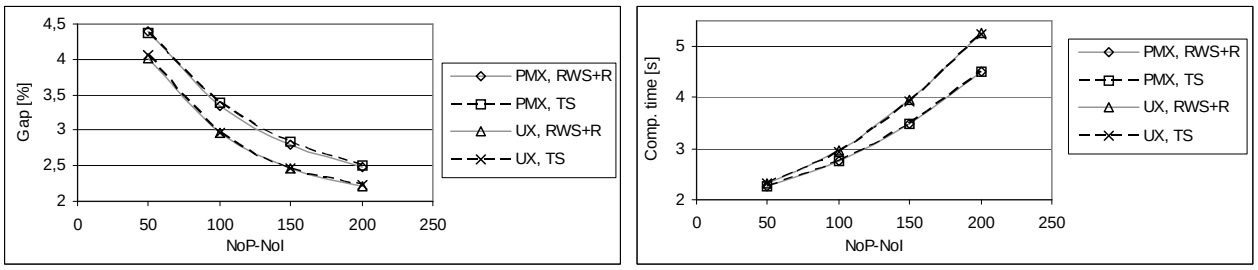
(a) (b)

Fig. 2 Relation between τ in TS and quality of results for PMX (a) and UX (b)

The experiments obviously show that the best value of the parameter τ in TS is 2. For this value the best results were obtained with both crossover operators PMX and UX for each selected *NoP-NoI* couple.

Finally, we compared the results of the experiments which we had obtained for each combination of the tested selection and crossover operators. The charts on the **Fig. 3** show the average gaps (a) and average computational times (b) for each combination of the tested operators.

The experiments show that the crossover operator UX is more efficient than PMX. Although, UX requires little bit more computational time than PMX, the difference is small and therefore we recommend to use the operator UX in the future research.



(a) (b)

Fig. 3 Comparison of efficiency (a) and computational time (b) for the selection and crossover operators

A brief analysis of the experiment shows that the efficiency of the selection operators RWS+R and TS(2) is nearly the same. This is because, as they write in [3], TS with $\tau = 2$ has similar property to the linear ranking when its some parameter converges to zero and we used RWS+R with such property. Based on the advice in [3], where they recommend to use rather TS than RWS, we determined the best combination of selection and crossover operators in GA as TS(2) and UX.

5. Conclusion

These days the evacuation plan design problem is an actual topic. In order to the evacuation plan can be completed VAP has to be solved. In this paper, we briefly showed the min-max approach for solving this problem where RVAP has to be solved in the each iteration. We used GA to solve the problem. We focused on an improvement of efficiency of the algorithm by using the suitable selection and crossover operators with appropriate setting of their parameters. We studied the impact of the individual operators on the quality of results and chose the best combination of the selection and crossover operators for GA.

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References

[1] JANACEK, J. Handling of a non-linear model of the evacuation plan design by IP-solver. In *Proceedings of the 10th International Symposium on Operational Research*. Nova Gorica, Slovenia : Slovenian Society Informatika, 2009. pp. 279-287.

[2] JANACEK, J., SIBILA, M. Optimal evacuation plan design with IP-solver. In *Communications*. ISSN 1335-4205, 2009, vol. 11, c. 3, pp. 29-35.

[3] REEVES, C. R. Genetic algorithms. In GENDREAU, M., POTVIN, J.-Y. (eds.) *Handbook of Metaheuristics*. New York: Springer, 2010. pp. 109-139.

[4] SYSWERDA, G. Uniform crossover in genetic algorithms. In SCHAFFER, J. D. (ed.) *Proceedings of the 3rd International Conference on Genetic Algorithms*. San Francisco, CA, USA: Morgan Kaufmann, 1989. ISBN:1-55860-066-3, pp. 2-9.

[5] TOMAN, L. Near-optimal solution of the evacuation plan design with using genetic algorithms. In *Journal of Information, Control and Management Systems*. Zilina: University of Zilina, 2013. ISSN 1336-1716, unpublished.

[6] TOMAN, L. The use of the genetic algorithm for the upper bound calculation of the vehicle assignment problem. In *Mathematical Methods in Economics: Proceedings of the 30th International Conference*. Karvina, Czech Republic: Silesian University in Opava, School of Business Administration in Karvina, 2012. pp. 903-908.

[7] ZELINKA, I. *et al*. *Evolucni Vypocetni Techniky*. 1. vydanie. Praha: BEN – technicka literatura, 2009. 534 s. ISBN 978-80-7300-218-3.

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Impact of Telecommunication Technologies on Business Air Travel

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Abstract. This paper deals with the issue of videoconferencing as an alternative to in-person business trips made by air travel. With the technology ever advancing and the costs of acquiring such a technology falling gradually it is only logical to consider such an option. Paper discusses main advantages and disadvantages of both videoconferencing and business trips. It gives an answer to a question why the videoconferencing has still not overwhelmed the costly and time consuming business air travel. Research shows that videoconferencing plays only a supporting role in business undertaking and is used mainly after the initial contract has been successfully arranged.

