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Dear Readers,

This volume of the Communications - Scientific Letters of the University of Zilina is dedicated to transport services, their operations, technologies, management and economy. Effective development of transport services and the development of sustainable mobility requires continuous search for new, innovative approaches and consistent implementation of adopted measures and tasks whose solution is highly important for the functioning and prosperity of every citizen and the state. The research in this area has the priority. Transport and mobility are of direct relevance not only for state authorities, enterprises of the whole transport sector, but especially for citizens and the environment in which they live. Passenger and freight transport is on a long-term upward trend. This is related to the growth in transport demand and mobility, which now play a key role in daily lives of citizens and are also an important factor of economic development, competitiveness and employment. Promotion of sustainable development with minimum environmental impact, non-discriminatory access and accessibility for everyone is a priority these days. This positive development is to be encouraged by the adequate research and dissemination activities. This issue of the journal presents the current status and direction of transport services and mobility with the ambition to contribute to the improvement in this area.

Marian Sulgan

Marian Sulgan – Jarmila Sosedova *

RATIONALIZATION OF INTERNAL TRANSPORT OPERATION IN THE INTERMODAL TRANSPORT TERMINAL

This paper presents the results of investigation of the possibilities for creating the internal circuit for the handling and moving the containers on the territory of intermodal transport terminal. It utilizes the theoretical knowledge from the investigation of queuing systems and the theory of stochastic processes.

Keywords: *Logistics, intermodal transport terminal, transhipment, container, stochastic processes.*

1. Introduction

The internal operation of the intermodal transport terminal is ensured by the transhipment handling equipment and vehicles of road, railway and waterway transport. In smaller terminals, the intermodal transport units (ITU)s may be transhipped from the railway wagon (or from the ship) directly to semi-trailers that are transported by the trucks to the shipper. During the collection of the ITUs, the direction of the transportations from the shippers to the terminal is opposite. During the rush hour, or at a time when the semi-trailers are not available, the ITUs are unloaded to the storage area from where they are subsequently re-loaded on vehicles and transported to the shippers. Inside the terminal, the internal traffic is not separated from the outside traffic. In larger terminals, ITUs (during the distribution) may be transhipped from the wagon (or from the ship) to the paved surface. Subsequently, they are transported, using the specialized transportation equipment of internal circuit (usually the reach-stacker, forklift truck, semi-trailer, straddle stacker or articulated vehicle), to the area served by the road vehicle (usually the articulated vehicle) of the external circuit. In this terminal, the operation is specialized for the handling and transport equipment in order to avoid the congestion caused by the arrival and departure of the external circuit vehicles. The queuing theory may be utilized for the purpose of theoretical basis for solving the issue of determining the marginal boundary for creating the internal circuit for handling and transportation of ITUs within the intermodal transport terminal [1].

The terminal represents the certain kind of queuing systems. In our case, we processed the issue of containers transhipment (re-loading) between the wagons and articulated vehicles. For transhipment, each device has its own specific performance and is able to perform the required container transhipment in a certain time interval. The value of this time interval may vary according to the different circumstances of the operational situation. Arrival of individual road vehicles is a random stochastic process. The question arises: "How we can describe the input traffic flow of these vehicles to the place of operation?" Containers transhipment is the requirement incoming randomly and individually to the system in a certain time interval with a value "t". However, the activity of the whole system, in addition to the arrivals of requirements, is determined by the time interval (period) of their operation and subsequent departure from the system as well. Therefore, the status of the system can theoretically be characterized by the number of requirements "X(t)", which are in the system at the time "t", whether they are operated by the channels (the transhipment handling equipment in our case), or waiting for the operation in the queue [2].

If we consider the random arrivals and random operation period, then "X (t)" is the random variable for the firm "t" and the activity of the whole queuing system characterizes the random process "$\{X(t) / t \geq 0\}$".

For the particular realization of this process, the function "$\tilde{X}$" randomly acquires the entire non-negative values so how the requests arrive and depart randomly.

Addiction of random variable "X (t)" from the values of previous random variables can be expressed by the conditional probability in the form:

$$P\,(X(t) = k \,/\, X(s_n) = j_n, \qquad X(s_{n-1}) = j_{n-1}, \ldots, X(s_1) = j_1),$$

* **Marian Sulgan, Jarmila Sosedova**
Faculty of Operation and Economics of Transport and Communications, Department of Water Transport University of Zilina, Slovakia
E-mail: marian.sulgan@fpedas.uniza.sk

where: "k, j_1, j_2,.., j_n" is a nonnegative number, "n" is a positive number and "$s_i < t$ for: i = 1, 2,...., n".

In order to apply the theoretical knowledge properly, it is necessary to have the correct classification of the queuing system. The queuing system is briefly and clearly characterized by a combination of letters and numbers in the form "A / B / C", introduced by D. G. Kendall. Letters that determine the stochastic process describing the arrival of requirements and the distribution of operating time are at the positions A and B. C is a natural number expressing the number of operation channels. Letters at the positions A and B are derived from the distinctive feature of the distribution of intervals between the successive arrivals and the operation periods.

The most commonly used letters are:

M - exponential distribution (Markov's attribute)

D - deterministic intervals and operation periods,

E_k - Erlang distribution with the parameter k,

G – optional distribution.

In addition, the designation is usually accompanied by other information, such as: "What is the discipline in a queue?"; "Is the number of requirements in the system limited or not (and hence the length of the queue)?" Disciplines of the waiting time may be as follows:

FIFO - first requirement is served as the first (front),

LIFO - last requirement is served as the first (inverse front),

SIRO - service (operation) is in random order,

PRI - service is realized by the preference (priority queue),

GD - optional discipline of the waiting.

This extended designation does not concern the departure of the requirement from the system after the accomplishing the service (operation). If the number of these requirements in the system is constant, these are designated as queuing systems. In practice, the ideal state is not always reachable where each physical present articulated vehicle comes to the terminal in the loaded state (carrying either loaded or empty container) and leaves the terminal in the loaded state. We did not take into consideration the arrivals and departures of solo trucks, because it would be the different system in switching the semi-trailers. In our particular case, the arrival of requirements is regular, that means, that the probability of arriving the "k" requirements in interval "t" does not depend on its beginning, but only on its length [3].

That means: "P (N(s + t) - N(s) = k) = P (N(t) = k)"; for each: "s ≥ 0 and t > 0".

The number of arrivals in any interval with the length "t" has the same distribution as the "N(t)", therefore, "N(t)" could be understood as the number of arrivals in interval with the length "t". Such processes are called homogeneous.

For homogeneous processes, it can be demonstrated that there exists the limit:

$\lim\limits_{t \to 0} \frac{1 - p(t)}{t} = \lambda \geq 0$, where λ is a parameter of a homogeneous process.

In a very short time period, the probability of arrival more than one requirement is negligible. That means:

$$\lim_{t \to 0} \frac{P(N(t) \succ 1)}{t} = 0, \tag{1}$$

what can be written as:

$$\lim_{t \to 0} \frac{1 - p_0(t) - p_1(t)}{t} = 0. \tag{2}$$

Such processes are called ordinal and, in practice, represent the individual arrival of the requirements.

The arrivals of requirements are independent of each other [4]. If the parameter of the Poisson process is "λ", then the periods of intervals between the successive arrivals will be independent random variables and will have an exponential distribution with the same parameter "λ". If the requirement arrives into the system at the time when the channel is busy, it will stay in a queue and wait for the operation, and the length of the queue will not be limited.

The operating time of each requirement has the exponential distribution with the parameter μ and is independent of the operation times of other requirements, as well as the intervals between the arrivals. If "λ" is the average value of the number of arriving requirements per unit of time, then "1/μ" will represent the average value of operating time of each requirement. Then, the channel will be able to serve "μ" requirements per unit of time and the "μ" will equal the intensity of service.

In the time interval of "T", on average, "λT" of requirements will come and the channel will be able to serve up to "μT" of requirements. It is obvious that in the case that "λ < μ", the channel will be able to serve all arriving requirements. However, in the case that "λ > μ", the situation will be opposite. The equality "λ = μ" represents a very tense situation, when the channel cannot be idle for awhile, in order to serve all arriving requirements. The relationship between "λ" and "μ" is expressed by the formula: "$\rho = \frac{\lambda}{\mu}$", where: "ρ" is the load factor of the channel (the ratio between the number of incoming requirements and the number of requirements which the channel is able to serve).

In the case that "ρ > 1", then the system will be overloaded. In the case that "ρ ≤ 1", then the average total operating time of the requirements (which will arrive in the time interval of "T") will be "λT(1/μ)".

Compared to the overall time period "T", the channel is in activity "(λT(1/μ)) / T = ρ". Load factor will express the working period of the system T when the channel is in the activity. Then, "ρ" is called the coefficient of utilization of the channel. In practice, so-called Non-Markovian systems with the unlimited queue often appear. For them, the input flow of the requirements has the Markovian characteristics, but the distribution of the operating time is optional - this system is designated as "M/M/1".

In more detail, this analysis is focused on the system "M/G/1". After the "n^{th}" requirement leaving from the system, the number of requirements will remain "X_n". Given the independence of the operating time period on the arrival of requirements, the number of requirements is independent on "n" and it is designated as a "Y".

Then:

$X_{n+1} = X_n + Y$, for $X_n = 0$. (3)

"n^{th}" leaving requirement keeps just "Xn > 0" requirements in the system. After the requirement leaving, "$(n + 1)^{th}$" operation of the subsequent requirement selected from the queue will beggin.

After the "$(n + 1)^{th}$" requirement leaving, just "X_n - 1" requirements will remain in the system. These requirements were already in the system during the "n^{th}" requirements leaving. Plus, the number of requirements arriving during "$(n + 1)^{th}$" requirements operation is "Y"; thus:

$X_{n+1} = X_n - 1 + Y$; for each: $X_n > 0$. (4)

By introducing the random variable "δ", the relationships (3) and (4) can be expressed with a single formula:

$X_{n+1} = X_n - \delta + Y$. (5)

Variable "δ" depends on the variable "X_n" as follows: δ = 0, if $X_n = 0$, δ = 1, if $X_n > 0$. On the basis of the formula (5), the average number of requirements in the system in steady state can be determined. Then, the following formula can be applied: $E(X_{n+1}) = E(X_n)$.

After the calculation of the average values of both sides of the formula (5), it can be stated:

$E(X_n) = E(X_n) - E(\delta) + E(Y)$; $E(\delta) = E(Y)$. (6)

From the definition of the random variable "Y", it is clear that "E (Y)" is the average number of requirements arrivals during the operating time period of one requirement. Again, the operaion time is a random variable that can be designated as "U" and it is expected that it has a finite average value "E (U)" and the dispersion "$D(U) = \delta^2$".

If the intensity of arrivals is "λ", then:

$E(Y) = \lambda E(U) = \rho$. (7)

where: "ρ" is the load factor of the system. The random variable "δ" has only two values 0 and 1; its average value is therefore: "E (δ) = 0.P (δ = 0) + 1.P (δ = 1) = 0.P (X_n = 0) + 1.P (X_n > 0) - P} X_n > 0)".

It expresses the probability that the channel is occupied. It is the coefficient of the channel itilization "ρ". Again, it is required so that "ρ < 1".

As for the the task of finding "E (X_n)", if both sides of the formula (5) are squared, then we will get: "$X_{n+1}^2 = X_n^2 + \delta^2 + Y^2 - 2X_n\delta + 2X_nY - 2\delta Y$".

The definition of random variable "δ" is "$\delta^2 = \delta$" and "$X_n\delta = X_n$". Then, after the transition to the average values, we get:

$$"E(X_{n+1}^2) = E(X_n^2) + E(\delta^2) + E(Y^2) - 2E(X_n) + \\ + 2E(X_nY) - 2E(\delta Y)".$$

The random variables "X_n", the number of requirements which are left in the system by the "n^{th}" served requirement "Y" and the number of arrivals during "$(n + 1)^{th}$" served requirement are independent. Then, the last two average values of the multiplied random variables are the same as the multiple of the average values of these variables.

In the steady state, it is applied: "$0 = E(\delta) + E(Y^2) - 2E(X_n) + 2E(X_n)E(Y) - 2E(\delta)E(Y)$". And using the formulas (6) and (7), it can be expressed "E (X_n)" in the form:

$$E(X_n) = \rho + \frac{E(Y^2) - \rho}{2(1-\rho)}. \tag{8}$$

Since, the process of the arrivals has the Poisson distribution, it can be proved that:

$$E(Y^2) = \int_0^\infty E(Y^2/u)a(u)du = \\ \int_0^\infty (\lambda^2u^2 + \lambda u)a(u)du = \rho^2 + \rho + \lambda^2\delta^2. \tag{9}$$

Then, from the formula (8), it can be expressed: "$E(X_n) = \rho + \frac{\rho^2 + \lambda^2\delta^2}{2(1-\rho)}$". This formula expresses the average number of requirements in the system, not only during the departures time periods of requirements, but also, the average number of requirements in any time. And therefore, the following formula can be applied: $L = \rho + \frac{\rho^2 + \lambda^2\delta^2}{2(1-\rho)}$. The first member is the average number of served requirements, and the second member is the average length of the queue:

$$Q = \frac{\rho^2 + \lambda^2\delta^2}{2(1-\rho)}, \tag{10}$$

where:"Q" is the average number of requirements waiting in the queue, "δ^2" is the dispersion of handling time (operation).

Both of these variables increase in proportion with the dispersion of the operating time "δ^2".

2. The proposal of the marginal boundary for creating the internal circuit of the articulated vehicles operation

On the territory of intermodal terminal, articulated vehicles may be intended not only for collection and distribution of the

ITUs, but also, for all other operations inside the terminal. These activities may be considered to be an obstacle within the fulfilling the main objective – the high quality of the collection and distribution of intermodal transport units (ITUs).

It is necessary to determine these circumstances and boundary when it is necessary to allocate one, two, or even more trucks (articulated vehicles) for operation within the internal circuit. This boundary can be determined from the comparison of idle times of trucks within the external circuit in the queue (if the internal circuit is not operated) with a total operating time of trucks operating within the internal circuit [5].

If the cumulative idle time of the trucks within the external circuit does not exceed the time period expressed by the active operating time of one truck, operating within the internal circuit, then the creation of internal circuit will be ineffective. Within this research, based on the theoretical knowledge, the creation of internal circuit for average idle time of requirements in the queue (10) of the single-line queuing system was verified.

It is expected that the entry of requirements for handling (operation) has the character of the Poisson distribution. The following relationship is applied: "$\rho = \frac{\lambda}{\mu}$". If variable "τ" is used instead of "$\frac{1}{\mu}$", then "$\rho = \lambda\tau$", and after its substituting into the formula (10), the following form of the furmula will be determined:

$$Q = \frac{\lambda^2\tau^2 + \lambda^2\delta^2}{2\cdot(1-\lambda\tau)} = \frac{\lambda^2(\tau^2+\delta^2)}{2(1-\lambda\tau)}, \tag{11}$$

where: "τ" is the average value of handling during the operation, "μ" is the number of requirements that can be served by the channel per time unit.

In the particular surroundings of the intermodal transport terminal [6], one requirement represents one operation of the handling equipment (transhipment of the container from railway wagon to semi-trailer, or vice versa). Two requirements represent the physical presence of one semi-trailer in the terminal. The container on the semi-trailer arrives into the terminal, and subsequently, it is transhipped (re-loaded) to the railway wagon. Then, another container is transhipped from the railway wagon to this semi-trailer.

Essentially, transhipment time (operating time of one requirement) generates the certain dispersion around the average value due to a number of specific operating conditions. In theory, it can be concluded that the value of this dispersion is in range of "p" % around the standard (average) value for the particular device (equipment).

Thus, the dispersion can be expressed as follows: "$\delta = p\cdot\tau$", "*p*" is the percentage deviation of the handling actual time from the average value (expressed in decimal form, not in percentage).

Value "$\rho = \lambda.\tau$" represents the load of one operating line. Then, the utilization of the transhipment equipment according to its fluctuating operating time represents a boundary for establishing the internal circuit. The individual values are shown in the following Table 1.

If "$\delta^2 = 0$", it will be idealization – each of the handling times will be considered to be constant. This inaccuracy is partly compensated by the assumption of the Poisson input flow of requirements. Actually, it may be expected that the input is slightly more balanced compared to the previous state. From the aforementioned, the simplified formula may be determined:

$$\text{“}\bar{\gamma} = \frac{\lambda\tau^2}{2\cdot(1-\lambda\tau)}\text{”}, \tag{12}$$

where: "$\bar{\gamma}$" – the average value of idle time related to one requirement in the queue.

The average idle time of one requirement in the queue "$\bar{\gamma}$"can be obtained from the fraction: "$\bar{\gamma} = \frac{Q}{\lambda}$". If "λ" is the average number of requirements entering the system per hour,

The marginal number of transhipped ITUs per one day (non-zero dispersion of the handling time during the operation) Table 1

Handling time	Daily working time in the terminal		Dispersion of the handling time during the operation			Load of one operating line	The average number of handling operations per minute	The marginal number of transhipped ITUs per day
τ			P		τ + p	ρ	λ	ITUs per day
	h	min	%	Min	min	%	1/min	
4	16	960	0	0	4	82.84	0.207	99
4	16	960	1	0.04	4.04	73.21	0.183	88
4	16	960	2	0.08	4.08	66.67	0.167	80
4	16	960	3	0.12	4.12	61.80	0.155	74
4	16	960	4	0.16	4.16	57.98	0.145	70
4	16	960	5	0.2	4.2	54.86	0.137	66
4	16	960	10	0.4	4.4	44.80	0.112	54
4	16	960	25	1	5	32.28	0.081	39
4	16	960	50	2	6	24.36	0.061	29

Source: authors

then "λ/2" will be the average number of trucks entering the system per hour. If the internal circuit is not in operation, then the total average idle time of the trucks in queue per hour will be in the form: "$\lambda/2.\bar{\gamma}$".

The existence of a truck in the internal circuit represents one "truck-hour" per hour. If "$\lambda/2.\bar{\gamma}$" does not exceed the value 1, the creation of the internal circuit is unfounded. The marginal value of "λ" can be achieved by calculating the condition: "$\frac{\lambda}{2} \cdot \bar{\gamma} = 1$". After the substituting and its modification, "$\rho^2(1+p^2) = 4(1-\rho)$" can be obtained. And after the subsequent modification, the following quadratic formula can be obtained: "$(1+p^2)\rho^2 + 4\rho - 4 = 0$, $\rho_{1,2} = \frac{-4 \pm \sqrt{16+4(1+p^2)\cdot 4}}{2(1+p^2)} = \frac{-2 \pm 2\sqrt{2+p^2}}{1+p^2}$". The positive root of this formula determines the searched marginal value:

$$\text{“}\rho_1 = \frac{-2+2\sqrt{2+p^2}}{1+p^2}\text{”}. \tag{13}$$

Let us denote "$\rho = \lambda.\tau$", then the formula "$\rho^2 + 4\rho - 4 = 0$" will be created and its positive root will have the value: "$\rho = -2 + 2.\sqrt{2} = 0.828428$". If the formula "$\rho = \lambda.\tau$" is considered to be the load of one operating line of the single-line system, then the utilization of transhipment equipment approximately at the level of 83 % will represent the marginal boundary for the establishment (creation) of the internal circuit.

3. Conclusion

If the transhipment equipment, which operates with the average handling time during the operation at the level of "τ" = 4 minutes, is utilized within the terminal, then, from the condition "4λ = 0.828428", the marginal value "λ = 0.207" handling operations per minute will be calculated.

That represents the number of 158,976 operations per working day (960 minutes) and 99 of ITUs per day. As for this value, the reduction of idle times of trucks in the queue equals the performance of one truck, which will be extra deployed.

If the number of transhipped ITUs in the terminal is, on average, higher than 99 of ITUs per day, then the trucks deployment for the internal circuit will represent the savings in work shifts of the trucks.

In this case, the creation of the internal circuit is well founded. Table 2 contains the marginal number of transhipped ITUs per one day.

The aforementioned considerations are related to a specific value of handling time during the operation equal to 4 minutes. Table 2 shows the calculated values of the marginal number of transhipped ITUs per one day (and the dispersion of the handling time during the operation is at the level of "0") for the handling times in the range of 1-10 minutes.

The marginal number of transhipped ITUs per one day — Table 2

Handling time	Daily working time in the terminal		Dispersion of the handling time during the operation	Load of one operating line	The average number of handling operations per minute	The marginal number of transhipped ITUs per day
τ			P	ρ	λ	ITU per day
	h	min	%	%	1/min	
1	16	960	0	82.84	0.828	398
2	16	960	0	82.84	0.414	199
3	16	960	0	82.84	0.276	133
4	16	960	0	82.84	0.207	99
4.5	16	960	0	82.84	0.184	88
5	16	960	0	82.84	0.166	80
6	16	960	0	82.84	0.138	66
6.5	16	960	0	82.84	0.127	61
7	16	960	0	82.84	0.118	57
8	16	960	0	82.84	0.104	50
9	16	960	0	82.84	0.092	44
10	16	960	0	82.84	0.083	40

Source: authors

Considering the previous calculations, it can be concluded that the values of marginal number of transhipped ITUs per one day are most influenced by selecting the particular type of handling (transhipment) equipment and the number of such equipment within the intermodal transport terminal.

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Eva Nedeliakova - Jana Sekulova - Ivan Nedeliak - Borna Abramovic *

APPLICATION OF RAYMOND FISK MODEL IN RESEARCH OF SERVICE QUALITY

This article describes the results of research focused on service quality after transportation by railway freight transport. The importance of these services completes the final quality of service and has crucial importance for customers considering the future use of railway transport. The proposed algorithm of evaluation of services after transportation is based on dynamic model of Raymond Fisk. This model represents a support tool for increasing service quality in the area of railway transport.

Keywords: *Service quality, railway freight transport, transportation chain, dynamic model.*

JEL Classification: R49

1. Introduction

One of the goals of a railway company operating in the area of services in railway freight transport is to obtain a lasting interest on the market with the prospect of increasing its operation. This goal can be fulfilled through constant monitoring and evaluation of the quality of the services provided, taking into account the specific characteristics of all parts of the transportation process.

Service quality in railway freight transport can be followed within the frame of the whole transportation chain or through division into its single constituent stages. It is currently a pressing problem to identify quality not only before the start of transport and during it but also after the end of transportation. At that point, the customer often requires supplementary services, and ultimately, if the customer is not content with the transportation, he may seek compensation.

In terms of the breakdown of single characteristics of transportation, several methods exist within the frame of world and domestic research. To meet the research requirement within the frame of research carried out for the Department of Railway Transport, the University of Zilina, in collaboration with the railway company Cargo Slovakia, Inc., applied a model that takes into account the characteristics of transportation, linking these with perceptions of service quality.

In practice, different objective and subjective methods of evaluating service quality are used, but the area of using dynamic models in railway freight transport has not previously been explored. The dynamic model of service quality addressed in this paper represents up to date trends in quality management. This model monitors the procedural characteristics of the services provided that are unique, unrepeatable and constantly changing.

2. CharacteristicS of The Dynamic model and Selection of characterS of quality for the last phase of the transportation chain after the end of transportation

In the area of providing services in railway transport, it is necessary to take into account that the requirements and claims of customers change over time [1]. It is necessary to know at any moment of the transportation service, what the expectations of the customer are, because it is he who assesses the quality of the services provided and decides whether or not to re-use the services of the railway undertaking [2].

Currently, in the area of services, several dynamic models of quality are used, including the models of Stauss and Neuhas, Liljander and Strandvik, Raymond Fisk, Boulding and others. The application of these models in the area of services forms the first assumption for its successful implementation in the area of railway transport.

In the research which was conducted for the Department of Railway Transport, several dynamic models were verified for application to the area of railway freight transport. In the

* [1]Eva Nedeliakova, [1]Jana Sekulova, [2]Ivan Nedeliak, [3]Borna Abramovic
[1]University of Zilina, Faculty of Operation and Economics of Transport and Communications, Department of Railway Transport, Slovakia
[2]Railway company Cargo Slovakia, a.s., Department of Strategy and Development, Zilina, Slovakia
[3]University of Zagreb, Faculty of Transport and Traffic Sciences, Zagreb, Croatia
E-mail: jana.sekulova@fpedas.uniza.sk

following part, we present part of this research in which the Raymond Fisk model was verified. Specifically, this is a phase of the transportation chain after the transportation has been completed.

In the Raymond Fisk model the aim is to integrate knowledge both from research on customer behavior and from research on customer satisfaction levels, based on defined characteristics (signs) of quality for normal and extraordinary operation. Within this model three phases are recognized: the buying decision, claims on performance and conditions after the purchase (after the transportation). The basic scheme of the Raymond Fisk model is shown in Fig. 1.

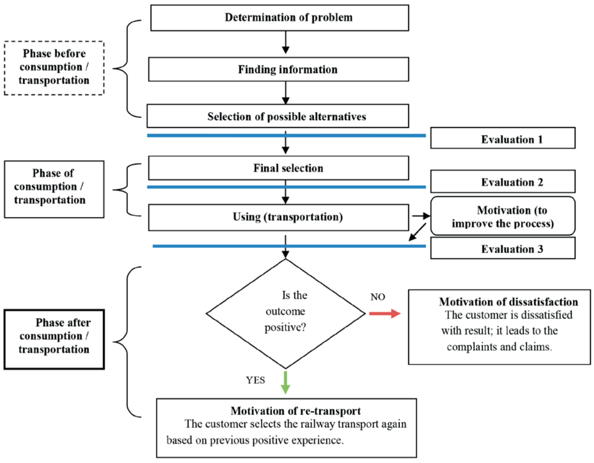

Fig. 1 Raymond Fisk model as applied to railway transport [edited by 3]

Selection of characters for ordinary and extraordinary operation within the frame of research was realized considering interconnecting the possibilities of assessing them by means of both objective and subjective methods, because the characteristics set is varied and some of them are challenging to qualify. To assess the resulting level of quality, it is necessary to connect the results of measuring and rating by means of both types of method (or exploiting the combination of several methods). All these principles were based on correctly defining the goal of quality in the transportation chain of railway freight transport, as well as on the expectations and needs of customers as identified from research [4 and 5].

For the last phase of the transportation chain, after the transportation was finished, six basic characters of quality were defined in the research:

1. Information,
2. Availability,
3. Reality,
4. Flexibility,
5. Customer care,
6. Understanding and knowledge of customers [6].

These characters of quality can be explained in more detail as follows:

1. Information = systematic provision of knowledge about the railway freight transport system, which has to assist in the realization of actions taken after the execution of transportation.

Processes defined and monitored by the research — Table 1

Process to ensure requirements	Explanation
1. Direct contact with customer	Pleasant demeanour, patience, verbal communication, neatness, employee helpfulness
2. Information about the arrival of the consignment	Immediate provision of information with customer feedback, provision of all necessary information to the customer
3. Unloading	Unloading, ensuring and securing the consignment, information about the unloading
4. Railway operation techniques	Modern and satisfactory, evolving in response to customer requirements
5. Cleaning of wagon	After the loading wagon is cleansed and washed out, goods can be repeatedly loaded up [9]
6. Resolving claims	Complaints promptly handled without delay
7. Invoicing of fees for transportation	Manual or electronic invoicing
8. Intactness of the consignment	Intactness of consignment and goods; informing customer about state of goods during and after unloading
9. Placing wagon on unloading	Correctly placed wagon; information about wagon location; readiness on unloading
10. Ensure the completion of the process	Full support solutions of customer problems after transportation and in his favor; settling of customs controls; periodic inspection of consignment during the day

Source: [5]

2. Availability = scope of the process in terms of time, frequency, geography and suitability of railway operation techniques.
3. Reality = temporal, spatial and informational security of the phase after transportation, including ensuring the consignment is intact after transportation.
4. Flexibility = speed of handling complaints in the case of additional customer requirements after transportation, including exact invoicing of fees for transportation.
5. Customer care = reinsurance of operations related with unloading of consignment at destination station, solution of problems that arise after the end of the transportation.
6. Understanding and knowledge of customers = helping and supporting customer needs, knowledge of customer needs.

Figure 2 characterizes the sequence of steps that were made within the application of the methodology in the real conditions of the transport market.

The selection of characters within the frame of research comes from practical operation, from experience of contact with customers, according to their interests, their requirements and needs, the factors that are attractive for them, and from watching with deciding about the utilization of railway freight transport and purpose-built units within the structure of a formally organized railway company [6 and 7].

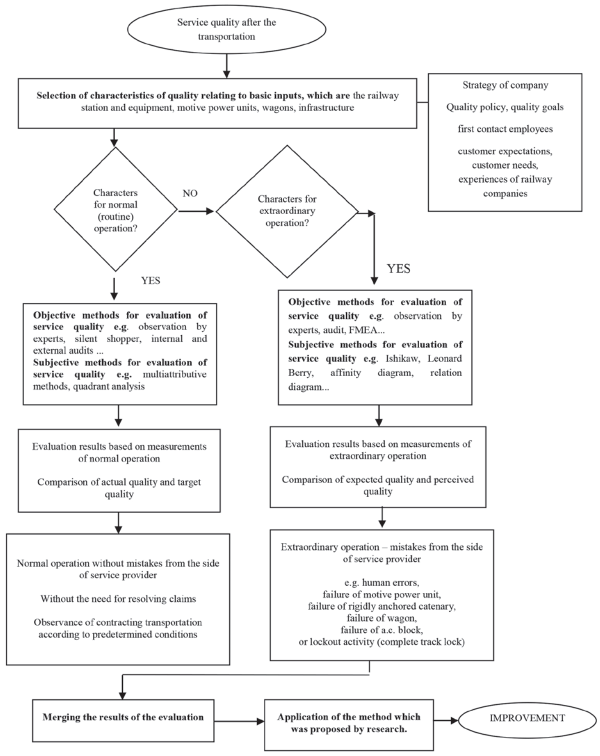

Fig. 2. Algorithm of service evaluation [8]

Partial output of research (No. 8 to 10) Table 2

Point rating of quality after transportation					
S.n.	**0 points = unsatisfactory**	**2 points = partially satisfactory**	**5 points = standard**	**8 points = above standard**	**10 points = fully satisfactory**
8.	Loss of goods	External damage to consignment, but goods intact	Consignment and goods intact	Consignment and goods intact; customer informed about state	Intact consignment and goods; customer informed about state of goods during and after unloading
9.	Wagon not placed	Incorrectly placed wagon; failure to inform about placing of wagon	Correctly placed wagon; customer informed about placing of wagon	Correctly placed wagon; customer informed about placing of wagon; readiness on unloading	Correctly placed wagon; customer informed; readiness on unloading, realization of unloading in accordance with customer requirements
10.	Without additional services	Partial additional services, insufficient support for flexible solution of requirements, even in the case of claim	Partial support solutions to problems for customer after transportation and in his favor	Partial support solutions to problems for customer after transportation and in his favor; settling of customs controls, periodic inspection of consignment during the day	Full support solutions to problems for customer after transportation and in his favor; settling of customs controls, periodic inspection of consignment during the day

3. Processes fulfilling Quality requirements after transportation

Within the frame of the mentioned characteristics, after the transportation ten processes needed to fulfill the quality requirements were defined and monitored, as documented in Table 1.

Table 2 presents the partial output of the research, giving an exemplary assessment of quality through the application of selected quality characteristics, which served as support for the identification of the quality of transportation services in railway freight transport in the phase after ending the transportation. Individual quality characteristics were monitored within the frame of ordinary and extraordinary operation.

4. Conclusion

The benefit of this research is the newly created methodology, with exact definition and detail of quality characteristics that has been designed for the management of railway companies. The benefits of the methodology consist in its clarity and in the selection of new characteristics for rating the quality of processes and services. It was created to be universal, and, therefore, offers the possibility of application across the whole transportation chain providing railway freight transport.

The research revealed that the biggest problems within the evaluated services occur with technical securing, but also with related inadequate equipment at railway stations (space, ramps, general loading and unloading track), or the poor condition and insufficient number of certain types of wagons. These problems interfere with the transportation chain even after the end of the transportation and play an important role in normal and extraordinary operation. Simultaneously it was found that there are important time, local or technological expressions of "resistance", which must be overcome so that customer, through the provision of a relevant process, is able to achieve the fulfillment of his requests, i.e. change of place from the starting station to the destination station.

Bottlenecks (narrow spaces), meaning constrained spaces, were defined in this article as hindering improvements to the total quality of the services provided. These bottlenecks should be the subject of review in order to define corrective measures and their subsequent implementation. The removal of bottlenecks will increase the quality of operational processes, which is an imperative condition of survival in a competitive business environment.

Acknowledgement

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Martin Jurkovic – Andrej David – Csaba Hargitai *

PROPOSAL FOR AN INLAND SCHOOL SHIP FOR THE DANUBE REGION

Aim of this study is the definition of a framework for the actual realisation of a common school ship in the Danube region. After a brief outline of best practice examples for (inland navigation) school ships in Europe, the study goes on with the summary of the technical aspects of the Danube School Ship and description of the feasible vessel design (with and without lifting wheelhouse) which responds to the previous research analyses.

Keywords: *Danube region, school ship, vessel design, navigation, project HINT.*

1. Introduction

Current European documents such as the NAIADES Action Programme and the European Union Strategy for the Danube Region emphasize the importance of education in inland waterway transport sector underlining that

"A functioning education and training system is a fundamental condition for a sound and competitive labour market. The existence of education and training institutions in the sector has to be secured and their curricula adapted to current managerial, technological, linguistic and nautical need" [1].

Besides the pure educational aspects, training is also crucial for safety reasons. In this respect, practical training is of utmost importance. The effectiveness of practical training resides in the advance of professional competencies, employability of trainees and securing safe working conditions on board of ships [2].

Practical training complements theoretical knowledge acquired in class and renders training coherent and complete. It bridges the learning environment to work place through the hands-on experience. Introduction of modern learning tools such as simulators and school ships is encouraged so as they support education and training institutions to be able to educate necessary qualified personnel [3].

Practical training represents the period in which already acquired skills are consolidated, complemented and perfected and it provides the trainees with a real picture of the work place they prepare for.

Through on-board practice trainees get familiarized not only with the installations and equipment, but also with working conditions on board of the ship, they acquire appropriate general and specific professional competences and they get a glimpse of their future duties to be fulfilled according to applicable regulations and procedures [4].

On-board practical training possibilities in inland navigation are unfortunately scarce in the Danube riparian countries, which makes the development of required competencies by inland navigation crew members very difficult. The concept of a joint Danube School Ship was worked out in project HINT [4] to solve or at least reduce the lack of on-board practical training possibilities on the Danube.

2. Best practices of existing inland navigation school ships in Europe

There are several school ships on the Danube. But these ships are mainly not designed or retrofitted for on-board training and they are used only for 1-3 days long training trips on national waterways.

Some schools and training institutes in Western-Europe use special school ships which can be example for a joint Danube school ship. They are sailing continuously on the Western-European waterways, and the students have 7-14 days long on-board trainings with them [5].

The **Prinses Maxima** (Fig. 1) is a motor cargo vessel with a length of 50 m, a width of 8.0 m and a draught of 1.5 m. The height of the wheelhouse is adjustable and it provides a double

* **[1]Martin Jurkovic, [1]Andrej David1, [2]Csaba Hargitai**
[1]Department of Water Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Department of Aeronautical, Naval Architecture and Railway Vehicles, Budapest University of Technology and Economics, Hungary
E-mail: martin.jurkovic@fpedas.uniza.sk

steering post for students and trainers. The vessel provides accommodation for 24 students and 4 trainers.

The **Prinses Amalia** (Fig. 1) is a lighter with a length of 30.0 m, a width of 8.0, a draught of 1.5 m and a weight of 388 tons. It is a tanker lighter with all necessary equipment for loading and unloading. The bunker mast can also be used for the transhipment of cars [6].

The vessels have one teaching room each, the one of Prinses Maxima is lunchroom and recreation area as well. On board of the vessels, students learn how to handle the equipment of a modern inland vessel, how to navigate a pushed convoy and the loading and unloading of liquid cargo (coloured water) [6].

Fig. 1 The training ships Prinses Maxima and Prinses Amalia
Source: Wikipedia

Operation of **Themis II** goes back to 10 October 2002 when the shipyard SKB, Antwerp completed the reconstruction of former vessel Romata built in 1965 (55 m x 7.20 m) and changed it into a modern school ship. The vessel received a new structure and was fitted with waterproof partitions. The bridge, lower deck, accommodation places, engines, equipment, tanks were all renewed and the new ship sailing under Belgian flag received from Bureau Veritas, on finalisation of works, the classification I 3/3 (E) N12 as passenger ship (hotel vessel) MACH (there is no classification as training ship). 17 cabins of 3 x 3 m each occupy a space of 13 x 5.5 m. A dedicated space of 6 x 5.5 m is used as lecture room [6].

3. Vessel requirements

The joint Danube school ship concept [4] imagines an international school ship. While she is sailing up and down along the Danube practical training courses are fulfilled with teachers and students from the whole Danube region. The trainings are 7-14 days long with 15-22 students. Beside the long trips the ship can be also used as exhibition area (while she is moored for a few days) or as a ship for practical exams of crew (e.g. for boatmaster exam two fully loaded barges have to be towed by the ship in some Danube country).

The education and training institutes can use the ship under the umbrella of an education and training institute association or they can rent her.

Functional requirements

According to the research of project HINT [4] and considering the best practice examples, the Danube School Ship should give accommodation for 20-22 students, 2 teachers and 4-6 crew members. In day cruiser operation (e.g.: sightseeing, floating exhibition, etc.) the vessel should be available for up to 50 passengers. This means that the Danube School Ship has to have accommodation for about 30 people, which also needs to be regarded at the kitchen, laundry, bathroom and storage (food, clothes, etc.) capacity. A larger room is also required for meals (breakfast, lunch, dinner) and education (classroom). The furniture of this room should be removable or changeable, because in day cruiser operation about 50 passengers have to be seated here. The education on board is planned to be organized in groups of 5-7 students [7].

Machinery requirements (propulsion, auxiliary engines and bow thruster)

The power of the main propulsion has to be determined by calculating resistance, taking the pusher option into account (two loaded barges). The minimum speed of the vessel has to be 13 km/h in calm water, according to the Danube regulations. The ship should have double screw propulsion, because of the relative shallow draught (max. 2m) and education purposes (how to navigate with two screws). The propulsion can be the conventional diesel with a reversing and reduction gear, but diesel - electric propulsion is also possible. Using alternative fuel (LNG, CNG, fuel cell, etc.) could increase the quality of the ship, but innovative technologies would raise the costs [8].

The Danube School Ship is a special passenger vessel. Based on example school ships the required power of auxiliary engines is about 2×200-250 kW. For better manoeuvrability of the ship a bow thruster may be procured. Besides increasing navigability of the vessel, this tool also increases the navigation training quality.

Navigation requirements (navigation area, navigation profile)

The main navigation area of the Danube School Ship is the Danube and its tributaries. Regarding the ship design, the AGN[1] classification of waterways helps to define the maximum dimensions of applicable vessels. The Danube as waterway is classified from Va. to VII AGN classes. For better usability the vessel should be able to use the main tributaries of the Danube (at least in the estuary). This means that the smallest waterways where it should operate are the AGN Class IV waterways. The navigation practice gives some additional limits on the measurements [9]. Because of some shallow water areas of the Danube river stretches the ship´s draft should not exceed 1.6 - 1.8m. However the minimum height under bridges in class IV waterways is 5.25m, there are only 20 bridges along the Danube with less than 7m clearance by HNWL[2] from the total 118 bridges. This means that the Danube School Ship can have 7m fix point height with an additional navigation limit by HNWL on the upper Danube section. From construction point of view the 7m fix point height can be fulfilled without wheelhouse lifting, but a wheelhouse lifting system is necessary to reach 5.25m fix point height [4 and 7].

The Danube School Ship needs fuel, fresh water, food and other stock storage capacities for 7 days of continuous operation. This means about 1000 km action radius upstream and about 3400 km action radius downstream. The operation profile should be the operating mode “B”: 24hours of continuous movement (Table 1). This profile requires unattended machine operation [10].

Minimum required number and qualification of crew Table 1

Vessel in operating mode „B“	Required number and qualification of crew
Self propelled vessel	3×boatmaster, 1×deckhand, 1×machinist
Self propelled vessel + 1 or 2 barges	3×boatmaster, 2×deckhand, 1×machinist

Source: Authors

4. New ship design

Although the common practice for creation of a school ship is reconditioning of an old vessel, it is more advantageous to build a new vessel rather than fitting an old one to the specific educational purposes. In this case an ideal construction, among given boundary conditions, is possible and every required design parameter can be fulfilled, while the cost of ship is almost same [4 and 11].

[1]European Agreement of the Main Inland Waterways

[2]High Navigable Water Level

5. Main dimensions

The Danube School Ship is a special vessel construction, because it is a cabin, cargo and pusher vessel at the same time. Considering its function, machinery and waterway AGN category No. IV., the requirements of the new Danube School Ship are 58m length, 9m width, 1.55m of draught and 5m of height (fix point height). In this case, the ship has to be equipped with a lifting wheelhouse, because the bridge clearance in waterway category No. IV. is 5.25m.

However, the Danube School Ship with a lifting wheelhouse (Fig. 2) can navigate under the Danube bridges at every navigable water level, but it has some disadvantages as well. The wheelhouse would be situated at the fore part of the vessel, which makes the navigation more difficult. The lifting wheelhouse has to be placed on the main deck, which makes the ship 58m long. This length is more like a tug ship on the Danube than a pusher, but the navigation with two barges needs a short pusher.

In case the Danube School Ship only moves on the Danube, there are only 20 bridges with less than 7m clearance under bridges during HNWL. The ship can have 6.95m fix point height, a lifting wheelhouse is not necessary, and it can be placed on the top of the vessel. Without a lifting wheelhouse (Fig. 2) the Danube School Ship has 54.5m length, 9m breadth, 1.55m of draft and 6.95m of height (fix point height) [4].

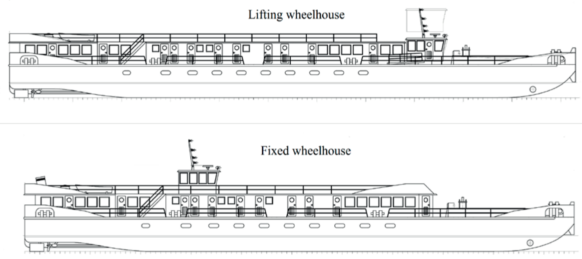

Fig. 2 New Danube School Ship with/without lifting wheelhouse
Source: Danube School Ship elaborated in the framework of HINT

6. General arrangements

The Danube School Ship has three decks either with a lifting or a non-lifting wheelhouse. The first is the lower deck above the double bottom, which has 700 mm height from keel. The second is the main deck 3200 mm above the keel. The third is the top of the superstructure, the so called sun deck 5700 mm above the keel [4].

Lower deck

The lower deck (Figs. 3 and 4) is inside the hull and divided into seven main areas by watertight walls.

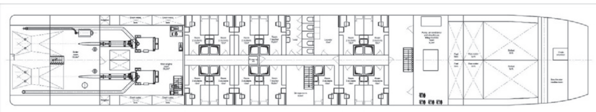

Fig. 3 Lower deck arrangement of Danube School Ship with lifting wheelhouse
Source: Danube School Ship elaborated in the framework of HINT

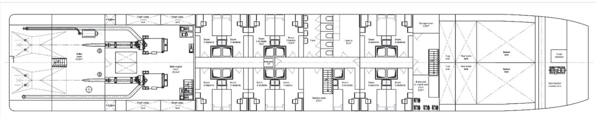

Fig. 4 Lower deck arrangement of Danube School Ship with non-lifting wheelhouse
Source: Danube School Ship elaborated in the framework of HINT

Collision spaces - The stern and bow collision spaces are because of the safety and the regulations. The rudder trunks run through the stern collision space, but the rudder machines are on the main deck in the auxiliary engine room.

Boiler room - The boiler for warm water and heating is located in the 33.8m^2 boiler room. This room is also for the warm water and Danube water hydrophores. The shaft tubes enter this space into the hull, sealed with glands. This space communicates by two watertight doors with the auxiliary engine room and the main engine room.

Main engine room - The machinery parts of propulsion (shaft, bearings, main engines, gearboxes, heat exchangers, fuel day tanks and pipe systems) are located in the main engine room, where the ship has a double side hull structure. However, the engines and other elements would not require 58.5m^2 room, this size of engine room makes it suitable for machinery maintenance trainings.

Accommodation area - The main part of the lower deck is accommodation area with 11 bedrooms for 22 students, 2 bedrooms for 2 teachers, a lavatory with 5 toilets, a laundry and a storage room.

Tank space - The fuel tanks are between the front wall of superstructure or the lifting wheelhouse and the cargo hold. Fuel tank capacity is about 40m^3. Under the bottom of cargo hold, in a 1.2m high space are the raw water and ballast tanks.

Bow thruster room - The bow thruster room is located under the main deck, behind the bow collision wall. The horizontal axis, electric bow thruster, its tunnel and the necessary electrical system is installed in this space. The bow thruster room is accessible by a hatch from the main deck. [4].

Main deck

The main deck (Figs. 5 and 6) is the top of the hull. Beside the open deck areas, the superstructure, the cargo hold - and in lifting wheelhouse version the wheelhouse and its lifting machine - are situated on the main deck.

Fig. 5 Main deck arrangement of Danube School Ship with lifting wheelhouse
Source: Danube School Ship elaborated in the framework of HINT

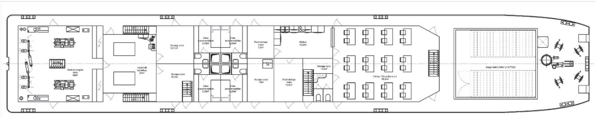

Fig. 6 Main deck arrangement of Danube School Ship with non-lifting wheelhouse
Source: Danube School Ship elaborated in the framework of HINT

Open deck areas - On the main deck there is a gangway around the superstructure. At stern the gangway is 1m wide, which allows training with ropes and practising the rescue from water. All doors of superstructure open to this area and stairs to sun deck and wheelhouse start from here. The side gangways are equipped with bollards for mooring and coupling of barges [4].

Cargo hold - The cargo hold is in the fore part of the hull, behind the bow deck and before the superstructure or the wheelhouse (non-lifting or lifting wheelhouse version). The cargo hold is 7.5m long, 6.2m wide, and 3.1m deep (with 0.9m high hatch coaming). It has about 144m^3 volume, and can be loaded with general dry cargo or two standard 20 feet containers [4].

Superstructure

The main part of the main deck is the superstructure, which has the following main areas: auxiliary engine room, locksmith workshop, storage rooms, crew accommodation area, food storage rooms, kitchen and dining or education room [4].

Sun deck - Even if the Danube School Ship is built with lifting or non-lifting wheelhouse, the top of the superstructure is the sun deck. The stern anchor machine and the service boat are in the back part of the deck, the remaining area is empty and serves some board training. The sun deck can be reached by stairs from both side gangway of main deck. At the non-lifting wheelhouse version the wheelhouse is placed on top of the sun deck, but at the lifting wheelhouse version the wheelhouse is before the superstructure and the sun deck [4].

Wheelhouse - The arrangement of the wheelhouse is different, depending on lifting or non-lifting version. In both cases the area is larger than a regular wheelhouse (20.8m^2 or 25m^2), because it is equipped with a master and a slave steering posts. On the back side of the wheelhouse are seats or benches for observer trainees or for the examination board. The wheelhouse is designed for 9 people to stay [4].

7. Machinery

The propulsion of the Danube School Ship has to be designed for navigation with two loaded Danube-Europe IIb standard barges at 13 km/h. Additional requirements for the navigation training is that the ship should be a twin screw vessel, because of this propulsion the navigation with two propellers can be practised [4].

The Danube School Ship is a special passenger vessel, which has large electric energy consumption while kitchen, air conditioning, training workshops, etc. are in operation. Due to regulations and safety reasons the Danube School Ship is equipped with two **auxiliary engines**. Based on example school ships the power of engines should be about 2×200-250kW [4].

The rudder system of the Danube School Ship has to be designed for navigation with two DE IIb barges. Compared to the conventional pushers on the Danube, the Danube School Ship is longer than the average. Therefore, the vessel should be equipped with 2×2 main rudders behind the propellers, and 2×2 flanking rudders before the propellers [4].

8. Conclusion

The idea of a joint Danube School Ship – to at least partly solve the lack of qualified nautical personnel – was already borne some years ago. Balanced acquisition of both knowledge and practical skills is an essential prerequisite of good training resulting in a highly performing crew on board ships. On-board practical training possibilities in inland navigation are unfortunately scarce in the Danube riparian countries, which makes the development of required competencies by inland navigation crew members very difficult. Aim of the study is to establish a framework for the proposal of the harmonized Danube School Ship and to build the basis for its implementation in to the practical use within the Danube region. The document describes a feasible manner for the technical and organisational design of such a vessel in two special modifications – with or without lifting wheelhouse.

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Eva Brumercikova - Bibiana Bukova - Leszek Krzywonos *

NFC TECHNOLOGY IN PUBLIC TRANSPORT

This article discusses the possibility of the application of the NFC technology as a system of selling tickets in public transport. The NFC (Near Field Communication) technology is a wireless and contactless technology of transmission of radio data over short distances (max. 5 cm).

Keywords: *NFC technology, public transport.*

1. Introduction

Public transport operators and authorities, financial service providers, telecommunications operators need to work together to combine their products on a single card. The most promising are smart cards and mobile ticketing. At present smart cards (making use of Radio Frequency Identification [RFID] technology) are still the most common form of e-ticketing. It is likely that, in the future, ticketing applications will evolve to be integrated into bank cards and/or Near Field Communication (NFC) enabled smartphones.

NFC technology

The NFC technology is a wireless and contactless technology of transmission of radio data over short distances (max. 5 cm), enabling an easy and secure either-way communication. This technology is very similar to the RFID (Radio Frequency Identification) technology.

The use of this technology in practice would mean a significant change in the quality of passenger transport. It is possible to integrate payment or loyalty cards, IDs and driving licenses, electronic keys or travel documents into the NFC technology. The use of the NFC technology has many advantages which result from noncash payments and the new advantages include:

- in case of the card expiry date it is not necessary to visit a bank institute to get a new card,
- the NFC technology can also replace physical or virtual keys (car, home, log into the PC),
- the NFC technology facilitates communication between all devices, which are currently widely used.

In order to use the passive NFC technology it is not necessary to own a mobile phone supporting this technology, it is enough to have the passive NFC chip (a so-called sticker), powered by the electromagnetic field of a payment terminal. Stickers take the form of a sticky label. In order to actively use the NFC technology, it is necessary to own a mobile phone, especially a smartphone that is equipped with an NFC chip. The most important brands of mobile phones supporting the NFC as of April 2015 include phone brands:

- Samsung 28 mobile devices,
- Sony 16 mobile devices,
- Apple 14 mobile devices,
- Nokia 13 mobile devices,
- further brands include LG, Xiaomi, Huawei etc.

Technical data and parameters of the NFC:

- the NFC technology has a reserved bandwidth and operates at a frequency of 13.56 MHz,
- the data transfer rate is 106, 212 or 424 kbps,
- the intended speed is 1 Mbps,
- the NFC technology uses radio waves for transfer,
- the transmission is Half-Duplex,
- the NFC connects two modes - active and passive,
- it uses its own Open Source protocol NFC.

The NFC technology has a wide range of applications, especially in mobile phones. In this case, via this technology the user can pay, buy tickets or exchange contacts with other devices supporting this technology [1, 2 and 3]. Table 1 shows the summary of different wireless technology comparative details.

* [1]**Eva Brumercikova,** [1]**Bibiana Bukova,** [2]**Leszek Krzywonos**
[1]Department of Railway Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Politechnika Lubelska, Lublin, Poland
E-mail: eva.brumercikova@fpedas.uniza.sk

Summary of the comparative details [4]

Table 1

Concept	NFC	Bluetooth	WIFI	GPRS/3G	NFC observation for public transport
Transaction distance	0.1m	10-100m	300m-40km	1km-35km	Intended for a voluntary action
Transmission speed	848kbit/s	2Mbit/s	54mbit/s	14Mbit/s	Acceptable speed
Connection set up time	20 milliseconds	6s	2s	1s	Extremely fast
Connection reliability	Extremely high	Low	Medium	Medium	Extremely reliable
Robustness against interferences	Extremely high	Normal	Normal	Normal	Extremely robust
Compatibility with transport infrastructures	Almost total	Zero	Zero	Zero	Compatibility with infrastructure
Compliance with transaction times	Total	No	No	No	Acceptable transaction times

2. Mobile NFC in transport today

The usage of mobile NFC transport-related services depends on consumers having NFC handsets that are compatible with the ISO/IEC 14443 standard that forms the basis for contactless infrastructure in the transport industry. These handsets should be certified to ensure that they comply with the full NFC specification, but industry-wide certification mechanisms don't yet exist. The availability of NFC handsets is now growing quickly. By 2015, 50% of the smartphones shipped will support NFC, according to one leading semiconductor vendor. By then, the vast majority of handsets sold in Europe will likely be smartphones.

Mobile NFC services have already been deployed commercially in several countries, such as Japan, South Korea, France and Turkey.

Preparations for rollout in European Union countries

Several of Europe's transport operators are adapting their existing electronic ticket systems to support NFC handsets. In this section, we outline some examples [5]:

Deutsche Bahn

Deutsche Bahn, Germany's main train operator, is preparing to expand its NFC support for the Touch&Travel system. Touch&Travel is designed to collect fares automatically by enabling passengers to check in and out of the public transport system using touchpoints. Today, the passenger checks in and out by entering the touchpoint ID number into the Touch&Travel app on their handset or scanning a 2D barcode. Alternatively, a customer can ask the app to find their location (using technologies, such as GPS and/or Wi-Fi) and then choose from a list of local stations. The handset then transmits the station information over the mobile network to Deutsche Bahn's systems, which charges the journey to the passenger's postpaid account, which is settled once a month. Following an extensive pilot phase, Deutsche Bahn is now preparing to enable passengers to touch their Android and Symbian handset against an NFC tag to check-in and check-out of the transport system.

Transport for London

Transport for London is planning to gradually replace its proprietary Oyster electronic ticketing system with a system that simply charges a passenger's debit or credit card for each journey made. Such a system will eventually enable Transport for London to reduce the cost of fare collection, as passengers will no longer need to purchase a dedicated plastic card and load money onto that card. Instead of tapping their Oyster card against a reader, the passenger will be able to tap a contactless debit or credit card compatible with the EMV standard. If a debit or credit card is stored in the passenger's NFC handset, then they will be able to use their phone in the same way.

Transport for London is developing software that will register each time the passenger taps in and out of the system. At the end of the day, the software will tally up the journeys made and charge the passenger's payment card via the existing EMV system. The passenger's daily expenditure will be capped to ensure that they aren't charged more than the cost of a day travelcard.

Transport for London is talking to the UK's mobile operators about enabling their wallets to track the passenger's spending on travel in London in real time. That would enable the passengers to see how much they have spent during the day, rather than waiting for the settlement to take place at the end of the day.

Transport for London intends to also introduce its own TfL card for people who don't have an EMV card or would prefer to use a prepaid system, in which case they buy credit up front, to control their spending. Again a passenger could store a virtual version of this card in an NFC handset.

Barcelona ATM, Spain

Barcelona ATM is the governing body for integrated fare collection covering the metro system, railways, tram systems, buses, and other forms of public transport within Barcelona and the 250 towns in the surrounding area. The agency provides the system for approximately 74 transport operators in the Barcelona metropolitan region, which covers 3,240 square kilometers and serves more than five million residents. More than 70% of the journeys made by customers are with integrated tickets.

ATM is now deploying a full NFC-contactless solution for ticketing, based on open standards and ISO-CEN compliant, which is intended to be a significant step towards the deployment of contactless services across the rest of Catalonia, as well as interoperability with transport systems in other regions. ATM is also building on the momentum of Barcelona City Council's TAP@GO project, which is enabling NFC-payments and municipal services within the city.

3. Development of the number of payment cards in Slovakia

Currently, payment cards have become a modern means of payment. It is a comfortable and safe tool for noncash bank transfers of financial resources. A payment card allows its holder to pay for goods in shops, restaurants, hotels, petrol stations or on the internet. Public transport is one possibility to widen the range of the use of payment cards. In the public transport cash payments and noncash payments are currently used only if purchasing tickets over the internet or payments with payment cards when purchasing tickets at the ticket office. The following Table 2 shows the development of the number of payment cards. The source of the presented data is the Slovak Banking Association [6]. This statistics provides relevant data about the number of payment cards issued in the Slovak Republic as well as the volume of transactions made with payment cards.

The given table demonstrates an increase in the number of payment cards as well as the volume of transactions made by payment cards. For comparison, the volume of transactions made in 2013 compared to 2008 increased by 145%. The number of payment cards issued increased by 158%.