Keywords: business air travel, videoconferencing, telecommunication technologies

1. Introduction

Personal meetings have long been acknowledged as the most effective way of doing business, key elements being the capacity to transmit equivocal information, produce immediate feedback and build a personal and authentic atmosphere [1]. These are qualities considered important in business life and have proved hard to replace with information and communications technology (ICT), including videoconferencing. However, recent years have seen a rapid change in videoconferencing technology. Manufacturers of videoconferencing equipment now offer flexible communication services for conference rooms, desktops and mobile terminals for different groups and usage situations.

This transformation is likely to shape the ways in which videoconferencing will affect business communication as new forms of collaboration and interaction are enabled. Travel substitution has been a key assumption of videoconferencing ever since its introduction in the 1960s. Now the topic is more relevant than ever in light of the high volume and growth in air traffic contributing to increased CO2 emissions. Moreover, stricter security policies at airports emerging as a response to the threat of terrorism put constraints on the business traveller [2].

A few years ago there were four million air passengers each day and 1.9 billion air journeys each year. Work-related travel globally counts for about 20% of all international travel. 48% of intra-EU air travel was for business purposes [3]. Moreover, some forecasts have predicted faster growth in business than in leisure air travel. At the same time, the market for videoconferencing shows strong growth rates. In 1991, the global equipment market was estimated at USD 210 million [4]. Fifteen years later, estimates indicate the total market at USD 1.06 billion (source: Tandberg), i.e. five times larger than in 1991.

Despite the growing acceptance of videoconferencing in modern organizations, documentation is sporadic and analysis of use inadequate, particularly compared to that on travelling and face-to-face meetings. Furthermore, the literature on transportation has generally considered videoconferencing as a uniform communication technology, while paying little attention to the fact that it comprises a wide range of technological platforms each providing unique communication opportunities and potentially different interfaces with travel.

2. Videoconferencing - Business Communication Tool

The possibility of simultaneous audio and visual communication by electronic means has a long history, starting with experimental tests carried out as early as the late 1930s [5]. However, it took almost 30 years before the first commercial video telephony system (Picturephone) was demonstrated by AT&T in 1964. Picturephone was a technological success, and one of very few that made the transition from field trials into commercial service. Picturephone and other incarnations of videoconferencing were still being developed into the 1970s, although technical and cost constraints hampered their mass market appeal [6]. The new digital technologies provided much more efficient bit rates for video and audio transmission that greatly benefited videoconferencing services. Yet, usage was still fairly modest. Most systems shared important disadvantages that slowed diffusion, including high cost, high (perceived) user threshold, low bandwidth and mediocre quality of service. There were reported no differences in problem-solving skills between groups that could see and hear each other and groups that only had audio communication. The video element of videoconferencing did not really provide extra value for the user; its value was incremental or even negative [7].

However, recent years have seen a large increase in videoconferencing sales and use. The single most important factor contributing to this development has been the integration of videoconferencing with PCs and computer applications over computer networks. New technologies offer more flexibility, in terms of range of services and modes of communication, than traditional conference room facilities. In turn, this has brought about more varied and less clear cut concepts of what videoconferencing constitutes. Important features of modern business practice are project organization and collaboration and the processing and annotating of digital material and content.

Today's integrated videoconferencing systems have to a large degree accommodated these practices, starting with the need for live display of presentation material, developing into the need for live and collective processing of data files and information. This has now evolved even further with the integration of web conferences, project cooperation tools, chat, access to archived work material, databases, and so on.

Desktop systems have made videoconferencing possible on PCs or notebooks, thus taking the videoconference out of the dedicated conference room.

An important technical development within telecommunication in recent years has been the opportunity to set up voice communication and multimedia sessions over Internet Protocol (IP) networks. Voice over IP service providers, such as Skype and Vonage, offer free calls, instant messaging, file transferring and videoconferences to anyone who subscribes to their services. These services have made videoconferencing much cheaper and more readily available to both consumers and business customers.

3. Business Travel and Videoconferencing

The relationship between ICT and travel has generally been described as comprising four possible effects:

(i) Substitution;
(ii) Complementarity;
(iii) Modification;
(iv) Neutrality [8].

Early research on the videoconferencing-business travel relationship reflected overwhelming optimism in respect of travel substitution. During the 1970s it was widely held that the traditional way of doing business, would gradually be replaced by more time-efficient virtual communication. The potential for substituting business travel was assumed to be substantial, up to 66% in a German estimate from 1974/75 [9]. Likewise, refers to a study released by the US Department of

Transportation in 1978 claiming that videoconferencing could reduce company travel by approximately 50% over the following decade [10].

However, at the end of the 1980s, videoconferencing had still not had any noticeable impact on business traffic, signifying that there was no simple one-to-one ratio between face-to-face contact and teleconferencing. Succeeding studies presented significantly lower estimates of the possibilities of ICT being substituted for business travel, typically ranging from 2% to 5% [11]. More recently it has been suggested that business trips would decline by 8.9% if ICT capabilities achieved the most optimistic forecast and if the associated costs decreased significantly [12].