In 2015, a survey of the interest and knowledge of public passengers about the NFC technology was conducted. The research involved 504 respondents who were contacted either directly or through the website on which a questionnaire was published. The research surveyed the knowledge of passengers about the NFC technology. The assumption was that the passengers will not have knowledge about this technology. It is a new platform through which payments can be made. The research results confirmed the low awareness of the respondents about the NFC technology. Almost 60% of respondents said they do not know about this technology. Interestingly, respondents with primary education knew the most about the NFC technology (63.64%). Subsequently, the respondent was informed about the NFC technology. After explaining what the NFC technology means, the respondents were asked whether they would use this technology when buying a ticket. Most respondents answered positively (37.09%), "do not know" said 25% of respondents, and certainly not 35.91%. Respondents who answered "no" explained that the reason was their concern particularly in case their mobile phone would be stolen and they were also worried about what to do in case the phone would turn off because of a discharged battery.

Development of the number and volume of card transactions in Slovakia [Authors] Table 2

Together	Number of prepaid cards	Value of transactions - by prepaid cards (in EUR)	Number of debit cards	Value of transactions - by debit cards (in EUR)	Number of credit cards	Value of transactions - by credit cards (in EUR)	Number of contactless cards	Value of transactions - by contactless cards (in EUR)
31.12.2008	-	-	3 913 009	3 208 859 621	1 321 382	197 467 398	-	-
31.12.2009	-	-	3 998 137	3 273 197 274	1 062 065	177 557 824	-	-
31.12.2010	-	-	4 176 196	3 648 132 517	795 777	176 247 505	-	-
31.12.2011	9 648	593 645	4 520 612	3 977 112 088	818 132	191 444 893	392 387	-
31.12.2012	51 587	601 000	3 929 979	4 232 266 519	604 992	199 587 443	1 207 052	15 646 327
31.12.2013	50 309	659 915	4 115 198	4 450 199 795	620 776	223 522 290	2 150 984	100 932 358
31.12.2014	70 175	13 704 482	4 313 089	4 892 084 535	654 281	247 927 042	3 216 030	229 471 014

4. Cycle product – NFC in mobile phone

This chapter describes the processes in which a transport card is involved when it is in an NFC mobile phone. The purpose is to give a view of the card life cycle and the implications involved for successfully achieving the implementation of the NFC mobile phone in public transport.

4.1. Differences when the card is in the NFC Mobile Phone

When a transport card is placed in a mobile phone, some important differences occur that need to be pointed out for a better understanding of its implementation implications in public transport.

- The transport card becomes "virtualized" inside the mobile phone's secure element (SE), therefore ceasing to exist as a physical card or physical chip.
- The transport ticket is also "virtualized" inside the card, but this in fact is nothing new as it is already happening in current transport cards.
- The SE is a support that will be able to hold other transport cards or other types such as bank cards, as well as other services, communications etc., which means that it can no longer be owned by the transport company.
- Since the card will be located inside the mobile phone, it may be accessed remotely at any time communication is activated.
- The mobile phone environment, and more with the NFC environment, makes it possible to make payment transactions from the mobile phone, which leads the way to card top-ups without having to go to a top-up point.
- As NFC technology is currently an emerging technology and has many requirements associated, it cannot always be guaranteed that the card will be downloadable to all mobile phone models in the market, meaning that the user will always have a choice during card request process on the mobile phone.
- The contactless card has certain limitations, among them its interaction capacity: we can only obtain information on the card if we hold it near a terminal that powers it and is able to authenticate and obtain the corresponding information. NFC makes it possible to remove this obstacle, since mobile phones today have large screens, connectivity and processing capability [7].

4.2. Ticket life cycle

The ticket life cycle diagram is complex. By way of example, a typical diagram is included to show it in Fig. 1.

Identity control in the case of personalized tickets - if the ticket requires the user to have specific characteristics. The user must be clearly identified despite not having a physical card with a photograph.

Transactions in general by lists - contactless cards are processed remotely by lists of cards that are sent to the devices and when they locate them, they act. With NFC technology, this may be done immediately. For example, if the user has 3 additional trips due to an incident, this balance may be increased remotely at any time.

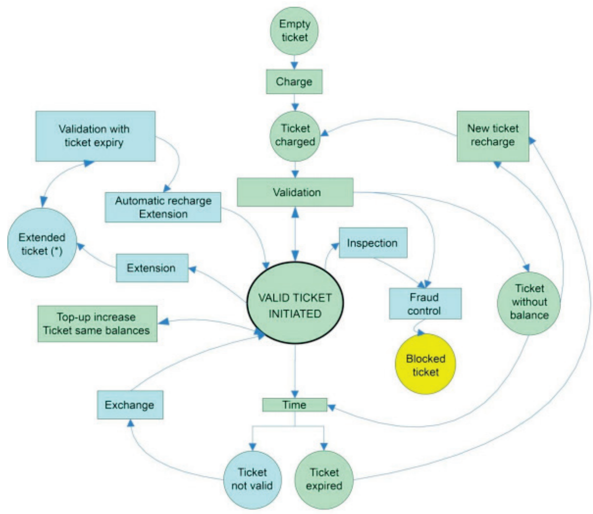

Fig. 1 Ticket life cycle [7]

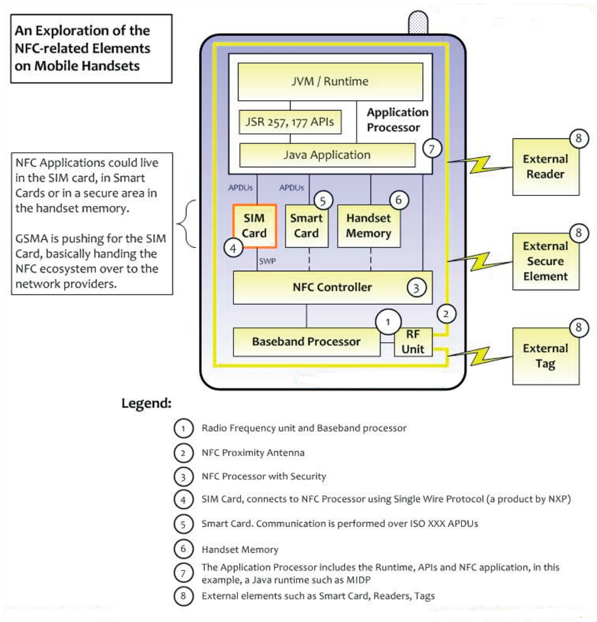

Fig. 2 An exploration of the NFC - related Element on mobile handsets [8]

Remote Charging - the ticket may be recharged remotely and in real time, without the need to have to wait to pass a top-up or validation point which has been reached by a list of cards that have made a top-up purchase on the web site [7].

The following diagram (Fig. 2) shows An Exploration of the NFC-related elements on mobile handsets.

Possibilities of NFC structural simulation

Near field communication (NFC) technology is attracting a lot of interest for mobile payment and ticketing applications. Behind the simple "swipe and go" operation is a complex system spanning many different standards and presenting challenges from the RF interface to the digital processing. Broadcom is currently developing chips to provide NFC solutions for handset manufacturers, and MATLAB and Simulink are an important part of both the system modelling and, through HDL Coder, generation of the actual digital hardware [9].

The internal structure of the NFC technology is shown in Fig. 3. This NFC model uses only a standard ASK modulation scheme and includes also an AGC support.

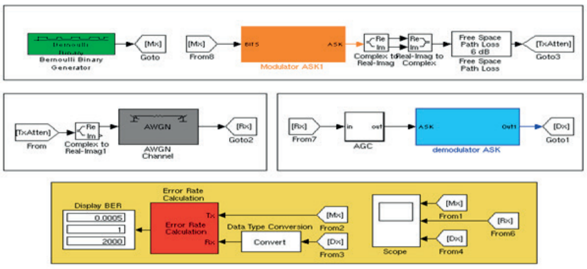

Fig. 3 The internal structure of the NFC technology [9]

5. Conclusion

Most experts agree that NFC is the smart technology of the future and that phone-based applications will become increasingly important. NFC applications can integrate several independent services and hold the promise of freeing single operators from the need to set up a cost-intensive infrastructure of check-in/check-out devices. Instead, the users - with their mobile phones or with their contactless bank cards - provide a large portion of the necessary infrastructure. Modern contactless (be-in/be-out) technologies in public transport, for example, do not even require the passenger to actively register at the ticket gate. Instead, a tag at each station or in each vehicle automatically detects and registers new passengers when they enter, during the trip and at the end to automatically calculate the most favorable fare. However, experts agree that customers want to have a choice among different payment options and that phone-based applications will not appeal to everyone. Therefore, different payment options should remain available. At present and in the medium term, smart cards offer an attractive medium to connect payment options in public transport with additional services – however, they require operators for larger investments in access control infrastructures. In either case, a change in the ticketing environment must be accompanied by a communication strategy explaining the change in detail, and emphasizing its benefits for all actors that are involved in the process [10 and 11].

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Tomas Kalina - Martin Jurkovic - Helena Binova - Bruno Gardlo *

WATER TRANSPORT - THE CHALLENGE FOR THE AUTOMOTIVE INDUSTRY IN SLOVAKIA

An important factor in choosing the transport mode in the automotive industry is not only the current price but also the shipping time. In some cases the latter one is even crucial and significantly affects the choice of the transport mode. Geographical location of the port of Bratislava allows its direct connection to the North and Black Sea. The study provides a comparison of transportation time from the selected Slovak car producers and shows advantages of water transport. Time of delivery is a criterion that can be easily quantified and mutually compared. The fastest transportation mode – the road transport saves the time of delivery eight times more on average than the water transport in the European transport network. The waterway, on the other hand, is cheaper and environmentally friendlier.

Keywords: *Automotive industry, transportation time, vehicles, logistics operator, water transport.*

1. Introduction

An approximate duration of the navigation from the port of Bratislava towards the North and Black Sea is based on the standard nautical terms, i.e. on water and weather conditions permitting safe navigation (Table 1). In autumn and winter may the period of the navigation be longer because of the early morning fog, ice drifts, which are necessary to take into account when planning the transportation. It is also important to consider the possible high water levels on the Main, which do not allow the navigation of pushed vessels [1].

Slovak Shipping and Ports (major shipping operator in Slovakia) has three vessels which enable the transportation of wheeled technologies. The standard DE IIb vessel type has the container transport capacity of 63 TEUs, 21 truck trailers or 70 cars can be transported by the Ro-Ro vessel. The formation of two or three pushing convoys of Ro-Ro vessels transport a maximum of 200 cars.

One possibility of increasing the transportation capacity is to extend the Ro-Ro fleet of multi-storey Ro-Ro vessels or of pushing convoys enabling the transportation of more than 500 cars. An example may be 2-3 storeys Bulgarian Ro-Ro ships called INTERSHIPPING-1, INTERSHIPPING-2, INTERSHIPPING-3 and INTERSHIPPING-4 pushed by the tugboat Naiden Kirov (Fig. 1) [2].

Transportation time from/to Bratislava — Table 1

Travel Time in Hours				Distance km	Port	Number of Locks	Travel Time in Hours			
4-unit pushed convoy	2-unit pushed convoy	MCV* 2.000 t	MCV 1.350 t				MCV 1.350 t	MCV 2.000 t	2-unit pushed convoy	4-unit pushed convoy
	196	183	194	1703	Ghent[1]	69	195	179	202	
	192	179	190	1682	Antwerp[1]	68	191	175	198	
	185	173	182	1588	Amsterdam[1]	68	185	170	191	
	185	173	183	1599	**Rotterdam**	65	183	168	189	
	167	157	164	1382	Dusburg	65	171	157	178	
	141	135	135	1098	Mainz	65	155	141	162	
	137	131	131	1071	Frankfurt	63	152	138	159	
	65	63	63	643	Nuremberg	24	91	77	92	
	48	47	47	543	Kelheim	15	75	61	76	
	45	44	44	505	Regensburg	13	69	56	71	
	36	35	35	416	Deggendorf	11	57	47	58	
26	22	22	22	263	Linz	7	36	30	37	41
24	20	20	20	244	Enns	6	33	28	34	38
19	16	16	16	190	Ybbs	4	26	22	27	30
13	12	12	12	130	Krems	3	19	16	20	22
6	5	5	5	52	Vienna	0	9	8	10	11
0	0	0	0	0	**Bratislava**	0	0	0	0	0
16	15	15	15	228	Budapest	1	24	21	24	29
25	23	23	23	389	Baja	1	39	33	39	47
35	32	32	32	535	Vukovar	1	54	46	54	65
41	38	38	38	615	Novi Sad	1	63	55	63	76
47	43	43	43	698	Belgrade	1	73	63	73	87
72	66	66	66	1077	Vidin	3	106	90	103	123
89	81	81	81	1376	Giurgiu	3	131	110	126	150
109	99	99	99	1744	Réni	3	161	134	155	183
116	106	106	106	1868	**Sulina**	3	172	143	164	195
107	98	97	98	1628	Constanta[1,2]	5	154	129	148	175
113	103	103	103	1811	Ismail[1]	3	167	139	160	190
115	105	105	105	1857	Kilia[1]	3	171	142	163	194

1 - connection for maritime transport, 2 - in the case of low water level 100 km detour through the shoulder Borcea, * Motor Cargo Vessel

Source: Authors

* [1]**Tomas Kalina,** [1]**Martin Jurkovic,** [2]**Helena Binova,** [3]**Bruno Gardlo**
[1]Department of Water Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Technical University in Prague, Faculty of Transportation Sciences, Czech Republic
[3]Austria FTW Forschungszentrum Telekommunikation Wien GmbH, Austria
E-mail: tomas.kalina@fpedas.uniza.sk

Fig. 1 Pushed convoy TR Naiden Kirov + INTERSHIPPING 2 (3)
Source: www.intershipping-bg.ne

2. SWOT analysis of the use of the port of Bratislava for transportation of automobiles and containers from Slovakia

SWOT analysis is a strategic planning tool used for the evaluation of the strengths, weaknesses, opportunities and threats that lie in a given project in an effort to undertake a certain goal. It involves monitoring internal and external marketing environment.

The following Table 2 presents the SWOT analysis which focuses on potential of the port of Bratislava in the transportation of cars and containers in export and import [3].

SWOT analysis Table 2

Strengths	**Weaknesses**
• strategic geographical position in relation to the localization of potential customers, • connection to the inland waterways of international importance (Danube-Main-Rhine) • cost of transportation, • environmental aspects, • direct connection to the rail network, • support of water transport by the EU, • direct connection of the port of Bratislava to the ports of Rotterdam and Zeebrugge.	• long transport time in water transport, • low transport capacity of the existing fleet, • obsolescence of fleets • navigation restrictions on the waterway, • poor awareness of the possibilities of using waterway by carriers and logistics operators in Slovakia, • technical condition of port infrastructure, • the need for multiple reloading, • weak waterway connection to the main target destinations in Western Europe.
Opportunities	**Threats**
• the improvement of the road network by completing the Bratislava ring road, • possibility of expanding capacity and activities of the port. • a growing trend in the field of logistics and international transport of goods, • increase production of cars and consumer goods in Slovakia, • orientation of the Slovak economy mainly for export.	• direct competition of rail transport • dependency on weather and hydrological conditions, • increased used of rail and road transport, • development of Koper port as a major logistics hub for Slovak automakers.

Source: Authors

3. Evaluation of requirements and needs of logistics operators in automotive industry

There is a difference between the transportation of completed vehicles and transportation of components and parts for automobile production. The components are supplied to the factories by Just-In-Time or Just-In-Sequence. This means to deliver the components to the appropriate production line in the correct order, in the required amount and in the given time. Trucks of different sizes and different types of semi-trailer may be used for these operations according to the quantity and nature of the cargo. As every automobile company tries to keep the lowest stock, they have the components only for 1 or 2 days or in some cases just for a few hours. The car manufacturers (PSA and VW), where the engine production is carried out of the Slovakia, average stock lasts only about **8 hours.** Their import is done from France only by the truck transport as it presents a high degree of flexibility. Shippers and logistics suppliers have to follow strict requirements. The vehicle transportation has its specifics because special transporters (especially trucks and trains), intended exclusively for the transportation of vehicles, are required for the implementation. And the vehicles transported by carriages require special instruments to provide loading and unloading. Moreover, the conditions of transportation on the open carriages are completely different from the transportation in the closed carriages. In practice, the carriages and vessels for the intermodal transportation of trucks fully loaded by cars or specially modified aircraft are also used [4, 5 and 6].

Delivery time, within the transportation of completed cars, plays an important role when choosing the transport mode. The attention of commercial policy of almost every company is primarily focused on the final customer, i.e. to satisfy their requirements on time and at the required level. An average delivery time, from setting the order by customer to taking the vehicle, is approximately **18 days.** Logistics schemes of operators are adapted to this priority.

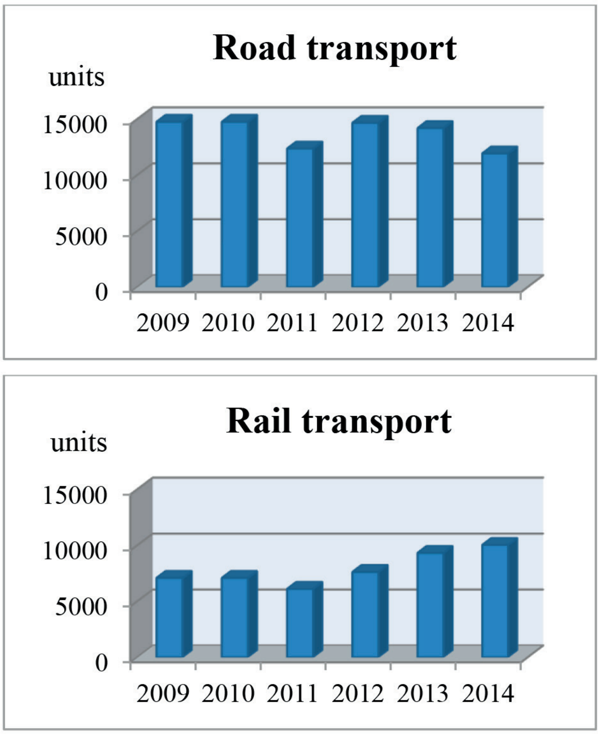

Fig. 2 The development of means of transport for the export of cars from Slovakia
Source: Annual reports, edited by authors

In the logistics process, transportation itself forms the largest component of the time fund. Administration, customs clearance and assurance of all the other requirements represent only about 10% of the time fund. The time of transportation is significantly affected by the final destination and the road approaches [7].

Logistics within the export of finished cars by "Finished Vehicle Logistics", is focused only on the road and rail transport (Fig. 2). The inland waterway transport is not currently used. In the last five years, there has been a significant shift in volumes from the road to the rail transport network (Fig. 3). Statistics in the year of 2014 were not completed [4, 5 and 6].

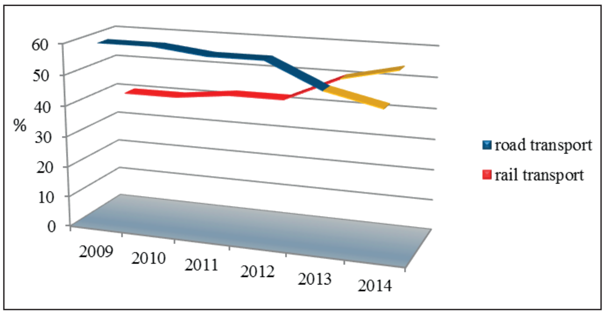

Fig. 3 The development of transport modes used for export of cars made in Slovakia
Source: Annual reports, edited by authors

Modernization of the railway transport network and the transport policy of the European Union aimed at finding the alternatives to the road transport are important factors that affect the constant increase of the environmental transport modes portion when transporting the goods all over the world. The EU orientation to alternative transport modes (in relation to the road transport) represents a high potential of the involvement in the "rare" usage of the inland waterway transport not only when transporting the vehicles [8].

However, if the water transport wants to be a competitive partner to the rail and road transport (Fig. 4), it is necessary to draw attention to its main advantages (environmental aspects, price of transport, capacity) and weaknesses (transport time, location and availability of trimodal logistics centres and their connection to the manufacturing companies, multiple transhipment) [9].

The capacity of a **truck,** when transporting the vehicles from PSA, is **6 personal cars**, the capacity of the double-deck carriage of the Lggs type is 14 personal cars, of the BLG carriage type (used by KIA) only 6 personal cars. A **train**, depending on the transportation road, can take about **220-250 personal cars** from PSA. **Inland vessels** have a capacity up to **500 cars**, which is more than twice compared to capacities of the railway transport. However, it is important to consider the shipping area, its possibilities and limitations [4, 5 and 6].

Slovakia has an important position in the automotive industry in Europe. Annual production of cars, approaching the million, confirms this fact. A huge amount of the car production is for the European market. France, Germany, Italy, the United Kingdom and Belgium are the countries with the highest import of vehicles produced in Slovakia. However, the export is realized only by the road or rail transport. Exports of cars from Slovakia according to their final destinations are expressed in Fig. 5 [10 and 11].

Fig. 4 Intermodal transport
Source: http://america.pink/intermodal-transport_2094257.html

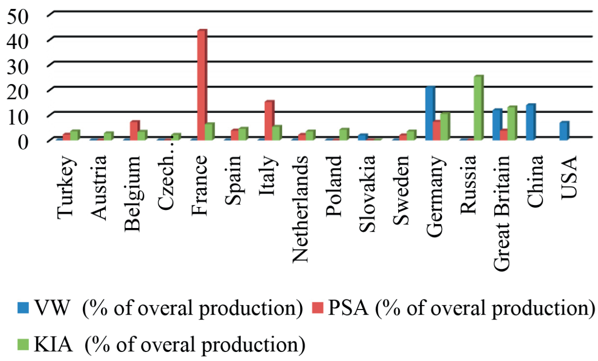

Fig. 5 Exports of cars according to their final destinations
Source: Annual reports, edited by authors

4. Conclusion

Europe has over 30,000 km of canals and rivers, which link together hundreds of key industrial towns and areas. The core of the network, approximately 10,000 km, connects the Netherlands, Belgium, Luxembourg, France, Germany, Poland, the Czech Republic, Austria, Slovakia and Hungary, Switzerland, Croatia, Serbia, Montenegro, Romania, Bulgaria, Moldova and Ukraine. The main part of this network consists of the main rivers such as the Rhine and the Danube, many tributary rivers and canals connect a network of smaller towns and industrial zones. A considerable number of ports in the network enables to use various types of the transport modes. Connection of Slovakia and the inland waterway network using the Danube River is a way how to unburden the transportation flows, especially from the road networks and also to reduce costs of this transport. It is necessary to meet the delivery time and consider navigation restrictions.

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Frantisek Brumercik – Michal Lukac – Jacek Caban *

UNCONVENTIONAL POWERTRAIN SIMULATION

This article presents an unconventional principle of the vehicle power flow transmission, different from the commonly used powertrains. Presented powertrain consists of a combined hydro-mechanical transmission with hydrostatic units and torque converter in parallel lines with mechanical components providing the continuous gear ratio change.

Keywords: *Vehicle, powertrain, CVT, simulation.*

1. Introduction

Most of the commonly used commercial vehicles have regular manual transmission, which works with the step ratio change via the so called range and split transmission gear groups. The tendency is to make the work of the driver less complicated by the automated manual gearboxes (Volvo I-Shift and I-Shift Dual Clutch, Scania Opticruise, etc.), increasing the efficiency and driving comfort [1].

The common structure of the drivetrain with an automatic transmission is the power transmission line built in the sequence of the engine - torque converter - automated step gearbox driven by the electromechanical elements - transaxle.

2. System and model structure

The presented transmission contains mechanical parts (gears, shafts, one-way clutches), the hydrostatic units and a complex hydrodynamic torque converter (Fig. 1). It was developed for vehicles with the maximum total engine power of 100 kW [2].

One of the hydrostatic unit is regulated via the proportional-derivative (PD) control system, which controls the angle of the unit regulation plate inclination (β). The power flow is divided into mechanical, hydrostatic and hydrodynamic line during the continuous ratio change – the gearbox works as a continuously variable transmission (CVT).

After the kinematic and dynamic analysis of the transmission structure was done, the mathematical block model was built. It is based on the Matlab/Simulink environment. The model is assembled from partial subsystems represented via calculation blocks [3 and 4]. Mechanical, hydrostatic and hydrodynamic

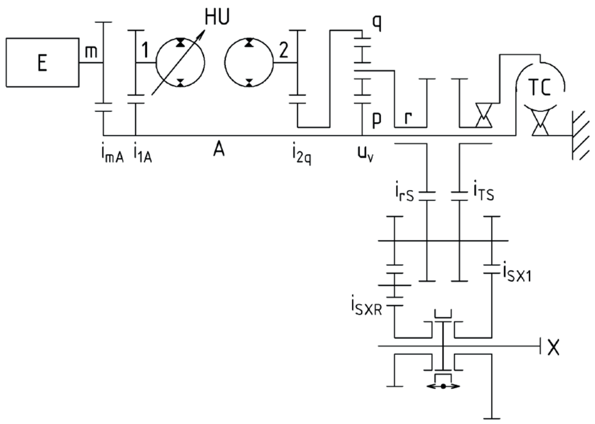

Fig. 1. Kinematic structure of the transmission: A – input shaft, X – output shaft; E – engine, HU – hydrostatic unit, TC – torque converter (Source: authors)

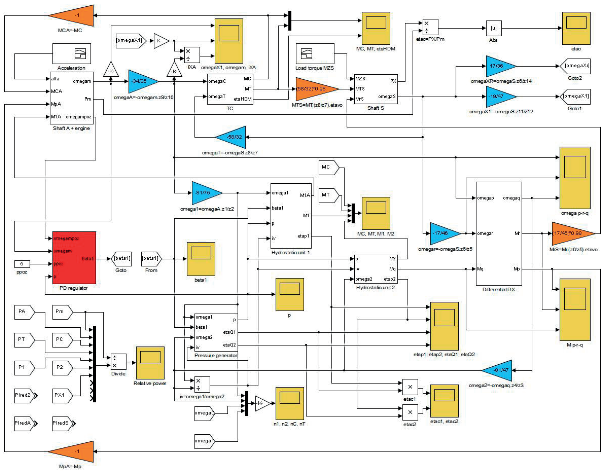

Fig. 2. Block structure of the mathematical transmission model (Source: authors)

* [1]Frantisek Brumercik, [1]Michal Lukac, [2]Jacek Caban
[1]Mechanical Engineering Faculty, University of Zilina, Slovakia
[2]University of Life Science in Lublin, Faculty of Production Engineering, Poland
E-mail: brumercikf@fstroj.uniza.sk

power flow line as well as the electronic control system has its own subsystem block, which is connected to other parts of the model. The diagram of the mathematical block model of the transmission system is shown in Fig. 2.

3. Simulation procedure

The simulation of described transmission is based on a system response to a load set, which represents the vehicle driving resistance forces or torques. The minimum and maximum resistance torques were calculated according to the kinematic structure without the consideration of power losses along the transmission power flow line [5].

After the simulation of the system response to the constant minimal and maximal loads, the step load change was simulated to test the quality of the control system. The real load changes in the traffic are not so steep, so the robustness of the PD regulator subsystem is tested properly. The load step change is shown in Fig. 3.

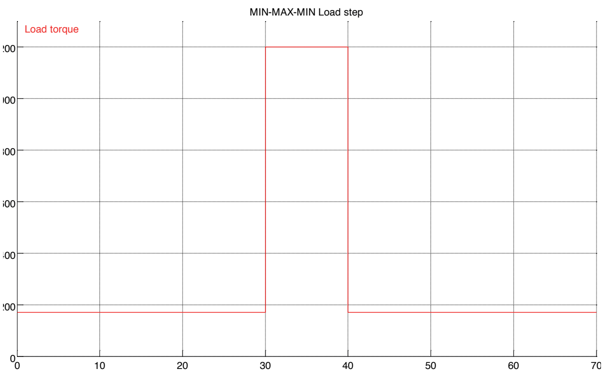

Fig. 3. Load step change diagram (Source: authors)

The initial conditions of the simulation progress were the engine idle running and the acceleration – pedal put on 100% by the minimal load applied. In the interval from 0 to 30 sec. the system variables are changed according to the initial conditions at the start of the simulation.

After 30 seconds, during which the gearbox output shaft X reached stabilised speed value, the load steps to maximum. This fact causes significant drop of the output shaft speed. This is the moment, when the observation of the system behaviour starts to be interesting [5 and 6].

The achievement of the steady state as a response to the load step in the 30-th and 40-th sec. is monitored and refers to the quality of the PD control system changing the β_1 parameter of the regulated hydrostatic unit. The results of this particular simulation are shown in Figs. 4 to 7.

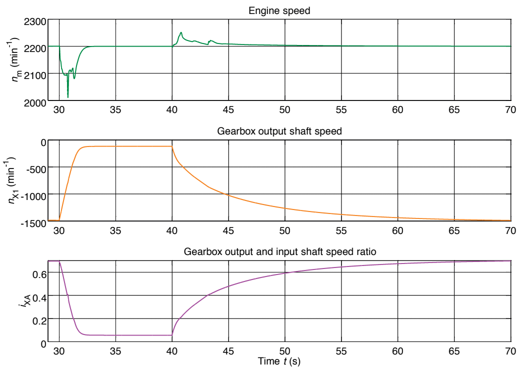

Fig. 4. Time development of the speed of the engine crank shaft (m), output gearbox shaft (X) and the gearbox output to input shaft speed ratio (i_{XA}) (Source: authors)

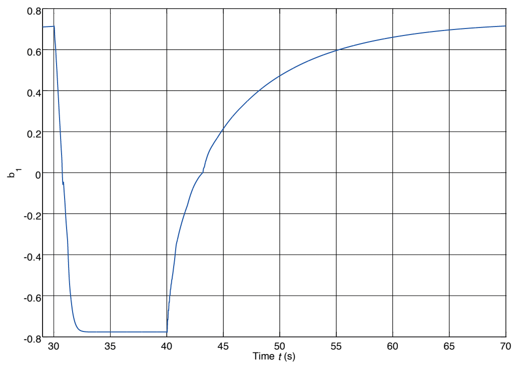

Fig. 5. Change of the hydrostatic unit regulation plate (β_1) (Source: authors)

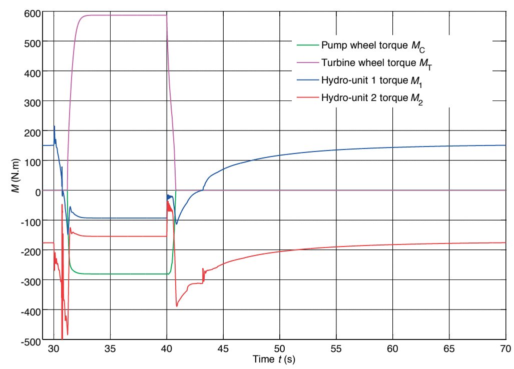

Fig. 6. Time development of the torque on the hydrostatic and hydrodynamic transmission parts (Source: authors)

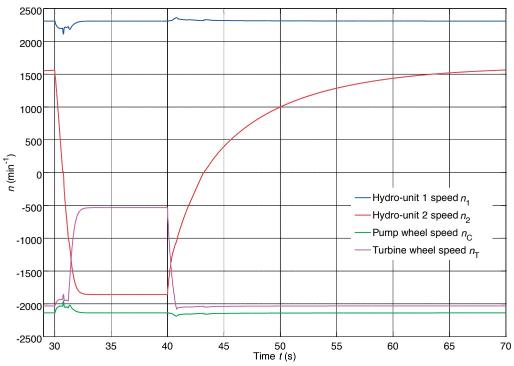

Fig. 7. Diagram of the speed of the hydrostatic and hydrodynamic transmission parts (Source: authors)

4. Simulation evaluation

The simulation of the step changes of the load torque allows to check the behaviour of the simulated PD regulation and to consider the change fluency of the observed values according to sudden load changes. These changes cannot happen as fast in the real transport operation, but the step load changes provide a view about the functionality of the hydrostatic control unit and thus the whole gearbox by extreme load cases.

By the change of the minimal value of 412 N.m to maximum of 2909 N.m, the notable drop of the engine and output shaft speed is visible (Fig. 4). The torque converter starts to operate at about 30-th sec. of the simulation process. The engine speed is after about 3 sec. back to the initial value of 2200 min^{-1} (Fig. 4). The hydrostatic unit regulation plate inclination changes fluently, without interferences by the extreme load change. The control system adapts the gearbox operation according to the desired engine speed and the pressure in the low-pressure pipe of the hydrostatic power flow line (Fig. 5).

When the load value changes back to minimal value of 412 N.m after about 10 sec. maximum load applied, the transmission output shaft speed starts to rise and the engine crank shaft is released. The PD regulation put the regulation plate inclination and also the engine speed to the value at the start of the step change at 30-th sec. of the simulation (Fig. 4).

The global efficiency of the power transmission by the minimal load in the stable state is above 0.8. This value is, with regard to the usage of hydrostatic and hydrodynamic elements without any ratio step controllers (automated friction brakes, clutches), quite satisfactory. The collaboration between the engine and the gearbox is permanently controlled via the PD controller of the regulated hydrostatic unit.

By the maximum load of 2909 N.m applied, the torque converter is operating during the whole period of step change. Thus, the global efficiency drops, but that is the consequence of the converter characteristics by the torque multiplication. The hydrostatic power flow line works in the range of power circulation, which is also negative considering the power transmission efficiency value. The torque demand by this working steady state is so high that the multiplication factor is much more important than the efficiency drop.

The torque and speed of the other particular transmission parts are shown in Figs. 6 and 7. The simulation results show that the PD controller can regulate the value of the regulating plate inclination according to the desired engine speed values in the wide range of load cases [7 and 8].

5. Conclusion

The article presents simulation results of an unconventional vehicle transmission, which can be used in commercial vehicles and mobile working machines. The kinematic structure and the dynamic behaviour of the system is extracted into the mathematical model [9]. Thus, the simulation of number of load cases can be done and the control system can be tested without the need of a number of prototypes to be built. The model provides also the possibility of all subsystem properties editing. This allows to shorten the development time and to cut the costs in the area of R & D process significantly [10].

Acknowledgement

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Michal Lukac – Frantisek Brumercik – Leszek Krzywonos *

DRIVEABILITY SIMULATION OF VEHICLE WITH VARIANT TIRE PROPERTIES

The aim of the presented article is to show the possibilities of vehicle tire mathematical model creation and present simulations of a typical driving manoeuvre of a vehicle model equipped with variant tire models.

Keywords: *Tire, vehicle, simulation.*

1. Introduction

The modeling of tires is one of the most complex tasks in the mathematical modeling area. The task consists of real physical model creation, which is most commonly mathematically described by the system of differential or algebraic equations. In a simpler case, these equations are linear. That means the possibility to get acceptable results in acceptable time of calculation. In a case, when the equations are nonlinear, the calculation is much more complicated [1].

2. Tire modeling

Simplified mathematical description of the tire behavior during operation leads to linear differential equations. This approach is acceptable in the case the tire is not in the centre of attention by the simulation. This can happen by the evaluation of the complex vehicle dynamics by different simulation scenarios. The main task of the calculation is then reduced to gather dynamic properties of vehicle parts or to analyze the level of vibrations or noise inside the vehicle, the level of frame parts loading, etc. [2].

If the calculation is focused on monitoring driving quality of tires, it is necessary to create a detailed model for calculation, including, for example, [3 and 4]:

- material properties of rubber and other structural elements of the tire,
- the level of inflators,
- shape and height of the tread etc.

This kind of calculation creates the need for application of modern computing resources to get acceptable results. An important factor affecting the duration of calculation is the right choice of the virtual mathematical model and also the method for creating the calculation algorithm.

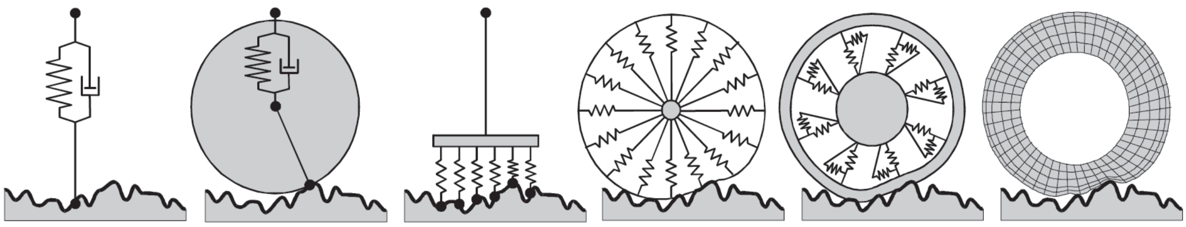
2.1 Tire models

It is possible to make principal distribution of wheel and tire dynamic models to [5]:

- simple dynamic models:
  - with the point contact (Fig. 1a),
  - with the cylinder contact (Fig. 1b).
  - complex dynamic models:
  - with the solid track (Fig. 1c),
  - with the radial springs (Fig. 1d),
  - with the radial and tangential springs and elastic ring (Fig. 1e).
- continuous dynamic models:
  - created by the finite element method (Fig. 1f),
  - created by the boundary element method,
  - created by other methods of continuum analysis.

The most commonly used model for dynamic analysis of vertical or longitude and transversal oscillations of the vehicle with consideration of wheel - road interactions is the model with radial and tangential springs and elastic ring (Fig. 1e). The detailed description of this model is shown in Figs. 2 and 3.

* [1]Michal Lukac, [1]Frantisek Brumercik, [2]Leszek Krzywonos
[1]Mechanical Engineering Faculty, University of Zilina, Slovakia
[2]Mechanical Engineering Faculty, Lublin University of technology, Poland
E-mail: brumercikf@fstroj.uniza.sk



a) b) c) d) e) f)

Fig. 1 Tire models (Source: [5])

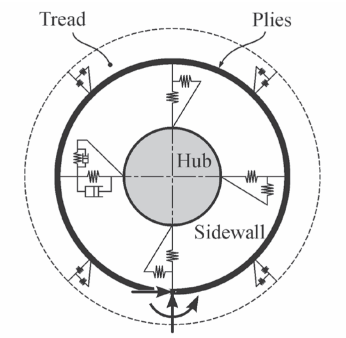


Fig. 2 Detail of tire model inner structure (Source: authors)

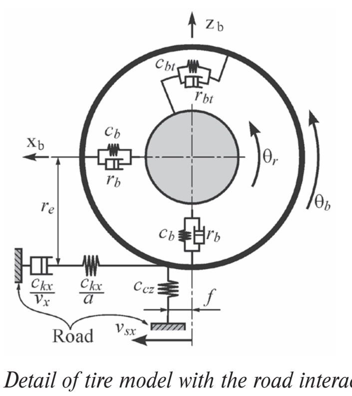


Fig. 3 Detail of tire model with the road interaction (Source: authors)

2.2 Vehicle models

One of the models of vehicle dynamics calculation is shown in Fig. 4. This model allows to obtain information about oscillations in the vertical and horizontal direction of the vehicle cab and axle. The tire model is in this case simplified. This model is suitable for prototyping simulation of vehicle stability in the transverse direction as well as the analysis of driving characteristics of the vehicle in the vertical direction [6].

Figure 5 shows a different vehicle model with a more detailed model of dynamic wheel with an elastic disk and also with elastic characteristics of the tire in the vertical direction. This model follows the vertical vibrations and it can be useful after some improvements to solve the dynamics of the wheel - road interaction.

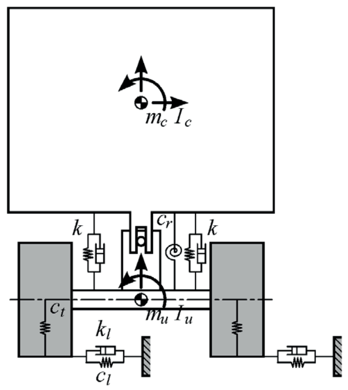


Fig. 4 Vehicle model with a simplified tire model (Source: authors)

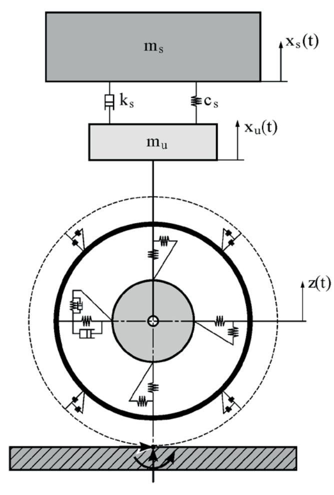


Fig. 5 Vehicle model with the wheel - road interaction (Source: authors)

The models described above can be used for solving the problems of computer evaluation of the driving characteristics of inflated and underinflated tires and especially the run-flat state.

2.3 Calculation software

The programs, which solve also tasks related to vehicle tires, are based on FEM [7]. The most popular are:

- ANSYS,
- LS-DYNA,
- ADINA,
- ABAQUS.

The simulation programs already obtain models of commonly used tires defined by their producers based on the so called "multibody dynamics". The best known software in this class is:

- ADAMS with its module Car,
- MEDYNA,
- NEWEUL,
- MATLAB – Simulink.

3. Simulation of iso lane change manoeuvre

The task solved in this example was focused on the simulation of a run-flat tire based on the standard driving manoeuvre – the ISO lane change. The model was based on the standard sedan car model platform in ADAMS/Car software (Fig. 6). The conditions and the results of the simulations are described below.

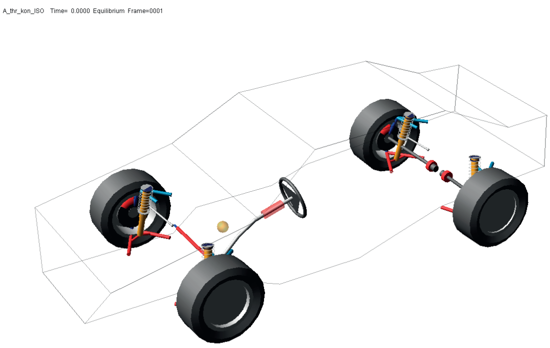


Fig. 6 Standard ADAMS/Car vehicle model (Source: authors)

The simulations were done for 6 types of tires inflated to 220 kPa and 4 tires under-inflated to 110 kPa. The configuration files were developed after experimental measurements of necessary relations.

The car behavior was monitored by the prescribed ISO lane change manoeuvre. This manoeuvre is simulated at an initial velocity of 60 km.h^{-1}. The acceleration pedal is held in a constant position during the manoeuvre. ADAMS/Driver controls just the direction of the steering axle of the car.

The scheme of the track and vehicle model developed for the overtaking manoeuvre is shown in Fig. 7.

Fig. 7 ISO lane change test track in ADAMS/Car environment (Source: authors)

The goal of the simulation was to follow the car velocity at the end of the manoeuvre. The calculation rating was selected by 0.8 according to the influence of ADAMS/Driver on the progress of the manoeuvre.

Figures 8 and 9 show the velocity diagrams during the manoeuvre for the inflated and under-inflated tires.

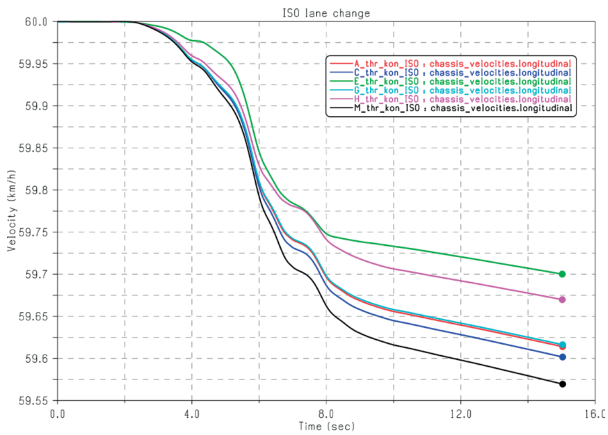


Fig. 8 ISO lane change velocity graph - inflated tires (Source: authors)

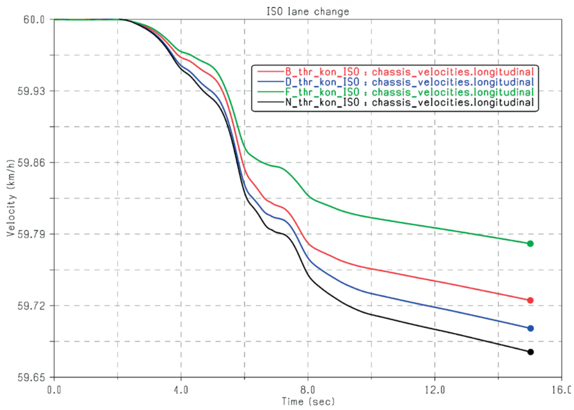


Fig. 9 ISO lane change velocity graph - under-inflated tires (Source: authors)

4. Conclusion

It is possible to create various vehicle models with elastic tires according to the user´s specific needs for particular calculations. It depends on the goal of the analysis and the decision which results are significant and which are irrelevant [8 and 9]. The presented simulation used the software model of a standard car equipped with tire models defined by the user. There was a specific test done and the velocity results for different tires presented in graphs enable to compare the behavior of the modeled tire types.

Acknowledgement

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Milos Hitka - Lenka Lizbetinova - Zdenek Caha - Yan Xu *

FACILITY MANAGEMENT - INSTRUMENT FOR THE MANAGEMENT OF SUPPORT PROCESSES FOR HRM OUTSOURCING

The aim of this paper is to identify the most important motivational factors for Slovak employees in 2015. The relevant data was sourced using the questionnaire method. For data processing purposes, the descriptive method was used as well as statistical analysis. The calculated level of p - significance for the different motivational factors was calculated by utilising the T - test. The definition of the differences in the average level of importance of individual motivational factors is the result of the research. The obtained results allowed us to define which motivational factors affect the performance of the Slovak employees. On this basis, for Slovak companies, it is possible to design a uniform motivational program that will suit the majority of their employees. Under specific conditions, the local analyses can be more effective and their results can slightly differ from the general average. It is also possible that the motivational requirements of employees will change if their needs are satisfied. For this reason, according to the possibilities of the enterprise, it is recommended to update the motivational programs continuously.

Keywords: *Facility management, support processes management, motivational program, T- test.*

1. Introduction

Work motivation manifests itself in the relationship between a person and their work. Within the context of motivation, work can not only be seen as a source of livelihood. It is also an attribute that brings satisfaction from the actual performance of the work, from the working results, from the social status and the prestige of a profession, from the social relationships related to those professional activities and the awards that an employee receives as part of a team [1]. The American, John Adair [2], one of the world's experts in leadership, says that the motivation means providing a motive or incentive to a person to make this or that. By this activity [3], the behaviour of a person is initiated and their interest stimulated. Motivation is an important factor in the performance and efficiency of an enterprise and its managers spend a lot of energy, time and money on it [4]. Of greater significance is the assumption that motivation is a conscious and deliberate investment of energy in order to meet an objective that has been stated in advance. To achieve the objective, it is necessary to possess self-discipline, perseverance and patience. It is never understood as a duty. Energy, dynamism and intensity are conceived only as "own" behaviour, and in no case as something that is determined by strangers or through external inducements [5]. To motivate someone means to focus them on a specific objective and give them some satisfaction in terms of their needs, habits, interests, ideals and values orientation. The subject that is responsible for this motivation is the manager and the object of the motivation is the managed employee [6]. The main objective of work motivation being to motivate employees to perform well at optimum costs [7].

Authors such as Sekhar, et al. [8] have identified key motivational techniques in existing literature and determined their interconnection with the performance of organizations. These motivational techniques [9] can be considered as an important factor in dealing with potential improvements in employee motivation and thus the performance of an organization [10]. All authors of motivational techniques draw the same conclusion. If employees are provided with the correct motivational techniques at the right time, their morale and confidence rises and this has a direct positive impact on their individual performance and that of the organization too.

* [1]Milos Hitka, [2]Lenka Lizbetinova, [3]Zdenek Caha, [4]Yan Xu
[1]Faculty of Wood Sciences and Technology, Technical University in Zvolen, Slovakia
[2]Faculty of Corporate Strategy, Institute of Technology and Business in Ceske Budejovice, Czech Republic
[3]Faculty of Corporate Strategy, Institute of Technology and Business in Ceske Budejovice, Czech Republic
[4]Department of Management, School of Economics and Management, North China University of Technology, China
E-mail: lizbetinova@mail.vstecb.cz

2. Objective and methodology

Understanding the causes of motivation, knowing what its possibilities to influence are, and knowledge of the methods by which to regulate motivation, or even change it, is of particular importance for the effective management of people. In practice, motivating employees, professionals and managers can be realized on the basis of three approaches: individual, small-group and complex-group [11, 12 and 13].

In current human resources management, there is a conceptual dissemination and use of outsourcing. Managers of enterprises establish and implement personnel policies and strategies for various human resources activities in collaboration with their HR department. These activities include, for example, the creation and development of an organizations personnel planning and talent management, sourcing and selection, evaluation and pay, and safety and health of workers [14]. Every enterprise is therefore faced with the problem of how to manage this area as efficiently as possible [15]. In the majority of cases, companies respond by creating their own team of specialists to work with human resources. An alternative to this approach is to outsource the management of human resources [16]. The advantage to the enterprise of outsourcing is that it is able to benefit from the latest knowledge and practices in this area in combination with the high standard of work. It can also mean an increase in resource efficiency not only in financial terms, but also in terms of human resources [17]. Earmarking selected activities [18] of business management and handing responsibility for them to a subcontractor leads to a narrowing of the organization, a simplification of the management work of managers and a better use of resources. The organization does not have to expend resources to acquire property and can utilise them elsewhere and for other purposes. In addition, there is no need to invest in the training and retention of specialists because they are available as required. If the requirements for personnel grow or decline, companies are also not under immediate pressure to find a solution for either problem. The obligations and liabilities associated with them, the economic risks and the associated agenda are covered by the provider of the outsourced services. The nature of the outsourcing contract with the provider of outsourcing services is therefore very important.

The introduction and implementation of outsourcing in human resources management is not easy and requires management to take a considerate and sensitive approach. Some personnel activities may be provided by external contractors, personnel agencies or companies acting as service providers in these areas. They can provide specific personnel activities such as: determining specifications per employee; retrieval, search and selection of employees; creation of motivational programs; performance management of staff; career management; knowledge management; motivation and stimulation of employees; evaluation and measurement of work staff training; evaluation [19]; remuneration of employees; creation of teams; creation of personnel information systems (as part of corporate information systems) [20]; conducting administrative affairs; personnel audits; personnel controlling; analysis of return on investment in human resources; social care of staff and improving staff performance [21].

Other activities including personnel planning, personnel policy and strategy, recruitment, orientation and placement of employees, creative management of employees, creation of corporate culture and philosophy, improving working relations, communication in the workplace, and the dismissal and retirement of employees should remain fully within the competence of an organization either in legal terms or in terms of strategy [22].

The decision on whether to outsource human resources management should therefore be based on a thorough analysis of the current situation within an organization and a comparison of how the selected personnel activities are provided in other businesses. This analysis also requires the reasons to be identified that show that it is more advantageous to transfer personnel activities to an outside agency. These reasons [23] may include:

- cost savings - outsourced services are less expensive and the personnel department can be reduced in size;
- HR employees can concentrate on key tasks – they are not distracted from their core tasks which results in quality gains;
- outsourced services are of a higher quality – there is an opportunity to gain know-how and experience that is not available within an enterprise.

3. Methodology of research

The aim of this work was to establish the actual and required level of employee motivation in Slovakia and attempt to identify which areas of employee motivation could be possibly outsourced. The research was conducted in 2015 on a research sample of 6,000 respondents from both the public and private sectors, including manufacturing and non-manufacturing enterprises, and service providers. The selection of respondents was carried out by simple random sampling, whereby each unit of the population had the same probability of being included in the sample. We used the questionnaire method to obtain the values for the motivating factors. This method allowed us to collect a lot of information in a short period of time. The first part of the questionnaire examined the qualifications and socio-demographic characteristics of the workers in the compared companies. This section provided basic data on the respondents´ age, gender, number of years worked in the enterprise, education level and position.

The second part of the questionnaire consisted of various motivational factors through which it was possible to establish information about the characteristics of the working environment, working conditions, application of evaluation and pay systems in the enterprise, personnel work within the enterprise, the system of social care and employee benefits, as well as on employee (dis)satisfaction, employees value orientations, attitudes to work and enterprise or relationships with colleagues. Our chosen motivational factors were arranged in alphabetical order to avoid influencing the respondent´s responses. Employees could assign the level of importance of each motivational factor on a rating scale of one to five [24]. They were subsequently asked to also score the importance of the required status, as well as the actual status of each motivational factor. The desired status was understood to be the ideal form of motivation for employees, or what would motivate them to increase their performance. Similarly, the actual status was understood to represent the level of employee satisfaction with the current motivational factors within their enterprise.

The research sample consisted of 6,000 respondents from Slovakia. Table 1 shows the structure of the respondents. The questionnaires were evaluated using the program STATISTICA 7 [25]. Descriptive statistics were used to characterize the basic set. Statistical characteristics were calculated for each motivational factor (see Table 2).

These characteristics summarized information about the properties of the studied basic set into a smaller number of numerical characteristics in order to facilitate the mutual comparison of the files. The essential characteristics of each motivational factor were summarily described in terms of their dimensions [26 and 27] and the variability of their quantitative characters – arithmetic average (Equation 1), standard deviation s_x and variation coefficient V.

$$\overline{X} = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n} = \frac{1}{n}\Sigma_{i=1}^{n} x_i \qquad (1)$$

whereby:
n - is size of the statistical set,
x_i – is average value of the i-th statistical unit [23].

In addition to a simple comparison of the values of the descriptive characteristics, we carried out a test correlation of the arithmetic means and standard deviations of the basic sets. In the test, the significance of differences in the arithmetic means and standard deviations of the individual motivational factors of the monitored sets was checked at the selected level of significance. The verification showed that the differences found by the descriptors are not caused by the sample. We used a two-sample T-test to test the correlation averages of the motivational factors. Within the T-test, there were only two cases that were contrary to these findings and which were subject to whether the variances of the compared basic sets were equal or unequal $(\sigma_1^2 = \sigma_2^2, \sigma_1^2 \neq \sigma_2^2)$, or whether the investigated characteristics X1, X2 were dependent or independent. Before calculating the T-test, we used compliance tests of variance (F-test). Based on the results of the F-test, two-sample T-tests were performed for independent samples with equal or different variance. The null hypothesis was tested against the alternative hypothesis (Equation 2).

Breakdown of the research sample — Table 1

Gender	Number
Male	3179
Female	2821
Age	**Number**
up to 30 years	1653
from 31 to 40 years	1829
from 41 to 50 years	1594
51 years and over	924
Education	**Number**
Primary education	168
Secondary school without graduation exam (A-levels)	1029
Secondary school with graduation exam (A-levels)	3376
University	1427
Number of years in the enterprise	**Number**
less than 1 year	673
1 - 3 years	1356
4 - 6 years	1277
7 - 9 years	1044
10 years or more	1650
Position	**Number**
Managers	342
Workers (labourers)	3888
Office workers	1770

Source: authors

$$H_0 : \sigma_1^2 = \sigma_2^2 \quad vs. \quad H1 : \sigma_1^2 \neq \sigma_2^2 \qquad (2)$$

H_0: It is assumed that the arithmetic means of the selected motivational factors (required and actual, in Slovak enterprises) are equal to each other. It is also assumed that the difference between them, if any, is caused by random fluctuations in the results of choice.

H_1: It is assumed that the arithmetic means of the selected motivational factors (required and actual, in Slovak enterprises) are not equal to each other. It is also assumed that the difference between them, if any, is not caused by random fluctuations in the results of choice.

The random variable T was used as a testing criterion, resulting in the Student´s t-distribution, as shown in Equations 3 and 4:

when $\sigma_1^2 = \sigma_2^2$; X_1 and X_2 are independent

Student's T-test employee motivation level in Slovakia - 2015 Table 2

Motivational factor		Arithmetic mean	Standard deviation	Number	Difference	Standard deviation of the difference	t	Confidence interval 95%	
Workplace atmosphere	S1	3.35	1.01					-1.10	
	P1	**4.42**	0.78	6000	-1.1	1.15	-72		-1.04
Good team work	S2	3.49	1.00					-0.97	
	P2	**4.43**	0.75	6000	-0.9	1.07	-68		-0.91
Additional financial reward	S3	2.75	1.06					-1.60	
	P3	**4.32**	0.82	6000	-1.6	1.36	-89		-1.53
Physical effort	S4	3.18	0.97					-0.71	
	P4	3.86	0.93	6000	-0.7	1.26	-41		-0.64
Job security	S5	3.16	1.08					-1.32	
	P5	**4.45**	0.79	6000	-1.3	1.26	-79		-1.26
Workplace communication	S6	3.28	1.02					-1.04	
	P6	**4.29**	0.82	6000	-1.0	1.18	-66		-0.98
Enterprise name	S7	3.33	1.02					-0.58	
	P7	3.88	1.03	6000	-0.5	1.20	-35		-0.52
Opportunity to apply one's own ability	S8	3.11	1.02					-0.98	
	P8	4.06	0.85	6000	-0.9	1.18	-62		-0.92
Workload and type of work	S9	3.29	0.98					-0.86	
	P9	4.11	0.84	6000	-0.8	1.14	-56		-0.80
Information about performance results	S10	3.15	0.99					-0.88	
	P10	4.00	0.90	6000	-0.9	1.17	-56		-0.82
Working time	S11	3.35	1.08					-0.90	
	P11	4.22	0.85	6000	-0.9	1,25	-54		-0.84
Work environment	S12	3.34	1.02					-0.90	
	P12	4.21	0.81	6000	-0.9	1.17	-57		-0.84
Work performance	S13	3.38	0.95					-0.79	
	P13	4.14	0.82	6000	-0.8	1.08	-55		-0.73
Moving up corporate ladder	S14	3.16	0.98					-0.92	
	P14	4.05	0.87	6000	-0.9	1.19	-58		-0.86
Competences	S15	2.91	1.00					-1.01	
	P15	3.88	0.93	6000	-1.0	1,28	-59		-0.95
Prestige	S16	3.01	0.96					-0.76	
	P16	3.73	1.00	6000	-0.7	1.23	-46		-0.69
Supervisor's approach	S17	3.26	1.15					-1.15	
	P17	**4.38**	0.83	6000	-1.1	1.28	-67		-1.08
Individual decision making	S18	3.08	1.02					-0.95	
	P18	3.99	0.89	6000	-0.9	1.21	-59		-0.89
Self-actualization	S19	3.04	1.02					-0.98	
	P19	3.98	0.89	6000	-0.9	1.23	-59		-0.91

Student's T-test employee motivation level in Slovakia - 2015 Table 2

Motivational factor		Arithmetic mean	Standard deviation	Number	Difference	Standard deviation of the difference	t	Confidence interval 95%	
Social benefits	S20	2.97	1.08					-1.24	
	P20	4.18	0.88	6000	-1.2	1.34	-70		-1.17
Fair appraisal system	S21	3.02	1.09					-1.43	
	P21	**4.41**	0.83	6000	-1.4	1.31	-83		-1.36
Stress /limitations	S22	2.91	1.01					-1.22	
	P22	4.10	0.92	6000	-1.2	1.34	-69		-1.16
Mental effort	S23	2.95	1.00					-1.10	
	P23	4.02	0.93	6000	-1.1	1.34	-62		-1.04
Enterprise mission	S24	3.06	0.98					-0.86	
	P24	3.89	0.97	6000	-0.8	1.22	-52		-0.79
Region's development	S25	2.82	1.02					-1.03	
	P25	3.82	1.04	6000	-1.0	1.37	-57		-0.97
Education and personal growth	S26	2.94	1.03					-1.15	
	P26	4.06	0.91	6000	-1.1	1.26	-68		-1.08
Enterprise relation to environment	S27	3.22	1.04					-0.75	
	P27	3.94	1.00	6000	-0.7	1.23	-45		-0.69
Free time	S28	3,08	1.05					-1.07	
	P28	4,12	0.92	6000	-1.0	1.29	-62		-1.01
Recognition	S29	2.96	1.04					-1.25	
	P29	**4.17**	0.87	6000	-1.2	1.30	-72		-1.18
Basic salary	S30	2.68	1.16					-1.91	
	P30	**4.55**	0.77	6000	-1.9	1.41	-103		-1.84

Note: The important motivational factors are highlighted in bold. S = actual status, P = required status. Source: authors

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{n_1 \cdot s_1^2 + n_2 \cdot s_2^2}{n_1 + n_2 - 2} \cdot \frac{n_1 + n_2}{n_1 \cdot n_2}}} \tag{3}$$

and when $\sigma_1^2 \neq \sigma_2^2$; X_1 and X_2 are independent

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1 - 1} \cdot \frac{s_2^2}{n_2 - 1}}} \tag{4}$$

At the end of the test we compared *t* to $t_{\alpha/2;f}$. Where $t \leq t_{\frac{\alpha}{2};f}$ we accepted H_0 and the tested difference was not considered as significant. Where this was not the case, we rejected H_0 at α% significant level and accepted the alternative hypothesis H_1.

4. Results

To define the basic levels of motivation, we compared the average actual status (actual perceived level) and average required status (required level) of Slovak employees motivation (see Table 2). The most important motivational factors are highlighted in bold.

The results show that between the required level (P) and the actual level (S) of perceived motivation there are fundamental differences in financial motivational factors (basic salary, additional salary, fair assessment and recognition) and in factors related to interpersonal relationships (workplace atmosphere, workplace communication, access to supervisor, stress, psychological stress). The issue of basic salary was the greatest source of dissatisfaction. All the data are defined at the significance level of 95%.

Each effective motivational program must recognize and evaluate all the factors that affect the work performance of employees. Suitably motivated employees lead to the fulfilment of business objectives and long-term prosperity. Therefore, companies should focus on observing and investigating such motivational aspects which can bring the most satisfaction to their employees. In our research, we defined the motivational factors of Slovak employees in 2015, divided according to required and actual factors. Based on the results, we can generally determine the needs of Slovak employees and define problem areas with regards to their motivation. On the basis of these results, we would suggest that managers concentrate on the motivational factors identified when creating their motivational programs.

5. Conclusion

On the basis of the results we can conclude that employees are fully aware of the importance of motivational factors (despite the recession) such as job security and of the factors related to human relations. Employees also realize that their employers are not always in a position to provide the required increase in financial remuneration. At present, employers should focus on the process of motivation through motivational factors based on interpersonal relationships and on job security. A more detailed analysis of the individual motivational factors would allow more attractive measures to be adopted that would be more readily accepted by employees, thereby reducing the number of factors which employees deem to be neutral in their work. During the economic crises, many companies do not consider the development and education of their employees as important. This approach is subsequently reflected in the overall future performance levels of enterprises [28 - 30]. For companies, it is important to consider the costs of ongoing education in comparison to the costs of employing someone new in the business. Failure to respect the described results could lead to a significant decline in work performance [29 - 31], a decline in receipts and a rise in business costs.

Creating an appropriate motivational program is a difficult and expensive activity for every business [30 - 32]. Developing such programs requires a thorough and targeted analysis of the motivational requirements of employees. On the basis of our analysis, we can draw the following conclusions. Despite the diversity of employees, for Slovak enterprises, it is possible to design the highly uniform motivational programs that suit the majority of employees. In specific terms, it is possible to carry out a local analysis, the results of which will only differ slightly from the general average. It is also possible that meeting the motivational requirements of employees can initiate their change. For this reason, the motivational programs are to be updated continuously [33 - 35].

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Heda Hansenova - Vaclav Cempirek - Petr Novak *

TRANSPORT AND LOGISTICS AND THEIR INFLUENCE ON EXPORT COSTS

The paper deals with the role of transport and logistics as they relate to exports. We searched for the impact of transport and logistics on exports using transaction dynamics as described by Coase and Williamson. We deal with the costs of exchange using international sales contracts where the traditional calculation structure, based primarily on costs of delivery is extended with transaction costs. Furthermore, we measure the impact of such adjusted costs of exchange on the added value using Porter's methods and determine which costs have the nature of investment. Finally, the effect of resource implementation into information and communication technologies and the related changes in transport and logistics are presented (in the paper).

Keywords: *Transport and logistics, export costs, information and communication technologies.*

1. Introduction

Transport and logistics belong to the category of services in the international trade, which cannot be currently separated from export and import of goods or substituted by another shipment technology. They have been a standard calculation item in the export costs structure for a long time, where they constitute the so-called delivery costs, and, in addition to other calculated exchange costs (export costs) they influence the added value in the export price.

The research of a calculation structure of exchange costs in export prices is a core subject of this paper. In this context, we focused on two problem areas. The first area dealt with three issues: 1. In what way can the commonly used calculation structure of export costs be expanded to include transaction costs as understood by Coase and Williamson? 2. Does export involve any exchange costs whose increase can have positive impact on the value added? 3. What are the effects of their mutual substitution? The second problem area focused on interpretation of the changing status of transport and logistics in export in relation to including transaction costs into export calculation and the related influence of information and communication technologies.

The main theoretical background was presented by Porter's theories of competitiveness [1 and 2], mainly the new business models of industrial companies in relation to implementation of modern information technologies (the third IT wave and production of smart connected products) and to theories of transaction costs according to Coase [3 and 4] and Williamson [5], which deal with contracts and ownership rights on the company level in the so-called golden triangle: contract, ownership and transaction costs. We used empirical research results published in works on transport demand of commodities in the international trade [6], on time as a barrier to trade [7 and 8], on resources and capacities influencing company export performance [9], on exchange costs [10], on alternative methodology to estimate the size of the transaction cost sector [11], on the empirical estimates of transaction costs [12].

The contribution is divided into three parts: the first part introduces a hypothetical calculation structure of export costs including transaction costs according to Coase and Williamson; the second part deals with methodology of measuring the value of export costs (exchange costs), as well as measuring the effects of their substitution and the follow-up specification of costs with positive or negative character in relation to their impact on the value added; in the third part, we used our findings regarding the importance of including resources in export costs of positive character to interpret the changing status of transport and logistics in time, with a special focus on information and communication technologies.

* [1]**Heda Hansenova,** [2]**Vaclav Cempirek,** [2]**Petr Novak**
[1]Department of International Trade, Faculty of Commerce, University of Economics in Bratislava, Slovakia
[2]Department of Transport Technology and Control, Jan Perner Transport Faculty, University of Pardubice, Czech Republic
E-mail: hedhan@yahoo.com

2. Hypothetical calculation structure of export costs according to Coase and Williamson

Creating the hypothetical structure of export costs, we used an idea published in the article of Alexandra Benham and Lee Benham entitled ”The Cost of Exchange“, where they state (on page 3):

”The cost of exchange is defined as the opportunity cost faced by an individual to obtain a specified good using a given form of exchange within a given institutional setting. More specifically, the cost of exchange C_{ijkm} is defined as the opportunity cost in total resources money, time, and goods for an individual with characteristics i to obtain a good j using a given form of exchange k in institutional setting m, where the form of exchange refers to the type of market (formal vs. informal) in which the exchange takes place, or to dimensions such as pecuniary versus barter exchange.“

In our research we specified:

a) the form of transaction that is international sales contract and its transaction mechanism heading to the change of the ownership, whereby the background for this idea was the Williamson´s premise of the bounded rationality and opportunism,
b) price wedge between the price of good in the country of import on the clause of DDP (Delivery Duty Paid) and the price of good in the country of export on the clause of EXW, the owner of the good in EWX is the sailing exporter and the owner of the good in DDP is the purchasing importer.

The price wedge in the export price [13 and 14]; involves a complex of costs whose structure can be viewed from many perspectives. One kind of such division is the division of legal and illegal costs (in the context of the Global Competitiveness Index data), then the cost of a positive nature (investment nature, in the context of global sustainability indices databases) and the cost of a negative nature (one-time costs - from the traditional perception of the cost structure export prices [15 and 16].

In this study of the contribution of the replacement, the importance of time (speed of delivery and interest) and the physical space (the capacity of vehicles and delivery) are emphasized and referred to as an indirect financial expense or income. For completeness, in the meaning of new institutional theories, included into a hypothetical structure of exchange costs were also the positive and negative externalities by Williamson [5]. The following are included in the export price as being related to the function of the exchange costs: marketing, conclusion, management and enforcement of the contracts, delivery, financing, risk, administrative costs (duties, taxes) associated with crossing the border, information and communications, knowledge, ethics and ecology. It is a whole complex of exchange costs in export price needed to be done to change the ownership of the goods from exporter to importer and maintain the sustainability of commercial transactions [17].

Fig. 1 shows a hypothetical structure of costs of exchange in export price.

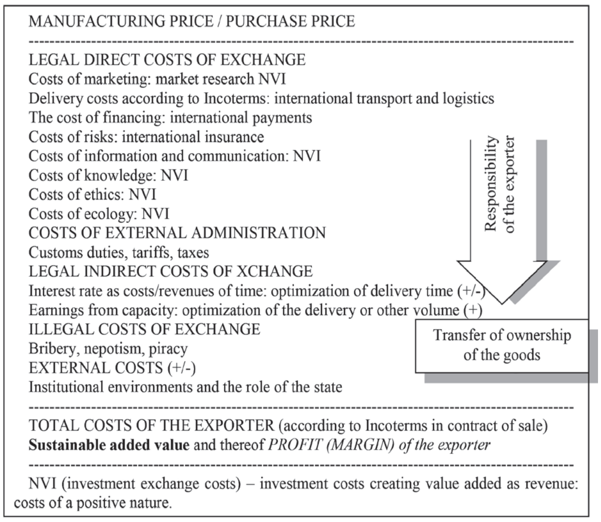

Fig. 1 Hypothetical structure of costs exchange in export price in contract of sale. Source: HANSENOVA, H. et al: Transport and its impact on transaction costs in export prices - draft of model of export prices. In: Cesko a Slovensko v medzinarodnom obchode a podnikani 2012, Medzinarodna konkurencieschopnost a nove vyzvy vyvolane ekonomickou krizou: zbornik prispevkov z 12. medzinarodnej vedeckej konferencie: Praha, 2012.

3. Methodology of the measurement of export costs: model TEAT

We use the outcomes from the dissertation Transaction Costs and Their Influence on the Competitiveness of the Slovak and EU Export [18]. In this paper, the methodology of measurement and management of export costs based on model TEAT (Transaction, Export, Added value, Transportation) was created. In Table 1 the Transaction Costs and Their Influence on the Competitiveness of the Slovak and EU Export for the territory of 143 countries from the world are given. Export costs are measured per capacity of 1 TEU container of the weight of 10t or of the good value of 20 000 USD. It is evident from Table 1 that if any cost issue from the axis x increases by 1 %, the rest of the costs issues change according to the indexes on the axis y. It is applicable for the given period of years for each examined country. The second important evidence of the outcome of the model TEAT is the confirmation of the existence of the positive (investment) character costs and the costs of the negative (the only single use of the expenditure) character and the effect of the increase of the positive character costs in consideration of the added value.

Transaction Costs and Their Influence on the Competitiveness of the Slovak and EU Export Table 1

axis y	Coefficient of determination R^2			R^2		R^2		R^2		R^2		R^2		R^2		R^2		R^2
	Control line		-1,00%		-1,00%		-1,00%		-1,00%		-1,00%		-1,00%		-1,00%		-1,00%	
	+	Marketing costs	x		-0,61%	0,39	-0,54%	0,42	0,99%	0,67	1,07%	0,63	-0,71%	0,71	0,59%	0,58	-0,83%	0,70
	-	Finance costs	-0,65%	0,39	x		0,10%	0,01	-0,79%	0,40	-0,85%	0,38	0,45%	0,27	-0,40%	0,26	0,49%	0,23
	-	Costs of risks	-0,77%	0,42	0,13%	0,01	x		-0,97%	0,46	-0,92%	0,33	0,59%	0,34	-0,68%	0,55	0,69%	0,34
	+	Information and communication costs	0,68%	0,67	-0,51%	0,40	-0,47%	0,46	x		0,85%	0,59	-0,57%	0,66	0,50%	0,62	-0,67%	0,67
	+	Knowledge costs	0,59%	0,63	-0,45%	0,38	-0,36%	0,33	0,70%	0,59	x		-0,55%	0,75	0,42%	0,54	-0,57%	0,60
	-	Unethic costs	-1,00%	0,71	0,60%	0,27	0,59%	0,34	-1,17%	0,66	-1,38%	0,75	x		-0,78%	0,72	0,99%	0,71
	+	Costs of ecology	0,99%	0,58	-0,64%	0,26	-0,81%	0,55	1,24%	0,62	1,28%	0,54	-0,93%	0,72	x		-1,09%	0,72
	-	Administrative costs	-0,85%	0,70	0,47%	0,23	0,50%	0,34	-1,00%	0,67	-1,05%	0,60	0,72%	0,71	-0,66%	0,72	x	
	Nature of the costs (+/-)		Marketing costs		Finance costs		Costs of risks		Information and communication costs		Knowledge costs		Unethic costs		Costs of ecology		Administrative costs	
			+		-		-		+		+		-		+		-	
	axis x																	

Source: MINARIK, M. 2014: Transaction Costs and Their Influence on the Competitiveness of the Slovak and EU Export (dissertation)

3.1 The creation of the database

When creating the database, the secondary data of the qualitative character from the Index of the Global Competitiveness 2012-2013 (GCI 2012-2013) and the secondary data of the quantitative character of the Doing Business 2013 (DB 2013) were used. It was necessary to focus on the part that deals with the measurement of the export costs per 1 TEU container in DB 2013.

8 indicators were selected out of all of the GCI 2012-2013 indicators that approximate as best as possible to the cost issues in the adjusted model of the export price:

Manufacturing price/Purchase price on the clause EXW
Export costs per 1TEU on the clause FOB

Marketing Costs (NM) = Extent of Marketing
Finance Costs (NF) = Soundness of Banks
Costs of Risks (NR) = Business Costs of Crime and Violence
Information and Communication Costs (NIK) = Firm-Level of Tech. Absorption
Knowledge Costs (NZ) = Extent of Staff Training
Unethical Costs (NN) = Ethical behaviour of firms
Ecology Costs (NE) = Quality of Overall Infrastructure
Administrative costs (NA) = Burden of Customs Procedures

Own Total Exporter Costs
Added Value/ Margin/Profit

Each out of 8 selected indicators (I) that form the structure of the export price is defined within the GCI 2012-2013 by a value that belongs to the interval <0;7>. The higher value is the probability of the application of the given indicator. The values are localized in the database A (casaespana.sk/databaza.xls). Furthermore, the database A was modified twice for the research needs in the following way:

3.2 Modification of the database

$$(I \times 100)/7 = P \tag{1}$$

For I - marketing, information and communication, knowledge and ecology costs

$$[(7 - I) \times 100]/7 = P \tag{2}$$

For I - Finance costs, costs of risks, unethical costs and administrative costs

The result value of P determines the number of cases out of 100, when the given indicator is applicable and contributes to the growth of the export price of 1 TEU container (database B, see casaespana.sk/databaza.xls).

The sum of all values of the cost issues for each country out of the 143 was calculated and the given values were modified one more time in a proportional way for a better interpretation in such a way that the sum of all of the cost issues was 100 for each country. The given value indicates 100 %.

$$X = \frac{100 \times P'}{\Sigma P_i'} \qquad (3)$$

X – adjusted indicator (2nd modification) for the need of the analysis (each cost issue that belongs to the model),
P´ - adjusted indicator from the 1st modification for the need of the analysis (each cost issue that belongs to the model),
i – means 8 cost issues.

The result values including the export costs per 1 TEU container on the clause FOB[1] INCOTERMS are localized in the database C (casaespana.sk/databaza.xls). Furthermore, a function was created; the export costs are equal to the sum of the 8 cost issues:

$$EN = f(NM, NF, NR, NZ, NIK, NN, NE, NA) \qquad (4)$$

Export costs (EN) are given in absolute value in USD and each cost issue on the other side of the function is given in %. The sum of the % for each country is 100. The difference is in the proportion of the particular cost issues for each country.

3.3 The measurement of the dynamics of the export costs

It was determined that there are two aspects of the evaluation of the dynamics of the export costs. The first one is the value of the particular cost issues that enter into the model of the export price (Fig. 2) and the second one is their mutual proportion (Fig. 3). These assertions are based on the finding that there are 4 cost issues of the positive nature and 4 cost issues of the negative nature out of 8 investigated.

The regression and correlation, which were realized, discovered the mutual relationship among all the pairs of the cost issues for the purpose to find out the alteration of each of them, if any issue changes by a certain percentage. The better interpretation produces a situation where, if a cost issue changes by 1 %, the extent of the change (in percentages) for the rest of the cost issues was determined. This property confirms the purpose of the research – not to increase the invoice price of the export but rather to try to logically rearrange the financial resources used so that it is possible to substitute the costs of multiple positive investments that improve the quality of the business environment for the costs of a single negative expenditure that decreases the quality of the business environment.

[1]FOB – Clause Free on Board INCOTERMS 2000

3.4 The measurement of the information and communication costs in the structure of the export costs: model TEAT

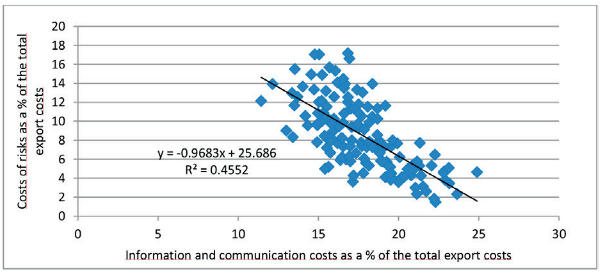

Fig. 2 Mutual relationship between the information and communication costs and the costs of risk. Source: MINARIK, M. 2014: Transaction Costs and Their Influence on the Competitiveness of the Slovak and EU Export (dissertation)

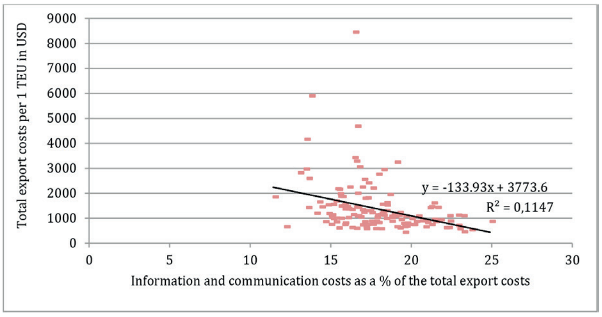

Fig. 3 Contribution of the information and communication costs to the total export costs per 1 TEU. Source: MINARIK, M. 2014: Transaction Costs and Their Influence on the Competitiveness of the Slovak and EU Export (dissertation)

4. Determinants of changes in international transport and logistics

The structure of the major determinants affecting the sustainable competitiveness of transport and logistics in the old and new economy is shown in Table 2. Transport and logistics are among the export costs sometimes classified as production transaction costs, [19] and the influence range of their application on business commodity transactions depends on the structure and complexity of the commercial market channels.

In the case of simple sales contracts with fixed prices, the position of transportation and logistics depends directly on used delivery clauses of INCOTERMS, which sometimes directly determine the modality of transport to be used, but mainly divide responsibilities of exporters and importers towards transport and logistics market. In the case of incentive price of delivery, or in the case of delivery of logistics chains, the place of delivery, risk and transition costs are set by means of other ways than the use of INCOTERMS: The most important function of transport and

Determinants of changes in international transport and logistics Table 2

Old economy	New economy	New economy after 2010 (solution of the crisis)
Exogenous development	Endogenous development	Sustainable development
International transport infrastructure	Global transport infrastructure	Global, smart, ecological transport infrastructure, smart production cluster/ product cloud
Transport modes	Interoperability/ Intermodality	Amodality, intelligent, green transport and logistics
Rival information, communication with interface, rival knowledge	Information technologies, communication technologies and non-rival knowledge	Integrated information technologies, integrated communication technologies, new technology stack/ innovations
Added value as a cost	Added value as revenue	Added value as sustainable revenue
Export price and delivery costs according to FOB (free on board)	Export price and delivery costs according to FCA (free carrier)	Export price and sustainable delivery costs according to FCA (free carrier)

Source: HANSENOVA, H. et al. 2012. Transport and its impact on transaction costs in export prices – draft of model of export prices. In *Czech Republic and Slovakia in international trade and business 2012.* Praha: Oeconomica Publishing house, 2012. ISBN 978-80-245-1876-3, s. 82-96. (modified)

logistics in export and import transactions is still the speed, quantity and quality of delivery, the information and good communication. An important interface that combines technology in transport and logistics with the creation of sustainable value added in export price on the basis of international sales contracts is the principle of interoperability, multimodality and amodality of goods delivery [20]. These technological principles allow not only to combine individual transport and logistics systems into a common chain of goods, but also to provide a comprehensive business solution with sole responsibility and liability. An important determinant of operation of these principles is integrated information and communications technology.

Now, in the third wave of IT transformation, products have become complex systems combining hardware, data storage, sensors and microprocessors, software and connectivity. These "smart, connected products" [2] have unleashed a new era of competition. It will bring further developments in integration of IT and communication technology in supply chain. Logistic and transport companies should be prepared for the new way of communication which requires building a new technology infrastructure. This so called "Technology Stack" includes modified hardware and software applications, network communication layer and a product cloud. Besides that an identity and security structure, external information sources and tools that connect the data with business system have to be involved [2].

5. Conclusions

The main goal was to point out to the possibility of connection between transaction costs and transport technology processes respecting the changes of ownership that are specified in the Contract of Sale in export. It has also taken into account the concrete economic category as lack, opportunism, usefulness and competitiveness. The aim of the research was to create a hypothetical costing structure of the replacement of the export price and to find its impact on the value added.

The objective was to confirm the existence of positive (investment) and negative (disposable) costs. The effect of substitution costs (negative costs reimbursement) was given.

It has been proven that if the recourses in ICT increase by 1 %, the rest of cost issues (administration, finance, risk management) are reduced. Export costs per 1TEU were calculated for each export (database of exports to 144 countries).

The proposed methodology has a lot of eliminations but the main goal was achieved. It was verified that there are both positive and negative costs and the effect of substitution of these costs was confirmed. We did not consider the subjective value of price chain.

We see the role of transport and logistics in the field of export transaction from the perspective of the process of transfer of ownership and optimizing speed and quality of delivered goods. The benefits can be seen from the perspective of the field of information and communication technologies (process of information about current position and status of goods, etc.). The biggest benefit of this research is in providing an open space in the production of smart connected products [21].

This statement is based on Porter‘s idea [2]. Porter says that it will be necessary to examine the business models of production the connected smart products in terms of competitiveness and the transaction leading to a change of ownership for products manufactured in this way.

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Jaromir Siroky - Hana Vohankova *

ECONOMIC EFFECTIVENESS OF OPERATION AND UTILIZATION OF LARGE CONTAINER CARRIERS

This paper deals with operational effectiveness of large container carriers transporting standardized transportation units. The calculation is related to costs per one TEU transported. What is a very important factor in maritime transport is the vessel's speed. Speed has a considerable influence on total costs, and that's why this factor is also taken into consideration in the calculation. Besides speed, there is another important factor, i.e. the utilization of the capacity of container ships, and that's why new container ship types (Suezmax and Triple-E) were considered in the calculation. In the conclusion, other factors are stated that are of importance for establishing the utilization and economic effectiveness of the given types of container ships.

Keywords: *Container, effectiveness, container ship, maritime transport.*

1. Operational effectiveness

Increasing effectiveness of maritime transport is related to vessel capacity, sailing frequency, idle time in ports, vessel draught limits, speed of service at the port, fuel consumption and cruising speed. It would be very complicated to include all these factors in the calculation. The authors draw on the results published in [1, 2 and 3], where the operational effectiveness of a container ship is illustrated by cost per 1 TEU transported. In this case, cost per TEU is compared in two generations of container ships: Suezmax (10,000–15,000 TEU) and the new EEE class (18,000 TEU).

Besides the ship construction, which was also taken into consideration in these two types of ships, fuel consumption was compared. Fuel consumption of container ships depends on the type of the ship and cruising speed; the consumption growing exponentially at speeds higher than 14 knots (26 km/h). That's why the costs per 1 TEU transported were calculated both for normal speed (20–25 knots; 37–46.3 km/h), which is an optimum speed for container ships, at which the engines operate most efficiently (most container ships are designed for a transportation speed of about 24 knots) and for slow steaming speed (18–20 knots; 33.3–37 km/h), where the engines operate below their speed capacity to ensure lower fuel consumption at the expense of a longer shipping time (it is used in ULCV, EEE container ships, which due to their large capacity require a more efficient drive to overcome the great resistance of the hull).

Operational effectiveness of large container ships was calculated and illustrated on an example comparing two types of container ships: Suezmax and the new Triple-E class generation [4 and 5]. Effectiveness was compared on the example of the Shanghai–Rotterdam–Shanghai route, which is used extensively and provides realistic data for the example calculation. Besides the one-way Shanghai–Rotterdam and Rotterdam–Shanghai routes, values for the Shanghai–Rotterdam–Shanghai cruise are also provided (see Table 1).

The calculation of cost per one TEU transported [N_{TEU}] was based on the following relation (1):

$$N_{TEU} = \frac{(t * c * b) + \Sigma_1^n p + T_S N_d * t}{(k * u_{E,W})} \quad [USD/TEU] \qquad (1)$$

where

t...cruise duration in days on the Shanghai–Rotterdam–Shanghai route at normal speed and slow steaming speed for the individual vessels [day],

c...fuel consumption (mazout) in tons per day [t/day],

n...number of calls at ports [number],

p(1-n)...port charge amount (disbursement) per day for the given vessel type in individual ports [USD],

b... current price of bunker fuel [USD / metric ton],

T_S... tolls, Suez Canal transit charges depending on the vessel's parameters [USD],

N_d...the vessel's daily operating costs besides fuel consumption [USD],

k... cargo capacity available in TEU, taking into account unified weight [12 t/TEU],

u_E... cargo capacity utilization factor in the eastern direction [-],

u_W...cargo capacity utilization factor in the western direction [-].

* **Jaromir Siroky, Hana Vohankova**
Department of Transport Technology and Control, Jan Perner Transport Faculty, University of Pardubice, Czech Republic
E-mail: jaromir.siroky@upce.cz

Calculation of unit costs per 1 TEU transported Table 1

Parameter	t	c	b	$\Sigma^{n1} p$	u	k	T	N_d	N_{TEU}
Normal speed, Shanghai-Rotterdam route									
Suezmax	24.6	225	618	449,010	0.85	13,114	263,825	14,500	379.0
Triple E	26.0	285	618	632,508	0.75	18,000	343,100	18,000	**427.7**
Normal speed, Rotterdam-Shanghai									
Suezmax	34.5	225	583	523,271	0.8	13,114	263,825	14,500	**528.9**
Triple E	25.8	285	583	463,704	0.6	18,000	343,100	18,000	**482.9**
Normal speed, Shanghai-Rotterdam-Shanghai									
Suezmax	59.1	225	600	972,281	0.825	13,114	263,825	14,500	**906.5**
Triple E	51.8	285	600	1,096,212	0.675	18,000	343,100	18,000	**896.0**
Slow speed, Shanghai-Rotterdam									
Suezmax	28.8	120	618	449,010	0.85	13,114	263,825	14,500	**269.4**
Triple E	30.6	150	618	632,508	0.75	18,000	343,100	18,000	**297.8**
Slow speed, Rotterdam-Shanghai									
Suezmax	39.05	120	583	523,271	0.8	13,114	263,825	14,500	**363.8**
Triple E	30.4	150	583	463,704	0.6	18,000	343,100	18,000	**339.8**
Slow speed, Shanghai-Rotterdam-Shanghai									
Suezmax	67.8	120	600	972,281	0.825	13,114	263,825	14,500	**631.9**
Triple E	61.0	150	600	1,096,212	0.675	18,000	343,100	18,000	**632.4**

Source: [1, 6, 7, 8, 9], authors

As can be seen from the result, the operation of container vessels at slow steaming speed is more economical than at normal speed. The figures resulting from the calculation show that the costs per 1 TEU were reduced from around USD 900 to 630. On the Shanghai–Rotterdam–Hamburg route, the difference was 270 USD/TEU. Despite a relatively significant reduction in transportation costs at 19 knots, it is important to consider the increase in shipping time by 9 days, as compared to transport at 23 knots. Fuel consumption follows an exponential function above around 18 knots. The figures show that the consumption increased by 105 t/day in Suezmax ships and 135 t/day in Triple-E ships. In Suezmax vessels, the shipping time was reduced from about 68 days to 59 days. Thanks to this reduction, the ship saves 9 days at a consumption of 120 t/day and at the same time, there will be additional 59 days at a consumption of 105 t/day. In Triple-E ships, the difference is even more marked: while saving 9 days at 150 t/day, the ship travels additional 52 days at 135 t/day. The total fuel consumption at slow steaming speed / normal speed is for Suezmax 8160 t / 13275 t; for Triple-E class it is 9150 t / 14820 t.

The total costs per 1 TEU on the cruise Shanghai–Rotterdam–Shanghai for Suezmax and Triple-E class are eventually almost the same. There are differences in the individual cruising directions; however, the overall differences are marginal. The lower consumption of Suezmax ships is traded off by more frequent port charges on the route. Moreover, the higher number of ports called at contributes to a higher utilization of the vessel. It's the utilization – the container ship capacity utilization factor – that has a massive impact on the overall operating costs of the vessel. However, it is a very variable factor. On the maritime transport route considered, the utilization of vessels is distributed unevenly, the western direction being used more due to the heavy Asian export to Europe [10].

2. Economic evaluation of operation

In the calculations shown above, the most significant variables were the vessel's utilization factor and port charges. These two quantities have a considerable impact on the operational effectiveness of the two compared generations of container ships. As can be seen from the result, the operation of container vessels at slow steaming speed is more economical than at normal speed. The figures resulting from the calculation show that the costs per 1 TEU were reduced from around USD 900 to USD 630. On the Shanghai–Rotterdam–Hamburg route, the difference was 270 USD/TEU. Despite a relatively significant reduction in transportation costs at 19 knots, it is important to consider the increase in shipping time by 9 days, as compared to transport at 23 knots. Fuel consumption follows an exponential function above around 18 knots, as can be seen in the chart in Fig. 1.

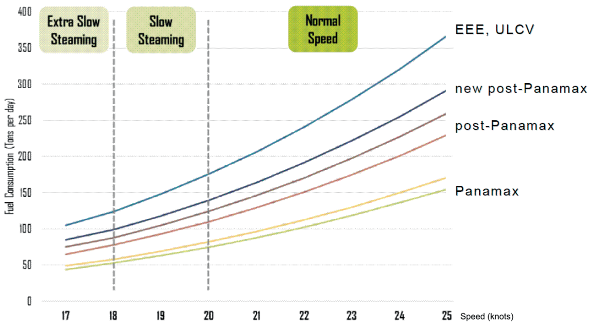

Fig. 1 Fuel consumption [tons per day] depending on speed and type of the container ship
Source: Hofstra University, New York [11]

The figures show that the consumption increased by 105 t/day in Suezmax ships and 135 t/day in Triple-E ships. In Suezmax vessels, the shipping time was reduced from about 68 days to 59 days. Thanks to this reduction, the ship saves 9 days at a consumption of 120 t/day and at the same time, there will be additional 59 days at a consumption of 105 t/day. In Triple-E class ships, the difference is even more marked: while saving 9 days at 150 t/day, the ship travels additional 52 days at 135 t/day. The total fuel consumption at slow steaming speed / normal speed is for Suezmax 8160 t / 13275 t; for Triple-E class it is 9150 t / 14820 t. Since the crisis years of 2008 and 2009, the shipowners operate the ships at slow steaming speed on their longer distance routes despite the longer shipping time. This trend will probably last until a container ship drive is developed with an equal or lower consumption than the one vessels now have at a speed of about 19 knots.

On the route discussed, port charges play a considerable role. As opposed to the Triple-E vessels, the Suezmax container ships are more encumbered with port charges on the Rotterdam–Shanghai route. This results in a difference of USD 24/TEU, where Triple-E ships at slow steaming speed are cheaper by this amount. In the opposite (western) direction, the number of calls at ports is the same for both vessels, and that's where longer idle times and larger dimensions of Triple-E become an important factor, due to which the costs per 1 TEU are in the western direction by almost USD 30/TEU higher than it is the case of the smaller Suezmax vessel.

The total costs per 1 TEU on the cruise Shanghai–Rotterdam–Shanghai for Suezmax and Triple-E are eventually almost the same. There are differences in the individual cruising directions; however, the overall differences are marginal. The lower consumption of Suezmax ships is traded off by more frequent port charges on the route. Moreover, the higher number of ports called at contributes to a higher utilization of the vessel.

It's the utilization – the container ship capacity utilization factor – that has a massive impact on the overall operating costs of the vessel. However, it is a very variable factor. On the maritime transport route considered, the utilization of vessels is distributed unevenly, the western direction being used more due to the heavy Asian export to Europe. The results indicate that the costs per 1 TEU transported are the same provided that the vessels operate at slow steaming speed and their utilization is 82.5% for Suezmax and 67.5% for Tripple E.

In the calculation of operating unit costs per 1 TEU, only those factors are considered that have the greatest influence on the operating unit costs for the carrier (i.e. shipowner). These are those factors whose impact on operating costs is known and that can be quantified and included in the calculation without complex algorithms. However, more factors influence operating costs in reality, which shouldn't be forgotten. Their values are unstable and considerably variable depending on time and place. Due to their high variability and instability, those aspects of operating costs are not included in the calculation, which from accounting and economic perspectives actually create the operating costs. Some aspects of operating costs are not included in the calculation simply because they don't influence the operating costs to a significant degree and as such are negligible [12].

Costs in the transport sector can be considered from different perspectives. From the perspective of carriers, it is the actual costs incurred to purchase factors of production and to operate them. From the perspective of users of transport, i.e. customers of maritime carriers in this case (shipping agencies, end customers, surface carriers, etc.) it is the users' costs paid for maritime transport services [13]. There are also infrastructure related costs, i.e. costs of construction, modernization and maintenance of the transport network. These infrastructure related costs also include costs incurred to operate means of transport, i.e. external costs incurred to other entities.

Only the costs of the carriers, i.e. the carriers' own costs falling into their operating costs, are considered in the example calculation. These costs are then of significant influence on the users' costs, where the price for maritime transport is derived from the carrier's own costs to a great extent.

In the model calculation, the following items have been included:

- fuel,
- transit charges,
- port charges,
- daily operating costs of vessels.

These are items of own operating costs incurred to operate factors of production, i.e. in this case in the realization of the shipping process in maritime transport. However, there are other costs not included in this calculation that have an impact on the carriers' operating costs. It is the depreciation of tangible fixed assets and property insurance.

In the depreciation of tangible fixed assets, the purchase price of factors of production is reflected, which were purchased for business purposes and to generate profit. This purchase price was paid before the actual operation of factors of production and has to be taken into consideration in calculating the operating costs. In this case, it is the different purchase prices of container ships that can influence the shipowners' operating costs.

When including the depreciation in operating unit costs, it is necessary to know the purchase prices of both ships and the approximate depreciation period of this kind of tangible fixed assets. The purchase price of a Suezmax container ship is approximately USD 110 M [14]. The expected purchase price of the new generation Triple-E class ship is USD 190 M [15]. Assuming the depreciation period of a container ship is 30 years [16], it is possible to quantify the impact of depreciation on the unit costs per 1 TEU. If the depreciation costs are quantified based on data obtained from the calculations and data on purchase prices and depreciation period, the depreciation costs per 1 TEU are as follows:

- Suezmax – USD 64 / TEU,
- Triple-E class – USD 88 / TEU.

This calculation was made for the Shanghai–Rotterdam–Shanghai route at the slower slow steaming speed. The calculations show that depreciation makes up for a difference in unit costs by USD 24 / TEU, these costs being higher for the newest generation of container ships due to the higher purchase price by approximately USD 80 M.

The impact of depreciation of fixed tangible assets (container ships) was not included in the calculation due to insufficient information on the ways and methods of depreciation in different countries in the world. Container ships are often registered in different countries than those where they were produced and where they perform the most shipping processes. It is not entirely clear which method of depreciation the container ship is subject to, i.e. straight-line or accelerated depreciation. In different countries, container ships can be parts of different depreciation groups leading to different lengths of depreciation periods. These depreciation rules depend on the legislation of the countries the ships fly the flag of. For this reason depreciation was not included in the calculation of operating unit costs and the amount of depreciation unit costs is indicative and is only to be considered from an overall perspective. Nevertheless, it is probable that the higher purchase price of the newest generation container ships is reflected in the operating costs to a certain degree, and as such it represents another cost item to be taken into consideration.

The ongoing trend of increasing the dimensions of cargo vessels together with an increasingly real threat of natural disasters which can endanger the container ship and its cargo are factors that lead to insurance companies increasing the premium. Threats like tornadoes, tsunami, ship collisions and other insured events occur more and more often nowadays. The price of the container ship itself together with the price of all the cargo it carries represent a significant amount, which can even be fatal for insurance companies. As a result, the premiums to insure vessels and cargo are continuously growing, which can also be reflected in the costs of the shipowner who will have to pay a higher premium to insure container ships with a capacity of 18,000 TEU as opposed to the shipowner who only has to pay for vessels with a smaller capacity.

3. Economic effectiveness related to utilization

As mentioned above, the utilization of a container ship is vital for the effectiveness of its operation. Vessel utilization and capacity are in terms of costs per 1 TEU closely related. The chart in Table 2 shows the costs expressed as a percentage depending on the capacity and utilization of the vessel compared to the costs related to a ship at full utilization, with a capacity of 14,000 TEU.

DNV Maritime and Oil & Gas made a study of transport costs depending on the capacity and utilization of container ships. The results of the study are presented in Table 2, showing that if a container ship with a capacity of 18,000 TEU were to replace a ship with a capacity of 14,000 TEU to reduce costs, its utilization should not be lower by more than 10% compared to the utilization of the container ship with a capacity of 14,000 TEU. In such case, it is possible to reduce the costs per 1 TEU transported. Otherwise, if a sufficient capacity is not ensured, there is no point in producing ships with a capacity of 18,000 TEU.

Costs per 1 TEU transported depending on the utilization and capacity of vessels Table 2

		Vessel Size			
		14 000 TEU	16 000 TEU	18 000 TEU	21 000 TEU
Utilisation	100 %	100 %	97 %	91 %	89 %
	95 %	105 %	101 %	96 %	94 %
	90 %	110 %	106 %	101 %	98 %
	85 %	117 %	112 %	106 %	103 %
	80 %	123 %	119 %	112 %	109 %
	75 %	131 %	126 %	119 %	116 %

Source: Hofstra University, New York [11]

In practice, it is vital to find a utilization balance, where costs per 1 TEU are the same for both types of container ships compared. This balance is a milestone leading to the new giant container ships becoming more economically effective due to lower unit costs per one TEU transported.

What is considered is the actual utilization of Suezmax container ships cruising between Europe and Asia for several years already. Therefore, it is possible to establish their average utilization, which is 82.5% [17] on the Shanghai–Rotterdam–Shanghai route. These real conditions serve as a basis for the

Calculation of transport costs at higher utilization rates of vessels Table 3

Slow steaming SHA-ROT-SHA								
	t	c	b	$\Sigma^{1}{}_{n}\, p$	u	K	T	N_d
Suezmax	67.8	120	600	972 281	**0.95**	13114	263 825	14 500
Triple E	61.0	150	600	1 096 212	**0.778**	18000	343 100	18 000
Suezmax 548.8 USD			**Triple-E 548.8 USD**					

Source: [1, 6, 7, 8, 9], authors

calculation of the minimum utilization of Triple-E class ships, which shouldn't be lower than 67.5% for the costs per 1 TEU not to be higher than those of the smaller Suezmax ships. If the utilization of Suezmax ships is 82.5% and the utilization of Triple-E class is 67.5%, the costs per 1 TEU transported are about the same, i.e. USD 632 [18].

For the new generation Triple-E class ships to be a real revolution in transport cost effectiveness, as they are claimed to be, their utilization should not fall below 67.5%, where the utilization of their competitors – the Suezmax ships – amounts to 82.5% on average.

As the utilization of a cargo ship is a variable quantity depending on the current state of world stock markets, it is good to establish a minimum utilization rate for the situations where the ships would be utilized more. Specifically the Suezmax ships being used at 95%, the minimum utilization rate that would keep the transport costs at least at the same level is 77.8% for the Triple-E class ship. This result is presented in Table 3.

The calculations have produced results for the new types of container ships (18,000 TEU), the utilization of which can be lower by a maximum of 15% compared to their competitors, i.e. the Suezmax container ships (with a capacity of 13,114 TEU).

4. Conclusion

The new types of container ships with a capacity of 18,000 TEU are suitable and effective to be used only on frequent maritime routes between large ports, where high volumes of goods are transported regularly regardless of the season. It should be those ports that are capable of serving this type of ships within 24 hours to prevent high port charges and idle times that are high due to the ship's dimensions. Ports suitable for the new types of container ships will have to be equipped with an adequate shipping system considering the container ship holds and more importantly, its infrastructure will have to be of sufficient capacity to ensure enough goods for loading and their fast moving after unloading for both the port and the berthing ships.

There are not so many such ports at the moment, and that is why it is advisable to operate Triple-E class ships on the Asia–Europe–Asia route between the ports of Rotterdam, Bremerhaven, Shanghai, Ningbo and Hong Kong. The Triple-E class ships are only operated more effectively compared to regular ships with a capacity of slightly more than 13,000 TEU provided that the utilization of the higher capacity vessels is lower by a maximum of 15%. This difference is illustrated by the calculations above. The results imply that it is advisable to operate Triple-E class ships in such seasons and on such routes, where there is a realistic chance to utilize the ship to such extent that this utilization would not be lower than by 15% compared to operating a smaller container ship already mentioned in this paper and in [1, 2 and 3].

In the event the shipping volumes will continue to grow and the ports on the Asia–Europe route will adapt to them continuously, the Triple-E class ships will be used more frequently and the smaller vessels they will substitute will be operated on less frequent maritime routes, where in turn the ports will have to adapt to their dimensions they are not designed for at the moment. These developments of maritime business becoming reality in the future, the transport costs will really be significantly reduced and Triple-E class ships' capacities will be used in full. However, before this happens it is to a certain extent a marketing strategy of large shipowner companies producing larger and larger container carriers, where at the same time they face the risk of the current maritime business situation, in which these high capacity ships cannot be utilized to an extent that would dramatically reduce unit transport costs.

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Vladimir Rievaj - Ondrej Stopka - Jan Vrabel - Lenka Mokrickova - Conrad Schmidt *

THE IMPACT OF AIR RESISTANCE ON THE FUEL CONSUMPTION IN REAL CONDITIONS WITHIN THE TRANSPORT OPERATION

This paper presents the impact of air resistance (air resistance) on fuel consumption of the particular vehicle under real traffic conditions. In the introductory and subsequent part of the paper, the individual resistances influencing the moving vehicle are characterized. In the following chapter, the specific factors such as air resistance, driving speed, air temperature and air resistance coefficient in the context of their impact on fuel consumption of the particular vehicle are identified and described; as well as the comparisons of fuel consumption when the vehicle is moving on the highway with closed and open windows under different conditions of road traffic are performed.

Keywords: *Air resistance, vehicle´s fuel consumption, resistance, driving speed, air temperature, air resistance coefficient.*

1. Introduction

These days, the significant climate changes have been ongoing on our planet. The most significant ones include the frequent changes in weather and temperatures that achieve long-term records. Thermophilic plants and animals have been found in more and more northern latitudes. The sea levels have been increasing every year. Without the necessary interventions into the human activities, at the end of the century, the sea levels will be higher by one or two meters [1].

Experts attribute these changes to the production of greenhouse gases, and above all carbon dioxide (CO_2). The transport is one of the main producers of these gases. For the drive of vehicles within transport, the conventional engines with internal combustion whose exhaust gases contain CO_2 are utilized particularly. If the vehicle consumes 1 liter of petrol, 2.5 kg of CO_2 is penetrated in the air. For the diesel engines, it is 2.7 kg of CO_2. By the ecologists, this gas is considered to be the most important in terms of the greenhouse effect creation. However, the exhaust gases are not only made up of carbon dioxide, but they contain NOx, incompletely burned carbon represented by CO, unburned hydrocarbons HC, carbon black, sulfur and formaldehyde as well. These substances also have an impact on the greenhouse effect creation and simultaneously, they adversely influence the human body [1 and 2].

2. Identification of resistances influencing the moving vehicle

When a vehicle is moving at constant speed, its resistance to motion, termed the tractive resistance, consists of: *Air resistance (AR)*: Air resistance (wind resistance) depends upon the size and shape of the vehicle - its degree of streamlining- and increases approximately as the square of the speed through the air; *Rolling resistance (RR)*: This depends mainly upon the nature of the ground, the tires used, the weight of the vehicle, and to a lesser extent, the speed (the last variation is usually ignored); *Gradient resistance (GR)*: This is determined by the steepness of the hill and the weight of the vehicle, which must, in effect, be lifted from the bottom to top; *Inertia resistance (IR)*: To accelerate the car speed it needs a force; this force is represented by the vehicle resistance to change its speed (inertia resistance) [3 and 4].

2.1 Air resistance

As long as a vehicle is moving, air resistance (drag or wind resistance) is always present. Aerodynamics effects on vehicle functions are: *Directional Control* (Driving Safety) [pitching, yaw, and rolling moments] - left and cross wind force; *Driving Performance and Fuel consumption* [air resistance] - tangential forces; *Comfort* [wind noises, passenger compartment ventilation,

* [1]Vladimir Rievaj, [2]Ondrej Stopka, [1]Jan Vrabel, [1]Lenka Mokrickova, [3]Conrad Schmidt
[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Faculty of Technology, Institute of Technology and Business in Ceske Budejovice, Czech Republic
[3]Technische Hochschule Wildau (FH) Wildau, Germany
E-mail: stopka@mail.vstecb.cz

dirty interior]; *Clear Visibility* [Dirty windows and lamps, Prevention of windshield misting]; *Auxiliary equipment functions* [engine cooling, engine compartment ventilation, brake cooling, air conditioning] [4 and 5].

The size of the air resistance can be determined with using the following formula (1):

$$R_a = \frac{1}{2} \cdot \rho \cdot v^2 \cdot c_x \cdot S \tag{1}$$

where ρ is the instant specific weight of the air [kg/m^3], v is the speed of the vehicle (driving speed; velocity) [m/s], c_x is the air resistance coefficient (drag coefficient or coefficient of influence of the body shape on air resistance) [-], S is the size of the front area of the vehicle [m^2].

Instant specific weight of the air corresponding to the particular conditions can be determined with using the following formula (2):

$$\rho = \rho_n \cdot \frac{273}{273 + t} \cdot \frac{p}{p_n} \tag{2}$$

where ρ_n is the instant specific weight of the air at temperature 0°C and under pressure 0.101325 MPa. Under these conditions, its value is 1.29 kg/m^3, t is the instant air temperature [°C], p is the instant air pressure [MPa], p_n is the normal air pressure [0.101325 MPa].

This indicates that the size of the air resistance is changed proportionally with the driving speed and the air pressure and inversely with the air temperature [6].

2.2 Rolling resistance

The rolling resistance of the tires is the second driving resistance that is always present as long as the vehicle is moving. At low speeds on hard pavement, the rolling resistance is the primary motion resistance force. In fact, aerodynamic resistance becomes equal to the rolling resistance only at speeds of 80-100 km/h. For off-highway, level ground operation; the rolling resistance is the only significant retardation force [6].

There are at least seven mechanisms responsible for rolling resistance: 1) energy loss due to deflection of the tire sidewall near the contact area, 2) energy loss due to deflection of the tread elements, 3) scrubbing in the contact patch, 4) tire slip in the longitudinal and lateral directions, 5) deflection of the road surface, 6) air drag on the inside and outside of the tire, 7) energy loss on bumps [6 and 7].

Considering the vehicle as a whole, the total rolling resistance is the sum of the resistance from all the wheels. Its size can be determined with using the following formula (3) [6]:

$$R_G = m \cdot g \cdot \sin\alpha \tag{3}$$

where m is the vehicle's weight [kg], g is the acceleration due to gravity [9.81 m/s^2], α is the angle of the road inclination on which the vehicle is moving [°], f is the coefficient of rolling resistance [-].

The value of the coefficient of rolling resistance depends on many factors: *construction* of the tire casing; *aspect ratio* of the tire; *radial load* of the tire; wheel offset; driving speed (velocity); tire temperature; tire diameter; tire slip; tire inflation pressure [6].

Typical values of the coefficient of rolling resistance under different conditions are shown in Table 1 [6 - 8].

Specific values of the coefficient of rolling resistance Table 1

Vehicle Type	Surface Type		
	Concrete	Medium Hard	Sand
Passenger vehicle	0.015	0.08	0.30
Heavy trucks	0.012	0.06	0.25
Tractors	0.02	0.04	0.20

Source: Authors

2.3 Gradient resistance

The gradient resistance (climbing resistance, inclined road force) depends on the angle of the road inclination and the weight of the vehicle.

It is actually the force acting parallel to the road. As long as the vehicle is moving along a sloping surface, the vehicle weight acts at a certain angle to this surface. Therefore, the weight of the vehicle weight is divided to the component perpendicular to the road and the component parallel to the road. The size of the gradient resistance can be determined with using the following formula [6]:

$$R_G = m \cdot g \cdot \sin\alpha \tag{4}$$

where m is the vehicle's weight [kg], g is the acceleration due to gravity [9.81 m/s^2], α is the angle of the road inclination [°].

2.4 Inertia resistance

This force depends on the weight of the vehicle and the value of the vehicle acceleration. Each body resists to change of its motion state and a vehicle is no exception. To change the speed of the vehicle, its engine must expend some energy corresponding to the inertia work required to overcome the inertia resistance [6 and 8].

The size of this resistance can be determined with using the following formula (5):

$$R_I = m \cdot a \cdot \delta \tag{5}$$

where m is the vehicle's weight [kg], a is the acceleration of the vehicle [m/s^2], δ is the coefficient of impact of the rotational mass [-].

The size of the coefficient of impact of the rotational mass depends on weight of the engine rotational mass (engine displacement, the method of ignition of the fuel mixture, the number of engine cylinders), gear ratio in the transmission system, weight and size of the wheels and the efficiency of the transmission system [6, 8 and 9].

3. Identification and description of the specific factors affecting the fuel consumption of the particular vehicle

As appears from the above, a range of factors affects the vehicle's fuel consumption. In order to determine the impact of the particular resistance, the measurement needs to be set in such a way that the other factors will not be changed. The efficiency of the engine and transmission system is an important factor. To eliminate this impact, all the measurements were performed on the same vehicle in a small period of time in order to avoid the influence of deterioration of the vehicle technical condition. For the purpose of measurements, the vehicle SUZUKI SX4 with the engine displacement of 1,500 cm^3 was used. Before the actual measurements, tires were inflated to the recommended pressure and the vehicle technical condition and its adjustment in accordance with the manufacturer's instructions were checked [6 and 9].

3.1 The impact of the air resistance

During the vehicle movement, the size of air resistance may vary according to the driving speed (velocity) v, change of the air resistance coefficient c_x, as well as the air temperature. To avoid the height profile impact, the measurements were performed on the same route, and it was necessary to minimize the impact of change in the vehicle driving speed. Journey on the highway meets these conditions best. On the highway, it was possible to achieve the necessary driving speed and maintain it throughout the entire journey section. The measuring section had a length of 6.42 km.

The fuel consumption measurement was started after achieving the required driving speed. In order to minimize the impact of the driver's behavior during the journey, the driving speed was maintained using the cruise control. The wind speed was up to 3 m/s and the vehicle windows were closed. The road surface was dry [6 and 10].

3.2 The impact of the driving speed

If it was necessary to change the driving speed due to the traffic situation, the measurement was annulled. Thanks to these measures, the driving speed was the only changing parameter. The measurement was performed for the driving speed 110, 120 and 130 km/h [9 and 10].

The final fuel consumption obtained from the measurement while the vehicle was traveling on the highway with the closed windows is shown in the following Table 2.

From the obtained results it can be noticed that with increasing the driving speed, the fuel consumption tended to increase. When changing the driving speed from 110 to 120 km/h, the change represents a value of 109.1% and the change in the fuel consumption mirrors this change by the growth of 109.6% of the original consumption. A more significant difference is observed when increasing the driving speed to 130 km/h, i.e. to 118.2% of the original value, the fuel consumption increases to 130.8% of the original value. These values result from the fact that in the formula for calculating the air resistance, the driving speed occurs in the square [10 and 11].

3.3 The impact of the air temperature

Air temperature affects the air density (specific weight) and thus as well as the size of air resistance proportionally. For comparison of the fuel consumption, the measurements for the driving speed of 120 km/h and air temperatures at 34 °C and 10 °C were performed. The results of measurements are shown in Table 3 [4, 6, 9 and 11].

An air temperature drop of 24 °C caused an increase in fuel consumption to 108.8% at the same driving speed.

The final fuel consumption on the highway with the closed windows — Table 2

Driving speed		Fuel consumption		Air temperature
[km/h]	Index of increase in speed compared to the speed 110 km/h	[l/100 km]	Index of increase in fuel consumption compared to the speed 110 km/h	
110	1.00	5.2	1.00	34 °C
120	1.091	5.7	1.096	34 °C
130	1.182	6.8	1.308	34 °C

Source: Authors

The fuel consumption for the driving speed of 120 km/h on the highway with the closed windows Table 3

Driving speed [km/h]	Fuel consumption [l/100 km]	Index of increase in fuel consumption	Air temperature [°C]
120	5.7	1.088	34
120	6.2		10

Source: Authors

3.4 The impact of the air resistance coefficient change

Especially in summer, drivers travel with the open windows in order to maintain an acceptable air temperature inside the vehicle. Vehicle's open window affects the airflow around the vehicle and influences the air resistance coefficient. For comparison, the journeys on the highway at the same driving speed and at the same ambient temperature were performed. One journey took place with the closed windows; during the second journey, the driver's window was open (ajar). The results are shown in the following Table 4 [4 and 10].

The travel with the open window represents an increase in fuel consumption of 1.9% at a speed of 100 km/h, of 1.8% at a speed of 120 km/h. The difference is negligible and this fact corresponds with the experimental data obtained when measuring the impact of driving speed on fuel consumption. At a speed of 130 km/h, the fuel consumption was increased by 2.9% [10 and 11].

3.5 The journey on the 1st class road

The fuel consumption of the vehicle under the normal traffic conditions, where the driving speed is limited by other road users and traffic regulations, already includes the inertia resistances and involves a change of driving speed. The comparison of fuel consumption was performed on the 1st class road between towns Bytca and Zilina. The driver tried to drive at a steady speed, where some journeys took place in dense traffic and driving speed was limited by the driving speed of other vehicles and did not exceed 80 km/h; and there were also the journeys without any other vehicles and the driving speed was therefore limited up to 90 km/h. On the road, the limitations in driving speed up to 50 km/h (twice) and up to 70 km/h (twice) occurred. The results of the measurement are summarized in Table 5 [4, 10 and 12].