Significance of relationships in business life claims that people who became acquainted through telecommunication would inevitably want to meet in person, and, as a result, that travel would increase. Likewise, videoconferencing extends spans of collaboration, and this too would generate more travel than videoconferencing could possibly replace. Frequent travellers were among those who most favoured virtual meetings (suggesting complementarity), although they also reported that people involved in sales and procurement, whose travel frequency was the highest, were reluctant to use videoconferencing owing to their high degree of external contacts [13].

The studies referred to above suggest that face-to face meetings have features that are difficult to replicate in electronic meetings, at least on a broader scale. Significant number of face-to-face meetings is negotiations involving informal and unstructured contact, while videoconferences have less complex content. Meeting content is the key factor that influences the choice between videoconferencing and face-to-face contact (by air travel) [14].

Several studies of communication and business travel have confirmed that regular face-to-face interaction is required to ensure development of trust, reciprocity and mutual understanding. There are five areas, where face-to-face interaction is critical in transnational corporations:

(1) Transnational operation: Face-to-face allows for the securing of establishments of new businesses and completion of projects across multiple organizational sites.

(2) Transnational control: Regular face-to-face meetings are needed to convince workers to implement strategic plans.

(3) Knowledge practices: Face-to-face interaction is needed to develop and share common knowledge.

(4) Innovation: Face-to-face allows for new and creative ways of working and for the development of new services.

(5) Coherence: Face-to-face is needed to develop a shared organizational culture [15].

In addition to these key benefits, business trips and face-to-face interactions may give benefits for the traveller related to opportunities for visiting novel or desirable locations, visiting friends/relatives, escape from stress at home or office, acquisition of frequent-flyer miles and more. Hence, even though mediated communication has features that to some extent are comparable to face-to-face meetings, videoconferencing still does not meet many of the key advantages of genuine face-to-face contact.

Business trips are particularly indicated for meeting persons for the first time, for presentations, conferences, exceptional meetings, training and commercial activities in foreign countries. The main advantages of business trips are: a more personal contact; a better understanding of the environment within which the persons operate; acquisition of new knowledge; more efficient demonstrations of new products; prestige; a certain touristic aspect, and customer loyalty programs.

The most important disadvantages of business trips are: absence from the office which results in additional efforts upon return and a loss of control over employees and projects; costs; fatigue because of long working hours; and the inconveniences associated with airplane trips (i.e. time wasted on ground transportation, waiting in airports, lack of space in planes, lack of flexibility of schedules, delays, cancellations, and impossibility of using cellular phones aboard and the very high costs of using phone services provided on planes). Videoconferences also have advantages and disadvantages. The advantages include: videoconferences bring a visual dimension to meetings and allow participants to rely on non-verbal language; time savings: videoconferences require less time

than business trips avoiding air traveling time, ground transportation and waiting time in airports; participants discipline: participants are more disciplined, go straight to the point and show more respect for the agenda; savings; not only in time but they also allow more people to attend; possibility to link many sites, and quality of image which is improving

Finally, in comparison with business trips, the following disadvantages were put forward: colder contacts; difficulty to present certain products well; prestige associated with business trips, and loss of certain privileges such as loyalty programs.

4. Conclusion

Although the research showed that there are people who believe some of their travel could be replaced by video-meetings, videoconferencing will not have substantial impacts on business air travel unless green taxes or other environmental instruments leading to large increases in air fares are introduced. Business travel develops in line with business cycles, and the main driving force in this market is economic growth. Historically, slowdowns in the economy have triggered tighter control of travel budgets and more focus on alternative ways of communicating, but these effects have to a large extent remained temporary. Modern work life is organized around different networks where travel and face-to-face contact are crucial. Virtual communication systems have an advantage over physical travel when the working task has a high degree of formality. However, business travel very often includes an informal element that is difficult to recreate in virtual meetings. As shown in the present data, and elsewhere, face-to-face contact and networking are embedded parts of business practice.

References

[1] Daft, R.L., Lengel, R.H., 1986. Information richness: A new approach to managerial behavior and organizational design. In: Cummings, L.L., Stawm B.M. (Eds.), Research in Organizational Behavior. JAI Press, Greenwich CT, pp. 191–234.

[2] Czinkota, M.R., Ronkainen, I.A., 2005. A forecast of globalization, international business and trade: report from a Delphi study. Journal of World Business 40, 111–123.

[3] Mason, K.J., 2002. Future trends in business travel decision making. Journal of Air Transportation 7 (1), 47–68.

[4] Kraut, R.E., Fish, R.S., 1995. Prospects for video telephony. Telecommunications Policy 19 (9), 699–719.

[5] Ogden, M.R., 2006. Teleconferencing. In: Grant, A.E., Meadows, J.H. (Eds.), Communication Technology Update, tenth ed. Focal Press, Oxford, pp. 325–344.

[6] Schnaars, S., Wymbs, C., 2004. On the persistence of lackluster demand – the history of the video telephone. Technological Forecasting & Social Change 71(3), 197–216.

[7] Noll, A.M., 1992. Anatomy of a failure: picturephone revisited. Telecommunicatons Policy 16 (4), 307–317.

[8] Haynes, P., 2010. Information and communication technology and international business travel: Mobility allies? Mobilities 5 (4), 547–564.

[9] Petersen, H., 1977. Telekommunikation und verkehr. Internationales Verkehrswesen 1977:224–228. (As quoted in Geels and Smith, 2000).