When traveling on the 1st class roads, the fuel consumption changed depending only on the driving speed. Column of vehicles drove fluently, however the driving speed did not exceed the value of 80 km/h. The impact of the lower temperature is remarkable, when the fuel consumption increased by 14.89% for the comparable driving conditions [6 and 13].

4. Conclusion

By optimizing the combustion process and using the catalysts, it is possible to reduce the amount of these harmful gases considerably; however, greenhouse gas CO_2 cannot be eliminated by any catalyst. The only solution is to reduce the fuel consumption

The fuel consumption comparison while driving on the highway with the closed and open windows Table 4

Driving speed [km/h]		Fuel consumption [l/100 km]		Index of increase in fuel consumption	Air temperature [°C]
[km/h]	Index of increase in fuel consumption compared to the speed 110 km/h	Closed windows	Open windows		
110	1.00	5.2	5.3	1.019	34 °C
120	1.091	5.7	5.8	1.018	34 °C
130	1.182	6.8	7.0	1.029	34 °C

Source: Authors

The fuel consumption comparison while driving on the 1st class road Table 5

Air temperature [°C]	Window	Fuel consumption [l/100 km]	Conditions
34 °C	Open	4.7	column of vehicles, driving speed up to 80 km/h
		4.9	free road, driving speed up to 90 km/h
34 °C	Open	4.7	column of vehicles, driving speed up to 80 km/h
		5.0	free road, driving speed up to 90 km/h
10 °C	Open	5.4	column of vehicles, driving speed up to 80 km/h

Source: Authors

of vehicles. The reduction of vehicles' fuel consumption can be achieved in several ways, for instance, by increasing the engine efficiency, reducing the driving resistances, optimizing the transport routes, and so on. During the vehicle's movement, resistances are acting against its free passage and trying to stop it. The engine of the vehicle must consume a certain amount of fuel to overcome these resistances. The size of individual driving resistances is not constant; but in the operating condition, it is variable according to the driving mode [14 - 17].

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Marek Vochozka - Penfei Sheng *

THE APPLICATION OF ARTIFICIAL NEURAL NETWORKS ON THE PREDICTION OF THE FUTURE FINANCIAL DEVELOPMENT OF TRANSPORT COMPANIES

It is logical that in an uncertain economic environment it is necessary for companies to be able to plan better, to report more precisely and to be able to better evaluate their future financial development. For their analysis, the authors of this article focus on a particular segment of the national economy, namely transport and freight forwarding companies.

The aim of this article is to utilize artificial neural networks to predict potential financial problems in transport companies in the Czech Republic.

Data on all companies involved in transport and freight forwarding in the Czech Republic for the period 2003 - 2013 were used for modelling the particular neural network. The data file contained nearly 15,000 records on companies for the individual years. These records included both financial statement data and non-accounting data (e.g. data on company employees).

The following networks were used for modelling the neural network: a linear network, a probabilistic neural network (PNN), a generalised regression neural network (GRNN), a radial basis function network (RBF), a three-layer perceptron network (TLP) and a four-layer perceptron network (FLP).

The analysis resulted in a concrete model of an artificial neural network. The neural network is able to determine with more than ninety per cent accuracy whether a company is able to overcome potential financial problems, within how many years a company might go bankrupt, or whether a company might go bankrupt within one calendar year. The text also includes the basic statistical characteristics of the examined sample and the achieved results (sensitivity analysis, confusion matrix, etc.).

The model can be utilized in practice by transport company managers, investors looking for a suitable company for capital investment, competitors, etc.

Keywords: *Transport company, financial problems, prediction, neural network, model.*

1. Introduction

Youssef Mohamed, Kumar and Motwani [1] evaluated selected variables of 165 production companies and transport companies in America. They analysed the ability of the companies to respond to the needs of their internal and external environments. They found out that significant differences exist between a transport company and a production company. Youssef Mohamed, Kumar and Motwani [1] claim that a transport company can be exactly identified and classified according to its response to the external environment.

Nowadays, companies use quality, the environment, health protection and safety management as tools with which to resolve certain problems. This also applies to transport companies [2]. Pavolova, and Tobisova [3] describe and assess in detail the quality management of suppliers to a particular transport company in Slovakia and put forward potential models for evaluating them, particularly in relation to the overall performance of the company.

Bielikova and Misankova [4] explain the importance of company culture, its establishment, development and application through research work carried out in a transport company. The authors claim that company culture is influenced by the permanent confrontation with business priorities and with the external dynamics of the environment in which it operates. The authors conclude by putting forward a new model for company culture in the analysed company

Litvaj, Ponisciakova, Stancekova and Drbul [5] focused on the processes in small transport companies, in one company in

* **[1]Marek Vochozka, [2]Penfei Sheng**
[1]Institute of Technology and Business in Ceske Budejovice, Czech Republic
[2]Henan University, School of Economics, Kaifeng, China
E-mail: vochozka@mail.vstecb.cz

particular, thereby characterizing the importance of knowledge management. The authors acknowledge that knowledge management is the basis of successful company management. The management of transport companies depends on numerous aspects that have to be taken into account. Each of these aspects directly and/or indirectly influences the viability of a company. The viability increases with good management of the individual company areas and by unifying planning activities, budgets, accounting, etc. [6]. Effective management systems are essential if a company is to improve and develop its products and services in order to be and stay successful in the market. It is in the interest of a company's market position to monitor the development of standards and resulting changes [2].

Kubecova and Petrach [7] evaluated the performance of 775 small transport companies in the Czech Republic for the period 2008 - 2012. They found that the number of legal entities active in long haul freight transport (international) grew during the period, whereas the number of companies involved in short haul freight transport (domestic) decreased.

Kovbatyuk and Shklyar [8] evaluated anti-crisis measures implemented by a transport company by means of production indicators and their financial situation (profitability index, business activity index, financial index, and manufacturing opportunity index). Verschoor and L. Reijnders [9] evaluated the viability of transport companies. They came to the conclusion that none of the monitored companies used the life cycle method appropriately. In four cases the life cycle studies were assessed from outside the company. The results of applying the life cycle method were used to reduce external risks, for databases or for the purchasing departments in five of the companies. Only two of the monitored companies assessed the risks correctly.

Zelin and Xunyin [10] defined the main factors that influence competitiveness and used them as indicators for evaluating company strategies and subsequently the strategic stages of a company´s life. Unfortunately, all companies insufficiently defend themselves against the dangers that attack the environment in which they operate which decreases their viability [9]. But in fact the theory of company life cycle has been used for a long time [10].

Ponisciakova, Sukalova [6] characterize the important aspects of management in transport companies e.g. management of services, assets, value, human resources, and qualifications. They also deal in detail with management as a tool, which is utilized in various company spheres to unify activities within a company that are often dealt with separately. Zelin and Xunyin [10] present the key factors affecting competitiveness and use these to evaluate various company strategies and the individual stages of a company´s life. They also put forward options for the strategic transformation and reform of companies.

De Vries, Lukosch and Pijper [11] accept the need for quick changes in regulations and the organization of the transport sector and consider the need for innovation within transport companies as inevitable. They also propose that competent persons in company management should define a strategy they will jointly adhere to. Sukalova, Ponisciakova [12] suggest that increased innovation in all aspects of life is a characteristic of this period of time. Innovation is an absolute necessity for a transport company. The ability to cope with changes in legislature, economic circumstances and other areas depends on an organization's ability to learn. A sustainable strategy is important for improving a company´s viability. An integrated portal built on information, communication, learning and performance improvement is the solution. In situations where such a portal already exists, the utilization thereof is usually insufficient and needs to increase [11].

The management of any company, within the transport sector or elsewhere, depends on the environment in which it operates. The present time is characterized by the increasing dynamics of innovation in all spheres of social and economic life. Information and telecommunication technologies are developing rapidly and the importance of knowledge is growing [12].

Cai, Cai and Yang [13] present the traditional theory of viability as a combination of internal and external factors such as an open and fully competitive market, weak government intervention policy, independent innovation, entrepreneurial spirit, etc. Nowadays, the entrepreneurial environment is characterized by globalisation and internationalisation. In conditions where there are constant changes in the entrepreneurial environment, the methods and tools for crisis management and risk management have to be integrated into change management [12].

The ability to predict the future is a necessity for all companies operating in a market [14]. Chu and Widjaja [14] see predicting as the basis for decision making in most organizations. Accurate predictions about the future will determine a company´s success. However, such decisions are not easy. Numerous methods are available to decision makers and selecting the right one requires extensive knowledge of statistics and good personal judgement.

Neural networks have successfully been applied to the identification (or classification) of healthy economic entities and those inclined to bankruptcy, as well as for the prediction of inflation and deflation, exchange rates and the prices of shares [15]. In contrast, Adya and Collopy [16] came with the opinion that the application of neural networks still gives rise to mixed results. They evaluated several studies and found that eleven of them were effectively verified and implemented with positive results, whereas others were effectively verified but encountered problems in their implementation. Nearly all the studies supported the potential of artificial neural networks to predict.

Artificial neural networks provide powerful models for the solution of numerous economic classifications as well as regression problems. This is why neural models are now included in most standard statistical software packages [15]. Weinlichova and Stencl [17] came with the possibility of applying artificial intelligence by means of neural networks. They found an opportunity to apply neural networks to managerial information systems. Neural networks have also successfully been utilized to predict exchange rates, however with the large quantity of parameters that need to be estimated, it is not easy to choose the appropriate networks. Scientists often overlook the influence of neural network parameters on the prognostic performance of a neural network. They also find that neural networks are often better than linear models, but only for short-term prognoses [18]. Weinlichova and Stencl [17] admit there are other possibilities for data processing apart from the tried and tested methods i.e. managerial information systems and business intelligence – namely by means of neural networks. Weinlichova and Stencl [17] monitor and describe this possibility in detail and compare it with existing possibilities.

The current interest in artificial neural networks for prediction purposes has led to a huge growth in research activities during the last ten years. Zhang, Patuwo and Hu [18] suggest that scientists are not completely sure about the influence of key factors for predictions on the performance of artificial neural works. Weinlichova and Stencl [17] present several possible applications of neural networks to various types of tasks in a managerial information system.

This contribution aims to utilize artificial intelligence, namely artificial neural networks, for the prediction of the future development of transport companies. Atrial will be performed with a concrete group of transport and freight forwarding companies.

The research hypothesis is set as follows: "Artificial neural networks can be utilized to predict the future development of transport companies".

2. Materials and analytical methods

The basic information on companies that is to be used for the analysis comes from the Albertina database. The data covers those companies classified by the Czech Statistical Office as transport companies. These companies fall into groups 49 (land and tube transport), 50 (water transport) and 51 (air transport) of the CZ-NACE classification (classification of economic activities). The final sample includes data on all companies that have transport as their core business in the Czech Republic and were operating on the market in the period 2003 - 2013. The data is processed into tables. Each line contains company development parameters for one company by year. The final sample contained exactly 14,874 data lines. Each line consisting of one hundred characteristics. These characteristics are financial and non-financial indicators.

The financial parameters include all the data from a company´s financial statements: balance sheet; profit and loss statement; and cash flow statement. The earnings before interest and taxation (EBIT) is also used.

The non-financial indicators include: company identification (name and registration number); region of activity; number of employees; and the auditor's statement.

On the basis of the input data we sought an artificial neural structure that would be able to classify each company into one of the following three groups: solvent company, will go bankrupt in the current year and will go bankrupt in the future.

First we determined the characteristics of the individual companies. We then defined the quantity of the output category. These were defined on the basis of the values presented in the column "final status" in the Excel sheet. For this purpose it is essential to know the results for each year of the period 2003 - 2013. It is on this basis that the category input values were set. These are non-financial indicators. All the items shown from the financial statements are continuous quantities.

After this process the sample was randomly divided into three groups of companies: a training group (the neural networks are trained on this group to achieve the best possible results); verification group (the success of the classification of the trained neural structures is tested on this group); and the validation group (used for second verification of the obtained results). The data was divided into the training, verification and validation groups in the following proportions: 70:15:15.

Costea [19] created several maps in which each company was located to a certain period and subsequently selected the best one which could be used for the analysis of a company over the course of time.

We can therefore claim that artificial neural networks can also be used for the classification of solvent, bankrupt and potentially bankrupt companies in cases where the input data are not limited to financial indicators because non-financial indicators can also be used.

Once this exercise was completed, 10.000 artificial neural structures[1] were generated, of which the 10 most suitable were retained. For the model, linear neural networks (Linear), probabilistic neural networks (PNN), generalised neural networks (GRNN), radial basis function neural networks (RBF), three-layer perceptron networks (TLP) and four-layer perceptron networks (FLP), were utilised.

For the radial basis function neural network we used 1 - 3,696 hidden neurons. The 2nd layer of the three-layer perceptron network contained 1 - 100 hidden neurons. The 2nd and the 3rd layers of the four-layer perceptron network both also contained1 - 100 hidden neurons. The perceptron networks classified the individual companies on the basis of entropy. The classification threshold was assigned on the basis of the highest confidence.

[1] Unless the improvement in the individual trained networks is significant the training of neural networks can be shortened

3. Results

On the basis of the parameters 10,000 artificial neural networks were randomly generated. The 10 networks which showed the best results (i.e. the highest rate of correct classification of companies according to their credit worthiness and, as the case may be, the tendency to bankruptcy), were retained for further assessment and subsequent processing [Table 1].

The ninth retained artificial (the most suitable and usable one) neural network is a radial basic function. A schematic illustration of the neural network, RBF 55:68-337-3:1 [Fig. 1].

55 variables, discrete as well as continuous, enter the model. Table 2 shows the ten variables which have the greatest influence on the final classification according to the sensitivity analyses and the application of the model (as before, from the point of view of the validation group of companies).

All the weights fluctuate above 1. Although the weights are significant, they fluctuate just above 1. This is important with regards to the network´s classification accuracy. It fluctuates at the highest level of all the models assessed so far. The lowest value (that of the training group) fluctuates above 94.1%.

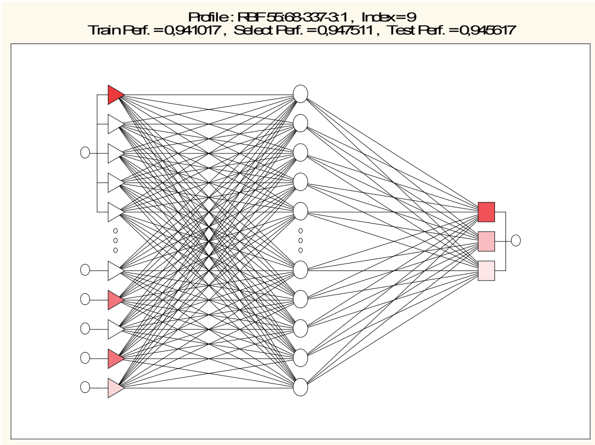

Fig. 1 Schematic illustration of artificial neural network RBF 55:68-337-3:1. Source: authors

Obtained neural networks showing the best potential to predict the future development of transport companies — Table 1

	Profile	Train Perf.	Select Perf.	Test Perf.	Train Error	Select Error	Test Error	Inputs	Hidden	
									(1)	(2)
1	MLP 1:14-38-3:1	0.939800	0.946429	0.945346	0.591421	0.559210	0.581395	1	38	0
2	MLP 1:14-51-3:1	0.939800	0.946429	0.945346	0.554447	0.532507	0.544601	1	51	0
3	MLP 1:14-34-58-3:1	0.939800	0.946429	0.945346	0.552794	0.529853	0.536205	1	34	58
4	Linear 2:2-3:1	0.939800	0.946429	0.945346	0.195252	0.184768	0.186567	2	0	0
5	Linear 1:1-3:1	0.939800	0.946429	0.945346	0.195251	0.184750	0.186551	1	0	0
6	PNN 38:54-7392-3:1	0.939800	0.946429	0.945346	0.194469	0.184331	0.186722	38	7392	0
7	PNN 39:55-7392-3:1	0.939800	0.946429	0.945346	0.194468	0.184331	0.186722	39	7392	0
8	RBF 32:45-337-3:1	0.940341	0.946699	0.945346	0.184744	0.181825	0.185517	32	337	0
9	RBF 55:68-337-3:1	0.941017	0.947511	0.945617	0.184981	0.181435	0.185941	55	337	0
10	RBF 76:92-337-3:1	0.941558	0.946970	0.945887	0.184503	0.181178	0.185548	76	337	0

Source: authors

Sensitivity analyses for network RBF 55:68-337-3:1 (10 selected most important variables) — Table 2

Input variable	T.Ratio. 9	T.Rank. 9	S.Ratio. 9	S.Rank. 9	X.Ratio. 9	X.Rank. 9
Long-term receivables - TCZK	1.05910	2.00000	1.05439	1.00000	1.04470	1.00000
Other operational costs - TCZK	1.05580	4.00000	1.04396	2.00000	1.04164	2.00000
Receivables &Debtors	1.05631	3.00000	1.03787	4.00000	1.03869	3.00000
Inventories - TCZK	1.04142	7.00000	1.04354	3.00000	1.03819	4.00000
Sales of goods - TCZK	1.05566	5.00000	1.03203	5.00000	1.02825	5.00000
Other short-term payables	1.03611	10.00000	1.02271	6.00000	1.02657	6.00000
Administration and other costs	1.02937	13.00000	1.01520	13.00000	1.01967	7.00000
Total trade payables (short term) - TCZK	1.04149	6.00000	1.02141	7.00000	1.01832	8.00000
Trade payables	1.04052	8.00000	1.02120	8.00000	1.01826	9.00000
Short-term payables - TCZK	1.03141	11.00000	1.01577	12.00000	1.01799	10.00000

Source: authors

Confusion matrix - extract of the generated neural network RBF 55:68-337-3:1 *Table 3*

Classification according to the individual neural networks	T. Solvent	T. Bankr. in future	T. Bankr. in current year	S. Solvent	S. Bankr. in future	S. Bankr. in current year	X. Solvent	X. Bankr. in future	X. Bankr. in current year
Solvent. 9	6943	337	94	3497	153	39	3493	156	44
Bankruptcy in future. 9	4	13	1	1	5	1	1	2	0
Bankr. in current year. 9	0	0	0	0	0	0	0	0	0

Source: authors

To obtain complete insight a confusion matrix was prepared. The matrix provides an extract of summary of the correctly and incorrectly classified companies in training, verification and validation [Table 3]. The companies of the training group are identified with T, of the verification group with S, and of the validation group with X.

4. Discussion

The confusion matrix confirms that all the artificial neural networks are able to predict relatively accurately which companies will survive. Their success rate is precise. For the majority of models this is approximately 100 %. However, the aim of this article was not to find a model with which to predict companies that would not go bankrupt. The aim was to find a tool that could identify companies that could not survive possible financial problems, be it either in the current year or in the near future. The results of the confusion matrix disqualifies most of the retained neural networks. Only the radial basic neural networks i.e. networks 8, 9 and 10 qualify. The networks that predicted the highest number of bankrupt companies had the highest value in terms of accuracy. The difference between networks 9 and 10 was relatively small. However, network 9 (i.e. RBF 55:68-337-3:1) was more successful. This network also shows the highest accuracy with regards to the classification of the companies. For the training group the accuracy was equal to that of network 10. For the verification group network 9 was more successful. For the validation group the reverse was true, network 10 was more successful. The higher success rate of the classification may therefore be derived from the absolute value of the predicted future situation.

With a deeper analysis of network 9 (RBF 55:68-337-3:1) we can obtain interesting insights into the characteristics of each of the three groups of companies.

The summarisation of the results and the arguments put forward in the discussion confirm the hypothesis. Artificial neural networks are able to predict the future development of a company with a probability higher than 94%.

5. Conclusion

This contribution set out to apply artificial intelligence, namely artificial neural networks, to the prediction of the future development of a transport company. An example of the application thereof was carried out on a sample of transport and freight forwarding companies.

A search into the knowledge of the management of transport companies reveals that the utilizing neural networks to predict the future development of companies can be effective. However, real evidence was required from applying them to a particular group of transport and freight forwarding companies in the Czech Republic. An analysis of data was performed. The data was subsequently used for preparation of models. The model with the highest prediction accuracy was subsequently identified from among these models. With a classification accuracy of 94% we can conclude that the selected model is applicable in practice. To summarize:

1. Artificial intelligence was applied to the prediction of the future development of a transport company.
2. An example of the application was performed on a particular group of transport and freight forwarding companies.

The aim of this contribution was therefore achieved.

The results can be used not only in the academic environment for those teaching transport and logistics, but also by economists, for research purposes, and in practice.

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Jiri Hanzl - Ladislav Bartuska - Elena Rozhanskaya - Petr Prusa *

APPLICATION OF FLOYD'S ALGORITHM ON TRANSPORT NETWORK OF SOUTH BOHEMIAN REGION

The introductory part of the paper deals with the theory of searching for optimal routes in transport networks, including a description of each type of optimization tasks. The aim of the article is demonstration of Floyd algorithm application to find the minimal paths from each node to another in network graph - in our case the network represents traffic model of road network in the region of South Bohemia.

Keywords: *Distance Matrix, Traffic Network, Transport Model, Floyd Algorithm, Optimal Route, Minimal Path.*

1. Introduction

Finding the optimal routes in networks (transport network, telecommunication network, etc.) is the most common task of Graph Theory used in everyday life. These tasks are solved within the models of real transport networks. An example of a schematic model of the transport network may bea common non-oriented, connected and edge-rated graph. We are searching for optimal routes at this graph (model) because we need, for example, to minimize the costs necessary for realization of journeys. Minimizing the costs (such as the fuel consumption) can be understood as a task of finding the shortest (minimal) path between two specified nodes in the graph.

But it is not always about the minimizing of costs. Tasks of the reliability and capacity belong to the issue of route optimization in networks as well. These examples belong to the tasks of important routes within the graph [1]:

- Task of the shortest (minimal) path;
  - from one specific node of graph (origin) to another;
    - a) searching for minimal path from origin to final destination;
    - b) searching for minimal path from origin to all other nodes of graph;
  - from each node to one another;
- task of the most reliable path;
- path with a maximum capacity;
- finding the maximum path in the graph (adjusted general algorithm).

In the following part a task of optimal route is generally formulated and a practical demonstration of the application of a simplified Floyd's algorithm on the transport network of I and II class roads in South Bohemian region is conducted for searching optimal routes in the network. Specifically, it is the application of the algorithm in the task of finding the minimal path from each of the network vertex to another [2].

2. Formulation of the problem of optimal route in network

Let us have a transport network as graph $G = (X, U, \varphi(h))$ wherein each edge $h \in U$ is rated with number $\phi (h)$, called the edge length. Then the task of the optimal route in a network of n nodes (vertexes) is to find the optimum route, namely [3]:

- from one node v_i (i.e. start or origin vertex) to other node v_j (i.e. the destination or final vertex) in the network;
- from the initial node v_i to each of the other nodes $v_j \in X$ in the network; $v_i \in v_j$;
- from every node $v_i \in X$ to each another final node v_j in the network; $v_i \neq v_j$;
- between all pairs (v_i, v_j), or between ordered pairs $[v_i, v_j]$; $v_i \neq v_j$; $i, j = 1,..., n$.

When choosing the best option, some optimality criterion always enters into the solution of the problem. For example, in dealing with the problem of possible routes between two nodes we can assess distance (length) of possible routes, the consumption

* [1]Jiri Hanzl, [1]Ladislav Bartuska, [2]Elena Rozhanskaya, [3]Petr Prusa
[1]The Institute of Technology and Business in Ceske Budejovice, Faculty of Technology, Czech Republic
[2]Plekhanov Russian University of Economics, Department of Foreign Economic Activity, Russia
[3]University of Pardubice, Jan Perner Transport Faculty, Department of Transport Management, Marketing and Logistics, Czech Republic
E-mail: hanzl@mail.vstecb.cz

of time needed for the relocation, the mutual availability of the nodes and the costs associated with relocation.

However, we always come to the two extreme tasks, namely [3 and 4]:

- to minimum => task to find the minimal path;
- to maximum => task to find the maximal path.

The most common practical example is the criterion of optimizing the costs associated with relocation, and because our demand is to minimize the distance after which the relocation occurs. In application on the transport network of South Bohemian Region we will discuss the task of finding minimal paths between all nodes in the graph $G = (X, U, \varphi(h))$ [4].

2.1 Model of transport network in South Bohemian Region

As already mentioned in the introductory part of the article, simplified transport network is composed of I and II class roads (Fig. 1). Based on the real map and real conditions the traffic model was created (non-oriented graph $G = (X, U, \varphi(h))$) showing simply the same transport network with the valuation of individual edges with the distance [km], but for simplicity intersections in rural areas are neglected - intersections of network are merely nodes = cities with a population over 5,000. This simplified model of the network is then shown in Fig. 2.

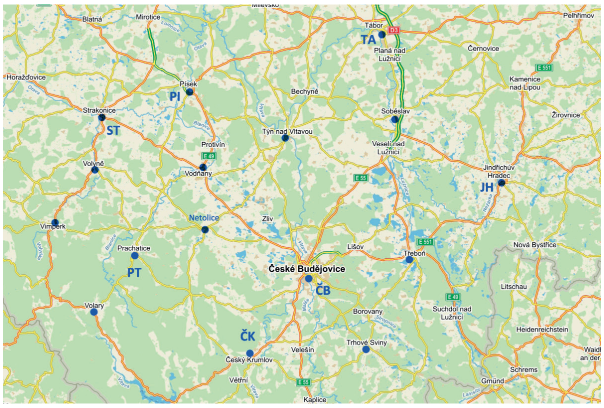

Fig. 1 The road network of South Bohemian Region with the nodes - towns and cities with population over 5,000 (source: http://www.mapy.cz) [5]

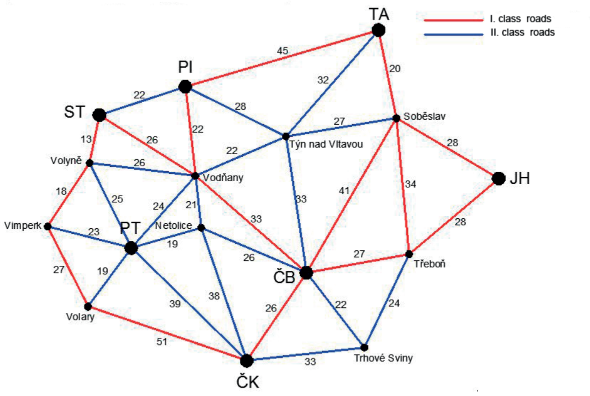

Fig. 2 A simplified model of the transport network in the South Bohemian Region with values of edges (km) (source: Authors)

2.2 Minimal paths from one node to another

The bulk of the tasks requires the calculation of distances between any two network nodes, thus the task is to find the minimal path between all pairs of nodes (v_i, v_j), more precisely between ordered pairs $[v_i, v_j]$ in graph $G = (X, U, \varphi(h))$, where $v_i \neq v_j$ and $i, j = 1, ..., n$. In the selected transport network the output of the algorithm will be a square matrix of minimum distances D of type $n \times n$, where n = number of nodes (towns and cities with more than 5,000 inhabitants) in the graph, in the case of the South Bohemian Region n = 16. The whole graph is thus shown as a square 16 x 16 matrix where the row and column headings constitute individual nodes (cities) of the graph (Fig. 3) [6].

2.3 Floyd Algorithm

To demonstrate the practical use of the algorithm in practice, Floyd algorithm determining the minimal path from each node to another one was chosen. This algorithm is suitable for all transport networks having the number of edges approaching the complete graph. The algorithm is applicable to oriented and non-oriented graphs. In the case of simplified transport network of South Bohemia region it will be a non-oriented graph G = (X, U, φ(h)).

1) First, we prepare the initial square matrix of direct distance $C_{k=0} = (c_{ij})_{i,j=1}^{n}$ of $n \times n$ type so that:

$$c_{ij} = \varphi(h), if\ \exists h \in U: p(h) = (v_i, v_j), i \neq j \qquad (1)$$

$$c_{ij} = 0\ for\ i = j$$

$$c_{ij} = \infty, if\ exists\ h \in U: p(h) = (v_i, v_j), i \neq j$$

for all i, j = 1, ..., n. [3]

C_0	TA	PI	ST	Volyně	Vimperk	Volary	CK	T. Sviny	Třeboň	JH	Soběslav	Týn n. Vlt.	Vodňany	PT	Netolice	CB
TA	0	45	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	20	32	1E+12	1E+12	1E+12	1E+12
PI	45	0	22	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	28	22	1E+12	1E+12	1E+12
ST	1E+12	22	0	13	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	26	1E+12	1E+12	1E+12
Volyně	1E+12	1E+12	13	0	18	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	26	25	1E+12	1E+12
Vimperk	1E+12	1E+12	1E+12	18	0	27	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	23	1E+12	1E+12
Volary	1E+12	1E+12	1E+12	1E+12	27	0	51	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	19	1E+12	1E+12
ČK	1E+12	1E+12	1E+12	1E+12	1E+12	51	0	33	1E+12	1E+12	1E+12	1E+12	1E+12	39	38	26
Trhové Sviny	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	33	0	24	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	22
Třeboň	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	24	0	28	34	1E+12	1E+12	1E+12	1E+12	27
JH	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	28	0	28	1E+12	1E+12	1E+12	1E+12	1E+12
Soběslav	20	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	34	28	0	27	1E+12	1E+12	1E+12	41
Týn nad Vltavou	32	28	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	27	0	22	1E+12	1E+12	33
Vodňany	1E+12	22	26	26	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	22	0	24	21	33
PT	1E+12	1E+12	1E+12	25	23	19	39	1E+12	1E+12	1E+12	1E+12	1E+12	24	0	19	1E+12
Netolice	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	38	1E+12	1E+12	1E+12	1E+12	1E+12	21	19	0	26
ČB	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	26	22	27	1E+12	41	33	33	1E+12	26	0

Fig. 3 Formation of the initial matrix C_0 of the graph direct distances (source: Authors)

The symbol $p(h)$ represents the direct distance between nodes v_i and v_j. Thus, if there is an edge in the graph directly connecting node v_i with node v_j, then we record to the matrix of direct distances the edge evaluation $\varphi(h)$ (= distance) between these nodes [7].

If the direct distance between nodes v_i and v_j does not exist, we write to the matrix of direct distances the symbol ∞ (in our case in Fig. 3, the symbol ∞ represents the large number 10^{12}).

2) The sequence of matrices C_k, where $k = 1, \ldots, n$ is being gradually constructed. In this cycle, for $k = 1, \ldots, n$, we search whether the way from the vertex v_i to v_j cannot be shortened through the vertex v_k (see the schematic representation in Fig. 4) [8].

For all $i, j \neq k$ we recalculate the elements in the matrix C_k according to the relation [9]:

$$c_{ij}^{(k)} = \min\left\{c_{ij}^{(k-1)}, c_{ik}^{(k-1)} + c_{kj}^{(k-1)}\right\}, \text{ where } i, j, k = 1, \ldots, n. \quad (2)$$

Thus for the matrix C_1 (see in Fig. 5), its elements are as follows.:

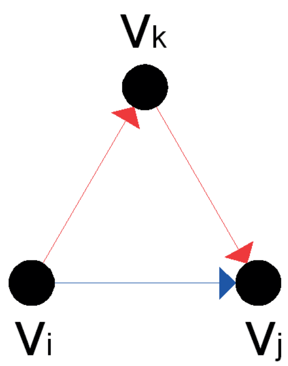

Fig. 4 Schematic representation of shortening the way from the vertex v_i to v_j through the vertex v_k (source: Authors)

3) If $k = n$, then the final matrix C_n is the searched matrix of minimal distances of the graph; thus, for all pairs of nodes i and j applies $c_{ij} = d_{ij}$, where d_{ij} is the distance (= the distance of the shortest path) between the nodes v_i and v_j for all $i, j = 1, \ldots, n$. The final matrix $C_n = D$ is called **distance matrix** [10 and 11].

The final distance matrix D for transport network model in South Bohemia is shown in Figure 6 including minimal distances

C_1	TA	PI	ST	Volyně	Vimperk	Volary	CK	T. Sviny	Třeboň	JH	Soběslav	Týn n. Vlt.	Vodňany	PT	Netolice	CB
TA	0	45	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	20	32	1E+12	1E+12	1E+12	1E+12
PI	45	0	22	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	65	28	22	1E+12	1E+12	1E+12
ST	1E+12	22	0	13	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	26	1E+12	1E+12	1E+12
Volyně	1E+12	1E+12	13	0	18	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	26	25	1E+12	1E+12
Vimperk	1E+12	1E+12	1E+12	18	0	27	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	23	1E+12	1E+12
Volary	1E+12	1E+12	1E+12	1E+12	27	0	51	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	19	1E+12	1E+12
CK	1E+12	1E+12	1E+12	1E+12	1E+12	51	0	33	1E+12	1E+12	1E+12	1E+12	1E+12	39	38	26
Trhové Sviny	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	33	0	24	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	22
Třeboň	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	24	0	28	34	1E+12	1E+12	1E+12	1E+12	27
JH	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	28	0	28	1E+12	1E+12	1E+12	1E+12	1E+12
Soběslav	20	65	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	34	28	0	27	1E+12	1E+12	1E+12	41
Týn nad Vltavou	32	28	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	27	0	22	1E+12	1E+12	33
Vodňany	1E+12	22	26	26	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	22	0	24	21	33
PT	1E+12	1E+12	1E+12	25	23	19	39	1E+12	1E+12	1E+12	1E+12	1E+12	24	0	19	1E+12
Netolice	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	38	1E+12	1E+12	1E+12	1E+12	1E+12	21	19	0	26
ČB	1E+12	1E+12	1E+12	1E+12	1E+12	1E+12	26	22	27	1E+12	41	33	33	1E+12	26	0

Fig. 5 Formation of the new matrix C_1 from C_0 (the elements c_{ij} which have been changed are marked in red) (source: Authors)

$C_{16} = D$	TA	PI	ST	Volyně	Vimperk	Volary	CK	T. Sviny	Třeboň	JH	Soběslav	Týn n. Vlt.	Vodňany	PT	Netolice	CB
TA	0	45	67	80	98	97	87	78	54	48	20	32	54	78	75	61
PI	45	0	22	35	53	65	81	77	82	83	55	28	22	46	43	55
ST	67	22	0	13	31	57	77	81	86	103	75	48	26	38	47	59
Volyně	80	35	13	0	18	44	64	81	86	103	75	48	26	25	44	59
Vimperk	98	53	31	18	0	27	62	90	95	121	93	66	44	23	42	68
Volary	97	65	57	44	27	0	51	84	91	119	92	65	43	19	38	64
ČK	87	81	77	64	62	51	0	33	53	81	67	59	59	39	38	26
Trhové Sviny	78	77	81	81	90	84	33	0	24	52	58	55	55	67	48	22
Třeboň	54	82	86	86	95	91	53	24	0	28	34	60	60	72	53	27
JH	48	83	103	103	121	119	81	52	28	0	28	55	77	100	81	55
Soběslav	20	55	75	75	93	92	67	58	34	28	0	27	49	73	67	41
Týn nad Vltavou	32	28	48	48	66	65	59	55	60	55	27	0	22	46	43	33
Vodňany	54	22	26	26	44	43	59	55	60	77	49	22	0	24	21	33
PT	78	46	38	25	23	19	39	67	72	100	73	46	24	0	19	45
Netolice	75	43	47	44	42	38	38	48	53	81	67	43	21	19	0	26
ČB	61	55	59	59	68	64	26	22	27	55	41	33	33	45	26	0

Fig. 6 The final distance matrix C_{16} = D (source: Authors)

from every major city to one another along existing I and II class roads.

3. Conclusion

The main objective of this paper was to describe the issue of searching for optimal paths in networks as one of the key areas of graph theory. For illustration, one of the most common tasks of graph theory was described - the task of searching for minimal path, which was, by means of using Floyd algorithm, applied to a particular transport network of the South Bohemian region [12].

The task solution is represented by the abovementioned distance matrix D indicating the minimum distances from each node of the network to another one. This procedure is applicable to other transport networks as well (road network in the Czech Republic) and has a practical use, for example in logistics (route planning, transport service of territorial units etc.) and other sectors of transport (telecommunications etc.).

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Vladimír Rievaj - Lenka Mokrickova - Juraj Rievaj *

IMPACT OF DRIVING TECHNIQUES ON FUEL CONSUMPTION

Climatologists constantly point to the change of the climate on Earth. They consider CO2 emissions to be one of the main causes of these changes. Transport is significant producer of the greenhouse gases. If one litre of gasoline is burnt, 2.5 kg of CO2 is released into environment. Incineration of one litre of oil means that the air gets 2.7 kg of CO2 [1]. Moreover, the air gets other pollutants, particularly nitrogen oxides NOx, unburned hydrocarbons, particulates. If we want to stop or delay the climate change, we should minimize production of the greenhouse gases. This objective could be implemented through legislation, designing of more efficient propulsion units, construction of infrastructure or using of alternative fuels. The easiest way is to minimize vehicle fuel consumption. This is dependent on driver and his driving techniques. The technical condition of the vehicle, route selection and the type of the vehicle are also significant [2]. We want to show the influence of the driving technique on the fuel consumption. Article describes four different driving techniques and their impact on the fuel consumption.

Keywords: *Transport, greenhouse gases, vehicle fuel consumption, driving techniques, change of the climate.*

1. Conditions for experiment

We compared the impact of a driving technique on the vehicle consumption by driving on the street circuit. To minimize the impact of inequalities and random effects on vehicle consumption we carried out two measurements for each driving technique. The third measurement was performed when the results between the first two measurements were significantly different. Traffic density has a significant effect on the car consumption. To eliminate this impact on measurements, we performed the measurements out in the evening with a minimum traffic density. When the waiting time at the traffic lights or junction was 1 minute or more, we annulled the measurement and started a new one [3].

Before measuring the consumption, the vehicle was warmed up to the operating temperature by driving to at least 10 km distance. The vehicle was operated by the same driver during the consumption measuring and the driver was following traffic rules and regulations valid in Slovakia. The measurements were carried out on Suzuki SX 4 with front-wheel drive. The technical characteristics of the vehicle are described in Table 1.

The basic parameters of the tested vehicle Table 1

Engine	Fuel	Number of cylinder	Stroke volume [cm^3]	Maximum power [kW/rpm]	Maximum torque [Nm/rpm]	Maximum speed [km.h^{-1}]	Number of gears
Spark ignition	Gasoline	4	1490	82/ 6000	145/ 4400	180	5
Dimensions [mm]					Standby mass of the vehicle [kg]	Payload [kg]	
Length		Width	Height	Wheelbase			
4 120		1730	1565	2500	1240	410	

Source: vehicle manufacturer

2. Description of the measuring circuit

Measurements were done on the circuit in the city of Zilina. The starting point of the circuit number 1 is at an altitude of 363 m. The highest point of the route is at an altitude of 401 meters and the lowest point is at an altitude of 351 metres. Altitude values were determined by the Google earth program. Altitude profile of the measuring circuit is shown in Fig. 1 [4].

* [1]Vladimír Rievaj, [1]Lenka Mokrickova, [2]Juraj Rievaj
[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Headington Close, Cambridge Cambridgeshire, United Kingdom
E-mail: vladimir.rievaj@fpedas.uniza.sk

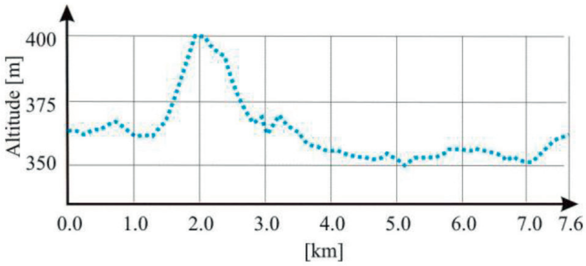

Fig. 1 Elevation profile of the measuring circle

The route was divided into sections depending on the longitudinal slope, the speed limit or obligation to give way to other vehicles.

The first section, 100 m long, was used to achieve a speed of 50 km/h. The driver drove through the second section at a speed of 50 km/h and he was obliged to slow down to 40 km/h at the end of the section. The driver kept driving at a speed of 40 km/h on the third section. The driver accelerated to 50 km/h in the fourth section and at the end of it he slowed down to a speed of 40 km/h. Here is an intersection where the driver turned to the right into the fifth section. The average slope of this section is 5%. The driver sped up to 50 km / h in this section. The driver slowed down to a speed of 40 km / h at the end of this section. The sixth section had degressive character and the driver braked by engine. He had to slow down to a speed of 30 km/h at the end of the section because he was obliged to give way to the vehicles traveling on the main road. The vehicle increased its speed again to 50 km/h on the seventh section and went through a slight incline. The eighth section of the road had a decline and at the end of it the driver entered a roundabout and had to slow down to 30 km/h. The driver could go through the ninth section at a speed of 50 km/h but at the end of it he had to slow down to 30 km/h as he entered a roundabout again. The tenth section had a decline. At the end of this section, the driver was turning to the left so he had to give way to the vehicles coming from the opposite side. The driver slowed down to 30 km/h and entered the eleventh section. This sector had an incline and the driver could increase the speed to 70 km/h. He increased the speed to this speed limit. There is a road sign STOP - GIVE WAY at the end of the eleventh section so the driver had to stop the vehicle. The beginning of the twelfth section had a speed limit of 50 km/h so the vehicle accelerated to 50 km/h. Then the driver had to slow down to 40 km/h due to the speed limit at the end of this section. At the thirteenth section, the driver went through the first 100 m at a speed of 40 km/h, after that he accelerated to 50km/h which was also the speed limit. The road had a slight decline. The driver had to slow down to 30 km/h at the end of the section as he entered a roundabout. The fourteenth section had a moderate incline. The speed limit was 50 km / h. At the end, the driver parked the vehicle at the spot where we started the measurements [5] and [6].

3. Driving technique description

The aim was to investigate the effects of driving techniques on the car consumption and, therefore, measurements were taken for different driving techniques. This route was selected so that the driver had to change the speed of the vehicle frequently and there were only short segments of the road where the driver could drive at a constant speed. The measurement was carried out for four different driving modes, which are described below.

A The vehicle engine was warmed up to the operating temperature. The driver tried to keep the vehicle engine at low revs, used deceleration of the vehicle and engine braking. The driver used only the first four gears.

B The engine of the vehicle was warmed up to the operating temperature. The driver tried to keep the vehicle at a low speed and turned on the cruise control when driving at the constant speed. He used only the first four gears.

C The engine of the vehicle was warmed up to the operating temperature. The ride was dynamic and the driver kept the vehicle at higher speeds. He used only the first three gears.

D The driver tried to drive the vehicle economically as described in section A. The only difference was that he started to drive as soon as he turned the engine on – the cold start [7] and [8].

The measurement results are in Table 2.

The results of the measurements Table 2

Section	Distance from start [km]	Average fuel consumption of the vehicle from the start, depending on driving techniques of driver [l/100 km]			
		A	B	C	D
1	0.1	16.2	15.1	17.9	27.6
2	0.6	6.5	6.5	7.4	8.1
3	0.9	5.5	5.5	6.5	6.2
4	1.2	5.1	5.0	5.9	6.0
5	2.0	6.7	6.6	7.4	7.5
6	3.0	5.2	5.1	5.5	5.6
7	3.5	5.4	5.2	5.5	5.7
8	4.2	4.8	4.8	5.3	5.4
9	4.4	4.8	4.7	5.4	5.2
10	4.9	4.8	4.6	5.4	5.2
11	5.6	4.8	4.7	5.3	5.2
12	6.1	4.9	4.8	5.4	5.4
13	6.6	4.8	4.7	5.3	5.3
14	7.6	4.9	4.7	5.3	5.3

4. Discussion of results

The results show that the lowest average fuel consumption was achieved when using the cruise control. Using this driving technique, the driver saved 0.2 litres of fuel per 100 km. The cruise control affects not only fuel consumption but it also contributes to road safety. While using the cruise control the driver doesn't have to watch the speedometer to make sure he doesn't exceed speed limit. This will enable him to give more attention to the other cars and to what is happening on the road and, therefore, to drive more carefully. Cruise control is automatically deactivated when the vehicle brakes, so there is no damage risk for the engine. However, it is necessary to be careful when changing the speed gears, because some cruise controls are unable to react to this and so the engine speed is increased unreasonably. If we compare the fuel consumption of driving at higher speeds and using only the 1st, 2nd and 3rd gear to the economical driving, the consumption increased by 0.4 litres / 100 km. When we compare it to the driving with the cruise control, the difference is 0.6 litres / 100km. The driver increased the dynamic potential of the vehicle but it was totally unnecessary. In addition to increased consumption, higher engine speed also means increased noise of the vehicle.

To measure differences in consumption we also looked at the driving with cold engine. The overall average fuel consumption of the vehicle was similar to the situation when the driver kept the engine at higher speeds by using only the 1st, 2nd and 3rd gear. In this case very significant is the increased average fuel consumption of the vehicle in the first three kilometres. After accomplishing this distance the vehicle engine was warmed up to the operating temperature and started to work economically.

The manufacturer of tested vehicle determines that fuel consumption is 7.8 litres / 100 km in urban mode.

5. Conclusions

Our measurements proved that the driver can significantly influence the consumption of his car by using different driving techniques.

If we compare the economical driving technique to the driving with the cruise control, the vehicle consumption was 0.2 litres / 100 km higher and it means increase by 4.3 %.

In the case of dynamic driving the vehicle consumption was 0.6 litres / 100km higher. It means an increase by 12.8%.

Cold start driving is a different case. The vehicle showed significantly higher fuel consumption on the first sections. This fact is even more serious because the catalyst vehicle begins to work with a time lag and the exhaust system emits unregulated emissions into the environment. Driving on short distance brings increased fuel consumption, but it also leads to increased production of emissions.

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Jan Zamecnik - Juraj Jagelcak - Sven Sokjer-Peterssen *

COMPARISON OF ACCELERATION ACTING ON CARGO IN FRONT AND IN REAR PART OF SEMI-TRAILER DURING BRAKING WITH AND WITHOUT USING THE SYSTEMS ABS/EBS

This article deals with braking tests of semi-trailer truck in forward and rear driving direction. It compares the accelerations and angular velocities in the front and rear part of the semi-trailer and their influence on forces in lashing points when using front lashing. The paper also contains a comparison between forces reached in the lashing points at the rate of cargo weight between the braking tests of semi-trailer and similar braking tests of a van. The first part of the paper contains also possibilities of using tracking devices for detecting accelerations acting on cargo in semi-trailer during transport.

Keywords: *Braking tests, semi-trailer, forces in lashing points, front lashing, accelerations, tracking devices.*

1. Introduction and possibilities of using tracking devices for measurement of accelerations in cargo space

Wrong cargo securing causes a lot of damages on cargo and also traffic accidents in the worst cases. Transport of heavy cargo such as coils, metal rolls or rods is the most risky [1]. Damages on cargo are caused mostly by intensive braking, maneuvering and too high speed on penetrated carriageways. High accelerations occur not only in longitudinal axis owing to the braking (in forward and rear driving direction) but also in vertical axis, mainly when a vehicle rides fast on penetrated carriageways. This also has to be considered for cargo securing. These accelerations are different in front and rear part of semi-trailers and this is needed to take into account when proposing the cargo securing in semi-trailer trucks. Dynamic stress during transport and insufficient cargo securing may cause damages either on cargo or vehicle itself as a result of cargo movement, fall or collapse of pallet units [2]. In practice, if the cargo arrives damaged but no traffic accident happened, it is very difficult to prove, where and why the hidden damages on cargo occurred and who is responsible for them. At present, technical equipment such as cameras and tracking devices, which are often used in road transport, can help to improve an investigation of circumstances, where, how and why the damages caused by improper cargo securing happened. Simple analysis of GPS data about positions and speed is not very reliable for detection of intensive braking, mainly if device with lower frequency of coordinates acquiring is used (1 Hz is well for tracking and tracing, but not for reliable detection of braking parameters) or the data are from places with low quality of GPS signal such as mountain valleys and city industrial zones where roads are placed next to steel buildings [3]. Tracking devices equipped with accelerometers and other sensors (sensors of temperature, humidity, door contact, gyroscopes etc.) are also available today. Such devices can be used for complex recording of conditions acting on shipments during transport. Data from tracking devices are one of important inputs to logistic information systems [4]. Data from various sensors are usually not transmitted continuously during whole transport, but they are downloaded after the transport is finished. Analysis of these data provides better overview, whether the required conditions during transport were followed. Integrated accelerometers and gyroscopes allow an accurate detection of accelerations and angular speeds acting on cargo during whole transport. Moreover, some of such devices allow an automatic evaluation of accident situations with sending a message about them to dispatching center [5 and 6]. Such devices are suitable mainly for monitoring of transports of valuable and fragile cargo as well as transports of dangerous goods, because they are more expensive [5 and 7].

Devices intended for tracking and tracing of containers and other intermodal transport units have to be equipped also

* [1]**Jan Zamecnik,** [1]**Juraj Jagelcak,** [2]**Sven Sokjer-Peterssen**
[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]MariTerm AB, CEO, Hoganas, Sweden
E-mail: jan.zamecnik@fpedas.uniza.sk

by satisfying battery capacity because such transports may last several weeks and no external source of energy is available usually [5 and 8]. Moreover, portable tracking devices are recommended also to improve the security. Using of two independent tracking devices in road vehicles, where one out of them should be placed in hidden place at the cargo space, is recommended because it brings a possibility of tracing of stolen vehicle also when GPS jammer is used in its truck cabin (it is common in cases of hijackings). Such portable tracking device should be placed in the rear part of semi-trailer [9]. If the device is also equipped with accelerometers, it can also be used for measuring the accelerations acting on cargo during the transport. Cargo in the rear part of semi-trailer is usually exposed to higher dynamic stress, which is also confirmed by our following research.

2. Measurements of accelerations during braking tests of semi-trailer

This paper deals with braking tests which were done with a semi-trailer truck and compares the accelerations reached in axes x, y and z in different parts of the semi-trailer. It also describes the influence of intensive braking on forces in front lashings used for cargo securing. A description of the semi-trailer truck used for these braking tests is given in Table 1.

The following equipment (incorporated to the Centre of Excellence for systems and services of intelligent transport at the University of Zilina [11]) was used for measuring of accelerations and angular velocities during the braking tests:

- XL meter™ Pro of University of Zilina[1]
- VDSU™ of University of Zilina[2], a sample rate of 200 Hz was used for evaluation of these tests. The placement of its two measuring units during the front and rear braking tests is shown in Fig. 1.

Description of semi-trailer truck used for braking tests — Table 1

Tractor	DAF FTXF H4EN3
Semi-trailer	Wielton NS3K
Curb weight of tractor	7 550 kg
Curb weight of semi-trailer	6 700 kg
Weight of cargo	12 100 kg
Total weight of semi-trailer truck	26 350 kg
Weight on axles in front braking tests	Tractor - front axle 6 550 kg, rear axle 9 040 kg Semi-trailer - tri-axle 3 x 3 590 kg
Weight on axles in rear braking tests	Tractor - front axle 6 330 kg, rear axle 7 540 kg Semi-trailer - tri-axle 3 x 4 160 kg
Cargo	6 coils of steel wire, each of them weighing about 2 000 kg
Floor in semi-trailer	Anti-skid plywood
Road surface used for braking tests	Dry asphalt with roughness on the road, placed askew to the driving direction before the braking place [10]

Source: Authors

The forces in the two front lashings securing the two foremost coils of wire were measured in these braking tests by four load cells. The combined weight of the two coils was 4 040 kg. The distribution of the cargo is shown in Fig. 1. Different load set up was used for braking tests in forward direction and braking tests in the rear direction. Ten braking tests were done in forward driving direction from initial speed 35 - 40 km/h (except tests No. 9 and 10 where braking was initiated at speeds 31 and 27 km/h respectively). Out of these tests 1 to 4 were done with the systems ABS and EBS on and braking tests 5 to 10 with these systems off. Nine braking tests in rear driving direction from initial speed 11 - 12 km/h were also done, where the tests 1 to 4 were done with the systems ABS and EBS on and tests 5 to 9 with these systems off. The placement of the lashing points 1 to 4, in which the forces acting during braking were measured, is shown in Fig. 1. Lashing points No. 1 and 2 were behind the secured cargo and lashing points No. 3 and 4 were ahead of secured cargo, closer to the front end of semi-trailer.

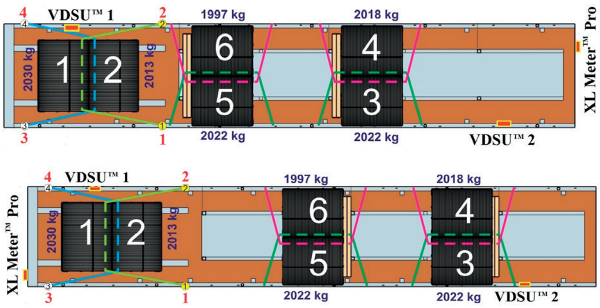

Fig. 1 Distribution of cargo, lashing points and measuring equipment during the forward braking tests (upper figure) and braking tests to the rear (lower figure). Source: Authors

3. Braking tests of semi-trailer truck in forward driving direction

The results of the braking tests in forward direction are given in Table 2 below. The data about the braking time, braking track, initial speed and mean fully developed deceleration (MFDD) were measured by the XL meter™ Pro device, except in tests No. 6 and 10, where the data from this device were not available, and therefore were replaced by calculated data from VDSU™ from

[1]http://www.inventure.hu/xl_meter_en
[2] http://www.inventure.hu/vdsu_en

Results of the braking tests in forward direction Table 2

Braking test	Braking time [s]	Initial speed [km/h]	Braking track [m]	MFDD [g][1]	Acc x in front part from VDSU™ [g][2]	Acc x in rear part from VDSU™ [g][3]	Acc x in rear part from XL meter™ Pro [g][3]	Forces SN1 + SN2 [daN][4]	Forces SN3 + SN4 [daN][4]
Braking tests with systems ABS and EBS on									
1	2.65	40.03	16.57	0.506	-0.503	-0.592	-0.604	970	308
2	2.54	41.01	15.53	0.537	-0.516	-0.599	-0.607	949	307
3	1.62	36.34	8.76	0.673	-0.712	-0.782	-0.795	1 525	702
4	1.78	35.34	9.81	0.652	-0.674	-0.752	-0.760	1 298	713
Braking tests with systems ABS and EBS off									
5	1.74	36.03	9.22	0.679	-0.726	-0.870	-0.803	1 491	616
6[5]	2.05	40.85	13.85	-	-0.689	-0.791	-0.689	1 356	540
7	1.98	40.91	11.89	0.659	-0.704	-0.839	-0.777	1 456	450
8	1.86	35.73	10.35	0.653	-0.620	-0.639	-0.729	1 184	498
9	1.56	31.45	7.64	0.702	-0.647	-0.765	-0.769	1 421	596
10[5]	1.485	27.17	7.3	-	-0.580	-0.690	-0.577	1 147	423

1 - MFDD was measured by the device XL meter™ Pro in the rear part of semi-trailer

2 – there are stated maximum accelerations reached during the braking in the front part of semi-trailer averaged in time of 80 ms

3 - there are stated maximum accelerations reached during the braking in the rear part of semi-trailer averaged in time of 80 ms

4 - there are stated maximum forces reached in particular braking tests

5 – data about the braking time, braking track and initial speed from the tests No. 6 and 10 are from the device VDSU™

Source: Authors

measuring unit 1 placed in the front part of semi-trailer. Accuracy of the data about the initial speed was verified by comparison with GPS data from device Garmin Virb Elite.

From the data in Table 2 above, it can be concluded that when the braking tests were done without using the systems ABS and EBS, the maximum reached values of braking deceleration (acting during 80 ms) were higher, especially in the rear part of semi-trailer. In two of these cases (No. 5 and 7) the deceleration reached (and according to the data from the VDSU™ even briefly exceeded) the value 0.8 g, which is the dimensioning acceleration specified in the standard EN 12 195-1:2010 [12] for calculation of cargo securing to prevent the movement in the forward direction. The accelerations acting on the cargo in the transverse axis y reached not more than 0.2 g in the rear part of semi-trailer. In the front part of the semi-trailer they were insignificant, about 0.05 g only. The diagram in Fig. 2 compares typical run of acceleration in longitudinal axis in the front and rear part of semi-trailer during braking.

The acceleration in the vertical axis z was oscillating during the braking and its values in the front part of semi-trailer did not exceed 0.2 g. In the rear part of semi-trailer this level was exceeded in braking tests 1, 3, 7 and 8, whereas the maximum measured value was 0.355 g in the braking test No. 8. However, higher vertical accelerations were measured before and after the braking. Before braking the semi-trailer truck drove across a roughness on the road, placed askew to the driving direction[3]. When the semi-trailer truck drove through it, the vertical acceleration ranged from -0.4 g to +0.4 g in the front part of semi-trailer and from -0.3 g to +0.3 g in the rear part of semi-trailer. Also after the vehicle stopped, vertical accelerations reaching about 0.6 g were generated in the rear part of semi-trailer. The plot of acceleration along the vertical axis before, during and after the braking is given in Fig. 3[4].

In Table 3, the average values are given for the maximum accelerations with a duration of at least 80 ms along axis x in the front and rear part of the semi-trailer, both for the braking tests with the systems ABS and EBS (tests No. 1 to 4) applied and without using these systems (No. 5 to 10).

[3] according to the requirements of the standard EN 12 642 for braking tests [10]

[4] differences up to +/- 0.1 g from stated peak values of accelerations in vertical axis were measured in particular braking tests

Average maximum reached values of acceleration in axis x acting for the time of 80 ms in the front and rear part of the semi-trailer Table 3

	Acc x in front part from VDSU™ [g]	Acc x in rear part from VDSU™ [g]	Acc x in rear part from XL meter™ Pro [g]
Braking tests with ABS, EBS	-0.601	-0.681	-0.692
Braking tests without ABS, EBS	-0.661	-0.766	-0.724

Source: Authors

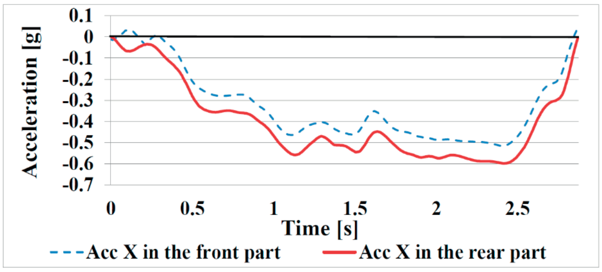

Fig. 2 Comparison of the acceleration in axis x in the front and rear part of the semi-trailer during braking in the braking test No. 2. Source: Authors

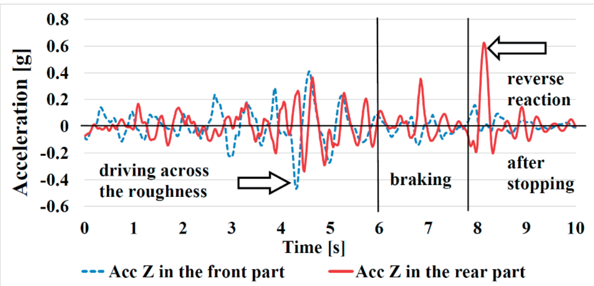

Fig. 3 Plot of the vertical acceleration (acc z) during the braking test No. 8. Source: Authors

The angular speed pitch (rotation around the transverse axis y) was also observed during the braking tests. High values of this angle speed were measured in the forward braking tests No. 5 to 8. The measured pitch ranged from 30 to 60 degrees/s (in the time of 80 ms) in the rear part of semi-trailer and acted downwards during the braking and upwards after the vehicle came to a stop. No intensive movement was observed in the front part of the semi-trailer. The pitch did not exceed 4°/s there. In the other forward braking tests the pitch values during braking and after stopping ranged from 2 to 5°/s both in front and rear part of the semi-trailer.

The lashing points No. 1 and 2 were during the braking stressed by increased lashing forces. The maximum combined lashing forces reached from 949 to 1 525 daN. The lashing force peaked simultaneously with the acceleration in the x-axis in the front part of semi-trailer, which points out the correlation between the accelerations reached during the braking and the forces in lashing points. The plot of forces was, after an initial period of increasing, relatively flat and the differences between maximum and average forces in lashings during the braking were not more than 15 %[5]. After the vehicle stopped there was a reverse reaction during which the forces in the lashing points 1 and 2 decreased almost to zero and the lashing points 3 and 4 became stressed by forces, the maximum sum of which reached 307 to 713 daN.

This means that lashing points 1 and 2 were stressed by the force equivalent to 25 - 38 % of cargo weight during braking and lashing points 3 and 4 were stressed by the force equivalent to 7 - 18 % of cargo weight during the reverse reaction after the vehicle came to a stop. For comparison, in similar braking tests which were done with a van, where the braking deceleration typically reached between 0.8 - 1.0 g, higher peak values of forces stressing the lashing points were observed. It means that the forces reached for a short time higher values than the average values of them during whole braking[6]. This occurred mainly when the slippery surface was used under the cargo and the braking was done from high initial speed. In braking tests performed with a van from initial speeds of 35 - 40 km/h (as is similar to the initial speed of these braking tests), the maximum peak values of forces reached about 78 % of cargo weight and the average values of forces were about 72 % of cargo weight when using a surface with friction coefficient 0.28 under the secured cargo. But when higher initial speed, from 60 to 90 km/h, was used in the braking tests with the van, peak values of forces in lashing points 1 and 2 equivalent to 114 % of cargo weight were observed and the average forces during braking were about 90 % of cargo weight. When a surface with higher friction coefficient (0.36) was used under the cargo, the peak values of the forces decreased significantly but their average values decreased only slightly. Plastic floor used in some of vans has lower friction coefficient (about 0.3) than wooden floor and anti-skid pads applied on it are not so efficient as when they are applied in contact with metal or wooden surface [13].

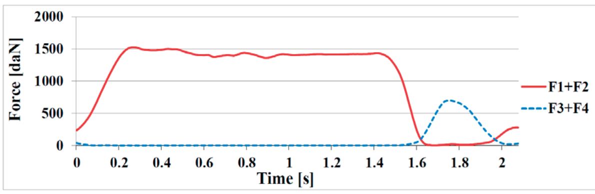

Fig. 4 Plot of forces in the lashing points 1+2 and 3+4 in the braking test No. 3. Source: Authors

[5] means: during settled phase when the forces acted, excepting increasing of forces at the beginning and decreasing of them at the end, see Fig. 4

[6] excepting main increase of forces at the beginning of braking and main decrease at the end of braking

A plot showing the forces in the lashing points during the braking and after stopping the semi-trailer truck is presented in Fig. 4 below.

4. Braking tests of semi-trailer truck in rear driving direction

Results of the nine braking tests in rear driving direction are presented in following Table 4.

In all braking tests in rear direction, accelerations exceeding 0.5 g for a duration of at least 80 ms were observed, both in the front and rear part of semi-trailer. The acceleration of 0.5 g is the level specified in the standard 12 195-1:2010 for calculation of cargo securing to prevent its movement in rear direction. We measured values of acceleration in the rear direction from 0.51 to 0.67 g in the front part of the semi-trailer and from 0.55 to 0.70 g in the rear part of the semi-trailer. Transverse accelerations did not reach high values and did not exceed 0.15 g in the front part of semi-trailer and 0.05 g in its rear part. Higher accelerations in comparison with the braking tests in front direction were measured in vertical axis z, in one case they exceeded 0.5 g. However, any higher vertical accelerations were not found out before braking and after the stopping as it happened in the braking tests in front direction. Higher values of vertical accelerations were recorded in the rear part of semi- trailer than in its front part. The angular pitch speed, meaning rotation around transverse axis y, reached 2 - 3°/s upward during the braking and 4 - 6°/s downward during the reverse reaction when the vehicle stopped in the rear part of semi-trailer. In the front part of semi-trailer the vertical movement was 1 - 3°/s during the braking and 2 - 5°/s during the reverse reaction after the stopping.

Table 5 presents average values of maximum accelerations acting in axes x and z with a duration of 80 ms in the front and

Results of the braking tests in rear driving direction

Table 4

Braking test	Braking time [s]	Initial speed [km/h]	Braking track [m]	MFDD [g][1]	Acc x in front part [g][2]	Acc x in rear part [g][3]	Acc y in front part [g][2]	Acc y in rear part [g][3]	Acc z in front part [g][2]	Acc z in rear part [g][3]
Braking tests with systems ABS and EBS on										
R1	0.78	11.85	1.25	-0.517	-0.592	-0.606	0.141	-0.049	0.421	0.556
R2	0.77	12.29	1.37	-0.533	-0.592	-0.596	0.149	-0.035	0.246	0.336
R3	0.8	11.65	1.32	-0.524	-0.572	-0.591	0.140	-0.023	0.291	0.352
R4	0.81	11.7	1.35	-0.490	-0.507	-0.553	0.144	-0.026	0.177	0.252
Braking tests with systems ABS and EBS off										
R5	0.85	11.65	1.54	-0.466	-0.570	-0.589	0.131	-0.020	0.300	0.371
R6	0.81	11.76	1.5	-0.488	-0.643	-0.678	0.106	-0.021	0.286	0.435
R7	0.99	11.43	1.89	-0.407	-0.587	-0.598	0.143	-0.021	0.272	0.404
R8	0.86	11.53	1.56	-0.441	-0.578	-0.592	0.121	-0.023	0.288	0.388
R9	-	-	-	-	-0.673	-0.697	0.128	-0.022	0.266	0.408

1- MFDD was evaluated by XL meter™ Pro placed in the front part of semi-trailer

2- there are stated maximum accelerations reached during the braking in the front part of semi-trailer averaged in time of 80 ms

3- there are stated maximum accelerations reached during the braking in the rear part of semi-trailer averaged in time of 80 ms

Source: Authors

Average maximum values of acceleration in axes x and z acting for the time of 80 ms in the front and rear part of the semi-trailer

Table 5

	MFDD [g]	acc x		acc z	
		in the front part [g]	in the rear part [g]	in the front part [g]	in the rear part [g]
Braking tests with ABS, EBS	-0.516	-0.566	-0.586	0.283	0.374
Braking tests without ABS, EBS	-0.451	-0.610	-0.631	0.282	0.401

Source: Authors

rear part of semi-trailer, both from braking tests with systems ABS and EBS on (braking tests 1 to 4) and with these systems off (braking tests 5 to 9). Although the MFDD values were lower in the braking tests without using the systems ABS and EBS, the maximum values of braking deceleration exceeded 0.5 g.

During the braking tests in rear direction the maximum combined forces in front lashings in lashing points 3 and 4 were from 600 to 1 100 daN, which is an equivalent of 15 - 28 % of cargo weight. These forces acted in the rear direction. During the reverse reaction after the stopping, lashing points 1 and 2 were stressed by combined forces of 500 - 900 daN in the forward direction, which is equivalent to 13 - 22 % of cargo weight. The highest forces in the lashings were reached during the first two braking tests. For comparison, in the similar braking tests with a van where a surface having friction coefficient 0.28 was used under the cargo the maximum combined forces in lashing points 3 and 4 reached an equivalent of 68% of cargo weight, and the average values (except the start of the force increase) were 61 % of cargo weight. Initial speed of braking in the van braking tests was about 15 km/h. When the surface with a friction coefficient 0.36 was used under the cargo, the average forces in lashing points 3 and 4 decreased to 38 % of cargo weight. Lashing points 1 and 2 were stressed by force equivalent to 23% of cargo weight when the surface with friction coefficient 0.28 was used and 14 % of cargo weight when the surface with friction coefficient 0.36 was used [13].

5. Conclusion

The main result of these braking tests is that higher accelerations in axes x and z are reached in the rear part of a semi-trailer than in the front part. Also the angle speed pitch (rotation around transverse axis y) reached higher values in the rear part in general, especially when the braking tests were done without using the systems ABS and EBS. However, in some cases of braking tests in front direction it also reached very high values. The highest forces in the lashing points, reaching about 38 % of cargo weight, were measured in the cases when the highest accelerations were reached in the front part of semi-trailer, where the monitored part of the cargo was placed. In two of the forward braking tests which were done without using the systems ABS and EBS, acceleration in axis x reaching or slightly exceeding 0.8 g, which is the dimensioning level specified in the standard EN 12195-1:2010 for calculation of cargo securing to prevent its movement in front direction, was observed. In the braking tests with the systems ABS and EBS applied this level was not exceeded. But the analogical level 0.5 g specified for cargo securing to prevent its movement in rear direction was exceeded in all 9 rear braking tests. The results of these braking tests confirm that higher accelerations and angle speeds acting on the cargo are needed to be considered in the rear part of a semi-trailer than in the front part for the securing of cargo. Tracking devices equipped with accelerometers can be used for recording of accelerations acting on cargo during the transport, which is useful to check, whether the required conditions during transport were followed and for investigation in case, if some damages on transported cargo occurred.

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Milos Poliak - Lenka Komackova - Stefania Semanova - Salvador Hernandez - Marek Jaskiewicz *

DEFINING THE INFLUENCE OF THE SUPPORT OF BUS SERVICE ON ROAD SAFETY

The paper deals with the relationship of increasing road safety through the support of bus service. The objective of the paper is to analyse the factors affecting road safety. Subsequently, the impact of the bus service support on road safety is expressed through those factors. The paper highlights the multiplier effect of the bus service support on road safety increase. First part of the paper analyses factors affecting road safety. The factors are divided into three groups in terms of infrastructure, vehicles and drivers. Further part emphasizes the possibilities for improving individual factors under the support of bus service. The last part of the paper processes a theoretical model which reflects the impact of the bus service support on increasing road safety.

Keywords: *Transport, accidents, safety, driver, vehicle, infrastructure.*

1. Introduction

Road safety represents an all-society problem not only in the EU but also in non-member states of the EU [1]. The number of persons killed per 100 000 population represents a value higher than 2 persons per year depending on the EU member state [2]. Many authors agree, e.g. Koorntra et al. [3] or Subramanian [4], the safety of road transport is improving because of the decrease of the share of killed persons in road traffic. However, the number of traffic accidents and particularly the number of fatalities is significantly higher than the aim specified in strategic documents of the EU [5].

So far, all measures aimed at increasing road safety have been focused on infrastructure, vehicles and drivers. Road safety in relation to infrastructure was increased through increasing capacity of infrastructure. However, the increased infrastructure capacity often results in further increase of traffic flow which causes additional requirements for the capacity increase. Particularly in the urban areas, possibilities for increasing the infrastructure capacity are limited. Measures aimed at vehicles improve technical equipment which increase safety of vehicles for passengers as well as the surroundings of vehicles (e.g. ABS components, airbags, and crumple zones of vehicle). By improving technical equipment of vehicles, however, drivers drive more risky because they rely on this equipment. The smallest share of attention is currently devoted to the third factor which is driver behaviour. Various courses on road safety are recently organized but public authorities try to control the compliance with safe driving only by direct road checks. The aim of the paper is to point out that the positive effect on road safety can be achieved through significant support of bus service. The authors of the paper try to prove the hypothesis that the support of bus service has a multiplier effect which is reflected in the change of all three groups of the factors affecting road safety.

2. Factors affecting the road safety

Road safety is affected by many factors. According to Evans [6], Elvik et al. [7] or Hakkert and Gitelman [8], the most important factors are: driver's behaviour, vehicle construction and infrastructure conditions. Based on the analysis of existing scientific outputs, individual elements of those important factors affecting road safety are defined in Fig. 1.

Based on the extensive analysis, Evans [6] states that all factors are important but the driver behaviour seems to be the most important factor with the gradual construction of motorways and highways.

Change in the quality of traffic infrastructure

Traffic engineering and operating characteristics of the road network provide the background for increase of road safety [9].

* [1]Milos Poliak, [1]Lenka Komackova, [1]Stefania Semanova, [2]Salvador Hernandez, [3]Marek Jaskiewicz
[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]School of Civil and Construction Engineering, Oregon State University, Corvallis, Oregon, USA
[3]Department of Automotive Vehicles and Transportation, Faculty of Mechatronics and Machine Engineering, Kielce University of Technology, Poland
E-mail: milos.poliak@fpedas.uniza.sk

Infrastructure	Vehicle	Driver
Speed limits	Structure (aggressive/protective)	Physical/congnitive impairment
Congestion	Mass	Fatigue
Traffic segregation/integration	Power	Drugs and medicines
Traffic calming	Conspicuity	Alcohol
Readability of the road	ABS	Risk taking (speed)
Fixed obstacles		Seat belt wearing (front/rear)
		Children seats use
		Helmet use

Fig. 1 Factors affecting road safety [Source: authors]

Elvik et al. classify traffic engineering safety initiatives in terms of road design, road maintenance, and traffic control. They find that in a global review of road engineering practices, the best safety benefit/cost investments come from separation of traffic (both direction and by vehicle type); from improved intersection design and control (left turn lanes, channelization, roundabouts at selected locations), black spot control and improvements, and improved signalling. Road maintenance practices have been found to have much lower safety impacts; the biggest safety benefits appear to be from increasing road friction and from good winter maintenance in terms of ice and snow control [7].

Vehicle safety

Vehicle design and performance attributes have two potential effects on safety: first, those aimed at reducing the risk of crashing; second, those aimed at reducing the consequences when accidents do occur.

Vehicle mass, size and speed have long been important concerns for manufacturers and for safety analysts. When accidents occur, vehicle mass and speed are two most important aspects determining accident severity and risk. Fatality risk depends strongly on the ratio of the masses of the vehicles; if one car is half as heavy as the other, the driver in the lighter car has approximately twelve times the fatality risk [10].

Accidents by nature involve rapid reduction in speed, and because vehicle occupants continue to move at the prior speed, occupancy protection devices are intended to reduce the likelihood and severity of collision. Both the integrated seat belt and shoulder harness, and even the basic safety belt, have been shown to be associated with major reductions in fatality risk [11]. In addition, airbags have been shown to be most effective when used in conjunction with seat belts.

Driver behaviour

Driver performance and driver behaviour are the biggest challenge in improving road safety [12]. Research literature finds strong safety effects for the increased use of seat belts, and control of speed. Driver education has little impact on safety [6]. Better knowing and increased enforcement of drunk driving laws has improved safety [13]. As Evans [6] notes, "The basic skills to stop, start, and steer vehicles are acquired remarkably easily and quickly. Complex higher level skills that are acquired only after many years of experience can contribute to reducing crash risk."

Based on the analysis of factors affecting road safety it is necessary to aim at the driver, driver's behaviour and skills.

The driving while intoxicated and effective control of alcohol use before driving have important role within driver's behaviour.

Ramsted [13] demonstrates that there is a correlation between the overall alcohol consumption in countries or provinces and fatal accidents rates. Yet, this correlation varies between different regions of the world and between the genders and age groups. An increase of 1l of pure alcohol per inhabitant of 15 years and above increases motor vehicle fatalities per 100 000 inhabitants for men by 0.05 in Northern Europe; 2.1 in Central Europe and 0.8 in Southern Europe, by 3.2 in the US, and 3.6 in Canada. For women, the increase in motor vehicle fatalities is generally smaller than for men. Sheehan [14] demonstrates parallel trends for alcohol consumption and percentage of fatally injured drivers and motorcycle riders with BAC of 0.5 g/l or greater for Queensland, Australia for 1982 – 2005.

The research states, that in traffic, it is possible to check a very small part of drivers despite of the fact that driving while intoxicated increases the risk of an accident. It is possible to check drivers of public passenger transport before starting working shift so increasing the share of those drivers can reduce the SPI level of driving while intoxicated.

3. Multiplier effect of support of bus service on the road safety increase

Within the support of public passenger transport it is possible to achieve change across all of the significant factors affecting the safety of road transport. Provided we proceed from the individual groups of factors and we assume that will not change the intensity of traffic flow (which implies the number of realized paths of the population), but it will increase the proportion of passengers using public transport, then it is possible for the support of public passenger transport, expect a multiplying effect on road safety.

By supporting bus service and transferring passengers to bus service, the density of traffic flow, which is expressed in number of vehicles per one kilometre of infrastructure, reduces [15]. We assume that the support of bus service decreases the density of traffic flow from H_A to H_B (see Fig. 2). The intensity of traffic flow is a function of the density that is:

$$M = f(H) \tag{1}$$

By changing the density of traffic flow it is possible to decrease the intensity of traffic flow:

$$\Delta M = f(HA\text{-}HB);\ \text{under condition } HA \leq Hopt \tag{2}$$

In case that $H_A > H_{opt}$, congestions arise on infrastructure. By transferring passengers to the public transport, decrease in the density of traffic flow would release congestions and the intensity of traffic flow would increase. Figure 1 depicts the state of change in the density of traffic flow from H'_A to H'_B. The figure also depicts speed S_{opt} which can be achieved at maximum intensity of traffic flow. Exceeding this intensity, the speed of traffic flow decreases. Therefore, zero speed and zero intensity of traffic flow is achieved at maximum density of traffic flow (H_{max}).

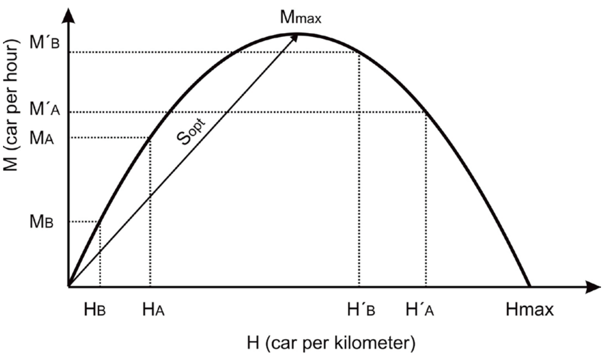

Fig. 2 Change of traffic flow intensity while changing the density of traffic flow under the support of bus service [Source: authors based on [1]]

Yannis, G. et al. [1] defined the relationship between the probability of an accident and the intensity of traffic flow. Yannis, G. et al. characterized the likelihood of an accident as a function of the intensity of traffic flow where a course of the function is dependent on the category of the road network. Courses of dependence are shown in Fig. 3. The figure includes four categories of roads (R1 – the lowest category, R4 – the highest category). The following relationship can be stated for a particular category of roads:

$$re = f(M) \tag{3}$$

Let us assume that a particular road of R1 category has the intensity of traffic flow - M_A and the probability of an accident - r_{e1A} which exceeds the acceptable value of the accident probability - r_{eacc}. In practice, such a road is usually adjusted to a higher category - R2 which leads to decreasing the accident probability from r_{e1A} to r_{e2A}. However, within urban areas, this solution is not always possible and so the decrease of accident probability can be also achieved by decreasing the intensity of traffic flow from M_A to M_B.

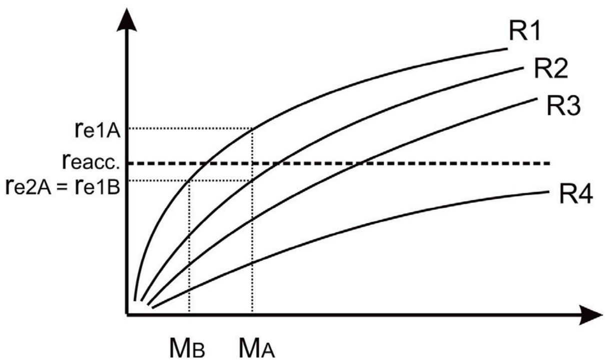

Fig. 3 Relationship between the accident probability and the intensity of traffic flow [Source: authors based on [1]]

This means that the result of the support of public passenger transport, through which the density of traffic flow would be decreased, can be expected in reduction of the risk of an accident, because the following applies:

$$\Delta re = f(MA\text{-}MB) = f(\Delta M) \tag{4}$$

under condition $H_A \leq H_{opt}$, further applies

$$\Delta re = f(f(HA\text{-}HB)) \tag{5}$$

Based on above equation, it can be concluded that the density of traffic flow decreases through the support of bus service. The reason is that there are less transport means on roads which results in increasing road safety.

While increasing the safety of road transport in the current period, most options are in the change of accident rates, in particular in connection with the driver. In supporting public passenger transport, the proportion of drivers of bus transport would increase in the total number of drivers who lead vehicles in respect of the carriage of the passenger. To an increase in the share of buses would improve the value of the following factors:

- The physical condition of the driver – the drivers of the bus have set out the conditions for the implementation of travel (e.g. Regulation (EC) No 561/2006) according to which, after a specified time of driving the driver must draw the rest. For passenger vehicles, the driver is not limited to the time of driving, which for long driving affects the reaction times of the driver and increases the likelihood of a car accident [16].

- Psychological condition of the driver – the drivers of the bus attend regular psychological checks. Given that the driver of a passenger vehicle after the issuance of a driving licence does not have to go through such checks, it is possible to assume that the drivers of the bus are in a better mental condition.
- Use of drugs, drugs and alcohol – the drivers of the bus at the beginning of their working shift are checked regularly or randomly on the ingestion of alcohol or other narcotic substances. The driver is also under the control of the driving of the vehicle through the online equipment of the vehicle or even the camera. Therefore, it is significantly less likely that drivers will drive under the influence of alcohol [17].
- Risky driving – the drivers of the bus are drivers, who have higher experience with the management of vehicles and are able to better respond in risky situations. The drivers of the buses are regularly trained on the way of safe driving with your vehicle, therefore it can be assumed that the technique of driving the driver is safer when compared to the average technique driving other drivers. In the case of a risky ride it is possible to expect the reaction of the passengers [18 and 19].

The mentioned statement may be verified by testing individual groups of drivers. To obtain reliable results, it would be necessary to test a large number of drivers. The assumption that the bus drivers are safer drivers can be confirmed based on the statistical data relating to the number of accidents from the years of 2012 and 2013. Table 1 contains an overview of the number of road accidents separately for drivers of passenger cars and drivers of buses. Responsibility for the accident was not investigated; it was substantial that the driver was a participant of the accident. Furthermore, transfer performance expressed in passenger-kilometre (pskm) was available for both transport modes over the period. The probability that a driver will be involved in an accident is necessary to calculate based on the number of road accidents and driving performance. However, Statistical Office of the SR does not measure and record driving performance for individual automobile transport. To determine the probability, the authors assume average utilization of buses at the level of 15 individuals (identified based on the Plan of transport serviceability in Zilina region - processing in 2008) and average utilization in individual automobile transport at the level of 1.5 individuals.

The average probability that a bus driver will be involved in an accident is at the level of 0.000000239. The average probability that a driver of a passenger car will be involved in an accident is 0.000000417. Based on this analysis, it can be concluded that the probability that a bus driver will be involved in an accident is lower compared to a driver of a passenger car.

Comparison of road accidents separately for drivers of passenger cars and buses [authors based on [20]] Table 1

Transport mode	**Indicator**	**2012**	**2013**
Bus service	Number of accidents	84	95
	Transfer performance (million pskm)	5 721	5 533
	Probability of an accident	0.00000022	0.00000026
	Average probability of an accident	**0.000000239**	
Individual automobile transport	Number of accidents	7 406	7 640
	Transfer performance (million pskm)	26935	27155
	Probability of an accident	0.00000041	0.00000042
	Average probability of an accident	**0.000000417**	

Based on the above mentioned, it is possible to verify the statement that the support of bus service has a multiplier effect on increasing road safety. On the one hand, it decreases the probability of a road accident through decreasing the intensity and density of traffic flow. On other hand, it increases the proportion of professional drivers whose probability to be involved in an accident is lower.

4. Conclusion

The aim of the paper was to prove the hypothesis that the support of bus service has a multiplier effect on increasing road safety. The paper confirms this hypothesis, and thus it can be stated that the support of bus service can significantly increase road safety. By increasing the number of individuals transported by public passenger transport, the multiplier effect of road safety increase can be achieved. The support of public passenger transport significantly decreases the risk of road accidents caused by drivers. Based on statistical findings, the probability of an accident caused by the professional drivers is lower by 42.7% compared to drivers of passenger cars. In addition, the risk of an accident is also decreased due to the change in intensity of traffic flow.

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Lucia Madlenakova – Radovan Madlenak – Anna Rudawska *

MODEL DESIGN OF THE INFRASTRUCTURE LAYER OF POSTAL SYSTEM

The idea and purpose of this article reside in addressing the postal system model by decomposing into independent subsystems in the form of displaying through a layered network model. Postal service is generally seen as a sequence of processes for collecting and distributing shipments for the purpose of their delivery. This service can also be defined as service guaranteeing functions in identified layers of the postal system. This allows to identify the functions and protocols for mutual communication and interoperability between different postal systems including solutions of issues of regulation.

Keywords: *Interoperability, postal system, layer model, the network layer, infrastructure.*

1. Introduction

Definition of the postal services sector, clear identification of postal markets, is not easy given the diversity and overlapping of the various categories of services. One possibility, however, is to look at these services in terms of their normative and regulative definitions. It is a typical approach to understanding postal services by dividing them into the category of universal and other services with the determination of their basic characteristics and conditions of their provision. In this sense, the postal service is characterized by a high degree of spatial and temporal availability and in regulated segment also by price affordability. Main characteristics including quality indicators are normative defined with a clear determination of the minimum standards of fulfillment. In the segment of mandatory (universal) services this fulfillment must be monitored. Normative and regulative aspects when defining and assessing the postal services are often supplemented by an analysis of the entire postal industry value chain, which includes four basic activities of the postal service. Such a definition of postal services is also obvious in the evaluation reports of the European Commission in [1 and 2] or in professional reports and discussions of many authors in [3 - 5]. It is a view on the postal services in terms of analysis of processes and sub-processes that are implemented in networks. This view has been recently significant, particularly in addressing issues of interoperability and of regulation of access to the public network. Looking for points suitable for third-party access to the postal system is closely related to the nature of the postal infrastructure and network processes. These processes are labor intensive and are also characterized by daily, direct contact with customers, which is intrinsically linked to the quality of services.

Network nature of postal services does not differ from other network systems. There is obvious overlap of common features with transport or telecommunications systems whether in the design and organization of the networks or in requirements for coverage of territory, particularly with regard to regulated services of general public interest. At a certain level of abstraction, a complex postal system can be seen in layers, as is the case of telecommunications services and systems. In both cases, when using a layered model, it is possible to consider the existence of the same input elements of system: forwarder and receiver/addressee, infrastructure as network nodes, available transmission path and means of transport as a transfer medium. It remains to determine the number of layers and functions to ensure the required communication services [6].

2. Objective and methodology

Since the service can be understood as ensuring the process to meet customer requirements on the one hand and to make a maximum legitimate profit on the other hand, postal system can be illustrated in the context of the layers. The legitimate profit is used for the growth of provider of these services. The aim of this

* **[1]Lucia Madlenakova, [1]Radovan Madlenak, [2]Anna Rudawska**
[1]Department of Communications, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Faculty of Mechanical Engineering, Lublin University of Technology, Lublin, Poland
E-mail: Lucia.Madlenakova@fpedas.uniza.sk

paper is to highlight the determination of the functions of the layers of postal system. At the same time, the paper highlights the definition of rules for communication between peer layers and determination of the interface between the layers, so that the model meets the requirements of open postal system which allows the interoperability with other systems in the functions and roles of the various layers of the postal system. Interoperability is particularly important in the network of the system, which is crucial in terms of implementing postal service. The methodology of modeling functions, tasks, interfaces and protocols is based on an analysis of principles of OSI Reference Model [7].

3. Results and discussion

Determination of the functions of each layer in the model is based on assumptions of underlying network arrangement of postal system. According to the pattern of open communication system OSI, which is standard, it is not compulsory to use a particular type of technology or equipment. It is about providing guidance on where it is necessary to ensure consistency in communication and to set the rules for the interconnection of networks. We consider the model divided into three layers (Fig. 1).

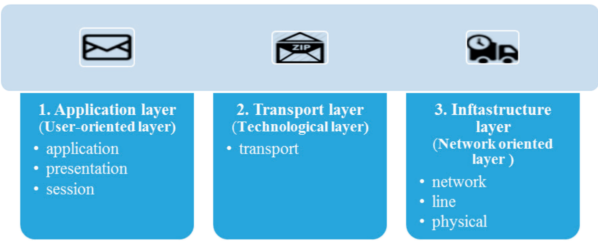

Fig. 1 Three-layer model of postal system

User-oriented layer mediates customer's contact with the postal system through equipment allowing a consignment to enter into the postal system at the collection stage and to exit from the postal system at the delivery stage. During the whole technological process of implementation of the postal services in justified cases (depending on the type of service and technology used) it is allowed to use the application services to monitor the movement of shipments. Technological layer ensures decisions on the use of appropriate techniques according to the requirements of the service provided at all stages of the postal service.

The infrastructure layer of the postal system decides about the physical transfer of shipments and provides these shipments. It necessarily covers all stages of the transfer process from the collection of consignment until its delivery. This layer provides the activities realized in stationary and mobile objects, which operate as traditional access and contact points of network (endpoints) but also as the processing centers. The infrastructure layer necessarily carries out activities related to the entry of shipments into the postal system from extraneous postal system, thus at the moment of permitted access of other postal operator to the network. In the process of transfer of shipments, infrastructure layer functions affect activities related to the use and movement of mobile device along the specified transport path. In the phase of sorting of consignments, infrastructure layer functions affect activities carried out in the processing centers, whose task is not only to sort consignments based on the tasks resulting from the technology layer of the network, but also to access the network for processing of consignments coming from external postal systems. At the delivery stage infrastructural layer works again in stationary or mobile devices. It performs activities related to the exit of consignments from the postal system [8].

3.1 Description and tasks of the infrastructure / network layer of postal system

Infrastructure (network) layer appears in terms of determining the functions of the postal system as the most important. Determination of its functions also allows the solution of important attributes relating to access and connection to the networks of individual operators or thinking about ways of construction and organization of postal transport networks.

General functions of the network-oriented part of model are:

- utilization of available infrastructure and the relevant types of transport to ensure the transport of postal substrate,
- creating of topological links between existing network nodes, creating links between two adjacent nodes,
- addressing, routing and route location of consignment/ shipping units to their destination.

Network-oriented part of layer model is actually associated with physical distribution of consignment, for which it uses existing infrastructure and real transmission medium as an operational postal rate [8].

The functions of the infrastructure layer

1. <u>Network part of infrastructure layer</u> is seen as an aggregate of equipment and physical media, which together form an autonomous entity available to the interconnection of postal systems to ensure the transport of postal substrate through the establishment of fixed route on the basis of identification element, which may be a direction sign determining the routing in each point of the network.
   - The task is to provide means for the implementation of the connection and transport of consignment between the individual postal systems.
   - It ensures the establishment of connection through a variety of configurations from simple two-point connection to a network connections supported by a complex combination of subnetworks, which are offered by a line section of the infrastructure layer.

Basic service provided to the technology layer: providing of transparent shipment so that the structure and content of the transport units of postal substrate is determined only by the layers above network layer. The network part of the infrastructure layer provides the functions necessary for hiding the differences of used transportation technologies of individual postal systems. This creates a consistent network service. Thus, the service provided at each end of the network connection is the same even if the network connection is established by means of several sub-networks with different types of processing or by various means of transport from which this connection is independent. The exception is the level of quality of individual sub-networks or means of transport.

Services provided by network part of infrastructure layer are as follows:

- transport of postal substrate in the prescribed form through selected network path,
- addressing in the network according to the identification element (identifier),
- creation of network connections from point to point,
- ensuring the quality of provided service,
- local detection of errors.

Protocol: network address - directional sign that uniquely identifies each of the end systems (to ensure access to the sub-network, or the network of other postal system).

Interface: a node in the network.

Quality: depends on agreement between the technological layer and services of infrastructure layer in selecting paths in the network, which will be the same at the endpoint as declared at the start. It is about fulfillment of parameters such as: availability, reliability, network capacity, speed, error rate. Safety: Safety services related to the provision of service of network part of infrastructure layer from one end system to another end system are the same as in providing access to the sub-network or other network [9]. In particular it is about:

- identifying the point of origin of postal substrate / consignment,
- secrecy of connections between nodes (ending nodes),
- confidentiality of transported flows,
- integrity of relocation.

2. <u>Line part of the infrastructure layer</u> provides the functional and procedural means for creation of physical connections between network nodes. It decides about joining of two adjacent nodes, and creates a network typology. Functions and services provided for network part:
   - mapping of postal substrate,
   - identification and exchange of postal substrate,
   - control of interconnection of systems - ability to manage interconnection of nodes in the physical part of the infrastructure layer,
   - detection of errors on transport units,
   - routing and transport of postal substrate between two points,
   - sorting, consolidation and deconsolidation of transport units and aggregates,
   - control of flows between nodes,
   - detecting or correcting errors that may occur in the physical part of the infrastructure layer.

Protocol: rules to control flows between nodes (transport order, postal traffic plan, timetable ...).

Quality: network capacity, the transportation time (a failure), error related to incorrect delivery of consignment and so on.

Safety: Safety protection is always carried out before the performance of the common functions in this part of the infrastructure layer: before dispatch of consignment in the flow and through ordinary layered functions - after acceptance of delivery in the next node (confidentiality of relocation) [10].

3. <u>Physical part of the infrastructure layer</u> provides the means for activating a physical - real connection of nodes in the network to ensure the transport of postal substrate between nodes in the network. The physical connection may also include other systems, each of these systems provides transportation of the postal substrate by means of the relevant transmission media (postal course) [11]. The functions in the physical part of the infrastructure layer are determined by the characteristics of used transmission medium and may be different:
   - activation and deactivation of the physical link,
   - transport of postal substrate - identification, loading and transport.

Protocol: Its role is to ensure administration and management of a physical connection (postal traffic plan, transport order, timetable...).

Interface: storehouse / loading ramp.

Quality: is derived mainly from used topological connections of nodes in the network and used transport [12]. It can be characterized by parameters:

- error rate - errors relating, for example to a loss of a consignment,
- availability of services,
- speed.

Safety: protection of the entire flow of consignments and implementation of confidentiality of flows and of connections between nodes.

3.2 Importance of infrastructure layer

In modeling of the postal system we can not only consider the use of the layer model ISO / OSI, but we can find some parallels with transport systems of which an important feature is network character and availability of offer. The demand for postal services and its incidence in terms of place of origin is likewise characterized as in transport systems and electronic communication systems. It can be said that it is everywhere, but the offer of postal services as well as transport services is given by territorial or spatial restriction, which is specified by access points in the network - postal premises, mailboxes, postal machines (postal system) or in transport stations, bus stops and so on (transport system). Some types of services in the electronic communications are available without space limit, especially in the segment of mobile services [13].

Each postal network is made up of the respective stationary and mobile installations carrying out specified functions, without which it would be impossible to ensure the full operation of the network. Tasks of mobile devices of postal network are considered as transport media. Their primary role is to ensure regular connection between stationary devices distributed in the postal network. In terms of postal services, these devices are identified as postal courses. They are steadily organized connection established by transport route, with time data about the movement of vehicles used for transport of postal substrate. Stationary devices have a fixed, stable position in the network and through them the postal system ensures customer´s requirements for individual service and carries out activities related to distribution of consignments (establishment of links between adjacent nodes) [14].

For postal systems it is typical to use hierarchical tree network configurations based on so called static route. It is the specifying of routes between regularly used network nodes, while the total set of nodes can be divided into inactive nodes, currently unused, and active nodes that are used as needed as transit points along the route. It means that in the postal transport network there are firmly established links between adjacent nodes in the network and defined routing between endpoints with the specified times of movement of the postal courses [15].

Configuration utilizing dynamic paths is typical by maximizing the flexibility of using a network structure with regard to the scope of requirements and by determining the size and solution of transport flows. The provider can choose from several connections in determining the route from point A to point B. This structure is often used when dealing with crisis situations such as unexpected interruptions in transport capacity and traffic collisions. Definition of the functions, tasks and rules for communication between different postal systems in the infrastructure part of the model permits consideration of the options for ensuring access to the postal operator network and mutual interoperability between postal systems [16].

A positive effect of the mutual interconnection of postal systems managed by different postal operators is support and strengthening of consumer interests through greater interoperability between operators. Aim of postal system interoperability is to build a monolithic block of services for users from sub-components that are technically different and are managed by their different operators. Compatibility and interoperability of the postal systems enable increasing the efficiency of the provision of services such as applying components of automation of system to which is secured an access or ensuring compliance or increasing the quality of services as required [17]. In order to pursue interoperability we should remember three basic aspects: system organization and a hierarchy scope, legislative environment and standards applied [18].

4. Conclusions

An important reason why the authors consider the postal system as the layer model is increasingly wider range of services and their penetration into the field of electronic communications, which are becoming indispensable part of the provision of postal services, in particular in the form of additional services, which are increasing the positive perception from the customer. An interesting area is the creation of hybrid products involving ICT (Information Communication Technology) in the process of collection and distribution, when a part of the chain is realized electronically. Here, there is room for discussion, especially in the area of regulation of services. Which regulatory regime should apply to these services? What regulatory authority will deal with that? Which regulatory provisions or measures are unnecessary and which, in turn, are absent?

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Milan Majernik - Naqib Daneshjo - Katarina Repkova Stofkova *

MODELING THE PROCESS OF BUSINESS MANAGEMENT SYSTEMS CONTROL

Innovative trends in production management increasingly involve implementation and auditing of standardized management systems according to ISO standards. Within the paper are presented the results of research focused on optimization of auditing system processes in the area of quality, environment and safety. There was constructed an algorithm and quantified mathematical model of integrated auditing and using Gantt chart, the visualization of annual auditing plan was realized. Verified and validated proposed model offers possibilities of its extending for the capacity management and indicators of integrated auditing processes of business management systems.

Keywords: *Modeling, control, management systems, auditing.*

1. Introduction

In the current business practice, with an increasing number of standards for the management systems implementation in organizations, increase also demands on their resources and controlling. Organizations are overloaded by ‘continuous’ auditing of their performance. Optimization of the traditional approach to audit results in the creation of methodical process of control via integrated auditing [1 and 2].

The aim of our research is to design a methodical process for optimizing the traditional auditing through integration of individual audit processes based on the requirements of ISO standards for partial aspects of management. When optimizing the traditional auditing methodologies, the methods of operational and systems analysis were used.

Research was based on the findings of the monitoring the situation of traditional (separately performed) and integrated business management systems auditing at home and abroad, as well as information gained from consultations with leading theorists and practitioners, in particular:

- lack of methodologies for optimizing management control procedures through an integrated auditing of implemented management systems in the organization,
- absence of application of management approaches in the process of integrated management systems auditing,
- undervaluation of advantages and benefits resulting from the integrated auditing in the audit practice.

2. Optimalization the processes of business management systems auditing

Starting from the formulation of issues and goals of research, detailed analysis of auditing process and possible scenarios of its development was carried out. Results of analysis served for designing the dynamic model with direct impact of input values of the model. For model designing, the methods of operational and systemic analysis were applied [3].

In the introductory phase of the model designing, the following issues have to be solved:

- analysis of the current knowledge-base,
- obtaining input data from the partial conclusions of the analysis,
- definition of the research object in measurable units,
- finding a method of mathematical description of the problem according to ISO standards,
- constructing a flowchart of auditing for the needs of model creation, determining its topology, the positions of entities and sessions between them,
- search for output data in such units that enables the comparison of output data (traditional - separated and integrated auditing).

Based on the detailed analysis of the problems and gained experiences, the model was designed and possibilities of its application in optimization of control by auditing in auditing practice were proposed.

* [1]**Milan Majernik,** [1]**Naqib Daneshjo,** [2]**Katarina Repkova Stofkova**
[1]Department of Management, Faculty of Business Economics with seat in Kosice, University of Economics in Bratislava, Kosice, Slovakia
[2]Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
E-mail: milan.majernik@euke.sk

At the beginning of creating flowchart of control audit, the audit processes and their topology were identified. Topology of the process of audit subsequently formed the input to the creation of the model.

Altogether there were identified at least 12 audit processes (Fig. 1). Determined processes are universal, applicable to all types (process, system) and forms (internal, external, certification, etc.) audits. If necessary, they can be extended to a range of other processes [4].

When developing the model, following parameters were determined:

a) Type, or form of audit - we considered the system audits of four management systems: quality management (audit 1), environmental audit (audit 2), occupational health and safety (audit 3) and information security audit (audit 4).
b) Term of audit realization (specific week of the year) - important for the model because of obligation to create the annual audit plan and because of its comprehensive approach to management.
c) Examined organizational unit of the organization - the necessary requirements for audit realization.
d) The presence of unconformities during the audit - affects the duration of the post-audit actions i.e. embedding mandatory corrective and preventive measures [3].

Generation of random numbers (Table 1) was carried out with pre-defined intervals of parameters and constants of aggregate of integers and the aggregates of logic statements [true - false]. The basis for created generator was the use of the cyclic intervals, where for each cyclic interval was performed variety of orders, or complex orders. Indexing variables were subsequently used for determining values of the above mentioned aggregates, and were via specific commands continuously stored in a text file after each cycle of the program. The number of cycles was defined by the sponsor on the basis of predetermined requirements resulting from the various ISO standards relevant for particular management systems (QMS, EMS, HSMS, ISMS) and the requirements of the model.

For the purpose of constructing a generator we used programming language Turbo Pascal 6.0, and we followed these steps:

- problem analysis,
- defining declaration section,
- defining the executive (command) section.

For the first step it was necessary to analyze the detailed topology of audit process and determine variables, constants and cycles necessary for converting the input to the searched result. When defining the declaratory part, we identified categories of variables necessary for the program performance which we monitored during verification of the designed algorithm. In the last step, we transformed the algorithm into form of commands

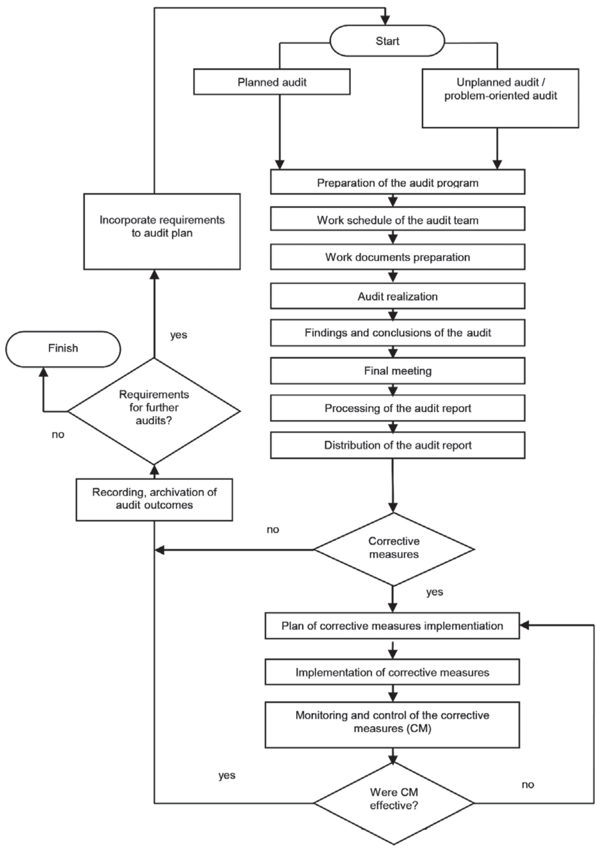

Fig. 1 General algorithm of the process of control audit

based on the structure of the programming language so that the commands comply input conditions of earlier carried out analysis of the problem.

2.1 Formalization and quantification of mathematical model

Based on requirements of ISO standards for key elements of the particular management system, we proposed a model of integrated auditing, which was created as a combination of the identified key processes of traditional auditing where optimization of the auditing process presents added value. We also focused on time saving of each audit process, which has a direct impact on reducing personnel and overhead costs, or otherwise it disproportionately increases the demand for capacity in relation to the performing of the mandatory annual audit plan of the organization.

The model is composed of two parts (Fig. 2):

- traditional approach to a separated auditing of management systems, sub-aspects
- integrated approach to auditing of management systems addressed in the first part of the model.

Generated parameters for traditional auditing and quantified input values of the model — Table 1

Type or form of audit (Vi)	Audited organizational unit (Xi)	Scheduling of audit (week) (Yi)	The occurrence of non-conformities during the audit (Zi)	Total duration of audit (days)	Total duration of audit (week)	Start of audit (week)	End of audit (week)
3	8	3	0	28	4	1	4
4	1	3	1	28	4	2	5
2	8	4	1	49	7	1	7
4	6	4	0	21	3	3	5
4	10	4	0	21	3	3	5
2	9	5	1	49	7	2	8
3	9	5	0	28	4	3	6
2	6	6	0	42	6	3	8
2	10	8	1	49	7	5	11
3	2	9	1	35	5	7	11
1	3	10	0	49	7	6	12
1	6	12	1	63	9	8	16
1	10	12	1	63	9	8	16
3	7	13	1	35	5	11	15
2	1	18	1	49	7	15	21
1	1	19	0	49	7	15	21
1	7	20	0	49	7	16	22
4	9	21	0	21	3	20	22
1	2	23	1	63	9	19	27
2	3	24	0	42	6	21	26
2	2	26	0	42	6	23	28
4	4	27	0	21	3	26	28
3	10	28	0	28	4	26	29
4	7	28	0	21	3	27	29
4	8	28	0	21	3	27	29
2	4	30	0	42	6	27	32
2	7	32	1	49	7	29	35
3	1	32	0	28	4	30	33
3	6	32	0	28	4	30	33
1	9	34	0	49	7	30	36
1	5	38	0	49	7	34	40
1	4	39	1	63	9	35	43
2	5	39	0	42	6	36	41
4	2	39	1	28	4	38	41
1	8	41	1	63	9	37	45
3	3	43	0	28	4	41	44
3	5	46	0	28	4	44	47
4	3	46	1	28	4	45	48
4	5	46	0	21	3	45	47
3	4	49	1	35	5	47	51

Both parts of the model are placed abreast, so the output drawn from different parts of the model are mutually comparable.

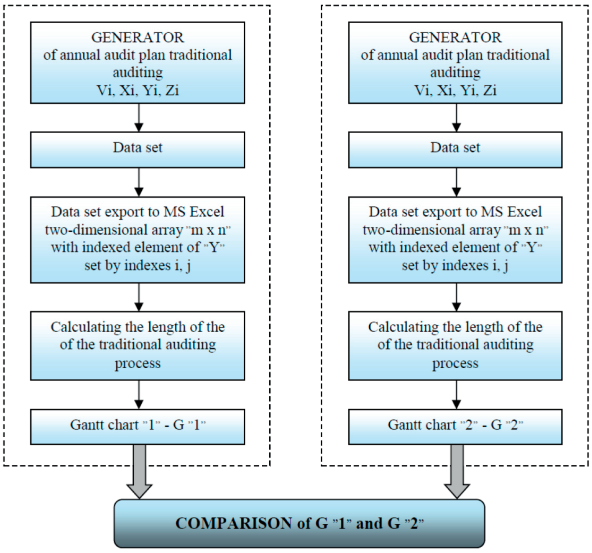

Fig. 2 Mathematical model of auditing

The basis of integrated auditing is that it is focused on auditing of individual management systems comprehensively; it is focused to the relevant auditing management systems as a whole, jointly, not separately. Model formation we realized with the support of Microsoft Office Excel, 2007.

In phase of quantification, the model was filled with concrete credible and objective data. The reliability of the data was achieved by expert estimates of their values and objectivity of data generation was achieved by using the program for generation of random numbers. Figure 2 characterizes the record and logics of model created.

Table 2 shows the total duration of formalized processes of individual audits. From the time evaluation of these processes (traditional auditing), we consequently quantified mean value, made correction of mean value for the purposes of the model, we also set a maximum and total sum of the duration of individual processes.

The model of quantified data for traditional auditing and integrated auditing expressing the relationship between these data provides several solutions, outcomes and conclusions. The first is creation of a Gantt chart of annual audit plan for traditional auditing as well as integrated auditing.

Using the Gantt chart we gained visualization of annual audit plan for both approaches to audit. The duration of each audit is shown on the horizontal axis and the vertical axis shows all planned audits, which - based on ISO standards – have to be performed during the year. The duration of the audit is shown on rectangle whose left side presents the point of the audit start and the right side presents the point of the planned end of the audit. The duration of each audit includes time assessment of the length of all 12 identified and formalized audit processes. In traditional auditing it is necessary to carry out 40 audits per year while in the case of an integrated approach to audit there should be carried out only 10 audits per year. Visualization of the annual audit plan we realized with the support of Microsoft Excel using conditional formatting functions.

Visualization of the annual audit plan for traditional auditing, showed in Fig. 3, reflects the current situation, quite common today, in the field of control via auditing of management systems. In principle, it is characterized by the fact that organizations are overloaded by continuous auditing of management systems, which have to be implemented in accordance with globally recognized standards.

Visualization of the annual audit plan within an integrated approach to auditing (Fig. 4) shows significantly reduced time requirements obtained with the newly designed methodology for establishing an annual integrated audit plan compared with the traditional approach to auditing.

Time consumption of audits and individual processes in weeks

Table 2

Process Audit	1	2	3	4	5	6	7	8	9	10	11	12
Audit 1	10	3	15	7	2	1	2	7	2	7	5	2
Audit 2	6	2	13	7	2	1	1	7	2	3	3	2
Audit 3	5	2	7	7	1	1	2	3	1	3	2	1
Audit 4	2	1	4	7	2	1	1	2	1	4	2	1
Mean	5.75	2.00	9.75	7.00	1.75	1.00	1.50	4.75	1.50	4.25	3.00	1.50
Correction of mean value for the purposes of the model	6	2	10	7	2	1	2	5	2	5	3	2
Maximum	10	3	15	7	2	1	2	7	2	7	5	2
Total	23	8	39	28	7	4	6	19	6	17	12	6

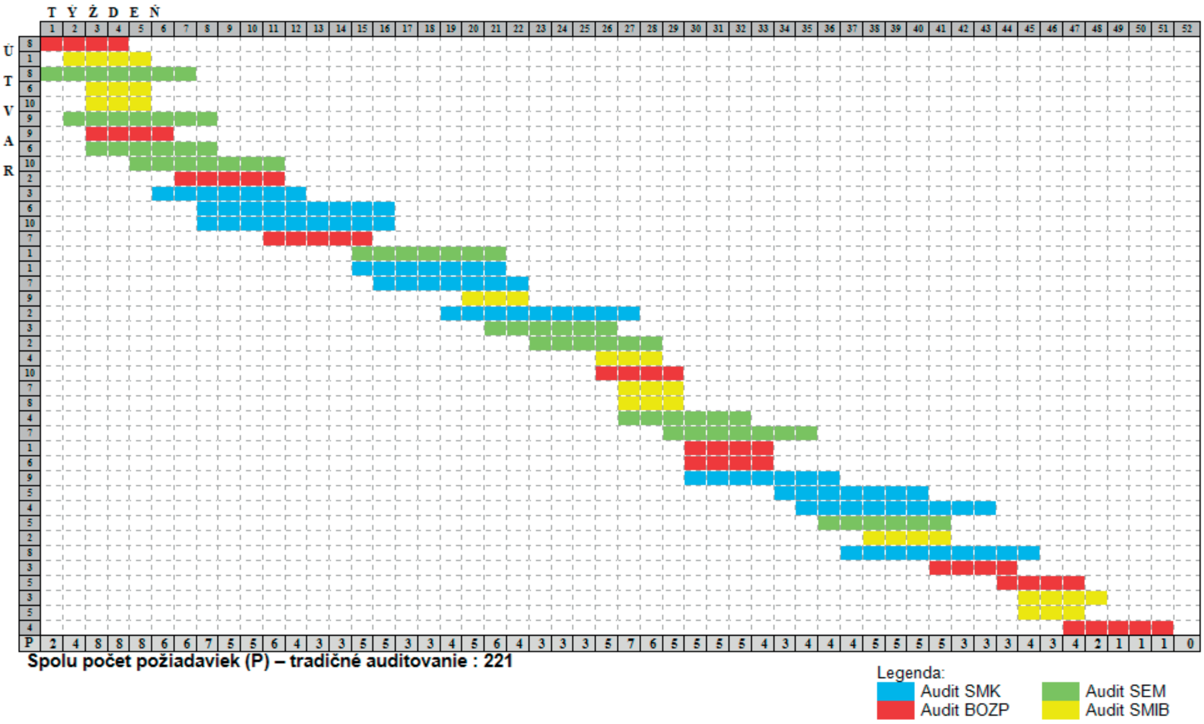

Fig. 3 Visualization of the annual audit plan, traditional auditing (G "1")

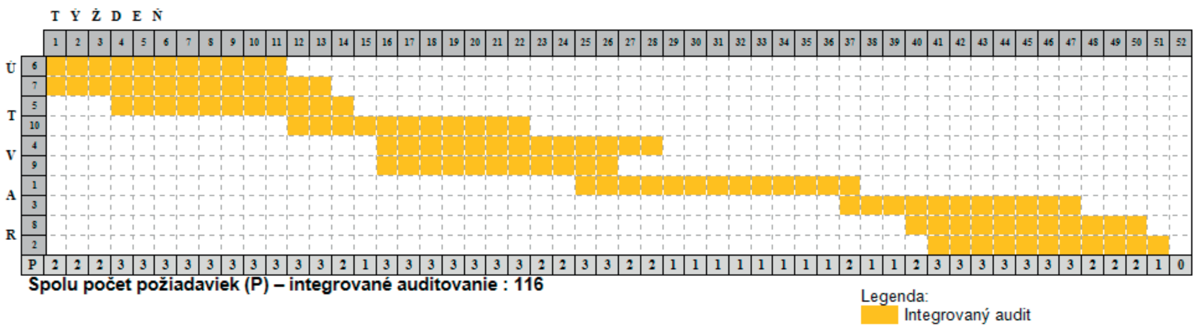

Fig. 4 Visualization of the annual audit plan, - integrated auditing (G "2")

3. Conclusion

Outgoing of analysis of traditional and integrated auditing and comparison of outcomes, we came to significant conclusions:

- by visualization of the annual audit plans we can determine which week and to what extent are audit teams work-loaded;
- traditional auditing is more capacity demanding (resources, funds, time), as shown by the total number of requirements that need to be met during the year in traditional auditing (221-conformities), whilst integrated auditing reduces total number of requirements to 116.

Based on the annual audit plan, in the traditional approach to audit there have to be carried out 40 audits per year. When quantified capability of one audit team is 5 audits per year, we will need 8 audit teams to perform all necessary audits set in annual audit plan. In case of integrated auditing, only 3 audit teams are required to meet annual audit plan. The main results of research are summarized in Table 3.