[10] Coddington, P., 1993. The impact of videoconfercing on airline business traffic. Journal of Travel Research 31 (2), 64–66.

[11] Denstadli, J.M., 2004. Impacts of videoconferencing on business travel: the Norwegian experience. Journal of Air Transport Management 10 (6), 371–376.

[12] Bonsall, P., Shires, J., 2006. Employer expectations for commuting and business-related travel in an environment rich in information and communication technologies. In: Transportation Research Record: Journal of the Transportation Research Board, No. 1977. Transportation Research Board of the National Academics, Washington, DC, pp. 268–276.

[13] Arnfalk, P., Kogg, B., 2003. Service transformation – managing a shift from business to virtual meetings. Journal of Cleaner Production 11 (8), 859–872.

[14] Lu, J.l., Peeta, S., 2009. Analysis of the factors that influence the relationship between business air travel and videoconferencing. Transportation Research Part A 43 (8), 709–721.

[15] Storper, M., Venables, A., 2004. Buzz: face-to-face contact and the urban economy. Journal of Economic Geography 85 (1), 351–370.

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Primary Marketing Research on Using Partner Post Offices in Terms of Postal Bank Products

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Abstract. In order to find out requirements and needs of Partner post offices' customers we made a quantitative marketing research on using Partner post office services by citizens of villages, in which there is a Partner post office. We used personal and electronic questioning for collecting necessary information. We analyzed the collected data and we found out that almost 95 % respondents use services of the Partner post office in their village, more postal services than banking services. Strong majority of respondents is satisfied with Partner post office employees when offering banking products. More than a half of them would welcome extended offer of Postal Bank products provided by Partner post offices, namely savings and loan products. Based on the research results we can assume that in villages, in which there is a Partner post office, there is a potential for extended banking products portfolio offered by Partner post offices.

Keywords: primary marketing research, questioning, Partner post offices, Postal Bank products.

1. Introduction

The goal of the primary marketing research we made in May 2012 was to find out how many citizens of villages with a Partner post office use its services, what Postal Bank products are used the most frequently and what products are missing in the banking products offer at Partner post offices according to their customers. We also wanted to know if citizens of villages involved in the research are satisfied or dissatisfied with providing Postal Bank products and services by employees of Partner post offices.[1]

1.1. Methods and Techniques of Data Collection

For collecting necessary data we used questioning, which is considered to be the basic and the most frequently used method for quick collection of actual data from the market. We used two types of questioning, namely personal questioning and questioning via email. Personal questioning was conducted in the village of Čičmany. Questioning via email was used to address all villages with a Partner post office, whose email address is listed in the Internet site www.e-obce.sk (it related to about 46 villages).

In the village of Čičmany (Žilina district), in which personal questioning was conducted, 80 inhabitants answered the questionnaire, what represented 48 % of the total number of its inhabitants (as of 31 December 2011 the Čičmany village had 167 inhabitants according to the Statistical Office of the Slovak Republic). 6 villages out of villages to which the questionnaire was send electronically answered it, what represented 13 % of the total number of addressed villages. They were these villages:

Village	District	Number of inhabitants as of 31. 12. 2011
Nová Vieska	Nové Zámky	736
Jatov	Nové Zámky	776
Matiašovce	Kežmarok	798
Baďan	Banská Štiavnica	213
Dolná Poruba	Trenčín	807

Prestavlky	Žiar nad Hronom	658

Tab. 1. Basic information about villages involved in questioning via email

The total number of respondents was 147, of it 44,90 % were females and 55,10 % were males. 80 respondents were questioned in person and 67 respondents via email. The average age of respondents was 50 years.[2]

1.2. Research Sample Size

We calculated the sample size using the following formula:

$$n = \frac{Z^2_{1-\alpha/2} * S^2}{H^2} \quad (1)$$

where $Z_{1-\alpha/2}$ is the required confidence interval that we chose to be 95% and its value from the tables is 1,96, H is acceptable error rate, i.e. maximum estimation error that we chose to be 5% and S is the standard deviation calculated using the following formula:

$$S = \sqrt{\tilde{p} * (1 - \tilde{p})} \quad (2)$$

where $\tilde{p}$ represents the share of respondents using Partner post office services.
The sample size thus calculated should be minimum 79 respondents.

2. Research Evaluation

The questionnaire results presented in the section were prepared also according to the identification question – age of respondents and the identification question – economic activity of respondents.

2.1. Evaluation of the Question Do You Use Partner Post Office Services in Your Village?

More than 94,5% respondents stated that they use Partner post office services in their village. Inhabitants at the age of 51 years and more (98,57 %) and all students and professionals (100%) use Partner post office services the most.

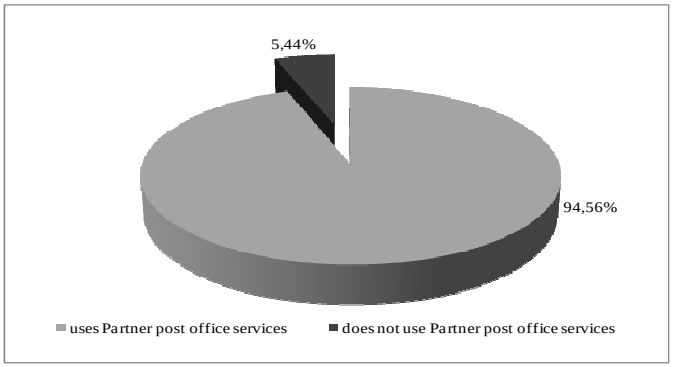

Fig. 1. Evaluation of Partner post office usage

2.2. Evaluation of the Question What Partner Post Office Services Do You Use More Often?

Out of 139 respondents to this question strong majority (almost 72 %) use postal services.

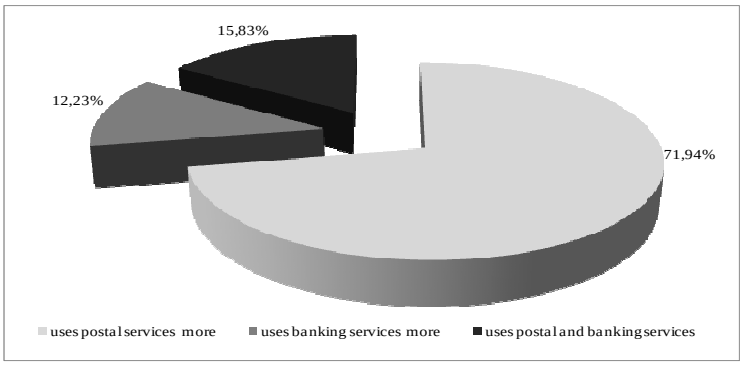

Fig. 2. Evaluation of services provided by Partner post offices

2.3. Evaluation of the Question What Banking Products and Services Do You Use Most at the Partner Post Office?

The most used banking products according to inhabitants of villages with a Partner post office are payment of cheques (48 %), cash deposits into and withdrawals from a current account (21 %) and acceptance of money orders (16 %) regardless the age or economic activity of respondents.

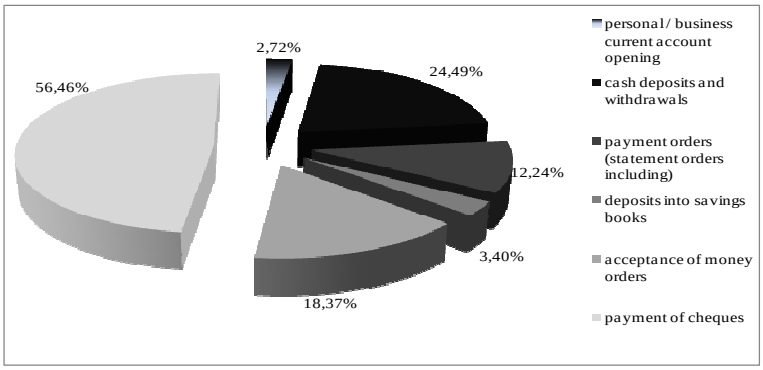

Fig. 3. Evaluation of using services provided at Partner post offices

2.4. Evaluation of the Question How Are You Satisfied with Providing Banking Products by Partner Post Offices' Employees?

We considered responses “very satisfied” and “satisfied” as “satisfied” and “little satisfied” and “dissatisfied” as “dissatisfied”. Then almost 90 % of respondents are satisfied and only 10,79 % are dissatisfied with employees of Partner post offices. The most satisfied customers of Partner post offices are respondents at the age above 50 years (more than 94 %) and professionals and unemployed (100 %).

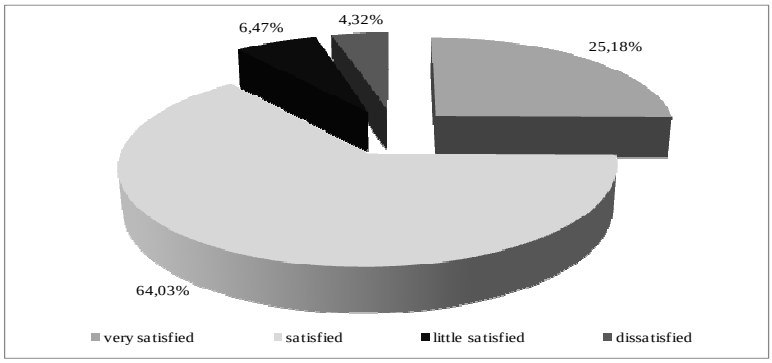

Fig. 4. Evaluation of satisfaction with Partner post offices' employees when providing banking products

2.5. Evaluation of the Question Would You Welcome if the Partner Post Office in Your Village Offers More Postal Bank Products and Services?

Out of 141 respondents who answered this question, up to 68,03 % would welcome extended offer of banking products provided by Partner post offices, mainly the youngest respondents at the age of 17 to 30 years and in terms of economic activity professionals and employed respondents.

Fig. 5. Evaluation of whether respondents would like more banking products at their Partner post offices or not

2.6. Evaluation of the Question What Postal Bank Products and Services Would You Like to Use at Your Partner Post Office?