Optimization process of standardized business management systems control through audit is carried out by modeling of the integrated auditing using operational and system analysis. Management approach of issue analysis using method "per partes" can provide the required input data. Therefore, based on the methodology, data were used for searching the optima in the studied areas.

Formalization of the model and using methods of operational and system analysis, optimization steps have been proposed, Main results of research Table 3

The main areas of achievements	RESULTS	
	Traditional approach to auditing	Integrated approach to auditing
The total number of audit requirements during the year	221 requirements	116 requirements
The workload of audit teams	inefficiently adjusted working time	efficiently adjusted working time
Capacity demands	higher	lower
Working ability of one audit team	5 traditional audits per year	4 integrated audits per year
The number of audit teams necessary to implement the overall annual audit plan	8 audit teams	3 audit teams
The comparison results of the processes duration in the planning stage of the audit in relation to the total length of the individual audits - a demonstration of the importance of the planning phase of the audit	Traditional audit without corrective measures: 33% - 57% (in relation to the total length of all processes of a particular audit)	Integrated audit without corrective measures: 67.53 % of the total duration of the audit processes
	Traditional audit with corrective measures: 25 % - 44 % (in relation to the total length of all processes of a particular audit)	Integrated audit with corrective measures: 57.14 % of the total duration of the audit processes

which can serve as a tool in the application of queuing systems. By analyzing the various key elements of the model and their subsequent combination and integration, we have achieved a synergistic effect on the process of integrated management systems auditing for control purposes in Deming PDCA cycle of continuous improvement.

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Lubomir Cernicky - Alica Kalasova - Jerzy Mikulski *

SIMULATION SOFTWARE AS A CALCULATION TOOL FOR TRAFFIC CAPACITY ASSESSMENT

Every town faces many problems one of which is ensuring good traffic situation in its territory. Road network in towns is limited by density of existing buildings and every traffic increase can lead to road network overcrowding. Therefore towns have to plan the future traffic in the way the roads are prevented from occurring traffic problems. In order to prevent traffic problems within the city every larger investment plan which may have impact on traffic has to come under the traffic capacity assessment before is approved by city. This paper is focused on various tools that may be used in traffic capacity assessment of every greater investment plan. You can find comparison of Aimsun simulation outputs, OmniTrans simulation outputs, and outputs of analytical calculation according to technical regulations valid in Slovakia in this paper.

Keywords: *Delay times, traffic capacity assessment, aimsun, technical regulations, omnitrans.*

1. Introduction

Good traffic situation is one of the objectives of every town. Road network in towns is limited by density of existing buildings and every traffic increase can lead to road network overcrowding, which may result in undesirable external costs such as traffic congestions, increased fuel consumption, and higher production of greenhouse gases and noise. This all ultimately reduces the attractiveness of the area. In order to achieve traffic sustainability all greater investment projects of developers that may have impact on the traffic have to come under traffic-capacity assessment, which is standard part of the preparatory or project documentation at present. Good traffic situation is important for both sides –for the town and its inhabitants and for the developers. But methods relating to traffic-capacity assessment used in approval process of investment plans may be processed non-uniformly, they may differ in the range of processing and may reflect a subjective approach of their processors [1, 2, 3 and 4]. Therefore, there is effort of the competent authorities to establish a uniform methodology for assessing the project documentation. Bratislava gave to create the methodology with uniform traffic engineering methods in order to avoid differences in approaches to the traffic-capacity assessments of great investment projects in its territory. Similar methodology is also applied in Presov. This methodology was based on the methodology of Bratislava, but it was modified in order to suit the conditions of the town Presov.

According to these methodologies the traffic-capacity calculations are carried out with the help of analytical methods and there are 3 basic junction types [5]:

- Uncontrolled junctions, where analytical calculations are set in Slovak standard STN 73 6102 [6] and in Technical regulations TP 10/2010 [7];
- Signal controlled junctions, where analytical calculations are set in Technical regulations TP 10/2010 ;
- Roundabouts, where analytical calculations are set in Technical regulations TP 10/2010 and in Technical regulations TP 04/2004 [8].

But there is an interesting part in these methodologies, which says that traffic-capacity calculation may be supplemented or even replaced by the virtual simulation of the assumed traffic on the communication network at the solved area or affected junctions. [5] Virtual simulation can be helpful in many traffic research areas such as in public transport priority investigation [9 and 10], traffic light coordination investigation [11], or in finding optimal use of communication network [12 and 13]. Also virtual simulation has an advantage over analytical calculations mainly because of its exceptional features such as clarity, versatility, ability to implement into calculation influence of the surroundings etc. [14].

Here, we can put the question: How much do the simulation outputs correspond (are simulation outputs comparable) to the analytical methods outputs? There is outputs comparison of the analytical traffic-capacity calculation - calculation according to TP

* [1]Lubomir Cernicky, [1]Alica Kalasova, [2]Jerzy Mikulski
[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Department of Transport, Faculty of Economics, University of Economics in Katowice, Poland
E-mail: lubomir.cernicky@fpedas.uniza.sk

10/2010 and simulation methods – simulation in Aimsun [15] and simulation in OmniTrans [16] in the following part of the paper.

2. Investigation procedure

In order to compare calculation outputs and simulation outputs there were carried out calculations and simulations at the two junctions in the town of Zilina, where traffic load data were available. The junctions and traffic flows are shown in Figs. 1 and 7. The First one was used for the assessment of uncontrolled and signal controlled junctions, the second one for the assessment of roundabouts. The examination procedure was as follows:

1. Delay time calculation according to TP 10/2010 [7];
2. Model creation and simulation in Aimsun [15];
3. Model creation and simulation in OmniTrans [16];
4. All the calculations and simulations were carried out for the traffic flows:
   a. according to traffic surveys uniformly reduced by 20% (-20%);
   b. according to traffic surveys uniformly reduced by 10% (-10%);
   c. according to traffic surveys (basic state - BS);
   d. according to traffic surveys uniformly increased by 10% (+10%);
   e. according to traffic surveys uniformly increased by 20% (+20%);
5. Calculations and simulation outputs comparison.

The delay time was chosen as a comparative unit, because the delay time is obtained as an output of calculation according to TP10/2010 and of both simulation software tools.

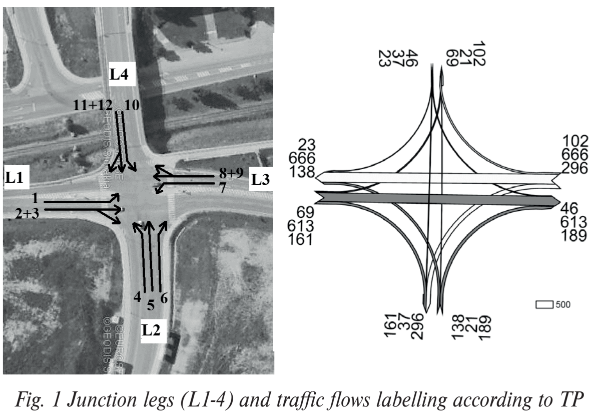

Fig. 1 Junction legs (L1-4) and traffic flows labelling according to TP 10/2010 rules (on left), traffic volume (pcu/h) during traffic peak (on right) [source: authors]

3. Results

Uncontrolled junctions

There are particular traffic flows at the uncontrolled junction, which are not obligated to give way to any other traffic flow, therefore it can be assumed that these traffic flows reach no delay times at uncontrolled junctions and it is not necessary to calculate them during assessment. These flows are represented by traffic flows No. 2, No.8 (straight movement on the main road), No.3, and No. 9 (right turnings from the main road). Other traffic flows are obligated to give way to 1 traffic flow (degree 2), to 2 traffic flows (degree 3), or to 3 traffic flows (degree 4).

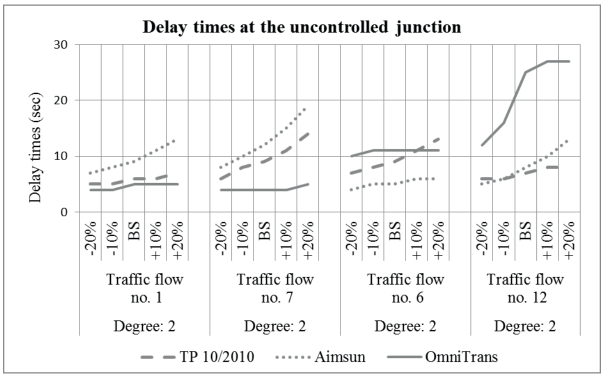

Fig. 2 Simulation and calculation outputs for the uncontrolled junction (traffic flows´ degree: 2) [source: authors]

Looking at the traffic flows which are obligated to give way to 1 traffic flow (Fig. 2) it is possible to see slight differences between analytical calculation outputs and simulations outputs, but there are also differences when outputs of 2 simulation tools are compared. The average difference between outputs of TP and Aimsun is about 3.3 sec (maximum of 7 sec), between TP and OmniTrans about 5.75 s (maximum of 19 sec), and between Aimsun and OmniTrans about 8.05 s (maximum of 17 sec).

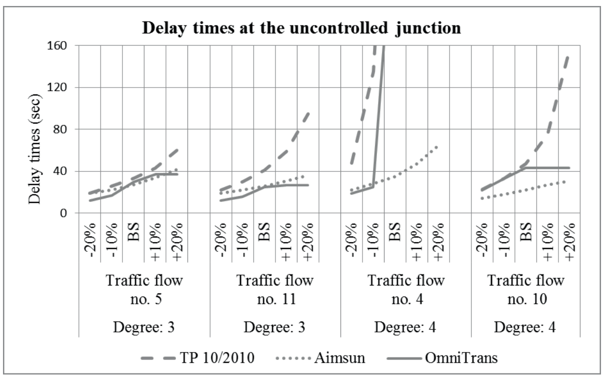

Fig. 3 Simulation and calculation outputs for the uncontrolled junction (traffic flows´ degree: 3 and 4) [source: authors]

Looking at the traffic flows that are obligated to give way to 2 traffic flows (Fig. 3, degree: 3, traffic flows No. 5 and No.11) it can be seen that increase in delay times according to TP is noticeably higher than increase in delay times according to Aimsun or OmniTrans. The difference in delay times between TP and OmniTrans for the traffic flows increased by 20% is up to 68 sec. But when we take into account the fact that delay times according to Aimsun (OmniTrans) are also higher (40 sec), relative difference between TP and Aimsun is 27.1%, between TP and OmniTrans is 63.3%, and between Aimsun and OmniTrans is equal to 26.7%.

Traffic flows which are obligated to give way to 3 traffic flows (Fig. 3, degree: 4, traffic flow No. 4 and No. 10) are the traffic flows with the highest delay times. Moreover, there are highest differences between calculation and simulation outputs. Calculation outputs according TP show extremely high delay times for the traffic flow No. 4 (up to 2012 sec when the traffic flow is increased by 20%). The outputs according to OmniTrans also show high delay times already at the basic traffic volume, but with the maximum value up to 300 sec, but the delay time 300 sec is the maximum delay time that OmniTrans can simulate. Therefore, it is possible to assume that there would be even higher delay times if the traffic flow was higher. In contrast, calculation according to Aimsun showed only slightly increased delay times – only up to the value of 65 sec. From these findings it is possible to come to the conclusion that at uncontrolled junctions:

- The more the traffic flows to which the assessed traffic flow is obligated to give way, the huger the differences between calculations and simulations outputs are;
- Aimsun gives us the lowest delay times compared to other tools;

Signal controlled junctions

These calculation and simulation outputs were supplemented with calculation according to Webster method [17] in order to put more objective view into comparison. According to the outputs (see Figs. 2 and 3), there are more significant differences between average delay times of vehicles entering the junction from the main road (Fig. 4), where delay times are lower (around 10 sec), and vehicles entering from the side roads (Fig. 5), where delay times are around 40 sec and higher. This may be caused mainly by different green, which is much longer for the main road in comparison to side roads (56 sec and 69 sec in comparison to 13 sec and 11 sec).

Delay time calculation according to Webster gives us the lowest delay time values. Also there are not significant changes in delay time in the case that traffic load decreases/increases by 20 % in any traffic flow. Even traffic flows turning left have not increased delay times values. According to this calculation it would be possible to declare that there are nearly no problems at this junction. The cars can pass through this junction with the acceptable delay also in the case that traffic load during traffic peak will increase by 20%.

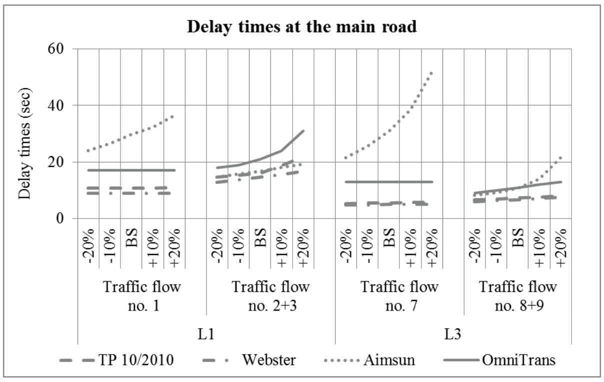

Fig. 4 Simulation and calculation outputs for the signal controlled junction (main road) [source: authors]

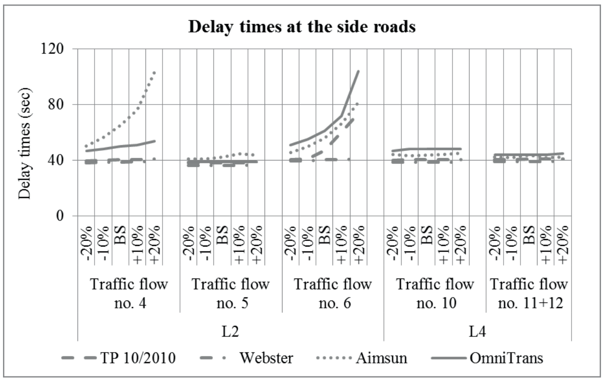

Fig. 5 Simulation and calculation outputs for the signal controlled junction (side roads) [source: authors]

Calculations according to technical regulations TP 10/2010 give us delay time values very similar to Webster´s outputs. The total average difference is only about 10 %. And also slight decrease/increase in delay time can be seen when traffic load changes and this decrease/increase is very similar to Webster´s outputs. The only significant increase compared to Webster can be seen in the delay times of the traffic flow No. 6 (see Fig. 5). According to this calculation it would be possible to point out potential problems at the junction leg L2, where right turning of the traffic flow No. 6 is expected to be problematic. Other traffic flows are expected to have no problems even when the traffic flow increases by 20%.

Simulation in Aimsun can show us significant difference in delay times at particular traffic flows in comparison to Webster and to TP 10/2010. The differences are visible mainly at the left turning traffic flows No. 1, No. 7, and No. 4, but not at the left turning no. 10 (see Figs. 4 and 5). For instance, the traffic flow No. 7 has according to Aimsun the delay time nearly 6 times higher than according to Webster calculations. At the same time, increased delay time is shown at the traffic flow No. 6, which is also problematic according to TP 10/2010. Simulation outputs for other traffic flows are similar to the outputs of other methods. According to Aimsun it would be possible to point out problematic left turnings of abovementioned traffic flows (No. 1, No. 7, No. 4) and problematic right turning No. 6.

Simulation in OmniTrans shows slightly higher delay times for nearly all traffic flows in comparison to other methods, but looking at Figs. 4 and 5, the only problematic traffic flow seems to be traffic flow No. 6, where increase in delay time is significant when traffic load is increased. Increased delay times can be also seen at other traffic flows (No. 2+3, and No. 4), but this increase is not very significant.

Roundabouts

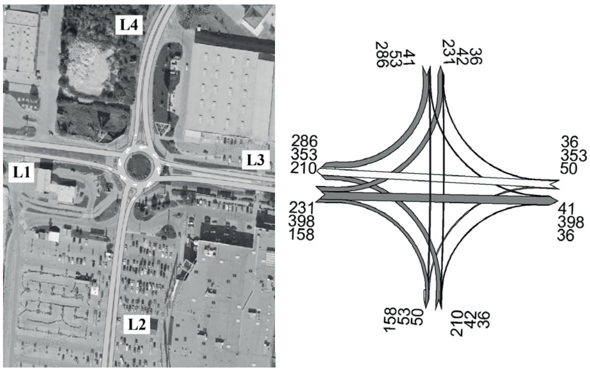

Fig. 6 Assessed roundabout (on left), traffic volume (pcu/h) during traffic peak (on right) [source: authors]

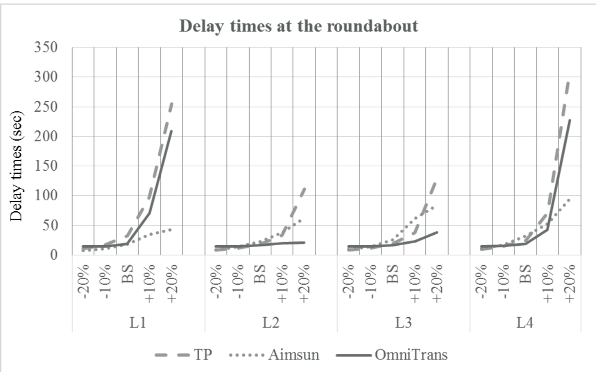

Fig. 7 Simulation and calculation outputs for the roundabout (main road) [source: authors]

Looking at the calculation and simulations outputs for roundabouts (Fig. 6) it can be stated that outputs of all tools are quite comparable when the traffic flow is low. If the traffic flow is decreased by 20%, the output values of all tools show the delay time values between 8 sec and 15 sec and the maximum difference in values between various tools is equal to 6 sec – between TP10/2010 and OmniTrans. But the differences in outputs increase when the traffic flow increases. For the basic state (present traffic volume) the differences in outputs increase to 13 sec (between TP 10/2010 and Aimsun), but for the traffic flow increased by 20% the differences in outputs increased to 211 sec (between TP10/2010 and Aimsun at the junction legs 1 and 2). You can also see in Fig. 7 that analytical calculation outputs show the highest delay time values at the all junction legs. Aimsun outputs show lower delay times than Omnitrans shows at the junction legs L1 and L4, which are the junction legs where the traffic load is relatively high, and Aimsun shows higher delay times than OmniTrans shows at the junction legs L2 and L4, where the traffic load is relatively low.

3. Conclusion

The aim of this paper was to show possibility of using the simulation tools in traffic capacity assessment. These simulation tools were compared to classical analytical calculations and to each other in this paper. Although simulation and analytical calculation were carried out for the same junctions and for the same traffic volumes the outputs of particular tools differed from each other. There were significant differences in outputs at some traffic flows and this might make contrary proposals when two different tools are used at the assessment or might create the space to influence the traffic capacity assessment outputs according to customers´ (developers´) needs. Therefore, it is possible to recommend further studies that would be focused on verification of particulars methods (e.g. delay times surveys at junctions) and which would clearly confirm the correctness or deviation of outputs from the real situation. Another recommendation is that towns (which will create methodology for traffic-capacity assessment) should pay attention on setting rules for approval/modification/rejection of the investment plan.

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Jaroslava Kubanova - Conrad Schmidt *

MULTIMODAL AND INTERMODAL TRANSPORTATION SYSTEMS

The aim of this paper is to provide information on the general characterization of multimodal transport, intermodal and combined transport. There is also mentioned the distribution of basic transport processes and types of transhipment. Finally, this paper describes the practical examples of multimodal transport.

Keywords: *Multimodal transport, intermodal transport units, transhipment, transport process.*

1. Introduction

Transport is at the foundation of any economy as it constitutes the heart of the supply chain. Without good transport networks the proper functioning of markets is impossible – particularly the European Market. Transport infrastructure investments boost economic growth, create wealth, and enhance trade, accessibility and the mobility of people. Transport is also a key ingredient for a high quality of life, ensuring accessibility and bringing people together. The transport industry is also an important component of the EU economy: when considering the whole logistic chain it directly employs around 10 million people and accounts for about 4.6 % of GDP. Furthermore, many European companies are world leaders in infrastructure, logistics, traffic management systems and manufacturing of transport equipment [1].

Transport and distribution are key considerations when planning for international trade. Choosing the right mode of transport is essential to ensure your import or export operation is efficient and cost-effective. There are four ways of importing and exporting - road, rail, air and sea - although the using more than one type of transport.

2. Modes and means of transport

There are several transport modes and means of transport (see Fig. 1). A transport mode provides the necessary infrastructure for using a certain means of transport. Without this infrastructure, no transport would be possible. The transport modes are situated on land, on the water and in the air, land transport comprises road, rail and pipeline transport, waterborne modes are inland waterway, deep sea and short sea shipping, the air mode comprises air traffic.

Means of transport are technical facilities and equipment for the transport of people or goods. Transport means in freight transport are, for example, the inland vessel, the truck or the plane. Due to the fact that transport cannot usually be handled using a single mode or means of transport, varying forms of transport have been developed, which are described as transport processes.

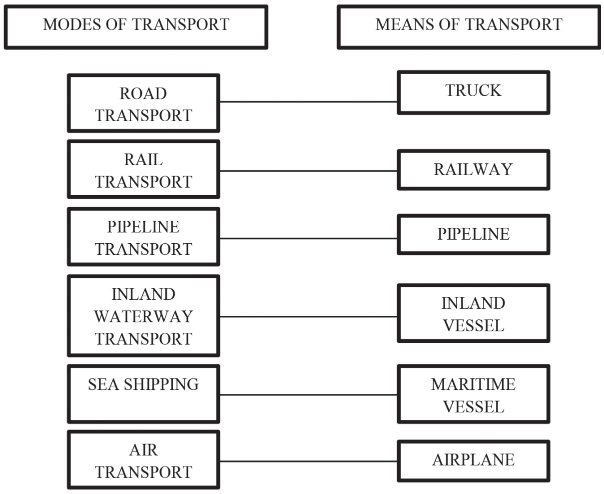

Fig. 1 Modes and means of transport [Source: authors]

3. Transport processes

Transport can be processed in several forms (e.g. either directly or by making use of several modes of transport) and it

* [1]Jaroslava Kubanova, [2]Conrad Schmidt
[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Technische Hochschule Wildau, Hochschulring 1, Wildau, Germany
E-mail: jaroslava.kubanova@fpedas.uniza.sk

is therefore necessary to specify these processes more clearly. Transport processes can be initially classified into direct and non-direct transport. In the case of a non-direct transport process, the transhipment of goods takes place, whereas in direct transport no such transhipment is needed.

In **direct transport**, goods are transported directly from a point of departure to the destination. For this reason, it is also called door-to-door transport. In this case, the means of transport (e.g. truck, vessel or railway) is not changed and there is also no change of transport mode (e.g. rail or inland waterway). Direct transport can always be classified as unimodal, goods are transferred from the starting point to the end point by one means of transport.

Multimodal transport is characterized by the transport of goods using two or more different transport modes. In order to change the means of transport, transhipment of goods is required. In doing this, the strengths of the several individual transport modes can be used and cheapest and most environmentally friendly combination can be chosen. Main characteristics of multimodal transportation are transhipment terminals that allow efficient cargo handling between short-distance and long-distance traffic as well as application of standardized and reusable loading units. However, combined freight transport can be organized in different ways. In general, trucks cover short distances between the loading area and the transhipment point or between the place of arrival and the recipient. Long-distance haulage is conducted by other means of transport such as train, ship or even plane. Multimodal transport is a very interesting approach that solves a big part of cargo mobility problems [2].

Combining private and state transport in a multimodal transport system offers the opportunity to capitalize the best rates and transit time possible.

As many understand, multimodal transport refers to a transport system usually operated by one carrier with more than one mode of transport under control or ownership of one operator. It involves the use of more than one means of transport such as a combination of truck, railcar, railways, aeroplane or ship in succession to each e.g. container line which operates both a ship and rail system of double stack trains.

Advantages of multimodal transport:

- Coordinated and planned as a single operation, it minimizes the loss of time and risk of loss, pilferage and damage to the cargo at trans-shipment points.
- The market is psychically reduced by faster transit of goods; Reference to Globalization challenge, the distance between origin or source materials and customers is getting to be insignificant thanks to the development of multimodal transport.
- The burden of issuing multiple documentation for each segment of transport is reduced to minimum.
- The consignor / consignee have to deal with only the MTO (multimodal transport operator) in all matters related to the goods transportation.

Intermodal transport can be classified as a special type of multimodal transport, whereby two and more modes of transport are used to transport the same loading unit or road vehicle. This means that, when changing transport means, only the loading units or the road vehicles are switched, while the goods remain in the same transport receptacles (such as containers or swap bodies) [2]. An example for intermodal transportation would be the transport by ship to a port, from which the containers are either loaded directly on the wagons or are transported by truck to the rail terminal. The containers are transported to the nearest hub by rail and are then transported to the final destination. Since only loading units or the road vehicles (and not the goods themselves) have to be handled, changing the transport mode requires very little time and helps saving on costs for transhipment. In additional, the risk of damage to the goods during transhipment is minimized.

Advantages of intermodal transport:

- The possibility of seamless door-to-door transport.
- Consolidation in the longer distance trunk line move. Consolidation leads to economies of scale and the possibility of transporting goods more economically.
- It has been proven to effectively reduce CO_2 emissions and improve the environment, which has become an important policy issue [3].

Combined transport is a special type of intermodal transport in which the major part of the trip is performed by inland vessel or railway and any pre- and/or end-haulage carried out by track is minimized. When rail or waterway transport is used for the main leg, combined transport represents an environmentally friendly transport alternative. Combined Transport will only be able to live up to its full potential, and deliver the modal shift expected of it by European transport policy-makers as well as the general public, if the regulatory conditions which presently do not fully support fair competition - either between the different modes of transport, or on rail - are corrected by the legislator [4].

A good example is the transport of a container from a Bratislava´s company to the Port of Bratislava by truck. This is followed by transport to Romania, which is handled via inland vessel and finally, a truck carries the container to the consignee´s location.

4. Types of transhipment

Transhipment can be divided into processes in which intermodal loading units are lifted and processes in which units are not lifted:

- **Lift-on-Lift-off (Lo-Lo)** is defined as the vertical form of transhipment. In a terminal, the loading unit or semi-trailer is lifted by crane or reach stacker from one means of transport to another (see Fig. 2) [5].

Fig. 2 Lo-Lo transhipment process [6]

- **Roll-on-Roll-off (Ro-Ro)** is defined as a transhipment, where loading units or semi-trailers are rolled in horizontally via a ramp (see Fig. 3). The main advantage here lies in the fact that loading units can be transhipped without cranes or reach stocker [5].

Fig. 3 Ro-Ro transhipment process [7]

- **RoLo** (roll-on/lift-off) vessel is another hybrid vessel type, with ramps serving vehicle decks but with other cargo decks only accessible when the tides change or by the use of a crane (see Fig. 4) [5].

Fig. 4 Ro-Lo vessel [8]

4.1 Intermodal transport units

To reduce time and costs during the transhipment process, standardized loading units are used in intermodal transport (see Fig. 5). Because of the standardization of the loading unit´s size and the necessary equipment (spreader), easier handling, better scheduling and higher exploitation of space (stackability of containers) can be achieved. Intermodal loading units – also intermodal transport units (ITUs) are transhipped between road, rail and waterway using specialized facilities.

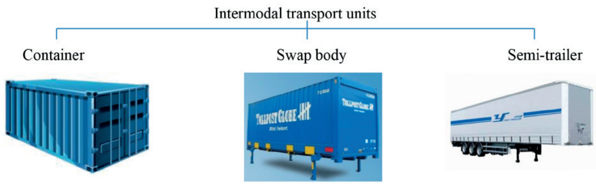

Fig. 5 Intermodal transport units [9]

Swap bodies and containers are dominating in continental European Combined Transport (road/rail). Semi-trailers are important in some markets e.g. RoRo process (see Fig. 6).

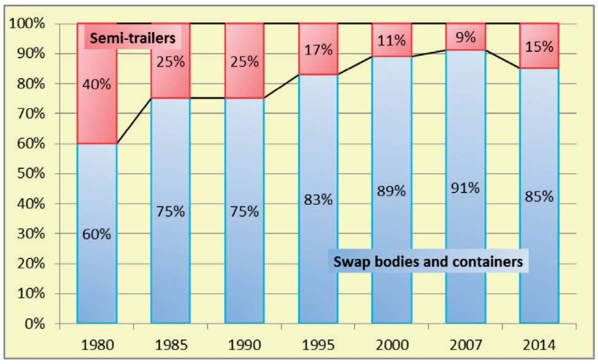

Fig. 6 Techniques in combined transport (1980-2014) [9]

Containers are standardized receptacles made of metal and available in different sizes and forms. Their many advantages are their extreme robustness and high stackability, resulting in optimum utilization of space minimizing risk of damage, reduction of packing expense, etc. Containers are available in various shapes and sizes for special purpose. Basic dimensions and permissible gross weights of intermodal containers are largely determined by two ISO standards: ISO 668:2013 and ISO 1496-1:2013 [2]. The most common sizes of container available are 20 feet, 40 feet and 45 feet in length.

Swap-bodies are trailers for trucks without a chassis and fully compatible with euro-pallets. The sizes of swap bodies are principally standardized [2]. The main advantage of a swap body is its ability to stand freely using four foldable legs that enable easy loading and unloading. The economic benefit for carriers is that just one vehicle can use multiple different swap bodies. While loading is taking place at the ramp, the truck can be transporting other swap bodies. Therefore, the truck can park an empty swap body at the ramp, and straight away pick up a loaded body and begin a new trip. [10] This minimizes idle and waiting times for the vehicles. The disadvantage of a swap body is its difficulty to stack. The swap-body is transferred from road vehicle to rail wagon by means of an overhead straddle crane, which has four arms that locate into slots permanently fixed to the bottom of the swap-body.

Semi-trailer a is non-motorized vehicle used for the carriage of goods intended to be coupled to an articulated vehicle. It is a trailer without a front axle [2]. A large proportion of its weight is supported either by a road tractor or by a detachable front axle assembly called a dolly. A semi-trailer is equipped with legs that can be lowered to support it when it is unhooked from the tractor. When coupled together, the tractor and trailer combination is often referred to as a semi, 18-wheeler, big-rig, articulated lorry, or truck and trailer. The purpose of a semi-trailer is to carry freight.

5. Multimodal transport in practice

5.1 Mineral raw materials

Source and destination:	From Rotterdam via Linz to the customer
Means of transport:	Inland vessel, maritime vessel, truck and railway
Type of transport process:	Split multimodal transport
Cargo:	Mineral raw material (bulk cargo)

Fig. 7 Transhipment of mineral raw material in the port of the Linz AG [11]

On a site of around 150 hectares, including 45 hectares of water surface, the Port of Linz provides the latest facilities for efficient transhipment services. Transport and transhipment of mineral raw materials are undertaken at the Linz AG´s port (see Fig. 7). The hygroscopic characteristics of this type of cargo (e.g. the raw material is extremely sensitive to moisture and pollution) make its handling difficult. Hence, the cargo hold of the inland vessel must be carefully checked before loading in order to avoid damage of the cargo [11].

At the start of the transport chain, the commodities are carried to Rotterdam by maritime vessels. In Rotterdam, the freight is transhipped to inland vessels by means of mobile cranes or luffing and slewing cranes. After this, the goods are transported from Rotterdam to the Port of Linz via the Rhine, the Main and the Main-Danube-Canal. Motor cargo vessels or pushed convoys are usually used for this, loaded with an average of 1,000 tons of cargo per vessel unit. After the arrival at the Port of Linz, the products are then transhipped to trucks or railway, depending on the customer, and transported to their final destination [11].

5.2 Steel products

Source and destination:	From Linz via Moerdijk (the Netherlands) to overseas countries
Means of transport:	Inland vessel, maritime vessel, truck and railway
Type of transport process:	Split multimodal transport
Cargo:	Steel products (general cargo)

Fig. 8 Transhipment of steel products in the covered transhipment hall of Industrie-Logistik-Linz [11]

The company Industrie-Logistik-Linz (ILL) provides logistics services throughout the entire supply chain. The company has offices in Austria (Linz and Steyr) and in the Netherlands (Moerdijk). 500,000 tons of steel are transported annually between Linz and Moerdijk on inland vessels. While ILL organizes transhipment in Linz and monitors the transport to the Netherlands, an inland navigation service provider or a partner company is responsible for the physical carriage by ship [11].

The steel products are collected by railway wagons from several warehouses on the production site. Following this, they are transported to the covered transhipment hall which is located at the factory port of the voestalpine in Linz (see Fig. 8). From there, the goods are directly transhipped from the wagons onto inland vessels. For this covered transhipment, a gantry crane with a maximum capacity of up to 35 tons is used. Subsequently, the goods are transported to Moerdijk by pushed convoy. There, the steel products are transhipped onto a maritime vessel and then transported to seaports located near the final customers. The latter are located in countries such as Brazil, the USA, Singapore, India, Malaysia or South Africa. In most cases, end-haulage is done by railway, though sometimes by trucks, as the best matching means of transport also depends on the size of the steel products [11].

6. Conclusion

The importance of freight transport for our society is beyond dispute, but transport volumes are ever growing and the problems to accommodate freight flows in an efficient and sustainable way become increasingly alarming. Traffic congestion is rapidly growing and the quality of freight transport is not able to keep pace with the rising ambitions: customers want higher reliability, lower prices, faster deliveries, more flexibility and higher service levels. This paper is primarily concerned with multimodal and intermodal transport.

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Iveta Kubasakova - Juraj Jagelcak *

LOGISTICS SYSTEM JUST-IN-TIME AND ITS IMPLEMENTATION WITHIN THE COMPANY

Just-In-Time (JIT) is a logistics system with its own technology for supply, production, distribution and management within the company. This article describes the technology of how to apply the JIT system in the company, about legal aspects of JIT and its positive and negative impact on the company's profits.

Keywords: *Logistics system, implementation, legal aspect, positive, negative.*

1. Introduction

According to Mr. Gregor and Kosturiak, JIT production is a philosophy of eliminating all forms of waste within the production process, from purchase of the materials and components to distribution of the final product. Production using the principles of JIT aims to produce high quality products in large quantities, which customers need within a certain time. This means that JIT manufacturing should be for specific customer orders only and goods are delivered once they are needed. JIT approach requires production of high quality products in order to reduce and eliminate storage of parts and thus lowering the overall cost of production [1 and 2].

2. JIT characteristics

The basis and philosophy of the JIT system means production of the goods, which are needed so that the storage of stock would not add value to the production process. A philosophy of JIT production is to supply only a specific product in order to eliminate wasted material and time" (Sliva, 2004).

Based on the opinion of Lambert, Stock and Ellram, JIT is a lean production of the high quality components. JIT production supplies the products needed after the customer had placed an order and therefore eliminates all wasteful processes at all stages of production. It means producing and delivering components and goods 'just in time'. JIT philosophy shows how to increase competitiveness of the company in the market, and contains all the areas in and out of the company [3 and 4].

It is about fulfilling customers' demands for the particular material in production or final product in the distribution chain. Also it includes meeting agreed strict deadlines of inventories "in the right time according to the customer's needs."

JIT is a production philosophy of management inventories in the company. Its aim is to provide reduction of wasted stock. The key of JIT is the idea to eliminate any losses. This philosophy is in conflict with the traditional philosophy "just in case (JIC)", according to which a company stores big inventories in case they are needed. The traditional producers in manufacturing "push through" the final product. This is not permitted in JIT manufacturing. According to JIT, it is considered to have a negative impact on society. On the contrary, JIT philosophy promotes the principle of 'pulled through' production and finished goods, 'just in time' to be sold.

3. JIT system

JIT system is the most widespread logistics technology in the field of supply, production and distribution. It satisfies the requirements of delivery of the particular materials, parts and components in the production or distribution of finished products (goods) by delivering them "just in time". It means that these goods are delivered accurately and by the deadlines according to the specific need of the customer. This system approach requires very frequent supplies of partly finished components 'just in time' to the customer. Therefore, the customer is a dominating article of the supply chain. The suppliers have to adapt in such a way that they create parts that will smoothly pass through all points of the handling operations at the production line.

* **Iveta Kubasakova, Juraj Jagelcak**
Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
E-mail: iveta.kubasakova@fpedas.uniza.sk

The aim of JIT strategy is to create a product as fast as possible by simplifying and rationalization of internal and external data flow in logistics and thus cutting the costs of the production process. It is important that the high quality supply chain is synchronized with production and thus delivers required materials. JIT goal is to reduce the amount of warehouses. This concept focuses on sophisticated planning, quality detection, designing efficient warehouses and stock supply, in particular:

- selection of means of transport,
- decision about location selection,
- collaboration with the suppliers.

The JIT method is used as a tool to reduce the storage of parts and early supply of the plant. The plants, using this method, concentrate particularly on the reduction of wasted time. The objective is to be closer to the customer and to react faster according to the changes and needs. The main advantage of JIT manufacturing is the shortening of the entire production (consumer) cycle. Time, during the whole cycle, causes acceleration of capital turnover, increases performance and flexibility and satisfies the consumer. Suppliers located closer to the production plant (place of consumption) do not bring any benefits to the supply chain because the transfer of the costs spent on stocks goes back to the distribution channel. If the rapid reduction of stocks is not simultaneously accompanied by the saving of time in the production process, it may cause a serious threat to the plant. To adapt to the needs of customers, the suppliers currently use synchronized strategies within JIT system, when there is only minimal safety stock for the case, e.g. of unexpected delay of transport or emancipation strategies, when the plant produces several supplies to the store, from where they are dispatched according to customer needs in JIT mode [5 and 6].

Implementation of JIT to the logistics chain Table 1

Choose	Corresponding methods of production management
	Define the lines of management of the sector
	Define production with JIT manage
	Define goals
	Create steering group
Shorter the interim times	Consolidate jobs in the lines or in groups
	Customize management parameters
	Reduce waiting times
	Eliminate downtime
Reduce setting times	Increase flexibility
	Reduce amount of production
	Waste reduction
	Reduce variable costs
Maintain balance of the activities	Increase consumption
	Collaboration between plants
	Adapt to demands
High quality products	Reduce faulty products
	Increase production
	Increase productivity
	Increase reliability of the products
Maintain efficiency of the manufacturing park	Increase production
	Increase effectiveness and reliability of the tools and machinery
	Reduce faults resulting in production shutdown
Create, Design	Adapt to work changes
	Motivate

Source: authors

The advantage of this system is the propinquity of the supplier and the customer. On the contrary, this strategy may be limited in case of a short transfer distance, border controls and freight forwarding equipage, in case of not complex composite assortment, in-adaptable structures of suppliers production or unsolved problem of connection in the material flow (not aligning of the means of transports, unsuitable way of unloading, ineffective quantitative and qualitative control upon receiving of goods, long follow-up of inter-operational handling) or in information flows (if not a smooth transmission of information). The first four above mentioned factors may be eliminated by accepting of emancipation strategy in the form of inserted common warehouse operated by a contractual freight forwarding agency. In this case, it also ensures the receiving of supplies sent by the supplier to the warehouse on the basis of appeal to the customer (e.g. storage operations and their evidence, supplies from the warehouse for consumption according to direct appeals in JIT mode). Moreover, this warehouse also provides information services and handles formalities connected with supply transport [7, 8 and 9].

If several suppliers are involved in the subsystem of transit storage supplies, the freight forwarder also performs completion or compilation of items within the supply from the warehouse, according to the order required by the customer. The importance of a freight forwarders´ involvement in storage systems increases in the current trend of distribution channels influenced by global logistics. (Table 1) In general, it is possible to say that JIT system operates in 4 basic fields:

- improvement of stocks turnover,
- better customer service,
- reduction of storage area,
- improvement of response time.

Impact of the introduction goes into business [4] Table 2

Activity	Improvement
Increased productivity	about 20 - 50%
Reduce purchase prices	up about 10%
Reduction in manufacturing inventories	about 50 - 100%
Reduction in finished inventories	up about 95%
Waste reduction	up about 30%
Reduce time required for the handling and transportation	about 50- 90%
Reduction of service processes	about 35 - 80%
Saving production and storage areas	about 40 - 80%
Improving quality	up about 55%

Source: [4]

The implementation of a JIT (Table 2) system may also cause the decrease of distribution costs, decrease of costs on transport, improvement of products quality from the suppliers and reduction of number of carrier haulers and suppliers. Within the JIT system, the importance of transport as a segment of logistics increases and high requirements are put on it:

- shorter and more reliable time of transport,
- more sophisticated communication,
- smaller number of carrier haulers with long-term relations,
- effectively proposed means of transport and equipment for manipulation with material,
- high-quality decision models about use of transport vehicles (own, public, contractual).

However, JIT has also some possible negatives. An emphasis on creating the best conditions for smooth production with minimal stocks may mean deterioration in conditions for the customer and limitations of the sub-suppliers. On the other hand, the companies with several suppliers may become too dependent. Similarly, a JIT system makes high demand on the organization of transport process (correct timing of supply, reliability of means of transport, etc.) [5].

4. Legal aspects of contracts with the suppliers (JIT approaches)

A contract with the supplier about the delivery/deliveries of materials is a final stage of the management processes of purchase strategy of the plant. In the case of determining quantity and value volumes of the material, the plant enters into *long-term contracts* with the suppliers. These contracts are intended to ensure supply of the plant, also during the periods of insufficient offer on the markets and so to protect the plant against unplanned events. Another advantage of long-term contracts is quantity rebates (price discount on supplied amounts). For the supplier, they are a subject of demonstration of withdrawal stability of products produced by it [10 and 11].

The following aspects are subjects of the contracts:

1 **Specification of materials and their qualitative parameters.** Material to be delivered has to be precisely specified, while drawings are often part of the contract. It also specified the necessary quality tests of both contractual parties, way of substitute supplies and substitutions of non-quality supplies.

2 **Specification of initial raw materials and materials and possibly their suppliers.** In order to ensure quality of materials, in terms of stability, the input parameters of initial materials are defined.

3 **Manipulation with tools, devices and forms.** If the customer is an owner or co-owner of the tools used by the supplier, their utilization has to be contractually agreed. Moreover, if the design of the material comes from the customer, it is their intellectual property. Then, the supplier cannot produce for anybody else without the express permission of the customer.

4 **Plan of formation of stock reserves and plan of supplies**

5 **Duration of contract validity and notice periods** The long-term contracts are usually concluded for 3 or more years; notice periods are usually at least 6 months.

6 **Prices.** Contractual prices are usually fixed for the period of 1 year. The contract usually includes a price calculation.

7 **Contractual penalties** for not meeting of contractual terms and conditions [12].

If the customer concludes a contract with the supplier about the JIT form of supply (supply synchronous with production), then the contractual relations are legally modified to three planning levels:

1 *strategic (long-term) level:* We talk about a frame contract, e.g. for the period of 3 years with frame annual division of volumes.

2 *medium-term level:* We speak about a one year contract with the specification of tasks of the supplier per quarter. Here, the supplier gets the necessary understanding of the needs of a customer in order to ensure the input of raw materials.

3 *short-term (operative and realization) level:* It represents monthly plans for the supplier with weekly or daily specifications that are also instructions for supply containing information about quantity, with possible modifications and places of delivery.

The transmission of information is especially difficult in the last level. It is necessary to use phones, faxes and e-mail [6].

5. Conclusion

It is very difficult to implement a JIT system, because it requires significant costs to ensure effective operation of the entire system. The most important benefits of the system occur only after a certain time of its operation. The process of material system includes a sub-system of material availability, material appeal, storage, material preparation, visual management and information system [13 and 14].

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Jan Lizbetin - Petr Vejs - Zdenek Caha - Lenka Lizbetinova - Philip Michalk *

THE POSSIBILITIES OF DYNAMIC SHIPMENT WEIGHING IN RAIL FREIGHT TRANSPORT

This article deals with an analysis of the methods of the dynamic weighing of rail vehicles. The measurement of axle load (both static and dynamic) is one of the current standard processes within the technical specifications for interoperability (TSI).

Keywords: *Rail transport, vehicle weighing, interoperability.*

1. Introduction

The weighing of posted shipments is important in all spheres of transport. Overloaded freight vehicles represent a serious danger for transport in the form of higher risks for other traffic participants and lower traffic safety. The issue also has significant impacts on the life expectancy of infrastructure and can lead to unfair competition between various modes of transport and their providers.

In most cases the sender is the one who specifies the weight of the goods. It is for this reason that a forwarder has the right to verify the specified weight anywhere and at any time. However, there is a problem with the availability of rail scales. This is why the number of overloaded modes of transport must be minimized. The introduction of in-motion weighing has big potential. New technologies have led to the development of a complex, fully equipped and reliable system for the dynamic weighing of rail vehicles i.e. in-motion weighing. Such systems are certified as so called rated gauges. The results of the checked weight are compared to the real weight and the permissible weight for a given means of transport infrastructure. Sanctions are then imposed on those vehicles exceeding the permissible weight [1].

2. Dynamic Weighing method

The current method of weight detection is similar to that for tolls in road transport. It is based on the detection of operational load and the number of passing rail vehicles. This may also include, as the case may be, the dynamic effect of the operation on the railway infrastructure in terms of the effects of wear on measurement and on the consequent processing and evaluation of the measured data for the purposes of tolling. This method requires – like for road tolls – the installation of measurement points at individual track sections which are part of a paid railway infrastructure. The measurement points consist of measurement equipment which can either operate on the principle of dynamic weighing or on the detection of the dynamic impacts of passing rail vehicles. This system has the advantage that it records the whole load as it passes through the installed measurement point [2].

The efforts to introduce the dynamic detection of the weight of shipments in rail freight transport relates to the efforts to ensure the so called interoperability of the European railway transport system. The interoperability of railway systems is the basic precondition for the functioning of the integrated trans-European conventional railway system. The term interoperability involves the ability to provide mutual support for various facilities, operational and technical links for safe and uninterrupted movements, and the provision of the basic operational and technical conditions on the selected network of railways for the safe and uninterrupted operation of rail vehicles [3].

To achieve these goals some measures have been taken, particularly in the field of technical standardisation, which resulted in the technical specifications for interoperability (TSI). The issue of the measurement of static wheel load is one of

* [1]Jan Lizbetin, [2]Petr Vejs, [3]Zdenek Caha, [4]Lenka Lizbetinova, [5]Philip Michalk
[1]The Institute of Technology and Businesses in Ceske Budejovice, Faculty of Technology, Department of Transport and Logistics, Czech Republic
[2]University of Pardubice, Jan Perner Transport Faculty, Czech Republic
[3]The Institute of Technology and Businesses in Ceske Budejovice, Faculty of Corporate Strategy, Department of Foreign Languages, Czech Republic
[4]The Institute of Technology and Businesses in Ceske Budejovice, Faculty of Corporate Strategy, Department of Tourism and Marketing, Czech Republic
[5]Technische Hochschule Wildau (FH) Hochschulring 1, 15745 Wildau, Germany
E-mail: lizbetin@mail.vstecb.cz

the standardisation processes in progress. The project team is currently drawing up a draft of this standard.

TSI limits the static axle load for interoperable rail vehicles to 17 and 19 tonnes for high speeds of 200-250 km/h and over 250 km/h respectively. These maximum values provide a tolerance of 2% on the average axle load of a complete train. A tolerance of 4% per individual axle is acceptable. In addition, the difference between the right and the left side of one vehicle must not exceed 6%. These values are considered achievable for the Rail WIM (weight-in-motion) system to measure. Some selected WIM measurement systems are briefly characterized in the following part of this article [4].

3. Footprint measurement station (NED-Train, Netherlands)

The measurement system consists of four sensors, an electronic recording unit and a central server (Fig. 1). The whole measurement system is based on the sensor unit, which is installed on the rail foot by means of special fixtures. The measurement principle is based on glass fibre technology and the change in their properties under load. The light guide technology has the advantages that it is quick to install and dismantle, demands little maintenance and operates independently of influences caused by electromagnetic fields [4].

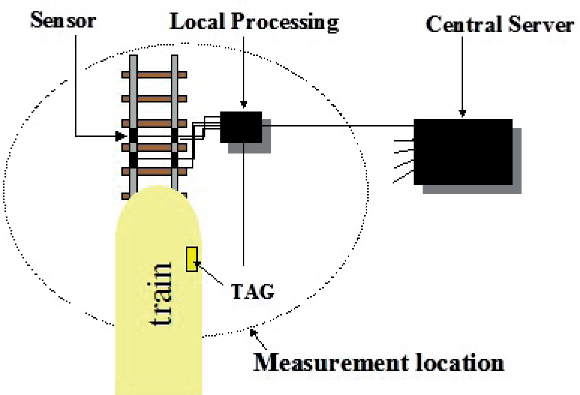

Fig. 1 Schematic illustration of the measurement system; source: [4]

The sensor consists of optical fibres and is attached to the bottom of the rail foot, where it measures the deflection of the rail at the moment of wheel passage. The signal generated by the wheel passage is shown in Fig. 2.

The axle passage is on the horizontal axis and the degree of deflection on the vertical axis. The passage of a defective axle not only causes the rail to deflect, but also to vibrate. Four sensors installed at exactly defined distances provide sufficiently reliable information about the wheel defect.

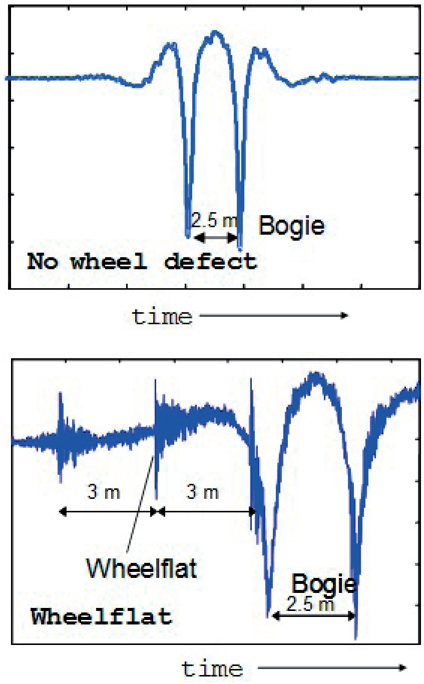

Fig. 2 The output signal of the sensor provides information on wheel quality: without a defect (left), with a defect (right); source: [4]

The whole system was tested up to a maximum speed of 160 km/h. Theoretical and laboratory tests have proved that the sensors are able to measure weights and detect load at up to at least 300 km/h. The passage speed of the individual axles can also be measured with high accuracy because two sensors are always installed on each rail. The sensors generate data, which after being processed by the local processor unit, provides information on axle load, wheel load, wheel quality, speed and the number of axles. The types of the individual wagons can also be detected and the symmetry of the load distribution on the individual wagons assessed [5 and 6].

4. Rail WIM measurement station (KISTLER, Switzerland)

The Rail WIM Kistler 9000M071 system is able to detect the weight, overload and asymmetric load of rail vehicles. The system detects the vertical load (force) on the individual wheels, axles and wagons in motion by means of a digital processor located in an electronic box. The partial load on the front and rear axles and the left-right load are also analysed to detect the asymmetric load on each rail vehicle. The addition of the individual axles and wagons is automatically performed by means of evaluation software. The total weight of the whole train is determined as the sum of the individual weights. The Automatic Equipment Identification (AEI) reader captures the identification numbers of the rail vehicle, which are held as part of the stored data [7].

Rail WIM is designed for installation on main routes, where it is able to detect, record and evaluate the load data of all the passing trains. The permitted train speed is from 5 to 60 km/h in both directions. Slower trains or those that stop at the place of measurement cannot be measured by this system. In such cases a system error occurs. The higher speed limit is limited in principle by the detection capability of the AEI antenna. The sensors themselves and the signal processing system are able to measure the weight of passing trains at speeds higher than 80 mph (approx. 130 km/h).

Rail WIM is designed for the measurement of individual rail wagons with an accuracy of 2% with a confidence interval of 95%. The 95% reliability level is defined as 2-sigma random error of measurement, which is the error without the calibration error. The calibration error can be arbitrarily small. It is adjustable by means of the system software, and depends on the accuracy of the "known" weights of rail wagons and locomotives [8].

Figure 3 shows a typical Rail WIM measuring station installed on a main railway. Detailed installation instructions are in the company user manual. The distances between the individual sensors have been shortened for the sake of the clarity of the illustration [8].

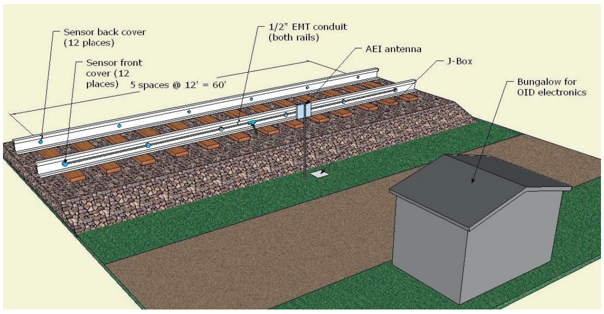

Fig. 3 Configuration of the Rail WIM Kistler station; source: [8]

5. Dynamic and static scales for rail vehicles (Buchmann, Germany)

"EcoRail" type

The device is used for the detection of rail wagon overloading. The weighing range is up to 120 tonnes with a scale segment of 50 kg and axle weight of up to 30 tonnes.

Weighing without a certificate is performed within the speed range from 8 to 10 km/h (vehicle passage speed). The measurement accuracy lies between 1.0% and 2.0%, depending on the railway body and the quality of the superstructure. The installation of the device is very simple. Eight sensors are pressed into pre-drilled holes in the rails. The sensors are installed in the rail sections between sleepers (Fig. 4). No special foundations or any alterations to the railway superstructure are required [9].

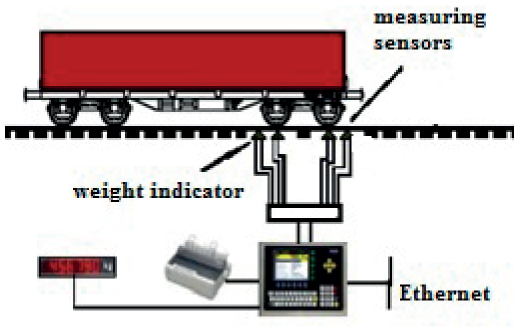

Fig. 4 Scheme of the Ecorail system; source: [9]

"EcoDywa" type

"EcoDywa" dynamic railway scales are certified according to the international metrological regulation OIML R106. The scale´s structure consists of steel bridge scales installed on a flat foundation of reinforced steel. The scales are designed for the dynamic measurement of the axle weight and total weight of rail wagons, including identification of wagon type. The scales are calibrated for the dynamic and static weighing of rail vehicles (including tank wagons) used for the transport of liquids, with loosely loaded goods and piece transport [9].

"Lars-M" portable static and dynamic railway scales

This is a system designed for quick measurements, e.g. wagon overloading (Fig. 5). The scales are suitable for rail gauge 1435 mm and various types of other rails S49, S54, UIC60, etc. The weighing is performed at speeds of up to 5 km/h [10].

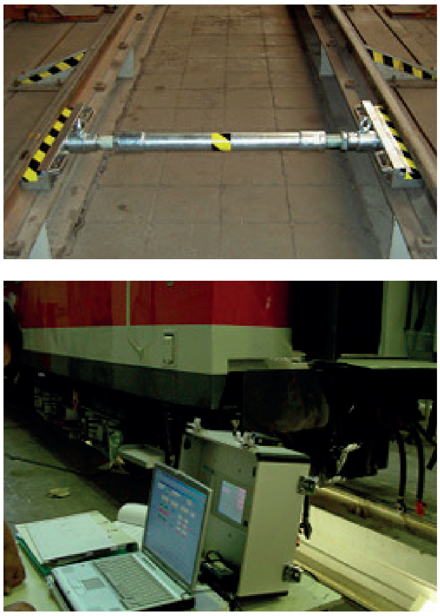

Fig. 5 Scheme and example of the Lars M system; source: [10]

6. Rail WIM (Israel)

The system is based on the principle of piezoelectric ceramic sensors, which are glued to a rail foot. The sensors are installed on various parts of the rail: on top of the rail foot, on the bottom of the rail foot and on the web of the rail. There are 20 sensors in total, installed equidistantly according to the wheel perimeter. The system measures forces (deflection) and can also detect defects on the individual wheels by means of an analysis of the signals. The measurement accuracy oscillates between 0.5% and 1% in comparison with static weight. The system measures wheel loads, axle loads and the total weight of rail vehicles. Auto-calibration of the Rail WIM system is performed by means of a "batch" unit (RFID), which is attached to an engine [11].

7. Conclusion

The practical significance of the detection of shipment weight, whether by means of a static or a progressive dynamic system, is particularly in the correct calculation of the price of use of the railway infrastructure. Errors in the weight of rail vehicles can result in the operator of the railway infrastructure loosing income from the charges for the use of the infrastructure. This income is important because it is compensation for the use of the infrastructure by forwarders and covers the operators costs related to the servicing of the railways and the organization of rail transport. For example, in 2013, the revenue of SZDC[1] was approximately CZK 4.2 billion. This means that the "average prices" per train-kilometre and per 1,000 gross tonne-kilometres are more expensive, which corresponds to the higher proportion of E category tracks in operation with higher charges TERFN[2]) [12].

If we calculate with an "average" price of CZK 40 per 1 train-kilometre and with the "average" price CZK 50 per 1,000 gross tonne-kilometres we get approximately CZK 1.5 billion for the operation of the railway infrastructure (train-kilometres) plus CZK 1.7 billion for ensuring the operability of the railway infrastructure (1,000 gross tonne-kilometres) i.e. total revenues of more than CZK 3.2 billion.

The above calculation is only indicative. It is based on just one rate per 1,000 gross tonne-kilometres. In fact tracks of different categories vary not only in the charge per 1,000 gross tonne-kilometres, but also with the characteristics of the operation (e.g. shorter transport distance, lower average weight of a train).

Damage to the transport infrastructure and rail vehicles as well as operational safety are some of the additional negative impacts of incorrectly specified vehicle weights [13].

[1] Sprava zeleznicni dopravni cesty - the operator (manager) of the railway infrastructure in the Czech Republic, which was established on the basis of the Act on the Transformation of Czech Railways, state organization (Act No 77/2002 on Czech Railways, joint-stock company and Sprava zeleznicni dopravni cesty, state organisation).

[2] TERFN – Trans-European Rail Freight Network, see Ministry of Transport Notification 111/2004, dated 25 February 2004, on the list of railways included in the European Railway System.

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Jan Ondrus - Lubomir Cernicky *

USAGE OF POLCAM DEVICE FOR PARAMETER MONITORING AND TRAFFIC FLOW MODELLING

This article deals with a proposal of using the Polcam PC2006 device for obtaining the traffic flow characteristics. This device is a first of a kind at the University of Zilina. The aim was to perform a practical measurement with a floating vehicle on a selected road section I/18 Zilina - Strecno - Vrutky, evaluate basic characteristics of a traffic flow with consequent modelling and use of software tools. Three measurements were performed in road traffic under different conditions. Individual calculations based on data obtained from practical measurements are processed at the end of the article. The results obtained from the measurement are used for traffic flow modelling in the programme Aimsun.

Keywords: *Traffic flow, traffic modelling, Polcam PC2006 device, intensity, density, speed.*

1. Introduction

Traffic modelling using software equipment presents a forceful working method in traffic engineering area. Traffic flow simulation models were created as a tool for theoretical study of different factors of analysed values of basic traffic characteristics. Specialised software products are being used presently for traffic problems solving, as these have excessive possibilities of simulations and settings. They enable us to simulate numerous scenarios of traffic infrastructure in short time period. By using the simulation it is possible to model current and future statuses of traffic for the respective traffic flow [1].

2. Traffic flow movement

Traffic flow is defined as a movement of vehicles (pedestrians) in one line or in parallel lanes in the same direction. It can consist of several driving (walking) lanes, and has its characteristics and specific features, which describe its movement under different conditions.

During the drive the situation is being changed continuously and complicated situations arise as the influences of road users, time, space and movement take effect. Vehicles have influence on other vehicles during movement both in line and parallel, move in groups and make use of their speed. Their movement is determined not only by the abilities and requirements of users, vehicles' performance, vehicles' number and types, but also by road parameters, surroundings and climate conditions. Traffic flow consists of all flow participants moving in line or in parallel in the same traffic direction. It can consist of one or more traffic lanes. Vehicles moving in traffic lane change their position in time [2].

2.1 Traffic flow characteristics

Basic characteristics of traffic lane, describing its quantity and quality, are:

- intensity,
- speed,
- density.

Indirect characteristics of traffic flow are:

- time gap,
- length gap among individual vehicles [2].

3. Monitored section characteristics

For the practical measurement a road section of I/18 Zilina - Strecno - Vrutky was chosen. It ranks among the most frequently used road sections in Slovakia. Based on the analysis of average daily traffic densities it is possible to figure out the growing traffic intensity on this section of road I/18. For comparison, in the year 2000 the intensity on entrance to the town of Vrutky was 14,784 vehicles, in the year 2010 it was already 25,463 vehicles, which

* **Jan Ondrus, Lubomir Cernicky**
Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
E-mail: jan.ondrus@fpedas.uniza.sk

presents an increase by 10 679 vehicles. The specified road section I/18 has a length of 16.444 km. The starting point set by the mile post is at 460.745 km, by the offset to Dubravy [3].

Then the road leads through the part called Mojsova Lucka, followed by Strecno. After passing through Strecno municipality it follows the river Vah up to the section Dubna Skala. The section ending point is set by the mile post at 477.189 km onto the I. class road at the entrance to the town of Vrutky. The width of the road in the specified section is between 9 m – 14 m. The overall section is pictured in Fig. 1.

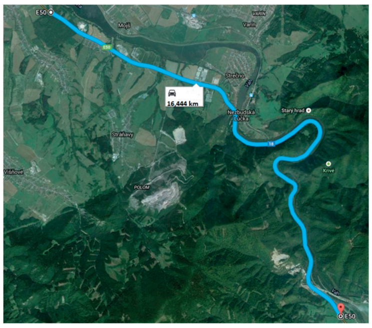

Fig. 1 I/18 road section map [4]

The owner of the road is the state and the administrator is the Slovak Road Administration Office. The respective road does not fulfil the requirements for safe and fluent road traffic due to following factors: construction, equipment, road surface, as well as placement in the surroundings.

4. Description of measurement technology

As a part of the operational programme Research and Development, project: Centre of excellence for systems and services of intelligent transport II, the Polcam PC2006, a device for traffic flow parameter monitoring, was obtained in the year 2014. This device was installed into a laboratory vehicle Citroen C6 3,0i V6 BVA, belonging to laboratories of the Department of Road and Urban Transport, Faculty of Operations and Economics of Transport and Communications at the University of Zilina (Fig. 2).

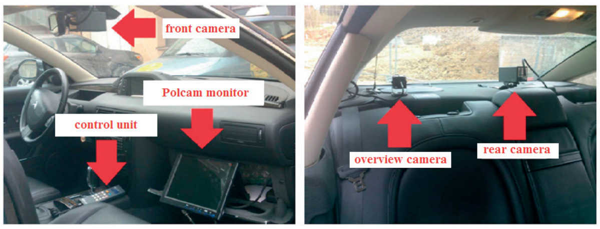

Fig. 2 Polcam PC2006 system installed in the vehicle [authors]

The mobile system Polcam PC2006 is a device designed to patrol the road traffic situation, exact measurement and average vehicle speed of the vehicle in which it is installed. It is designed for indirect measurement of the vehicle speed in front of, or behind the vehicle, in which the system is installed. The respective measurement is based on time measuring and passed distance. The system measures the average speed based on the exact measurement of distance and time.

The system Polcam PC2006 consists of:

- Polcam control unit,
- Remote control,
- Display unit Polcam EC-M (optional 7''-10" monitor),
- 28 x zoom camera Polcam EC-C (C28E) [5].

To these basic Polcam PC2006 components other additional equipment is connected:

- Digital registering equipment with HDD up to 320 GB and 4 to 8 inputs of format H.264,
- Cable system (connection of individual parts of the system and installation on the vehicle),
- Overview wide-angle cameras VS,
- GSM and WiFi antenna,
- Wireless equipment for sound transfer.

The control unit is connected by cable system with individual parts of the road speed meter, to power from the dashboard and screening of the vehicle speed [5].

The control unit fulfils the following functions:

- measures distance and time and from these data calculates the average speed,
- shows the video inputs and measured data on the monitor,
- processes measured data and controls auxiliary equipment.

The control unit calculates the distance from data obtained from an ABS sensor, or from vehicle data collector CAN BUS. Based on these data - sensor equipment impulses, a constant is set (number of impulses on a precisely set track, usually 500 to 1 000 m) to calculate an instantaneous speed. For synchronization of wheel perimeter and the track passed, the central unit has a possibility of changing the constant due to wheel dimension of individual vehicles (a constant of road speedometer is the number of impulses *ki* on a formerly set out and passed track *kd* [5].

The setting up and check of the constant of road speedometer is being done during official validation of the Polcam PC2006 system. During validation the value of distance (track) *kd* and number of impulses on the passed distance *ki,* are inserted into the central unit memory of the road speedometer, inserting is being done by a procedure specified by the manufacturer.

All information displayed on the screen is being saved on a hard disc of the recording equipment. Following pieces of information are continuously displayed on the monitor of the measuring device: date, time, camera identification /arrival, departure/, camera zoom, number of photos, distance passed, instantaneous vehicle speed, number of impulses, firmware number, equipment manufacturing number, identification of the equipment, control links for measured vehicle picture size assessment, and data from other optional additional equipment [5].

The system Polcam PC2006 can also be equipped with additional systems and equipment for:

- speed measuring - speed measuring of the vehicle while driving and stationary (radar),
- speed measuring - speed measuring of vehicles on standby and measuring distance when stopping (laser),
- ANPR (Automatic Number Plate Recognition) – system for automatic plate numbers recognition.

5. Processing of the measured data

For the processing of results acquired from the measuring device Polcam PC2006 the programme Polcam Playback was used.

It is used to playback, edit and evaluate the records, preparation of speed measuring proofs, or for other regulation breaks in road traffic. The programme Polcam Playback is connected to Google maps, in particular with Google Street View. The advantage of this connection is a 3D projection of the respective road section (Fig. 3).

Fig. 3 SW Polcam Playback connected with Google Street View

6. Measured and calculated parameters

Section monitoring measured by a floating vehicle is sometimes named a Floating vehicle method. A measured track is divided into partial sections, as homogenous as possible from the construction point of view, as well as usage and traffic load.

6.1. Values obtained by practical measurement

Three measurements were done – morning peak hour, saddle, and afternoon peak hour.

- morning peak hour - measurement performed on April 16, 2015
  - direction Zilina - Vrutky: start 7:48:21, finish 8:03:03
  - direction Vrutky - Zilina: start 8:05:38, finish 8:19:53
- saddle - measurement performed on March 30, 2015
  - direction Zilina - Vrutky: start 12:48:23, finish 13:00:30
  - direction Vrutky - Zilina: start 13:01:58, finish 13:14:47
- afternoon peak hour - measurement performed on April 20, 2015
  - direction Zilina - Vrutky: start 16:00:17, finish 16:13:03
  - direction Vrutky - Zilina: start 16:14:06, finish 16:27:56

Measurement method

During the execution of a measurement with the use of a floating vehicle, firstly the vehicle moves in the direction of the measured section of the traffic flow, then in the opposite direction. In both cases measurements and numbers of overtaken and overtaking vehicles are being recorded. When driving back, the vehicles driving in opposite direction are being counted. In our particular measurement the number of vehicles passing (passed) in the same direction was zero.

Intensities (M) obtained by practical measurements were recalculated into hours. Individual intensities are shown in the following Table 1. Only the saddle case is shown.

Traffic flow intensities for the saddle Table 1

	DIRECTION	Zilina – Vrutky	
SADDLE	Vehicle type	Intensity obtained by measurement	Intensity converted to hours
	Personal vehicles	219	504
	Trucks	12	28
	Buses	2	5
	Truck semitrailers	47	108
	Total	280	645
	DIRECTION	**Vrutky – Zilina**	
	Vehicle type	Intensity obtained by measurement	Intensity converted to hours
	Personal vehicles	174	401
	Trucks	23	53
	Buses	1	2
	Truck semitrailers	53	123
	Total	251	579

Section speed (V_u)

Section speed was obtained from Polcam device, which evaluated the respective section upon measurement completion.

Maximum distance, 9 999.9 m, is predefined in Polcam device. After exceeding this distance we continued the measurement after repeatedly pressing the START/STOP button. When calculating the section speed we used the weighted arithmetic average (Table 2).

Density (H)

Model calculation for saddle is shown below as an example. Density is calculated based on the formula below:

$$H = \frac{M}{V_u}$$

Overview of basic characteristics for "saddle period" is in the following Table 2.

Basic characteristics overview Table 2

Measurement				
Saddle	Measurement time		13 minutes 49 seconds	
	Measurement direction		Zilina – Vrutky	
	Vehicle type	Intensity - M	Section speed (km/h)	Density (vehicle/km)
	Personal vehicles	506	76.22	8.46
	Trucks	27		
	Buses	4		
	Truck semitrailers	108		
	Total	645		
	Measurement time		12 minutes 7 seconds	
	Measurement direction		Vrutky – Zilina	
	Vehicle type	Intensity - M	Section speed (km/h)	Density (vehicle/km)
	Personal vehicles	402	81.39	7.11
	Trucks	53		
	Buses	2		
	Truck semitrailers	122		
	Total	579		

7. The use of results for the purpose of traffic flow modelling

7.1. SW Aimsun

To verify and evaluate the actual state, the respective road section I/18 was modelled in the programme Aimsun. This programme enables both macroscopic and microscopic simulation. Input parameters for modelling were obtained from practical measurement.

Traffic model, created in such a way as to represent the real situation in the respective section to the most possible extent, is based on traffic net. Matrixes for all types of traffic were created. Although the road is predominantly used by personal vehicles, there are also trucks and buses on it. The model was created in the time period of morning peak hour, afternoon peak hour, and saddle [1].

The model is based on a map imported into the programme from a map database Open Street Map. Gradually the lines of individual communications were created, connected in joints in the spots where in the reality cross-roads are situated.

During modelling the focus was put on the true resemblance of all items of net, and maximum permitted speeds and lanes structure were taken into account. An identical model of the existing status was created, which, after filling with values, can be considered reliable. To create the modelling the supporting information from maps was used, mainly for obtaining the distances measurements, which in real traffic would be very difficult to measure.

The model load

After communication model creation it was possible to start with model loading. Loading of traffic model was done based on a practical measurement performed by the floating vehicle, equipped with the Polcam device. Values of all intensities were inserted into matrixes in programme Aimsun and the traffic model was loaded with them.

7.2 Data obtained from the model

We compared the data obtained from the traffic model with the data obtained by the practical measurement. Individual measurements were divided into morning peak hour, afternoon peak hour and saddle. A 30 minutes heating up was predefined in traffic model. All calculations and values in the tables were calculated by the authors themselves.

Intensity

Individual intensities, evaluated by the traffic model, copy the intensities obtained by a practical measurement, which shows that the respective traffic model mirrors the real conditions on the road. In most cases the intensities obtained by the practical measurement were a bit higher compared to the model (Table 3).

Intensity (vehicle) Table 3

	DIRECTION	Zilina – Vrutky	
Saddle	**Vehicle type**	Intensity obtained by traffic model	Intensity obtained by measurement
	Personal vehicles	513	504
	Trucks	29	28
	Buses	3	5
	Truck semitrailers	102	108
	Total	647	645
	DIRECTION	**Vrutky – Zilina**	
	Vehicle type	Intensity obtained by traffic model	Intensity obtained by measurement
	Personal vehicles	385	401
	Trucks	74	53
	Buses	3	2
	Truck semitrailers	110	123
	Total	572	579

The delay time

Out of the data provided by the traffic model we picked the delay time as a next parameter. In the following Table 4 the delay times for sections Zilina - Vrutky and Vrutky - Zilina are shown. Delay times are stated for individual vehicle types. The delay was calculated as the average of individual replications of the traffic model. Out of the individual replications the delay times of vehicles on traffic model were set. Delay time of vehicles in traffic model was influenced by the position of individual vehicle types in traffic line.

Vehicles delay time in traffic model Table 4

Saddle	Delay time (s)	
Vehicle type	**Zilina – Vrutky**	**Vrutky – Zilina**
Personal vehicles	151.60	137.37
Trucks	71.01	66.53
Buses	78.34	74.87
Truck semitrailers	70.17	64.27

CO_2 emissions

The programme Aimsun based on the Panis model recalculates the CO_2 emissions released by the vehicles in the traffic model. The CO_2 emissions are shown in grams. The emissions are stated for the individual types of vehicles released during a morning peak hour, an afternoon peak hour and a saddle. The highest amount of emissions was produced during the morning peak hour on the road section Vrutky - Zilina. Out of the individual vehicle types the highest amount of emissions was produced during the morning peak hour in the section Vrutky - Zilina by personal vehicles. The lowest emissions reached were in the section Vrutky - Zilina produced by busses. The overall lowest produced emissions were reached in section Zilina - Vrutky during the morning peak hour. The CO_2 emissions are in the following Table 5 stated in grams.

CO_2 emissions Table 5

Saddle	Emissions CO_2 (g)	
Vehicle type	**Zilina – Vrutky**	**Vrutky – Zilina**
Personal vehicles	669 24.66	574 694.85
Trucks	103 239.30	97 005.35
Buses	7 008.03	13 719.18
Truck semitrailers	131 917.71	268 255.02
Total	**911 412.70**	**953 674.40**

The section speed

To draw a comparison we herewith state section speeds obtained from the traffic model and the ones obtained from the practical measurement. The section speeds obtained from the traffic model were evaluated for the individual types of vehicles. In case of the measurement we obtained section speed data only for the individual sections (Zilina – Vrutky / Vrutky – Zilina). Section speed of the traffic model and practical measurement can be compared by comparison of average section speed of the traffic model (76.58 km/h) and section speed evaluated from the measurement (76.22 km/h); see Table 6.

Section speed (km/h) Table 6

Saddle	Traffic model	Measurement	Traffic model	Measurement
Vehicle type	**Zilina – Vrutky**	**Zilina – Vrutky**	**Vrutky – Zilina**	**Vrutky – Zilina**
Personal vehicles	76.91	76.22	78.4	81.39
Trucks	75.68		76.42	
Buses	76.58		76.43	
Truck semitrailers	75.67		76.53	
Average value	**76.58**		**76.58**	

The density

The density of the traffic flow obtained from both traffic model and the practical measurement reached similar values. Different aspects, such as section speed obtained from evaluation device Polcam PC2006 and traffic flow intensity, influenced the density in the traffic model (Table 7). With growing traffic flow intensity also the density grew, and, on the contrary, with growing section speed the density dropped.

Density (vehicle/km) Table 7

Saddle	Traffic model	Measurement	Traffic model	Measurement
Vehicle type	**Zilina - Vrutky**	**Zilina - Vrutky**	**Vrutky - Zilina**	**Vrutky - Zilina**
Personal vehicles	7		5	
Trucks	1		1	
Buses	0	8	0	7
Truck semitrailers	1		2	
Average value	**9**		**8**	

8. Conclusion

Traffic modelling with the use of information technologies (IT) represents a powerful working method in the field of Traffic engineering. This broadens the possibilities of complex task and problem solving. The Traffic modelling included not only the traffic simulation, but a broad scale of assisting tools, from simple, single-purpose applications, to complex tools for proposing and verification of the communication networks. The results obtained from traffic model are nowadays considered to be sufficiently reliable and relevant and they create base for reviewing current state of basic characteristics in the traffic flow. The outcomes from the traffic model can be used at different stages of urban planning and development, as well as for the evaluation of impact on particular solutions of traffic situations in the respective system.

In the traffic model we created, also the environmental influences of vehicles were considered.

Acknowledgements

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Jan Vrabel - Ondrej Stopka - Vladimir Rievaj - Branislav Sarkan - Kristyna Pruskova - Philip Michalk *

MEASURING THE RESISTANCE OF TIRES FOR PASSENGER VEHICLE AGAINST THE ROLLING AND SLIDING ON LOADING AREA OF THE FLATBED TRUCK WHEN PROVIDING THE TRANSPORT SERVICES

This paper deals with the size of the forces affecting the vehicle during the transportation on a flatbed truck, railway wagon or container. It is necessary to secure the vehicle against these forces properly in order to prevent vehicle´s replacement. The laboratory measurements were performed in order to find out the size of coefficient of friction between the tire and the vehicle´s loading area. During the measurements, vehicle had different gears in order to determine to what extent the size of mechanical resistances affects the fixing and securing the vehicle against its replacement on the loading area. However, this paper does not propose the solution for securing the passenger vehicle on the loading area of a truck, railway wagon or container.

Keywords: *Mechanical resistances of the vehicle, fixing, securing, loading area, sliding friction, dynamic coefficient of the sliding friction.*

1. Introduction

These days, vehicle has become a common part of our lives and this factor has represented the impulse for substantial increase of vehicle production. The Slovak Republic has become an important vehicle manufacturer with production of almost 1 million vehicles per year. This represents the significant part of the whole industrial production in the Slovak Republic. Vehicles need not only be manufactured, but also transported to the determined place. An important part of safe transportation is the proper cargo fixing and securing on the loading area of a truck, railway wagon or container. The objective is to determine and subsequently evaluate the physical phenomenon forming while rolling and sliding the tire (wheel) [1 - 3].

2. The interaction of wheel and surface

Forces generated between the wheel and surface present a specific case of force transmission. The flexible part (rubber of the tread) is in contact with a rough unyielding surface (road, transport vehicle floor, etc.) [2].

Friction is an essential part of our existence. Friction is the result of mutual forces of two surfaces which are compressed with the certain force. There would be no vehicle or bicycle movements, or any other activities, such as walking or even pen writing, without this phenomenon. Nodes would be spontaneously loosened and woven fibers would be spontaneously disintegrated easily [3].

While the body is moving on the surface, firstly, a short connection and then sliding the contact surfaces are initiated. Repeating the sliding and connecting the contact surfaces might cause their oscillation. This phenomenon could be accompanied by the different sounds which were heard while measuring, particularly, when vehicle wheels were secured against their rotation by handbrake. Friction can be static and dynamic [2 - 4].

2.1 Sliding friction and frictional forces

Sliding friction is a physical phenomenon that occurs when the body is moving (sliding) on the surface of another body. Its origin is mainly in the roughness of both contact surfaces which connect the bodies with each other. Rough nesses of different areas and surfaces impinge, deform and abrade between each

* [1]Jan Vrabel, [2]Ondrej Stopka, [1]Vladimir Rievaj, [1]Branislav Sarkan, [2]Kristyna Pruskova, [3]Philip Michalk
[1]University of Zilina, The Faculty of Operation and Economics of Transport and Communications, Department of road and urban transport, Slovakia
[2]The Institute of Technology and Business in Ceske Budejovice, Faculty of Technology, Czech Republic
[3]Technische Hochschule Wildau (FH) Hochschulring 1, 15745 Wildau, Germany
E-mail: vrabel@fpedas.uniza.sk; stopka@mail.vstecb.cz

other when the bodies are sliding. That represents the origin of frictional force. The point of application of frictional force is on the contact surfaces of both bodies and its direction is always heading upstream the direction of movement of the body. Frictional force does not depend on the size of contact surfaces, but only on the amount of force which presses the surfaces to each other (see Fig. 1) [1 and 4].

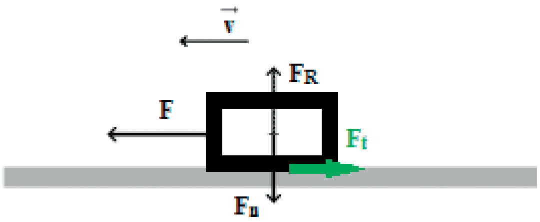

Fig. 1 Forces generated during the sliding friction, Source: Authors

If the surfaces were stationary at the beginning of acting the F force, firstly, it would be necessary to achieve the overcoming of the forces caused by the roughness of surfaces that interact with each other. Friction resistance decreases after the overcoming of these forces, because the roughness of surfaces has no longer an option of intense defense against the mutual sliding. Figure 2 presents the measuring of the sliding friction force from the beginning of its acting when the block is in the rest through the commencing of the movement until the uniform motion. This situation concerns the time when the body starts moving and frictional force starts reducing subsequently [1, 3 and 4].

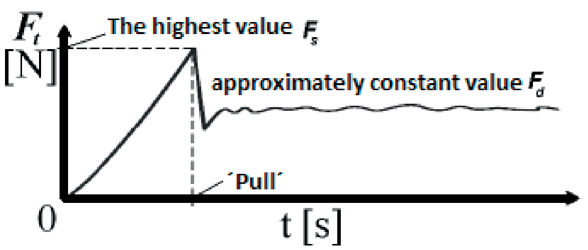

Fig. 2 Dependence of increasing force acting on the body which needs to be set in motion, Source: Authors

The amount of force F_s reaches the maximum value $F_{s,max}$ given by the formula (1):

$$F_{s\max} = \mu_s * F_n \quad (1)$$

where μ_s is the static coefficient of friction, F_n is the amount of the normal compressive force that presses the body to the surface, F_R is the size of response of the surface - it is equally large but oppositely directed as the force F_n.

In case the force F, acting on the body, is greater than $F_{s,max}$, the body begins to move. In this moment, the friction force to keep the body in movement decreases and F_d is sufficient. The amount of this force can be determined with the following formula (2):

$$F_d = \mu_d * F_n \quad (2)$$

where μ_d is the coefficient of dynamic (kinetic) friction.

During the whole movement, the value of dynamic friction force F_d remains the same [3 and 4].

3. Methodology for measuring the mechanical resistance and its evaluation

The methodology was determined on the basis of Annex B of standard STN EN 12195-1:2011, which provides two possible alternative procedures. For determining the friction coefficient during the measurement, the appropriate procedure was defined in the Standard STN in paragraph B.1.3 of the Annex B - *Tensile test* [5].

3.1 Vehicle used for the measurement

The measurements were made with the passenger vehicle DAEWOO KALOS. Its dimensions and parameters are presented in Table 1. A more detailed specification of tires is shown in Table 2.

Dimensions and parameters of the vehicle DAEWOO KALOS

Table 1

Length	3880 mm
Width	1670 mm
Height	1495 mm
Wheelbase	2480 mm
Mass	960 kg

Source: Authors

The measurements were done in laboratories of the Department of Road and Urban Transport - University of Zilina. A hydraulic cylinder was used in order to create the necessary tension force. It is shown in Fig. 3.

Due to the possibilities of piston ejecting and the Annex B of standard STN EN 12195-1:2011, a distance of one movement (pull) up to 80 mm and follow-up force release at least 30% in every effort were chosen. This distance was manually controlled using the control unit through which the piston moved [3, 5 and 6].

A more detailed specification of the vehicle DAEWOO KALOS tires

Table 2

Tires	BARUM Polaris 3 175/70 R13 82T
Manufacturer	BARUM
Speed Index	T = 190 km/h
Load Index	82 = 475 kg
Class fuel economy	F
Wet grip class	C
Noise level	71dB
Inflation Pressure	220 kPa front
	210 kPa rear
Kind	winter

Source: Authors

It was decided to use the plywood in order to achieve the most faithful simulation of surface of the flatbed truck loading area. All measurements were performed on both sides of plywood - on a smooth and rough side [6 - 9].

Fig. 3 Connection of the vehicle to the piston by the towing device at the back, Source: Authors

Evaluated results using the statistical values for the vehicle secured by the gear backward (reverse gear) are presented in the following Table 3.

Graphical representation of mixed coefficient of resistance against the movement for the vehicle secured by the gear backward is illustrated in the following Fig. 4.

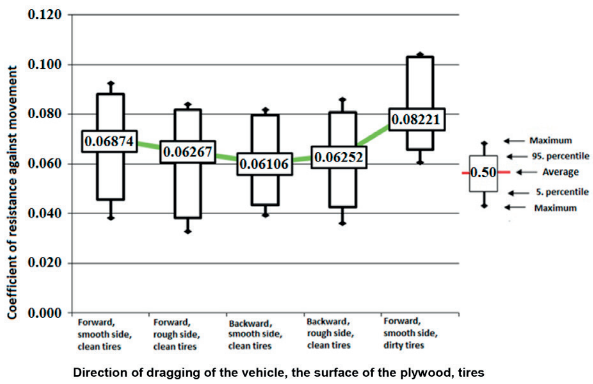

Fig. 4 Chart of mixed coefficient of resistance against the movement for the vehicle secured by the gear backward. Source: Authors

When securing the car by the gear backward, it can be noticed that the increase and decrease of the force depends not only on the track (route) and speed of dragging (pulling). Above all, it depends on the current position of the vehicle transmission system which varies according to the traveled distance. Transmission system and the vehicle engine have the most significant impact on the value of the coefficient [8, 9 and 10].

The amount of force for the vehicle secured by the gear backward is shown in Fig. 5.

Results using the statistical values for the vehicle secured by the gear backward

Table 3

	Forward, plywood smooth side, clean tires	Forward, plywood rough side, clean tires	Backward, plywood smooth side, clean tires	Backward, plywood rough side, clean tires	Forward, plywood smooth side, dirty tires
Minimum	0.03823	0.03292	0.03929	0.03610	0.06052
Maximum	0.09238	0.08389	0.08176	0.08601	0.10410
Average	0.06874	0.06267	0.06106	0.06252	0.82210
Median	0.07008	0.06477	0.06052	0.06371	0.08282
Modus	0.08070	0.07539	0.04991	0.07008	0.92380
Standard deviation	0.01375	0.01349	0.01176	0.01257	0.01162
Range	0.05415	0.05097	0.04247	0.04991	0.04354
5. percentile	0.04570	0.03820	0.04350	0.04250	0.06570
25. percentile	0.05730	0.05200	0.05100	0.05200	0.07480
75. percentile	0.08070	0.07430	0.07110	0.07330	0.09190
95. percentile	0.08810	0.08180	0.07960	0.08070	0.10310

Source: Authors

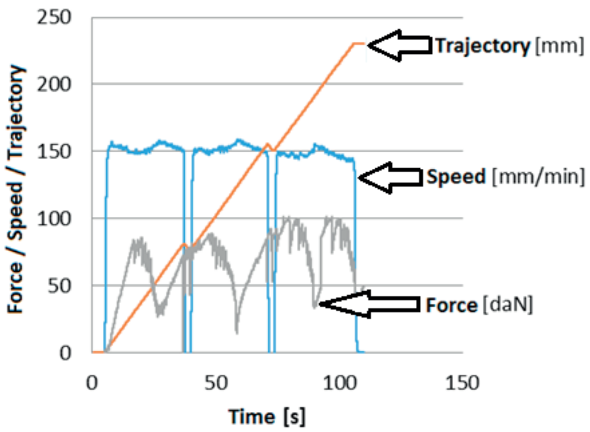

Fig. 5 Representation of the amount of force for the vehicle secured by the gear backward, Source: Authors

3.2 The impact of a particular gear on the coefficient of resistance against the movement

The following Table 4 presents the amount of force (in percentage) needed to overcome the total resistance against the vehicle movement. This means how great must be the force in order to put the vehicle in motion when the vehicle is secured by the gear [9 and 12].

The amount of force needed to overcome the total resistance against the vehicle movement Table 4

Gear	Force presented by the percentage	Percentage comparison compared to the first gear
R - reverse	103.35 %	+ 3.35 %
1	100.00 %	-
2	58.10 %	- 41.90 %
3	47.49 %	- 52.51 %
4	38.55 %	- 61.45 %
5	32.40 %	- 67.60 %

Source: Authors

From the table above, it was found out that the greatest force to put the vehicle in motion is needed with the gear backward (reverse gear). Slightly less force is needed for the first gear. For the second gear, the force of amount 41.9% lower than the first gear is needed to put the vehicle in motion. As for the fourth gear, the necessary force is by 61.45% lower than the first gear. Specific amounts of forces are shown in the following chart - Fig. 6 [4, 5, 11 - 14].

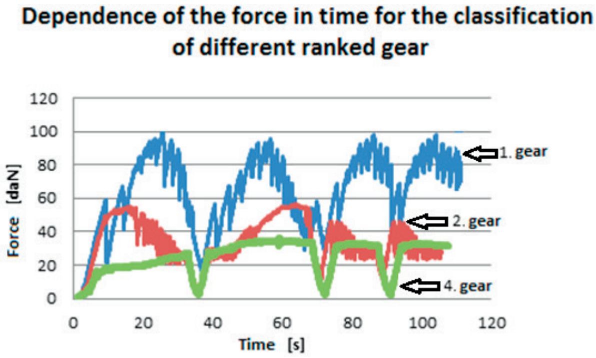

Fig. 6 Graphical representation of the amount of the force with different gears, Source: Authors

4. Conclusion

Based on the results, it can be concluded that if the vehicle is secured against undesirable movement only by the gear, the current position of the vehicle transmission system has a significant impact. Position is changed according to the traveled distance.

Direction of dragging (pulling) the vehicle, as well as the surface of pad, does not affect the results of the measurements significantly, since no sliding was in this case. Mud stained tires had slight effect on the increase of the coefficient in the measurements performed with the reverse gear [14 and 15].

It was also found out that the greatest force for putting the car in motion from the rest to "move back" position is needed by reverse gear securing, provided the car is not secured any other way. Vice versa, the lowest value of the force is sufficient for the highest gear, the fifth gear in this case [4 and 16].

When securing the vehicle on the loading area only by the gear, it is necessary to consider the dynamics of the movement (acceleration and deceleration), which may cause that the engine resistance will be overcome and crankshaft will be rotated. So, this would cause the unwanted vehicle replacement. The possibility that the driver set the gear (I, R) incompletely is another risk. During the transport services, due to the dynamics of the movement, it could lead to the spontaneous setting to neutral and this would mean that the vehicle is be able to move freely on the loading area [3, 6 and 17].

Securing the vehicle on the loading area only by a gear is insufficient (as shown in Fig. 5), also on the basis of the necessary securing force 0.8 times of *g* in the direction of traveling (forward) and to the sides and 0.5 times *g* backward.

Measurements clearly show that vehicles, during the transportation from the manufacturer to the customer, must be secured by the lashing straps [2 and 18].

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Rudolf Kampf - Jiri Cejka - Martin Telecky *

APPLICABILITY OF THE DEA METHOD ON THE TRANSPORT UNDERTAKINGS IN SELECTED REGIONS

With respect to achieving the economic goals within ordering of the suitable public transport system it is currently necessary that the economic indicators which contribute to the amount of a provable loss be evaluated rationally. The authors, therefore, will use the DEA method to efficiently assess the economic situation of the specific transport company to find out whether its business is economically attractive. At the same time, the involved companies will be compared with respect to their economically attractive behaviour. The article is based on the public domain information – economic indicators which the undertakings are obliged to publish by law. Despite this fact, it can be concluded that the source data are suitable for the analysis of economic health of a particular transport company.

Keywords: *Input-oriented BCC model, transport companies, the DEA method, the constant revenue of scale, the variable revenue of scale.*

1. Introduction

This paper is aimed to ascertain whether the selected transport companies are effective in using their inputs and outputs.

For the evaluation of effectiveness of these entities, the DEA (Data envelopment analysis) will be used; or more precisely, the input-oriented BCC model will be used under the conditions of variable revenue of scale (BCC).

The DEA method is a specialized model tool used especially to assess the effectiveness, performance and productivity of the homogeneous production entities. The selection of these entities was made upon the identical production, i.e. with the same inputs and outputs. This method is aimed to break the entities down into the effective and ineffective ones as well as to recommend reduction or increase in the inputs or outputs.

The DEA-method based models consider the set of admissible options formed by possible combinations of inputs and outputs. For graphic representation, the so-called effective boundary is used, i..e. the entities lying on this effective boundary are considered effective. Otherwise, they are considered ineffective and the changes thereof need to be proposed.

The CCR model maximizes the rate of effectiveness of the evaluated entity as a quotient of weighted outputs and weighted inputs on condition that the rates of effectiveness of other entities are less than or equal to one. The input-oriented CCR model focuses on such an amount of inputs which are consequently evaluated by this model. The model recommends such changes so that the ineffective entity becomes the effective one. At the same time, the model foresees the constant revenue of scale; i.e. the change in the amount of inputs will be directly proportional to the change in the output amount. For each entity this model will set individual weights of inputs and outputs to maximize the technical efficiency coefficient.

Certain conditions, however, must be met, namely:

- Weights cannot be negative;
- When using this set of weights for all entities, no coefficient of the technical efficiency must be greater than one.

The input-oriented BCC model is the modification of the previous model CCR. This model already takes into consideration the variable revenue of scale, i.e. increasing, decreasing or constant revenue. It foresees the variable, in certain parts linear revenue of scale and can evaluate the efficiency of entities for the generally non-constant output of scale [1 and 2].

Table 1 contains the basic input data to evaluate the economic health of the specific transport company. For the evaluation purposes, the regional towns without a specific traffic (except for Prague and Brno) were selected [3 - 5].

Table 2 contains the values recommended by the DEA method so that the management of the specific transport company is effective, i.e. the company effectively uses its income to perform traffic services. To take the saving measures, it is appropriate to consider the modification of those inputs which do not have a direct effect on the traffic services, i.e. they will concern only

* [1]**Rudolf Kampf,** [1]**Jiri Cejka,** [2]**Martin Telecky**
[1]Institute of Technology and Business in Ceske Budejovice, Czech Republic
[2]Faculty of Economics, South Bohemia University in Ceske Budejovice
E-mail: kampf@mail.vstecb.cz; telecm00@jcu.cz

the modification of the scope of travelled kilometres. Here, the effective tool can be the modification of employment in the context of modification of the number of vehicles (better distribution of vehicles throughout the day - optimization of circulations and the related optimization of the number of employees - optimization of shifts). The appropriate tool is also the modification of sales from the transportation activity. However, with respect to the current issue, i.e. the massive growth of private motor vehicle transport,

Basic input data of selected transport companies — Table 1

	Number of employees	Personnel costs	Cost of sales	Travelled kilometres in relation to the specific route	Vehicle - kilometres	Number of vehicles	Sales	Transported passengers
Ceske Budejovice	398	178 399 000	117 146 000	564776000	5651000	139	123 462 000	38541000
Hradec Kralove	385	155 784 000	112 194 000	475524000	5950000	126	118 345 000	34106000
Chomutov - Jirkov	239	98 824 000	103 313 000	172550000	1825000	47	47 432 000	5102000
Jihlava	175	70 657 000	31 579 000	212255000	3032000	63	47 867 000	13777000
Karlovy Vary	258	109 810 000	78 809 000	225242000	2584000	61	58 868 000	9587000
Liberec	390	152 472 000	130 418 000	680462000	7755000	212	195 909 000	42045000
Most - Litvinov	446	175 507 000	145 362 000	419405000	4512000	138	103 496 000	27420000
Olomouc	438	175 092 000	138 433 000	651153000	6196000	150	146 783 000	52193000
Pardubice	404	162 308 000	85 734 000	557912000	5730000	129	117 220 000	25919000
Teplice	263	107 571 000	109 808 000	299597000	5658000	130	95 164 000	14843000
Usti nad Labem	484	205 627 000	145 958 000	733999000	7266000	150	186 476 000	43162000
Zlin - Otrokovice	331	129 335 000	77 076 000	451512000	4824000	95	117 620 000	31866000

Source: Authors

Recommended values as per the input-oriented BCC model — Table 2

	Number of employees	Personnel costs	Cost of sales	Travelled kilometres in relation to the specific route	Vehicle - kilometres	Number of vehicles	Sales	Transported passengers
Ceske Budejovice	365	144 884 774	102 826 113	513193026	5188460	115	123 462 000	38541000
Hradec Kralove	339	133 356 942	84 354 747	470012254	4942745	102	118 345 000	34106000
Chomutov - Jirkov	239	98 824 000	103 313 000	172550000	1825000	47	47 432 000	5102000
Jihlava	175	70 657 000	31 579 000	212255000	3032000	63	47 867 000	13777000
Karlovy Vary	258	109 810 000	78 809 000	225242000	2584000	61	58 868 000	9587000
Liberec	390	152 472 000	130 418 000	680462000	7755000	212	195 909 000	42045000
Most - Litvinov	310	122 156 819	79 365 839	400970253	4313677	88	103 496 000	27420000
Olomouc	438	175 092 000	138 433 000	651153000	6196000	150	146 783 000	52193000
Pardubice	330	128 998 510	76 815 097	450139976	4813724	95	117 220 000	31762268
Teplice	263	107 571 000	109 808 000	299597000	5658000	130	95 164 000	14843000
Usti nad Labem	484	205 627 000	145 958 000	733999000	7266000	150	186 476 000	43162000
Zlin - Otrokovice	331	129 335 000	77 076 000	451512000	4824000	95	117 620 000	31866000

Source: Authors

Total evaluation as per the input-oriented BCC model — Table 3

Input - oriented BCC model BCC		
Transport undertaking	**Percentage**	**Effectiveness evaluation**
Chomutov - Jirkov	100%	effective
Hradec Kralove	98,80%	ineffective
Jihlava	100%	effective
Karlovy Vary	100%	effective
Liberec	100%	effective
Most - Litvinov	95,60%	ineffective
Olomouc	100%	effective
Pardubice	89,60%	ineffective
Teplice	100%	effective
Zlin - Otrokovice	100%	effective
Ceské Budejovice	91,80%	ineffective
Usti nad Labem	100%	effective

Source: Authors

Recommended percentage changes as per the input-oriented BCC model — Table 4

	Number of employees	Personnel costs	Cost of sales	Travelled kilometres in relation to the specific route	Vehicle - kilometres	Number of vehicles	Sales	Transported passengers
Ceske Budejovice	-8,19%	-18,79%	-12,22%	-9,13%	-8,19%	-17,20%	0,00%	0,00%
Hradec Kralove	-11,86%	-14,40%	-24,81%	-1,16%	-16,93%	-19,03%	0,00%	0,00%
Chomutov - Jirkov	0%	0%	0%	0%	0%	0%	0%	0%
Jihlava	0%	0%	0%	0%	0%	0%	0%	0%
Karlovy Vary	0%	0%	0%	0%	0%	0%	0%	0%
Liberec	0%	0%	0%	0%	0%	0%	0%	0%
Most - Litvinov	-30,51%	-30,40%	-45,40%	-4,40%	-4,40%	-36,47%	0,00%	0,00%
Olomouc	0%	0%	0%	0%	0%	0%	0%	0%
Pardubice	-18,29%	-20,52%	-10,40%	-19,32%	-15,99%	-26,50%	0,00%	22,54%
Teplice	0%	0%	0%	0%	0%	0%	0%	0%
Usti nad Labem	0%	0%	0%	0%	0%	0%	0%	0%
Zlin - Otrokovice	0%	0%	0%	0%	0%	0%	0%	0%

Source: Authors

this point depends on the promoter´s decision on how the urban traffic will be promoted. This aspect is not directly depending on the transport company. With respect to this fact all values of the modification of sales are zero!!! The results of recommended modifications are listed in Table 4 [6, 7, 8 and 9].

2. Results

Table 3 shows that the transport companies in the towns of Chomutov - Jirkov, Jihlava, Karlovy Vary, Liberec, Olomouc, Teplice, Zlin - Otrokovice and Usti nad Labem are the effective entities, i.e. the model entities for the ineffective transport undertakings. Based on the model entities, the % change is recommended for the ineffective entities to make them effective. For the needs of the specific percentage changes, the input-oriented BCC model has been proposed (i.e. minimization of the costs under the conditions of maintaining the same volume of outputs (sales, number of transported passengers). The transport companies marked in blue (Table 4) are ineffective.

The transport company in Pardubice is the least effective and, therefore, the result is not only the input change but also the output change. To achieve higher effectiveness, it is recommended to increase the number of transported passengers by 22.54%, i.e. by 5,843,268 transported passengers and, at the same time, to reduce the number of employed vehicles by 26.5%. It follows that the time interval should be increased by a few minutes and the number of links should be reduced or cancelled.

In case of the Most - Litvínov transport company, nearly 40% changes are recommended for some inputs, however, this recommended change is practically unreal. The prerequisite would be reduction of some inputs if the situation allowed so. The highest and the most recommended change is the cost of sales which includes, but is not limited to, the consumption of material and services. It is, therefore, appropriate to find a more effective method for the management of material and other items. Personnel costs represent the next group of recommended changes. Here, it is necessary to distinguish the wages of the drivers, clerical employees, managers and other staff. It is advised to decrease the salaries of senior managers, however, the wages of drivers should be maintained on the same level.

The transport company in Ceske Budejovice is the second most ineffective entity. The biggest change is foreseen in the personnel cost item. This case is identical with the transport company in Most - Litvinov. The next important item to be changed is the number of employees which is closely related to the change in the number of employed vehicles. The cost of sales concern all ineffective entities and it is generally recommended to find more appropriate methods of use of materials and other items.

The transport company in Hradec Králové should also shift its focus on the cost of sales. Reduction of the number of employees and the number of vehicles concern all transport undertakings. Of all ineffective transport companies, the required change of the personnel costs is , however, the lowest. The same also applies to the travelled kilometres in relation to the specific route [10 - 14].

3. Conclusion

Based on the above table it can be concluded that the cost of sales of selected transport companies require the necessary changes. The task is to find an appropriate way how to manage the cost of sales items.

The input-oriented BCC model where only the minimization of inputs was applied while maintaining the same outputs (this rule was exceptionally breached in case of the Pardubice transportation company) is just an indicative model. For more detail recommended changes it would be desirable to break down some cost items. Another factor for evaluating the transport undertakings is the verification of the accounting data quality, i.e. quantitative and qualitative data.

The DEA method focuses on a few models: the CCR and BCC models, which evaluate effectiveness of the entities using the set parameters in terms of constant revenue of scale and variable revenue of scale. The goal is to determine the preference of transport companies, i.e. if they want to expect the increase (maximization) in outputs or decrease (minimization) in inputs. Each of the applied models will evaluate the effectiveness of entities with the recommended different changes [15 - 19].

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Bibiana Poliakova - Jozef Stoklosa *

THE IMPACT OF PROPOSED PRICES ON THE PUBLIC TRANSPORT PROVIDERS AND PASSENGERS FOR INTEGRATED TRANSPORT SYSTEM IN KOSICE REGION

The article deals with the price construction for integrated transport system as the key part of integration because it has the impact on the involved public transport providers and passengers, but also for the third very important part – the self-government regions or cities as the orders of public transport services. The data in this article are used for integrated transport system in Kosice region in Slovakia where the process of integration is in the preparing phase.

Keywords: *Integrated public transport, integration, tariff, tickets, parameters, price, passenger.*

1. Introduction

The process of integration is very difficult. The tariff system is the key part of it because it has the financial impact on the passengers and their decision to use or not to use the public passenger transport for their regular but also irregular journeys. The tariff system has to be solved comprehensively. Each part of tariff system follows the other one and they influence each other. It is necessary to analyse the current tariff system of transporters who will be involved in the integrated transport system. Following proposal of tariff system should be attractive for passengers and simultaneously financially interesting for transporters and municipalities. The tariff integration together with transport integration should make the public passenger transport more attractive and should provide increasing number of passengers.

2. The development of integrated transport system creation

The development of integrated transport system for Kosice region has begun in the 1999 when the test operation of integrated transport system started with integration of railway, bus and urban transport. It was focused mainly on the passengers - employees of US Steel Kosice, the biggest employer in the region with more than 10,000 employees. From 2001 the normal operation started but due to the negative financial results the operation of this integrated transport system ended.

However, the city of Kosice and the self-government region has continued to work on the solution of public transport in this area. In 2004 the Agreement about the cooperation was signed in which the city, region, and the provider of railway transport in the region declared willingness to cooperate in the process of providing the integrated public transport. In other steps, some studies and projects were realized with the cooperation with also regional bus transporters. Also, in this time, the coordinator of integrated transport system has been established but for now it does not provide its function. The function of coordinator is now represented by the department of transport of the Kosice self-governing region [1].

3. The process of price construction

The process of tariff integration is very complicated. It affects all the involved subjects, providers, passengers and it can be the key part of integration success.

Within the project of Kosice self-government region which was focused on the analyses and preparing phase of integrated transport system the problematic of tariff integration was solved too. The basic parts of tariff integration were set and the basic price construction was defined for the need of additional solutions.

* [1]Bibiana Poliakova, [2]Jozef Stoklosa
[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Faculty of Transport and Computer Science, University of Economics and Innovation in Lublin, Poland
Email: bibiana.poliakova@fpedas.uniza.sk

3.1 The tariff zones

Firstly, the area of Kosice region was divided into the 114 tariff zones (Fig. 1). The cities and villages were assigned according to the various criteria from which the most important was: the transport relations, the transport infrastructure, the distances, etc. It was the first and basic area division and it is supposed that the changes will be necessary during the process of tariff construction [2 and 3].

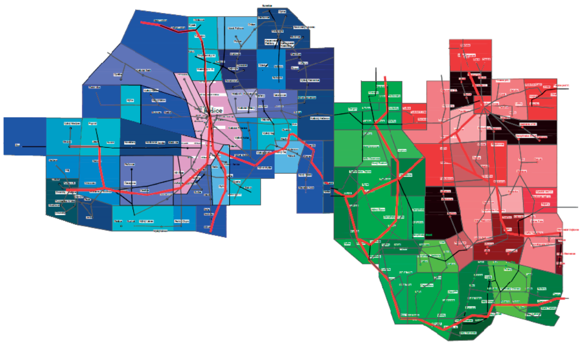

Fig. 1 First proposal of tariff zones. Source: authors

3.2 The basic price construction

The price structure should be based on the both basic prices as well as the proposed parameters for season tickets either on the basis of passenger journeys number for a given period or of traveled distance. The construction of price has to allow to make the changes for the individual ticket types independently and also it has to allow the vertical and horizontal price degression as according to equation:

$P_T = BM \cdot P_J \cdot P_D$

where: P_T price of ticket,
BM basic module,
P_J parameter value for discount fare according to the number of journeys,
P_D parameter value for discount fare according to the traveled distance.

The setting of the basic ticket price creates the basis for the price construction for all the tickets [4 and 5].

As the basic module the basic value of the single ticket is used within the one zone. It is the basis for the fares when the

The selected travel distances and current prices from Kosice to the villages in the region and the number of proposal zones and price for one zone according to the current price by regional bus transport Table 1

Village	Bus		Railway		Number of zones	Price for 1 zone
	km	price	km	price		
Malá Ida	11	0.90			2	0.45
Šemša	16	1.1			3	0.37
Hodkovce	17	1.1			3	0.37
Nováčany	20	1.3			3	0.43
Rudník	26	1.7			4	0.43
Jasov	29	1.7			4	0.43
Poproč	32	1.9			4	0.48
Medzev	36	2.1			5	0.42
Vyšný Medzev	39	2.1			5	0.42
Štos	50	2.6			6	0.43
Nižná Hutka	13	0.9			2	0.45
Nižná Myšľa	17	1.1	15	0.86	3	0.37
Vyšná Myšľa	16	1.1	17	0.94	3	0.37
Olšovany	14	1.1			3	0.37
Vyšný čaj	17	1.1			3	0.37
Ruskov	19	1.3	22	1.16	3	0.43
Ďurkov	16	1.1			3	0.37
Nižný Čaj	21	1.5			4	0.38
Blažice	22	1.5			4	0.38
Bohdanovce	19	1.3	19	1.2	4	0.33
Rákoš	23	1.5			4	0.38
Slančík	31	1.9			5	0.38
Slanec	27	1.7	29	1.46	5	0.34
Nový Salaš	31	1.9			5	0.38
Slanská Huta	34	1.9			5	0.38
Slanské NM	30	1.7			5	0.34
Kalša	33	1.9	34	1.66	5	0.38

Source: [8,9,10], *authors*

passenger travels through more zones as well as for the fares of season tickets.

For the basic module the three values were selected, 0.50 Eur (Variant 1), 0.45 Eur (Variant 2) and 0.40 Eur (Variant 3). They were determined on the basis of the average value of one zone (Table 1). This value was the result of an analysis of the proposed zones and the current values of fares for transport by regional bus transport calculated for one zone. Other higher values were determined on the assumption that the price for the single ticket is supposed to be higher that the prices of season tickets [6].

For the first draft proposal of prices 10 regional zones were considered as the basis for other evaluation steps. The combination "Kosice city" (urban transport) - "regional zone" (regional bus/railway transport) was not considered in this first step.

On the base of above mentioned the three variants of the values of single tickets were calculated for the transportation through the different number of zones. The values were calculated without the vertical price degression - case A, and with the vertical price degression - case B (Tables 2a and 2b). The vertical degression supposes that the price of ticket decreases with the tariff distance or with the number of zones. In this case 5 cents is the value of which the price of the single ticket decreases with the higher number of zones.

The proposed prices in this first step were compared with the current prices of regional bus transport. The railway regional transport was not compared because there are more connections by bus transport to all the towns and villages in the region. The part from this comparison is shown in Table 3.

As it can be seen from Table 3 the comparison of all the variants of proposed single tickets with the price for the bus

Comparison of proposed prices for single tickets and current bus transport prices

Table 3

Village	Bus		Railway		Number of zones	Price for 1 zone	Comparison of proposed tariff with current prices within bus transport					
	km	price	km	price			V1	V2	V3	VsD1	VsD2	VsD3
Malá Ida	11	0.9			2	0.45	1	0.9	0.8	0.95	0.85	0.75
Šemša	16	1.1			3	0.37	1.5	1.35	1.2	1.4	1.25	1.1
Hodkovce	17	1.1			3	0.37	1.5	1.35	1.2	1.4	1.25	1.1
Nováčany	20	1.3			3	0.43	1.5	1.35	1.2	1.4	1.25	1.1
Rudník	26	1.7			4	0.43	2	1.8	1.6	1.85	1.65	1.45
Jasov	29	1.7			4	0.43	2	1.8	1.6	1.85	1.65	1.45
Poproč	32	1.9			4	0.48	2	1.8	1.6	1.85	1.65	1.45
Medzev	36	2.1			5	0.42	2.5	2.25	2	2.3	2.5	1.8
Vyšný Medzev	39	2.1			5	0.42	2.5	2.25	2	2.3	2.5	1.8
Štos	50	2.6			6	0.43	3	2.7	2.4	2.75	2.45	2.15
Nižná Hutka	13	0.9			2	0.45	1	0.9	0.8	0.95	0.85	0.75
Nižná Myšľa	17	1.1	15	0.86	3	0.37	1.5	1.35	1.2	1.4	1.25	1.1
Vyšná Myšľa	16	1.1	17	0.94	3	0.37	1.5	1.35	1.2	1.4	1.25	1.1
Olšovany	14	1.1			3	0.37	1.5	1.35	1.2	1.4	1.25	1.1
Vyšný čaj	17	1.1			3	0.37	1.5	1.35	1.2	1.4	1.25	1.1
Ruskov	19	1.3	22	1.16	3	0.43	1.5	1.35	1.2	1.4	1.25	1.1
Ďurkov	16	1.1			3	0.37	1.5	1.35	1.2	1.4	1.25	1.1
Nižný Čaj	21	1.5			4	0.38	2	1.8	1.6	1.85	1.65	1.45
Blažice	22	1.5			4	0.38	2	1.8	1.6	1.85	1.65	1.45
Bohdanovce	19	1.3	19	1.2	4	0.33	2	1.8	1.6	1.85	1.65	1.45
Rákoš	23	1.5			4	0.38	2	1.8	1.6	1.85	1.65	1.45
Slančík	31	1.9			5	0.38	2.5	2.25	2	2.3	2.5	1.8
Slanec	27	1.7	29	1.46	5	0.34	2.5	2.25	2	2.3	2.5	1.8
Nový Salaš	31	1.9			5	0.38	2.5	2.25	2	2.3	2.5	1.8
Slanská Huta	34	1.9			5	0.38	2.5	2.25	2	2.3	2.5	1.8
Slanské NM	30	1.7			5	0.34	2.5	2.25	2	2.3	2.5	1.8
Kalša	33	1.9	34	1.66	5	0.38	2.5	2.25	2	2.3	2.5	1.8

Source: authors

Proposal of single ticket prices without degression Table 2

2a)

Number of zones	Prices for single tickets (EUR)		
Case A	V1	V2	V3
1	0.50	0.45	0.40
2	1.00	0.90	0.80
3	1.50	1.35	1.20
4	2.00	1.80	1.60
5	2.50	2.25	2.00
6	3.00	2.70	2.40
7	3.50	3.15	2.80
8	4.00	3.60	3.20
9	4.50	4.05	3.60
10	5.00	4.50	4.00

2b)

Number of zones	Prices for single tickets (EUR)		
Case B	VsD1	VsD2	VsD3
1	0.50	0.45	0.40
2	0.95	0.85	0.75
3	1.40	1.25	1.10
4	1.85	1.65	1.45
5	2.30	2.05	1.80
6	2.75	2.45	2.15
7	3.20	2.85	2.50
8	3.65	3.25	2.85
9	4.10	3.65	3.20
10	4.55	4.05	3.55

Source: authors

transport show many differences. The red color of price means that the price is lower than current price. The blue color of price means that the price is the same and the black color means that the price is higher than current price. But as it was already mentioned it is very important at least to provide the level of price or to provide lower price for commuters.

4. The proposal of basic season tickets

For adjusting the season ticket prices for integrated transport system it is needed to propose the value of parameters for discount fare according to the number of journeys, tariff distances or number of zones [5, 6].

The proposal of parameter for fare discounting according to the number of traveled zones:

- Its adjustment will result from the tariff structure, or the size of tariff zones for a given tariff structure.
- Its value will decrease with the more traveled zones or/and from the certain distance the value of this parameter will be constant.
- In the case of season tickets the value of this parameter will be lower than in the case of single tickets and the difference will depend on the basic fare adjustment.

The proposal of parameter for fare discounting according to the number of journeys:

- Its adjustment will result from the range of season tickets proposed for integrated transport system.
- Its value will be constant for journeys regardless of the number of zones or for the journeys for the higher number of zones the lower value of this parameter can be proposed.
- With longer duration of season tickets the value of parameter will be lower.
- The parameter will represent an advantage of season tickets that will provide the use of season tickets by passengers as much as possible.

The parameter for fare discounting according to the number of journeys was proposed on the base of the experiences from existing integrated transport systems in Europe, but mainly from the cases of integrated transport systems in the Czech Republic, South Moravian Integrated Transport System and Integrated Transport System of Moravian-Silesian Region.