More than three quarters of respondents would like to use savings products (term deposits, savings and investment products). Respondents are also interesting consumer loans (31,78%).[2]

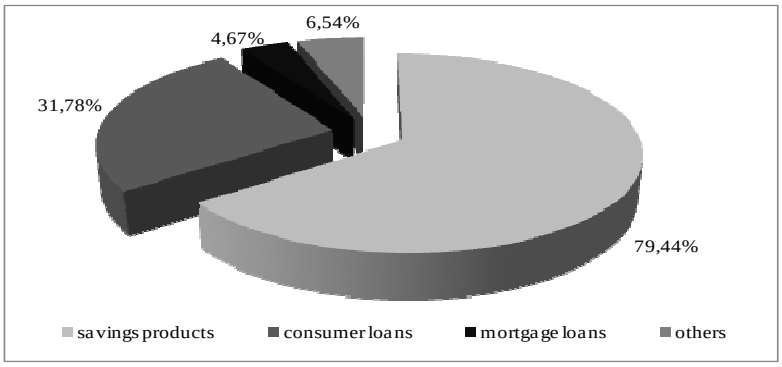

Fig. 6. Evaluation of what banking products respondents would like to use at their Partner post offices

3. Conclusion

According to the primary marketing research results we can state that inhabitants of villages with a Partner post office use its services, more postal than banking and they are satisfied with employees of their Partner post offices. On the other hand they consider the offer of Postal Bank products insufficient and they would prefer having wider offer of banking products and services.

Based on the research results we can assume that in villages, in which there is a Partner post office, there is certain sales potential for Postal Bank products, mainly savings products and consumer loans.

References

[1] VOPALECKÁ, B. *Franchising in postal sector conditions*, paper to dissertation thesis, ŽU, F PEDAS, Žilina, 2010.

[2] VOPALECKÁ, B. *Proposal of banking products portfolio at the Partner post office*, dissertation thesis in process, ŽU, F PEDAS, Žilina, 2013.

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THE SECTION SPEED ESTIMATION USING SMOOTHING SPLINES

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Abstract. This paper presents a method for the section speed estimation in the road sections. The method uses the advantageous properties of smoothing splines for the heterogeneous traffic data sources fusion. The main data source is a large corporate vehicle fleet equipped with GPS receivers, which is not originally intended to monitor the traffic flow. FCD are fused with fixed detector data using the presented method and verified by ALPR system output.
The research goal is to present a universal portable method which will significantly improve the ability to monitor the quality of transport services on highways in real time, using the currently available various sources of traffic data.

Keywords: Section speed estimation, smoothing splines, FCD, GPS, ALPR, outliers

1. The Introduction

Speed, travel time, and delay are the related measures commonly used as performance indicators for traffic facilities [1]. Travel time and delay are very easy to understand by the majority of drivers. Most of the early studies mainly used loop based detectors as the only source of traffic data, but the range of these detectors is very limited [2].

Since GPS receivers became more common, some later studies have introduced methods for integration of both, induction loop (video) data and probe vehicle data [3].

This paper presents a method primarily using data from a large commercial fleet and results are verified by the automatic license-plate recognition (ALPR) system. The proposed method is capable of integration various data sources both floating cars data (FCD) and fixed infrastructure data (inductive loop and/or video detectors). Unfortunately, the video detectors within the testing site did not have spot speed data available at that time.

2. Source data description and testing road location

The proposed method mainly uses FCD, concretely data from a commercial fleet of 15 000 vehicles were used as the input for section speed estimator. These data are not originally intended for the traffic stream monitoring purpose, therefore there is no additional cost to obtain them.

Each data record contains GPS coordinates, current date and time, the speed and, finally, the flag determining the vehicle type (personal or truck). The in-house and precise map was measured by a GPS receiver in order to reduce the dimension of the present floating vehicle position following way. The origin was chosen in the same place where the first (initial) ALPR system camera is placed (the green flag). The location of the each vehicle is reduced from GPS coordinates (3 variables) to the distance from the origin (1 variable). The map is later used to determine the direction of each probe vehicle from the data record sequence.

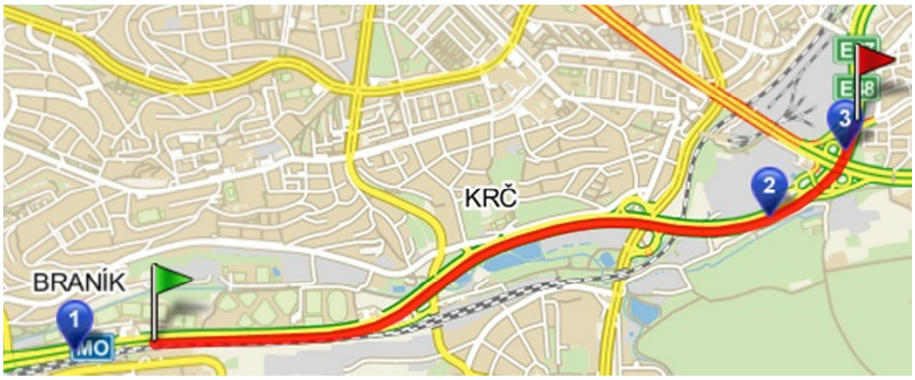

Fig. 1. The link arterial in Prague (Jizni Spojka) with ALPR system (flags) and fixed detectors position

The testing road also contains 3 video detectors which measure the flow and occupancy in 5-minute time intervals (numbers in blue bubbles). On average, only 1/3 of all vehicles will pass the whole road section, the rest will exit or join the road after the first ALPR camera. This was determined by the comparison of the flow from video detectors and ALPR system.

3. The Proposed method

The cubic spline [4] function g is a piecewise polynomial function defined on some interval $[a, b]$, where $a < p_1 < \cdots < p_n < b$, if two conditions are satisfied: polynomial pieces fit together at the points t_i in such a way that g itself and its first and second derivatives are continuous at each data point t_i and on each subinterval the function g is a cubic polynomial.

Let $S(g)$ be the penalized sum of squares in form

$$S(g) = \sum_{i=1}^{n} \{Y_i - g(p_i)\}^2 + \alpha \int_a^b \{g''(x)\}^2 dx, \tag{1}$$

where $\{p_i, Y_i\}$ are data pairs, $\alpha > 0$ is the smoothing parameter and $\{g''(x)\}^2$ is the roughness penalty. For $\alpha = 0$ only the left side is valid and $S(g)$ becomes an interpolation spline. For $\alpha \to \infty$ the left side has no effect and $S(g)$ is a straight line, which minimizes the sum of squares.

In [5] a method called Generalized Cross Validation (GCV) was introduced. It automatically determines the smoothing parameter α. The proposed method uses the weighted case of the smoothing spline and GCV, where each data pair has assigned time weight W_t, which determines how old each GPS data record is and, additionally, it could use the second weight [6] to determine and eliminate outliers in the following form:

$$Wr_i = \begin{cases} 0 & if \ \left|\frac{u_i}{4{,}685}\right| \geq 1 \\ \left(1 - \left(\frac{u_i}{4{,}685}\right)^2\right)^2 & if \ \left|\frac{u_i}{4{,}685}\right| < 1 \end{cases} \tag{2}$$

The complex definition of Studentized residual u_i is in [6]. The final weight is a product of both mentioned weights as follows: $W = W_t W_r$. The weight is used for exponential forgetting and for outliers handling in robust version.

In the following Fig. 2 you can see the final result (the smoothing spline) based on FCD using only time weight. The weight of each data pair is pictured by both color and size. In this particular case data were processed in 5-minute intervals with forgetting parameter $p_f = 0.65$ and all data records with time weight below 0.04 were erased in order to maintain sustainable size of the computational spare data matrix. The time interval, the forgetting parameter and erasing parameter are 3 variables determining the exponential forgetting, data matrix size and finally the final spline behavior. Exponential forgetting weight was used in the following form: $W_t = W_{t-1} \cdot p_f$.

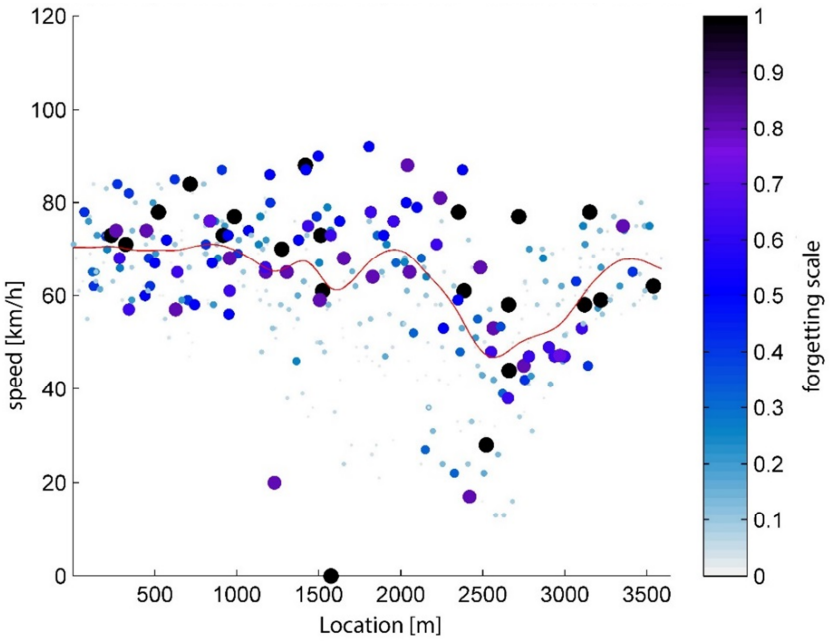

Fig. 2. The smoothing spline determines speed/location characteristics on arterial road

4. The experiment

FCD data were rigorously filtered and sorted in order to compare the results from the proposed method with the aggregated section speed values from ALPR system in the same time interval (step) as the spline. ALPR system monitored all three lanes on the testing road, but we cannot distinguish the lane in which the floating vehicle was present from GPS records. ALPR section speeds were also combined by weighted mean to compare the results with smoothing spline outcome (all vehicle types) in following way:

$$v_{all} = \sum_{lane=1}^{3}(v_{lane} \cdot q_{lane}) / \sum_{lane=1}^{3} q_{lane}, \qquad (3)$$

where q_{lane} is a vehicle volume for the given lane, and v_{lane} is the average section speed for the given lane. On the other hand, all GPS records were divided into the vehicle categories and partial results were calculated only based on the one vehicle category at a time. Finally, the trucks were compared to the right lane aggregated result and passenger vehicles to the left and middle lane.

The following Tab. 1 summarizes differences between ALPR section speed mean values or 50% percentile in desired time interval (5 mins.) and the smoothing spline / robust smoothing spline method (deals with outliers) based on FCD only.

	Section speed difference [km/h]				Section speed difference [%]			
	left lane	middle lane	right lane	all lanes	left lane	middle lane	right lane	all lanes
50% percentile	9,0	1,0	0,8	4,0	8,1%	-0,8%	-1,1%	3,8%
50% percentile robust	8,5	0,5	0,4	3,7	7,5%	-1,3%	-1,6%	3,5%
Mean	7,7	-0,1	0,2	2,8	6,6%	-2,4%	-1,7%	2,0%
Mean robust	7,2	-0,7	-0,2	2,5	6,0%	-3,0%	-2,2%	1,8%

Tab. 1. Experiment results

The closest to zero difference was the middle lane ALPR, compared to passenger vehicles FCD. A more detailed result is depicted in the following Fig. 3. Three colored areas denote 1, 2 and 3σ areas, and dashed lines denote mean (black) and median (green). Approximately $\pm 5\ km/h$ error for 1σ means approx. $\pm 10\ sec$ error for design and expected speed: $v_e = 80\ km/h$.

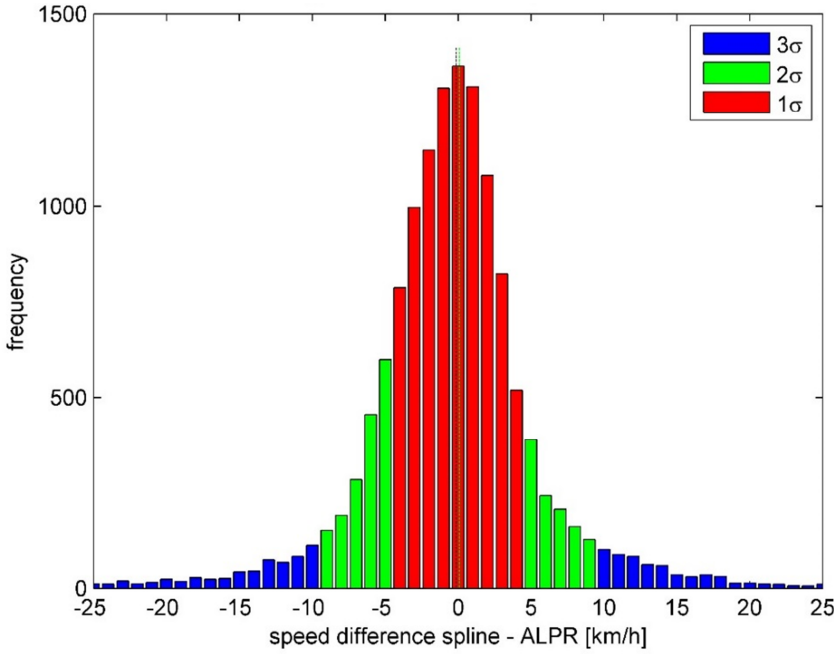

Fig. 3. Histogram of result speed difference for middle lane with 3σ areas

5. Conclusion

The presented method enables to estimate travel times using raw FCD with the minimum delay. The first results show very promising performance even without using another data source.

Next research will be focused on the heavily-used D1 highway in the Czech Republic, where (due to absent ALPR system) data from Electronic Fee Collection (EFC) will be used as reference speed data. It is expected, due to the ECF data nature (only trucks present), that another data source will be required in order to validate left and middle lane.

Acknowledgement

The presented research and results are parts of the student's upcoming Ph.D. Thesis.

References

[1] ROESS, R. P., PRASSAS, E. S., MCSHANE W. R. *Traffic Engineering*. 4th ed. Prentice Hall, 2011

[2] COIFMAN, B. *Estimating travel times and vehicle trajectories on freeways using dual loop detectors*. Transportation Research Part A: Policy and Practice, Vol. 36, Issue 4, p. 351 – 364, 2002

[3] WESTMAN, M., LITJENS, R., LINNARTZ, J. P. *Integration of probe vehicle and induction loop data estimation of travel times and automatic incident detection*. Technical report, PATH Research Report UCB-ITS-PRR-96-13, Institute of Transportation Studies, University of California, Berkeley, CA, 1996.

[4] GREEN, P. J., SILVERMAN, B. W. *Nonparametric Regression and Generalized Linear Models*. Chapman & Hall, 1994

[5] WAHBA, G. *Spline models for observational data*. 59 / CBMS-NSF Regional Conference Series in Applied Mathematics. Philadelphia, PA : Society for Industrial and Applied Mathematics (SIAM), 1990

[6] ROUSSEEUW, P. J., LEROY, A. M. *Robust Regression and Outlier Detection*. John Wiley & Sons, Inc., New York, NY, USA, 1987.

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