Calculated prices for season tickets in Euros Table 4

Number of zones	Case A - without degression				Case B - with degression			
	V1	Monthly	Quarterly	Yearly	V1	Monthly	Quarterly	Yearly
1	0.50	14.00	36.40	126.00	0.50	14.00	36.40	126.00
2	1.00	28.00	72.80	252.00	0.95	26.60	69.16	239.40
3	1.50	42.00	109.20	378.00	1.40	39.20	101.92	352.80
4	2.00	56.00	145.60	504.00	1.85	51.80	134.68	466.20
5	2.50	70.00	182.00	630.00	2.30	64.40	167.44	579.60
6	3.00	84.00	218.40	756.00	2.75	77.00	200.20	693.00
7	3.50	98.00	254.80	882.00	3.20	89.60	232.96	806.40
8	4.00	112.00	291.20	1008.00	3.65	102.20	265.72	919.80
9	4.50	126.00	327.60	1134.00	4.10	114.80	298.48	1033.20
10	5.00	140.00	364.00	1260.00	4.55	127.40	331.24	1146.60
Number of journeys	1	40	120	480	1	40	120	480

Source: authors

On the base of all these foreign experiences and facts the following values of parameter were proposed:

- - monthly ticket - 28times of single ticket,
- - quarterly ticket – 2.6times of monthly ticket,
- - yearly ticket - 9times of monthly ticket.

The parameters were later used for calculation of season ticket prices for all variants. Table 4 shows the calculated prices for variant 1. This variant was selected mainly for the hypothesis that the prices of the single tickets should be higher than the prices of season tickets. As Table 3 shows variant 1 provides higher prices than current regional bus transport prices which give more opportunities to vary with season ticket calculation.

5. The impact of proposed prices

The process of tariff integration has to include also the verification whether and how the prices will be changed for the passengers and if they are acceptable for passengers but also for all the involved subjects.

As the example of verification the direction Kosice – Moldava nad Bodvou was selected as the case study because it is the direction on which the biggest employer – the U. S. Steel Kosice company is situated. Because of inhabitants commuting from region to this company the new transfer terminal has been built in Moldava nad Bodvou. So it is very important direction.

The common regular passenger with no social discount was considered.

Regional bus transport:

- Source of journey: bus station Moldava nad Bodvou
- Destination of journey: bus station Kosice
- There are 3 different ways of line with 29 km, 31 km and 33 km. For 29 km distance the price is 1.70 Eur, in the case of using the card it is 1.61 Eur. For 31 km and 33 km distance the price is same and it is 1.90 Eur, in the case of using the card 1.82 Eur.

The railway transport:

- Source of journey: railway station Moldava nad Bodvou
- Destination of journey: railway station Kosice
- The tariff distances in this case is 31 km and the price for single ticket is 1.80 Eur.
- If the commuters use the weekly track ticket (11.70 Eur) or monthly track ticket (39.60 Eur), and if it is supposed that commuter makes 10 journeys per week or 40 journeys per month, then the price is 0.585 Eur/1 journey or 0.495 Eur/journey.

The integrated transport system - the proposed prices (Table 4):

If the variant 1 is considered, it means the case of the highest prices, and the example of passenger who travels through 3 zones and through 4 zones, the following prices are calculated per one journey:

Calculated prices for season tickets in Euros Table 5

Type of ticket		€/journey
		Regional bus transport
single one way ticket paid by card		1.82
Railway transport		
one way single ticket		1.80
track return ticket		
weekly		0.59
monthly		0.50
Integrated transport system		
Variant 1 - basic modul 0.50 Eur		
Variant:	A-without D.	B - with D.
Ticket	3 zones	
single	1.5	1.4
monthly	1.05	1.4
quarterly	0.91	1.21
yearly	0.79	1.05
Ticket	4 zones	
single	2	1.85
monthly	0.98	1.30
quarterly	0.85	1.12
yearly	0.74	0.97

Source: authors

It can be seen from Table 5 that the value for one journey is lower in the case of season tickets proposed for integrated transport system regardless of considered variant than the value for one journey by regional bus transport or single ticket in the case of railway transport.

6. Conclusion

The proposal of the basic module for single tickets and season tickets is based on the analysis of current prices of public transport providers in the region with the main focus on the regional bus transport and from the first selection of the area into the tariff zones. In the next steps of process it will be necessary:

- to verify the zoning of area, its impact on prices for all existing possible connections,
- to solve the value of basic module as well as other parameters with all the involved public transport providers regarding to their current prices, the range of tickets (there are not the season tickets for regional bus transport),

- to propose the method of calculating the price for combined tickets, it means tickets for using the regional transport with combination of the urban public transport,
- to calculate the expected revenues in the case of expected numbers of passenger using the single or season tickets.

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Bibiana Bukova - Eva Brumercikova - Pavol Kondek - Dusan Sojcak *

THE IMPACT OF INTERNATIONAL INTREPRENEURSHIP ON THE DEVELOPMENT OF TRANSPORT

The article deals with the perspectives for the development of international entrepreneurship and the development of transport. Perspectives were determined based on research and the results of this research are presented in the article.

Keywords: *International entrepreneurships, development of transport.*

1. Introduction

The international environment is characterized by differences in its political, legal, sociocultural, economic and technological fields. Political decisions affect tariffs and taxes, laws on the protection of international investors. Economic indicators affect the level of prices, interest rates and unemployment. Technological environment influences the scientific and technological development and innovation [1 and 2].

2. Impacts of international entrepreneurship on the development of transport

To determine the impact of the development of international entrepreneurship on the development of transport, it is necessary to analyze the international environment and its influence on international entrepreneurship also in the transport sector. The following analyses were used in the study:

1. Analysis of tariff instruments.
2. Analysis of non-tariff instruments.
3. Analysis of the legal framework regulating the international entrepreneurship of foreign entities.
4. Analysis of trade relations formed in the international environment.
5. Analysis of the development of distribution channels in the international environment.
6. Analysis of the overall export and import of goods in international entrepreneurship.
7. Analysis of the global competitiveness of the international environment.
8. Analysis of the GDP growth and the trade balance of the international environment,
9. Analysis of other factors of international entrepreneurship in an international environment.
10. Analysis of customers in international entrepreneurship.
11. Meta-analysis.

Based on available data and carried out analyses we can evaluate each of the selected countries in terms of: commercial and political conditions, specific tariff and non-tariff instruments, customs tariffs and legislation which defines the international entrepreneurship of foreign entities, trade relations forming in the international environment, the development of distribution channels, overall export and import of goods, global competitiveness, GDP growth, trade balance and behavior of customers [3].

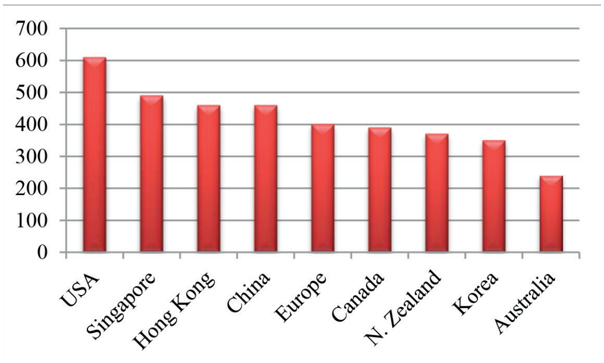


Fig. 1 The total score of countries with the most suitable conditions for international entrepreneurship (authors)

* [1]Bibiana Bukova, [1]Eva Brumercikova, [1]Pavol Kondek, [2]Dusan Sojcak
[1]Department of Railway Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]Enersense International Oy Gallen-Kallelankatu, Pori, Finland
E-mail: bibiana.bukova@fpedas.uniza.sk

The total score of each country (authors) Table 1

Country	1	2	3	4	5	6	7	**8**	**9**	**10**	**11**	**Total**
China	100		40	100		90	80				90	460
Hong Kong		90	50			40	50	40	90	100		460
Singapore	90	100	70			20	20	90	30	70		490
Mauritius	80											80
Georgia	70	30	30									130
New Zealand	60	80	100		50				80			370
T. Leste	50											50
B.Darussalam	40											40
Australia	30		90		60					60		240
Haiti	20											20
Cook Islands	10											10
USA		70		90	90	80	90	80		80	30	610
Canada			80		80	30	40		50	90	20	390
Macedonia			60									60
Rwanda			20									20
Kazakhstan			30									30
Belarus			10									10
Ireland									70			70
Germany								60		50	40	150
Malaysia		50		100	20							170
Korea		40		100	30	60	60				60	350
Great Britain					70			20		40	100	230
Norway		20							40		70	130
Japan					40	70	70	50			10	240
Russia						50						50
India							30					30
European Union				100	100	100	100					400
Mexico							10					10
Oman					10							10
Switzerland								100	20			120
Finland								70	10		80	160
Sweden								10	60	10		80
Netherlands								30		30		60
Denmark		60							100		50	210
Spain										20		20

Source: own processing

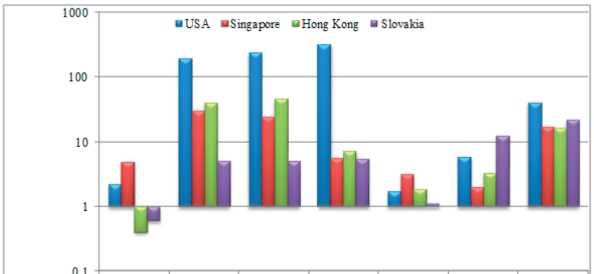
Summary results of the carried out analyses are presented in Table 1. The scores of particular countries are from 100 to 10 according to the placement in the above-mentioned analyses.

Graphical illustration of the Top 10 countries from the total score is shown in Fig. 1. Those are countries that, based on the carried out analyses, reach the most suitable conditions for international entrepreneurship.

Figure 1 shows that the most suitable environment for international entrepreneurship is in the United States.

For an overall assessment of the USA, Singapore, Hong Kong and their comparison with Slovakia, the comparison of the following selected economic indicators is necessary: GDP growth rate, overall export and import, number of population, average monthly wage, unemployment rate and the corporate income tax.

All data for the same time period of December 2014 are shown in Fig 2.



	1. GDP Growth %	2.Export bil. USD	3. Import bil. USD	4. Number of population in mil.	5. Average monthly wage in thousands USD	6. Unemploy ment rate %	7. Corporate income tax %
USA	2.2	195.002	240.603	318.9	1.688	5.7	40
Singapore	4.9	30.303	23.809	5.47	3.113	2	17
Hong Kong	0.4	40.454	45.257	7.2	1.857	3.3	16.5
Slovakia	0.6	5.076	5.09	5.4	1.1	12.29	22

Source: own processing

Fig. 2 Assessment of the USA, Singapore, Hong Kong and Slovakia

The following prospects of the development of international entrepreneurship and development of transport can be evaluated from the assessment of the United States, Singapore, Hong Kong and their comparison with Slovakia.

3. Development perspectives of international entrepreneurship and the development of transport

Prospects for entrepreneurship in the USA are the developed market with transport services which is stimulated by the size of population. Perspectives are: development of services through modernization, IT technologies, simplifying of purchase, building self-service systems and eliminating intermediaries in trade.

Prospects for entrepreneurship in Singapore are international investments in the development of services or production. A low unemployment rate and a high average salary of the population increase the demand for quality products and transport services. Perspective are products with the possibility of original and tailor-made products through mass customization [4].

Prospects for entrepreneurship in Hong Kong are investment in production and services. The market of manufacturers in Hong Kong is popular due to producing cost-effective and quality products with quick delivery time resulting from a rapid production rate and eliminating intermediaries in the hierarchy.

Despite the fact that the USA maintains a position of economic power, Asian countries are “progressing“ in favorable conditions for international entrepreneurship. Low import tariffs, a simplified process of starting a business, an established system to protect investors, trade freedom, tax burden, bureaucracy, established bilateral relations and the low costs of labor and materials allow Asian countries to create the most suitable environment for international entrepreneurship. Europe also provides a suitable environment for international entrepreneurship, however, it protects its internal food market, which to a large extent, has consisted of imported food in recent years.

Prospects of international entrepreneurship are in the phase of the development of enhancement and modernization of transport services such as simplification of purchase and removing intermediaries. Further prospects are in increasing export through the production of quality, innovative and cost-efficient products with short delivery time and the production of original and tailor-made products through mass customization [5].

4. Conclusion

The international environment is constantly evolving and changing, regions that were among developing regions begin to evolve and the financial inequality deepens. The international environment contains entities with the availability of large amounts of capital and, on the other hand, ”poor“ environment with low living standards. Products are designed to meet the needs of consumers - customers. Several experts point to major changes in behavioral patterns of customers, which ultimately has an impact on the competitive forces on the global market. Ongoing trends, particularly those relating to the use of digital technologies also bring threats and opportunities for manufacturers as well as carriers [6 and 7].

Acknowledgment

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Peter Kolarovszki - Jirí Tengler - Dragan Perakovic - Marko Perisa *

IMPACT OF SORTING MACHINE ON LIFE CYCLE OF PASSIVE UHF RFID TAGS PLACED ON LETTER MAIL

This article deals with research of passive RFID technology in conjunction with letter-size mail, which is placed into sorting machine. RFID technology is a part of automatic identification and data capture. In this article we would like to describe an identification of letter mail based on passive technology. We would like to specify, how the sorting machine impacts a readability of RFID tags placed on letter mail. We have established a number of variants of placing RFID tags into envelopes. After passing these tags, we evaluated their readability. Then we compared the results before and after passing the letters through the sorting line. All results are verified by measurement at the Slovak post main processing center located in Zilina. The results of our research bring the new point of view and indicate the ways of using of UHF RFID technology in postal and logistics applications. At the end of this article we evaluate the impact of the selected sorting line on a life cycle of RFID tags.

Keywords: *RFID technology, sorting machine, passive tag, letter mail, identification.*

1. Introduction

This article deals with research of life cycle of passive RFID tags passed through the sorting machine. We performed research of readability of RFID tags in different conditions of selected parameters. Areas of application of RFID technology are also postal and logistic processes. In this context there are several questions of feasibility of the use of identification of letters, parcels etc. Today, postal operations have implemented RFID in various closed-loop systems to measure, monitor, and improve operations. For example, RFID is used to monitor international mail service between major hubs. By randomly "seeding" tagged letters into trays, elapsed delivery time can be measured. This allows service issues to be identified and addressed in a reliable and cost-effective manner. By allowing information to be captured automatically, RFID makes sure it is done, even under stressful conditions.

2. Objective and methodology

Objects of the research were the transport items (letter mail) and passive RFID identifiers placed into thesetransport units. RFID tags were read by passive RFID readers in several positions and conditions. In order to achieve the relevant results of the research (Fig. 1), more than 100 measurements were performed. Measurements were realized by various types of testing.

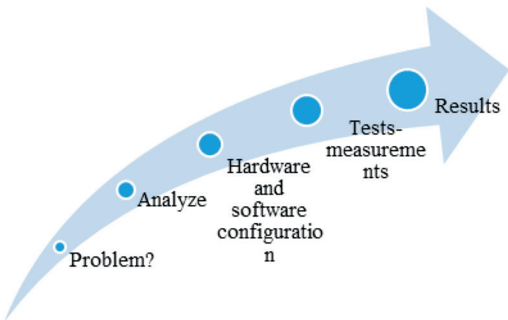

Fig. 1 Steps to achieve good results

3. Theoretical background

3.1 RFID system

The RFID system architecture consists of a reader and a tag (also known as a label or chip). The reader queries the tag, obtains information, and then takes action based on that information. That action may display a number on a hand held device, or it may pass information on to a POS system, an inventory database

* [1]Peter Kolarovszki, [1]Jirí Tengler, [2]Dragan Perakovic, [2]Marko Perisa
[1]Department of Communications, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Slovakia
[2]University of Zagreb, Faculty of Transport and Traffic Sciences, Croatia
E-mail: kolarovszki@fpedas.uniza.sk

or relay it to a backend payment system thousands of miles away. Let's take a look at some of the basic components we have used in our research.

RFID tag is a small device that can be attached to an item, case, container, or pallet, so it can be identified and tracked. It is also called a transponder. The tag is composed of microchip and antenna. These elements are attached to a material called a substrate in order to create an inlay [1].

Tags are categorized into three types based on the power source for communication and other functionality.

- Active.
- Passive.
- Semi-passive.

RFID interrogators (often called readers) which are devices that wirelessly communicate with tags to identify the item connected to each tag and possibly associate the tagged item with related data. Both the tag and interrogator are two-way radios. Each has an antenna and is capable of modulating and demodulating radio signals [2].

Middleware is software that controls the reader and the data coming from the tags and moves them to other database systems. It carries out basic functions, such as filtering, integration and control of the reader. RFID systems work, if the reader antenna transmits radio signals. These signals are captured by tag, which corresponds to the corresponding radio signal. This is a very special software device enabling mutual communication between two and more applications. This device is marked also as a mediator between various application components [3].

3.2 Characteristic of sorting machine

Compact reader sorter (CRS) provides cancelling on mail pieces which are aligned on their bottom edges. It also provides address reading and videocoding, barcode reading and printing techniques (Fig. 2). The main focus is to sort letter mail items up to 24 stackers in inward and outward sorting options [4].

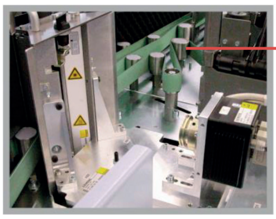

Fig. 2 Possible damage zone [5]

3.2.1 Address reading

In order to recognize the addresses of the mail pieces, which are running through the machine, a letter scanner scans an image of each mail piece. To achieve this, the mail piece is illuminated and the reflected light is photographed with a camera. The scanner electronics converts the gray image into a binary image. The scanner passes the image on to the reader electronics (IP-PC) [5 and 6].

Furthermore, the scanner passes on image-accompanying data e.g. in which areas of the image the address should be searched for. Mail pieces, which are correctly aligned and whose addresses can be read and recognized, are sent to a designated stacker. If the address of a correctly aligned mail piece can not be read, the machine control computer directs it to a special sorting stacker. If a video coding unit is connected to the system the address is coded manually and thus allows later refeeding of the mail piece. For this purpose the mail piece must be additionally tagged with an ID-tag in a different unit of the system [7 and 8].

3.2.2 Barcode reading and printing

The mail pieces pass by a faceplate with an integrated scanning zone. Two reflection light barriers in the faceplate determine the beginning of the mail piece and check the correct height orientation of the mail piece. The bars of the barcode are lit fluorescently through LED lighting. This optical signal is recorded with an arrangement of lenses, changed into an electric signal and forwarded to the evaluation electronics. The evaluation electronics transfers the results to the control computer, via a serial RS232 interface. The control computer directs each mail piece, in accordance with the sorting plan, to a stacker.

A destination barcode or an ID barcode printed on the mail piece identifies the mail piece and contains information like e.g. serial mail piece number. This makes it possible to determine the address of the mail pieces "off-line". If the machine can not read the addresses itself, it can forward the image of the mail piece to an off-line Video Coding System [9].

4. Description of measurements

4.1 Scenario of measurement

Scenario of measurement was realized by two levels. First level deals with testing of RFID tags on logistic units before and second level after the selected physical effects. In this way we gained the status of RSSI and read count before any damage to the RFID tag and after the possible damage. The measurements were realized under the same conditions, before and after damaging the RFID tags, in a single cycle, i.e. linear line (100 of transitions). Speed of transition of RFID tags on the linear line and recording period information was selected on the basis of secondary research, which served as a starting point for selecting these values. In the secondary measurements we combined rate of passage through the RFID gate by the linear line ranging from 0.100 meters per second up to 2 meters per second. We set the period (latency possible load) from 0 ms and 2500 ms by using the antenna in a horizontal, vertical and then horizontal and vertical position. From the total number of combinations in terms of the RSSI, the read count and used antennas, the combination of period 0 with speed 0.7 meters per second, and one antenna in a vertical position was selected. This selected combination was used in the primary measurement. Accurate placement of RFID antennas within linear line realized by secondary and primary measurement is shown in Figs. 3 and 4.

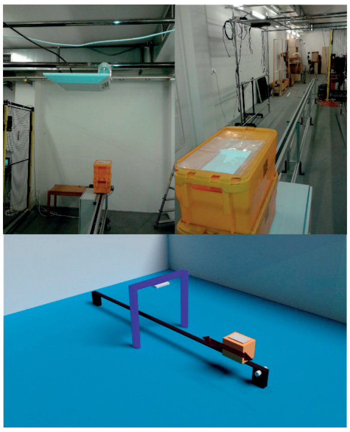

Fig. 3 Linear line / conveyor

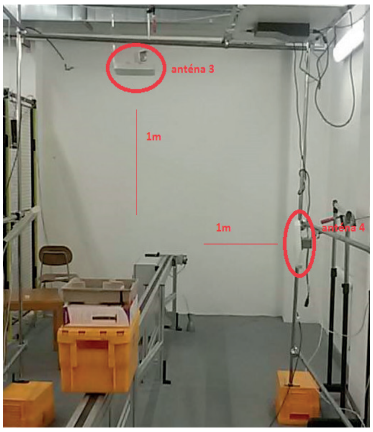

Fig. 4 Placement of antennas

4.2 Used equipment

- Motorola FX7400
- RFID tag
- middleware Aton OnID v.2
- MySQL Enterprise Edition
- CRS
- postal sorting center

4.3 Physical effects

On the letter mail with RFID tags following physical effects were tested:

1. Impact of frost (by the transportation in the winter time)
2. Impact of the magnetic and electromagnetic fields (during a contact with mechanized equipment possibly with other shipments)
3. The effects of water (after loading and unloading time)
4. Impact of the moisture (in case of rain and drizzle)
5. Exposure to high temperatures 40 and 60 degrees (by the transportation in the summer time)
6. Pressure (contact and friction with other letter-size mail)
7. Damage of the RFID tag (tearing of the label apart due to poor handling or contact with other letter mail)
8. Impact of sorting line

4.4 Damaging of RFID tags

The physical effects were realized in different environments. The first seven types of physical effects were realized under laboratory conditions. The last physical effect was realized in the postal sorting center of letter mail.

5. Measurement results

5.1 Result of damaging of RFID tags under laboratory conditions

As mentioned above we focused on two specific parameters and those were RSSI value i.e. average value within one cycle and the read count of RFID tags within one cycle. Before starting with the trial results, it is necessary to mention that we worked with the starting and end values of RFID labels as a single unit. The reason was that every RFID tag is a bit different. That is the reason that starting values for each label are different, sometimes even dramatically. In Fig. 5 the read count of RFID tags before and after impact of physical influences can be seen. Based on the results of the measured values we can confirm these conclusions. The biggest differences we found out in the impact of frost over the period of 72 hours (RFID tag was frozen for 72 hours). Also results with the frost-free period of 24 and 48 hours were not negligible. Differences were on average 72%, 41%, 36%. We observed also the big differences after impact of electromagnetic fields and exposure to high temperatures (40 to 60 degrees) within one hour of measurements. Differences were on average 56%, 49%, 46%. We recorded lower differences in the impact of water and steam, or moisture, where the difference between two impacts was 36%. Surprisingly, the lowest differences were seen in impact of classic magnet and neodymium magnet even under pressure. The difference was 1%, 11%, and at a pressure 2%, what is negligible.

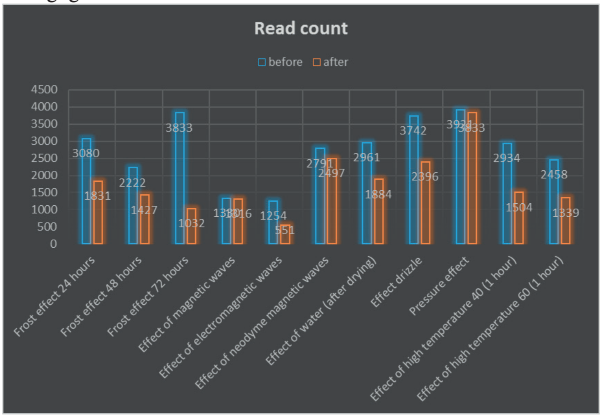

Fig. 5 Read count value before/after

In the measurement and result evaluation, we evaluated a second parameter which was RSSI (Fig. 6). In terms of the measured range we can´t make any justified conclusions, because differences in terms of the measured range are quite negligible. So we can say that RFID tags mostly maintain its radiation properties.

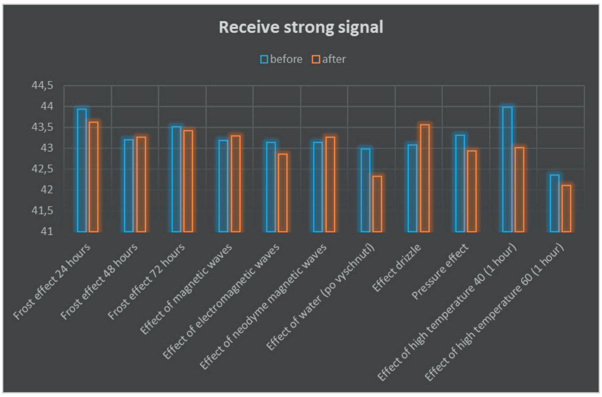

Fig. 6 RSSI value before/after

5.2 Result of damaging of RFID tags in CRS

As in the previous case, again we focused on RSSI value and read count (Fig. 7). The most differences were recorded in letter mail that passed through the sorting line two times with one and three sheets of A4. In this case the value of count read decreased by 53% and 70%. In other cases, we observed a decrease in values between 8% and 24%.

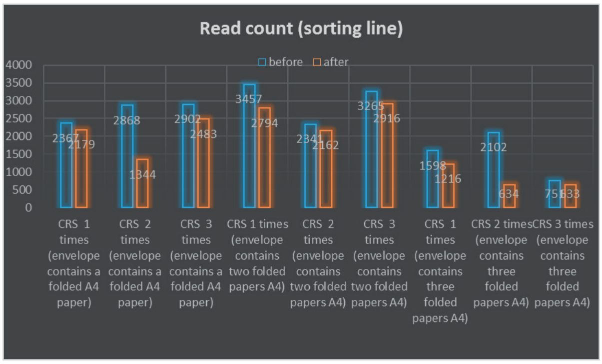

Fig. 7 Count tags read (sorting line)

In our measurement we again focused on RSSI values, but we could not unequivocally confirm the impact of the physical effect through the sorting line. Differences in values (Fig. 8) before and after the sorting line are minimal.

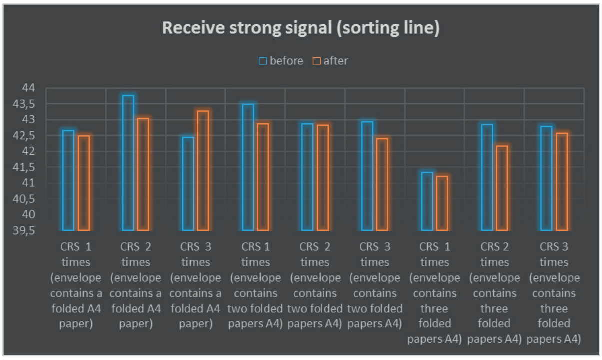

Fig. 8 RSSI value before/after (sorting line)

6. Conclusion

The aim of this article and also related measurements was to demonstrate the effects of selected forms of physical effects which the letter item fitted with RFID tag can meet with during the transportation. As part of the recorded values we obtained read count number and RSSI value. We made two measuring parts, first part was before and second after impact of physical effects. The difference between these two measuring parts subsequently provided the requested data. For the first scale of data (read count of RFID tags), the differences were so big that we could clearly, for most of their physical effects, confirm the negative effect of RFID tag. Despite the large decrease in the read count of each tag, these tags still remained powerful and capable of working. Within the measurements we compared these with the value of RSSI. With this type of measurements, the differences were so small that we could not conclude any clear conclusions, since the majority of RFID tags quality signal didn´t change significantly from the antenna of RFID tag. Therefore, we were able to prove uniquely only the impact of physical effects in terms of read count that was in frost condition (effect after 72 hours) 73%. The impact of the sorting line was strongly observed in only two of the nine options. Similar results were seen in RSSI value. Based on the results of the impact of the sorting line on RFID tag, we can only assume that there is a physical effect, but this situation probably occurs randomly. Physical effects were acting only once on individual tags. In this case we can say, that read count and RSSI values were stabled even more by the repeated impact of physical effects.

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E! 7592 AUTOEPCIS - RFID Technology in Logistic Networks of Automotive Industry

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Petr Kurenkov - Alexey Astafiev - Olga Kaplina *

DIFFERENT EXEGESIS OF THE CONCEPTS RELATED TO MIXED TRANSPORT

This article contains a short history of existing types of mixed transport in Russia and abroad. The system of export freight delivery is analyzed in association with all forms of interaction between various modes of transportation and the subjects of the transport service market (TSM). There is focus not only on the transport complex organization departments and management levels of various modes of transportation, but also on other TSM subjects (carriers, cargo owners, forwarders, stevedores, marine agents, banks, organizations responsible for expertise, customs control and document completion, etc.).

Keywords: *Mixed transport, multimodal transport, railway, trailer transportation system, piggybacking, containers.*

1. Introduction

There are various approaches to interpreting the transport terms. According to UNCTAD (United Nation Conference on Trade and Development) intermodal transport refers to carrying goods by several modes of transport when one carrier is responsible for the whole delivery from one departure point through one or more transshipment points to the destination point. Depending on responsibility for transporting goods various shipping documents are issued. The person organizing multimodal transport is responsible for transporting the goods along the whole route, irrespective of the number of carriers when completing the single shipping document [1].

At the European Conference of Ministers of Transport held in 1994 it was stated that multimodal transport refers to transporting one type of freight by not less than two modes of transport, whereas intermodal transport means transporting goods by one mode of transport with the transshipment of the sealed container en route [2].

2. Interpretations

A. Avetikyan and N. Solovyeva [3] say that "integration between transporting and manufacturing processes gradually shifts from intermodality of cargo movement, i.e. internal isolation and autonomy from the results of producing goods, to transmodality (integration of freight transport by various modes of transport according to the single documents)".

According to V. Goryainov [4], L. Mirotina and Y. Tashbaev [5], intermodality is integrated 'from door to door' freight transport according to the single consignment; the transport involves at least two modes of transport.

The similar definition is given by V. Galaburda [6]: "Under the intermodal system the cargo is carried 'from door to door' by two or more modes of transport under single management and according to a single document (such system is also called 'direct mixed transport', though we don't think this is an apt term to describe the process).

The idea of intermodal transport is to deliver ULD (a container or package) according to the schedule agreed by all modes of transport under control of the forwarder that takes responsibility for meeting transportation conditions and completing the required documents. The forwarder (transport organization, container association, special forwarding company, etc.) as a legal entity concludes a contract with the cargo owner and transport organization (carrier) and takes responsibility to calculate the optimal transportation process and to ensure its quality... The system with the forwarder being one of the modes of transport and interacting modes being its customers is called the multimodal transport system".

The decision taken by the EU Ministers of Transport in January 1997 says: "Transport intermodality is the possibility to influence the dominance of one mode of transport over others...

* **Petr Kurenkov, Alexey Astafiev, Olga Kaplina**
Department of Transport business, Faculty Institute of Management and Information Technologies (IUIT), Moscow State University of Railway Engineering (MIIT), Russian Federation
E-mail: petrkurenkov@mail.ru

Transport intermodality is aimed at integrated use of every mode of transport to benefit from its specific characteristics...”

O. Goncharuk [7] as well as L. Mirotin and Y. Tashbaev [5] say that “in contrast to intermodal systems where ULD are carried according to the single tariffs and shipping documents with all carriers having equal rights, in multimodal transport one mode of transport is the carrier whereas interacting modes of transport are the customers paying for the services”.

S. Miloslavskaya [8] says: “Intermodal transport is successive transportation of cargo by several modes of transport in the same freight unit or vehicle without its reloading in transshipment. According to [8] “intermodal transport means carrying cargo in the same freight unit and the same vehicle which are successively used by the modes of transport without cargo handling when changing the mode of transport”.

In the proceedings of the Conference on Transport and Environment (1996) we read: “Combined transport is intermodal transport with the largest part of the European route handled by railway, inland water or sea transport; any initial and/or final route section operated by road transport is maximally short”.

According to N. Venzik [1] “combined transport in contrast to intermodal transport is transporting cargo in the same piece of freight or vehicle by combining road, railway and inland water transport”. L. Matyshina and L. Izosimova [9] write that ‘according to the European Agreement on Important International Combined Transport Lines and Related Installations (AGTC) combined transport means transporting cargo in the same piece of freight, the same transport installations (large capacity containers, swap bodies, semitrailers and trucks) using several modes of transport”.

In the materials prepared for the board meeting of the Russian Transport Ministry [10] we read: “Combined transport means carrying cargo using more than one modes of transport and organizing door to door transportation according to the single document”. The definitions mentioned above are published in the digest prepared by the United Nation and Economic Commission for Europe – UN/ECE, European Conference of Ministers of Transport – ECMT and European Commission (Terminology on Combined Transport) route [2], where all these definitions are reduced to the same denominator.

As for the terms like amodal, bimodal, unimodal, threemodal, segmented and other transport, there is no confusion about their interpreting because they are used not often.

Amodal transport is control of moving transport and freight units irrespective of the modes of transport involved and the role each one plays in the transportation process (successive, parallel or combined). Amodal transport is controlled from one dispatcher center [3].

Bimodal transport is carrying cargo in specialized vehicles having chassis and wheelsets capable of moving both on highways as tractor trailers and on rails as wagons of freight trains and even as passenger cars.

The trailer transportation system is a system of freight delivery in ULDs – trailers (automobile trailers or semitrailers with canopy or special demountable bodies). Main goods transported are trucks, self-propelled machinery, bulky and heavy freight.

Bulky and heavy freight (pipes, steelwork) is placed on the vehicles (trailers, rolltrailers, heavy-load chassis) which avoids the need to dismantle the equipment into separate units for their transportation from the consigner to the consignee. Rolltrailers are used only for carrying freight in the sea and river links of this transport system. Other ULDs are used in continental transport involving motor and road and railway transport. Both vertical and horizontal (with various tractors) crane loading-unloading is used in depot processing.

Nowadays there are various approaches to interpreting the term ‘piggybacking’. Can be transporting a truck, which initially was moving under its own power and later was placed onto the flat wagon, considered as piggybacking? Is the truck to be loaded? If so, transportation of neither the tsar’s coach nor empty trucks on flat wagons can be referred to as piggybacking. Similarly, it would be incorrect to refer transportation of military machinery on flat wagons to piggybacking.

The unimodal transport means carrying freight by one mode of transport and one or more carriers. If one carrier is involved, it issues its own transport document: a bill of loading, consignment note, etc. If there are more carriers (e.g. the carrier that moves freight from one port to the other with the transshipment in an intermediate port), one of them can issue a through B/L covering the whole journey. On the return side of the B/L certain terms of transportation may be specified, and the carrier is responsible for the whole trip or only for the part of the trip covered by its own vessel [8].

The segmented transport means that the carrier organizing transportation may take responsibility only for its own part of the process. In this case it issues the B/L to carry intermodal or combined transport [8].

Containerization has been successfully used since 1950s. According to “International Transport Journal” (Switzerland), in 1995 the share of containerized cargo was 95 percent – one third was transported ‘port-to-port’ whereas the rest was carried out by mixed traffic. In 1995 the world container fleet was over 50 million units.

The main container fleet (over 80 percent) includes general-purpose large capacity ISO containers. Generally, mixed transport is carried out by 20- and 40-feet general-purpose containers. The International Convention for Safe Containers (CSC), 1972, has two goals: to maintain a high level of safety in the transport and handling of containers by providing generally acceptable test procedures and strength requirements, and to facilitate the international transport of containers by providing uniform international safety regulations.

The Convention applies to the great majority of freight containers used internationally, except those designed specifically for carriage by air. In the Russian Federation containers have the certificates issued by of the CIS Register or other standard certificates/documents. Special customs rules are drawn that regulate export and import of containers as well as container traffic record.

In the 1970s, shipping companies started unloading containers on the western coast of the USA; from there they were brought across the whole country to railway flat wagons with the final delivery by the road transport. American President Lines Ltd., a transportation and shipping company, that operated only in the Pacific region bought its own railway flat wagons and organized traffic of separate container trains. Initially, these trains went only to the East coast ports of the USA; from there containers were carried by road transport to eastern markets.

Later, amendments in the legislation enabled shipping companies to carry goods to the inland destination points, and these companies started transporting containers by rail from the western coast to every part of the country. Actually, this type of service known as 'landbridge' took the place of the marine container route across the Panama Canal to the East coast of the USA and to the Mexican Gulf.

This traffic can be divided into 'minibridge', 'microbridge' and 'landbridge'. Their common feature is that they are carried out according to the single tariff, to the single B/L or other document; profit distribution between marine carriers responsible for door-to-door delivery and land carriers as their customers is agreed upon in the tariff.

The "minibridge" transport includes carrying freight/container according to the single marine B/L from the port of one country to the port of another country, then by rail (landbridge) to the second port of this country and from there to the railway inland terminal of the destination country.

Its basis is the through container rate calculated from the port of the departure country to the end terminal in the destination country. The "minibridge" tariffs are issued by marine carriers, not by railways that receive commissions for transporting freight (containers) on the land section of the route. A classic example of the "minibridge" land section is the route carrying freight between the East and West coasts of the USA.

Compared with the marine transport the "minibridge" system has a number of advantages' both the total time and transportation costs are reduced. Since 1983 double-deck trains have been operating between the USA coasts for container transportation, which resulted in 20-25 percent cost saving.

Container transport on the Russian Railways in international traffic is regulated by the following documents:

- the instruction on how to record freight trains, wagons and containers passing through the division points;
- rules of operating, tracking each number of the container fleet and making calculations for using general-purpose containers of other countries' ownership;
- and other regulating documents.

Container systems prove to be highly efficient on the routes with stable flows of general cargo.

The essence of the palletized transport is to enlarge the piece of freight mainly with flexible bundling and flat pallets.

The cargo is placed on them forming packets with the parameters adequate to use freight capacity and carrying capacity of vehicles, transshipment equipment as well as to ensure safe transportation of cargo, to provide complex mechanization of loading-unloading operations, and to reduce the time required for handling the vehicles.

The terms of commerce have various interpretations. Thus, for example, the B/L tells about the cargo whereas the Customs code about the goods. One and the same cargo can be declared under different codes which may cause incorrect charging of the customs duty.

From what has been said above we can draw a conclusion that the definitions of the types of the mixed transport are to be formulated depending on what party is responsible for transportation, what procedure is followed when completing the shipment documents, the role of each mode of transport, the number of national boundaries to be crossed and geography of these countries and other factors.

However it should be admitted that the terminology concerning freight traffic involving various modes of transport is far from perfect.

It is easier to use the common definitions of various modes of transport: local, direct, mixed direct, direct international, direct mixed international, etc. However, to play an equal role on the international transport market and be adapted to globalization processes we are to know generally accepted terminology which is not as simple as one may think [11], [12] and [13].

There is not much experience in the organization of piggyback traffic which causes a number of problems in the interaction of various agencies dealing with the customs clearance of cargo and vehicles used for its transportation (tractor and trailer rigs and railway flat wagons).

For this reason of primary importance is to analyze normative documents regulating this traffic both in the home country and abroad (international agreements, federal laws, other normative and regulatory legal acts) to pick up the rules and regulations that are to be captured in legislations or (if necessary) amended. As the concepts of "contrailer" and "piggyback traffic (shipment)" are ambiguous, a number of amendments should be introduced into some federal laws (for example, the federal bill "On mixed (combined) transport") and other regulatory legal documents.

Under present economic conditions logistic management of the export freight delivery in the mixed transport is to provide optimal work of transport agencies; it is aimed at improving operating and regulating activity by using reserves of the transportations system and optimizing interaction and coordination of all TSM players involved in export freight delivery.

Managerial decisions are to provide coordinated solution of global and local tasks to achieve the common goal – increasing freight transport profitability and satisfying the cargo owner' needs (the cargo is to be delivered in time, in the required volume and according to high-quality standards). In other words, the managerial decision is to be taken on logistics principles.

According to the estimates of the 1970-80s, over 90 percent of freight transported by sea transport and about 50 percent of cargoes carried by river transport are transferred to railways or come from the railway transport. Therefore, the main problem of organizing the work not only of transport hubs based in sea ports but of those based in river ports was improving of all forms of interaction and coordination between railway and river transport, such as organizational, informational, technological, technical, commercial, economic, financial, legal forms, etc.

Usually a transport hub is the place of interaction between railway and road transport; road and water transport; railway and water transport, railway, road and water transport. Besides, these modes of transport interact with the industrial transport.

Interaction between railway and water transport is carried out in a greater number of transfer points (compared with sea transport), but the volume of work in river ports is not as large as in sea ports. Compared with sea ports, river ports more actively interact with road transport.

During the pre-reform period, transport hubs used to solve their tasks through close interaction and cooperation between related enterprises - railway stations, sea and river ports being the part of the transport hub, as well as truck agencies.

Some authors interpret coordination and interaction as synonyms. We do not agree with this point of view. There is no single approach to picking out the forms, areas, methods, spheres, aspects etc. of coordination and interaction and describing the role every concept play in the whole process.

Some authors say that coordination is harmonization of fundamental directions, complex planning of the development of various transport modes, improving management and control systems, cooperating in legal regulation of all modes of transport in the Unified transport system. Coordination mainly refers to the highest levels of transport hierarchy (ministries) and, partially, to the middle levels (railway administrations, shipping companies, regional department of road transport).

Interaction is aimed at coordinated decision making to complete fundamental directions of coordination between various transport modes; of primary importance is to complete the plans of transporting goods with the least expenses. Its goal is to optimize operational planning and monitoring of the coordinated work of every transport agency. It should be stressed that the interaction between the services within every mode of transport as well as other enterprises of the national economy is required.

Other authors say: "Interaction between modes of transport means coordination of operations in various transport modes involved in the whole transportation process. Coordination is coordination of the activities of the transport bodies and links to achieve maximum efficiency in carrying goods. With the increased traffic volume and modernized machinery and technology of all modes of transport their coordination is of special importance. Breaking freight delivery times and malicious use of vehicles is mainly caused by the lack in coordination between the links of the transportation chain. For this reason, better coordination in the transport industry is at the top of the agenda.

During the pre-reform period interaction was carried out at the middle links of the transport hierarchy (railway administrations and shipping companies) and, mainly, at its lower links (railway divisions, stations, ports, wharfs, truck agencies, etc.). Interaction between all modes of transport (in large hubs) was referred to as complex; in case two or three transport modes were involved interaction was bi-three-lateral.

Nowadays when export freight passes through sea and river ports interaction is carried out not only between various modes of transport but also between carriers and forwarders, between forwarders and cargo owners, between forwarders and stevedores, between stevedores and agents, between agents and the customs, between forwarders and the customs, etc. In other words, nowadays interaction and coordination cover practically all levels of management of all transport modes. As the export freight mixed transport involves not only government bodies but also private companies, the transport market is an intricate system: government and commercial structures both interact and coordinate at every level of management.

The system of freight goods delivery moves transport and freight flows as well as information, financial and energetic flows; hence various forms of coordination and interaction between various modes of transport and the TSM subjects.

Some authors say that "there are several forms of interaction between various transport modes: economic technical, technological, organizational, commercial and legal".

Latest achievements in computer engineering encourage the development of the informational form of interaction.

V. Galaburda [6] says: "Interaction of transport modes is carried out in the technical, technological and economic forms. Coordination of transport modes is to be carried out in the organizational and legal areas. Coordination in the organizational area, to be more exact, in the area of the national transport management, is aimed at correcting mistakes caused by organizational disunity of separate transport modes and their subordination to various transport ministries, organizations and departments".

A. Komarov [14] points out: "The tasks of development coordination and interaction between various modes of transport are diverse and can be solved in the planned-economic, technical, technological, financial, organizational and legal spheres (areas). There is also an informational sphere (area) of interaction, but it is obviously a component part of technological interaction". Some authors say about the areas of interaction, whereas others prefer spheres of coordination.

3. Conclusions

Under the market conditions, apart from interaction and coordination between various modes of transport and TSM subjects, special attention should be paid to the competition factor.

Competition on the TSM is seen not only between various modes of transport and between transport departments of various countries but also between transport companies dealing with forwarding, agency service, declaring, store handling, stevedoring etc. and having the right to render or resale services of one or several modes of transport.

Besides, competition is seen in every marine port, between Russian and foreign ports of one sea basin and one region.

RZD JSC and Transport Ministry agencies are to conduct regular advertising campaigns for ship owners and forwarders to attract export freight flows to the Russian transport communications and ports.

Integration and partnership of TSM subjects, EDM, latest computing technologies, flexible tariff and tax policy supported by the normative and legal basis, complex management of transport, freight, information, financial and energetic flows in the legal framework are certain to improve management efficiency at every stage of export freight traffic in the mixed transport.

To improve the quality of transport service the term "legal logistics" should be used meaning timely preparation and approval of normative legal acts regulating the interrelations in the legal framework, particularly, between the TSM subjects when carrying out export freight traffic in the mixed transport.

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Martina Vackova - Maria Kancirova - Lucia Kovacova *

THE IMPORTANCE OF INTERDISCIPLINARY RELATIONS OF PHYSICS AND STATICS

The article will discuss the importance of respecting and applying the didactic principle of interdisciplinary relations in Physics and Statics taught at the University of Security Management in Kosice. The subjects Statics and Physics, which are based on natural principles, allow to get the necessary analytical and logical thinking for understanding other technical and science subjects. Application of the principle of interdisciplinary relations helps to increase efficiency and quality of the teaching process, motivates and activates students. The article describes the possibilities of using physical knowledge in the subject Statics.

Keywords: *Interdisciplinary relations, teaching process, physics, statics.*

1. Introduction

The quality and content of higher education is currently a frequently discussed issue in society. For students, university is not only a source of information and knowledge, but through university teachers it provides them with skills and treatment of theoretical methods that help students classify, process and adequately apply in an effective manner the acquired information in practice.

The objectives and tasks of the teaching process help create optimal conditions for the conscious and positive activity of well-educated and skilled security managers of different specializations [1]. The current dynamic changes in our society will be substantially reflected in the structure and functioning of the labor market. The various professions are changing as fast as the demands of employers, which in turn, necessitates a rapid response in education and training systems [2]. The aim of education is to prepare a group of experts for the management of security institutions of different sizes and varying degrees of complexity. It is necessary to develop and clarify its own terminology of the relevant terms, used in the preparation of security experts - in education of security management specialists [3].

Nowadays, higher education goes through a number of changes - the changes in the curriculum, forms of education and methods of knowledge evaluation. Changing the content of the curriculum is not an exception - the reduction of unnecessary, non-functional information and replacing it with the content and knowledge necessary for practice, which can be used and applied by students in practice. This modification is also possible due to the systematic application of the didactic principle of respecting interdisciplinary relations.

A didactic principle of respecting interdisciplinary relations in teaching requires that any new knowledge be created by building on the knowledge of other sciences. By application of interdisciplinary relations and links the knowledge isolation is overcome, which leads to a reduced amount of unnecessary, non-functional information, substitution of its content by the knowledge necessary for life.

In order to meet the main objective of university study, namely the real usability of the acquired knowledge in practice, there should be a change in course content. Durability of the acquired knowledge is affected by various factors and, in certain circumstances it may be extended. Only the acquired information, which has previously been sufficiently understood by the student and processed in his consciousness, can become student‘s permanent property.

In an effort to educate as many graduates as possible to approach the ideal graduate profile it is necessary for the learning process to be optimal, rational and efficient. The teaching process has its own set of goals that must be achieved in due time. This is associated with the energy expended by both the teacher and the student, from which then arise adequate results of teaching activities in relation to time and energy. To make the learning process effective and meet its objectives, the teacher must use teaching methods, material resources, apply the principles of teaching, create organizational forms and, finally, apply

* **Martina Vackova, Maria Kancirova, Lucia Kovacova**
Institute of Humanitarian and Technological Science, University of Security Management in Kosice, Slovakia
E-mail: martina.vackova@vsbm.sk

interdisciplinary relations, as the acquired knowledge is without connections and contexts fragmented.

The need to address this issue from a didactic point of view, we focus on two study subjects, Physics and Statics, which are included in the study programme Management of Security Systems at the University of Security Management in Kosice (USM). Physics and Statics arise from natural laws, both enabling to acquire necessary analytical and logical thinking for understanding other Technical and Natural Science Subjects. The role of these subjects in the field of study Protection of Persons and Property and the present study programme is to enable students to acquire basic analytical capability necessary for addressing a number of technical problems and acquire knowledge necessary for passing other subjects, particularly Elasticity and Strength. These subjects create a solid and logical basis for, particularly, technical studies. The fact that the graduate of the study programme Management of Security Systems, the field of study Protection of Persons and Property also acquires knowledge of Technical Sciences is appropriate.

2. Interdisciplinary relations

Interdisciplinary relations can be understood as the intersection of a particular topic and the curriculum content of different subjects or methods of work and the use of these links in knowledge systematization. We define them as links between elements of didactic systems of different subjects. They are based on the content matches of the curriculum content of individual subjects (content bonds), common methods and forms of work (methodological bonds) and the temporal link of the curriculum of individual subjects (time binding).

The aim of interdisciplinary relations is the projection of knowledge of several subjects into a comprehensive picture of reality. An important factor here is the coordination of teaching in related subjects and timing of the topics covered [4].

The application of interdisciplinary relations in teaching provides the student with a comprehensive view of things. Its advantage is the change of the student‘s view of the possibility of applying the acquired knowledge, which undoubtedly leads to increasing his motivation. On the other hand, the application of interdisciplinary relations requires intensive preparation by the teacher. The educator must find suitable topics and prepare materials for them. If one decides for interdisciplinary teaching, he must cooperate with the other teacher and synchronize the inclusion of topics in the curricula with him. From the point of view of the teacher time saving in teaching is an advantage, as the teacher may refer to the knowledge of the other subject, the duplication is removed [5].

The implementation of interdisciplinary relations should already start in curriculum and teaching plans and the further analysis of the curriculum in each of the subjects should be reflected in the textbooks and other teaching aids necessary for educators and students, as well as in the work in this field.

Interdisciplinary relations as a didactic means allow a better systematization of knowledge, as they develop the ability to synthesize and transfer knowledge from one subject to another. Their purposeful application allows you to remove the often artificial boundaries between subjects [6].

3. The application of the didactic principle of interdisciplinary relations of Physics and Statics

The reason for the application of the didactic principle of interdisciplinary relations in the teaching of Statics and Physics at the University of Security Management was that university teachers began to realize that students had a distance of these subjects, considering them difficult and hard to understand, useless. For the teachers the aim was to arouse the students‘ interest in these subjects by applying interdisciplinary relations, and thus motivate them more effectively. At the USM the subject of Physics is taught in the first year of the summer semester, in the scope of 2 lectures, 1 practice lesson. Statics is taught in the 2nd year of the winter semester, 2 lectures and 2 practice lessons.

The main objective of teaching Physics at the USM in Kosice is to provide students with the basic knowledge and demonstrate the possibilities of application of the acquired knowledge and expertise in downstream subjects, specialized and profiling. From the point of view of the application of physical knowledge Physics and Statics have much in common.

The use of Physics in the subjects of Mechanics has its roots in the distant past and the development of Mechanics was also influenced by the solution of physical problems. Gradually Mechanics separated from Physics as an independent scientific discipline exploring mechanical movement of material (tangible) objects. Mechanics of solid bodies can be divided into [7]:

1. Mechanics of solid bodies and mechanical systems – where we can include the subject of Statics.
2. The mechanics of pliable bodies - where we include Elasticity and Strength.

The content of the subject of Physics is focused on the deepening, consolidating, broadening of the knowledge and skills acquired in the previous stage of education. An important goal of teaching Physics at the USM in Kosice is to provide students with the basic knowledge of Physics and, in particular, to demonstrate the possibilities of the application of the physical apparatus in the subjects in the field of Mechanics and in practice. The emphasis is laid on knowledge systematization, integration and generalization.

The scope of the issues is aimed at familiarization with the conceptual apparatus, basic laws and ideas of the growing importance of Physics for the development of Natural and Technical Sciences and the development of human society. In

Physics students acquire basic knowledge of vector quantities, vector calculus and laws needed for the follow-up study in subjects such as Statics, Elasticity and Strength, etc.

The subject of Statics enables students to acquire basic analytical capability to address many technical problems. It provides knowledge of the theory of force systems, static solution to the systems of bodies including the bar systems without and with passive resistance. At the same time it is the basis for understanding another subject of this field: Elasticity and Strength. Statics' scope is chosen to suit the requirements to be met by graduates in this field of study. It is focused on selected parts of Statics only, which are beneficial for students to cope with other subjects, and not to bring opacity to this subject or overburden students with lots of knowledge and tasks. Statics teaches you to understand, logically explain and justify a lot of everyday phenomena, commonly encountered in your area. Its application in various activities will enable doing things more safely and more efficiently. Therefore, it is necessary to acquire the basic knowledge of technical subjects as well, to which Statics undoubtedly belongs [8].

The content of the course syllabus of Statics [9]:

- Basic concepts and terms of mechanics. Basic axioms of statics and the consequences resulting from them. Force and Force systems. The linear force system. The central force system (planar, spatial). Point links in the plane.
- Sliding and rotating effect of a force. Moment of a force about a point. Possible effects of force systems. Shape and static determination of structure. General and parallel force system (planar, spatial).
- Moment of a force about a skew axis. The resulting effect of a force and moment in space.
- Center of tied parallel force system. Center of geometric shapes. Center of gravity of material objects (bodies). Linear load.
- Planar system of bodies and bar systems.

The content of the course syllabus of Physics [10]:

- Subject, methods and division of Physics. Physical quantities. Units of physical quantities. The International System of Units (SI).
- The basic relations of vector algebra.
- Kinematics of a material point, basic quantities characterizing the motion, motion classification. Dynamics of a material point. Newton's laws of dynamics, momentum, impulse of force, moment of force and angular momentum, energy, work, power, kinetic and potential energy, law of conservation of mechanical energy.
- Newton's universal law of gravity. Intensity and potential in a gravitational field. Movement of bodies in a gravitational field.
- Introduction to molecular physics and thermodynamics, kinetic theory of matter, total and internal energy of the system, temperature, heat, heat capacity, specific heat capacity and molar heat capacity, calorimetric equation, ideal gas, root mean square (rms) velocity, mean kinetic energy of the gas molecule, equation of state, working gas volume, laws of thermodynamics and actions.
- Mechanical oscillations and waves - basic concepts and terms. Undamped harmonics. Energy of harmonic oscillator. Muffled (damped) oscillations. Forced oscillations and resonance. Harmonic analysis. Formation of waves and basic concepts. Wave equation. The equation of a plane wave.
- Electromagnetic oscillations. LC oscillation circuit. RLC oscillation circuit and resonance. Formation and properties of harmonic alternating current. Effective values of voltage and current. Work and power of alternating current. Electromagnetic waves and their propagation.
- Electromagnetic theory of light, wave properties of light.

In Statics, since the first week of teaching, it is obvious that students need to have mastered the curriculum of vector algebra, to be able to perform vector operations: addition and subtraction of vectors (in analytical and graphical form), scalar and vector product. Students acquire this knowledge in Physics. Therefore, even in the beginning of teaching Physics it is very important to apply the interdisciplinary relations and motivate students in learning vectors and operations with them.

A student who wants to study Statics successfully must have mastered the physical apparatus that is used. And vice versa, a good motivation for students in the study of Physics may be the inclusion of the applications of Physics in teaching Statics. As regards higher education, the focus is mainly on the feasibility and usefulness of the acquired knowledge in practice.

Educators in Statics require that students must have the ability to apply the knowledge of Physics, methods in scientific disciplines and to solve problems of engineering practice. They are required to have skills and abilities necessary for the use

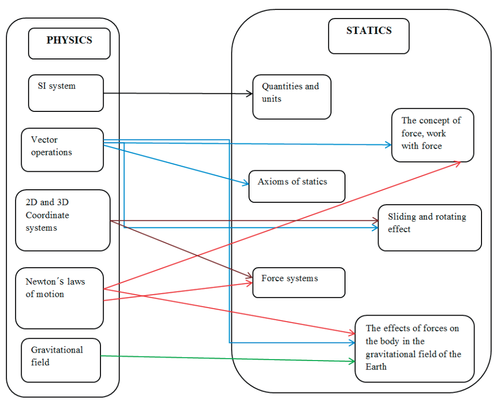

Fig. 1 The application of the didactic principle of interdisciplinary relations between Physics and Statics

of a physical apparatus allowing them to gradually master the solution of technical problems. In view of these requirements, the teaching of Physics at the University of Security Management in Kosice has begun to be focused more on the application of the knowledge of Physics, practices and methods to problems that occur in specialized subjects such as Statics. All this, however, cannot be achieved without the cooperation of teachers of Physics with the teachers, who cover the subject of Statics.

Based on the close relationship between Physics and Statics the didactic principle of interdisciplinary relations has started to be applied at the University of Security Management. In preparing the teaching plans of the subjects the teachers closely cooperate. The application of interdisciplinary relations of these subjects is shown below (Fig. 1).

In Fig. 1 we can see how closely the two subjects are linked. The knowledge acquired by students in Physics, are applicable in the subject of Statics. Therefore, we would like to say that the application of the didactic principle of interdisciplinary relations between these subjects is necessary and important, and not least, nowadays, it is the best way to educate as many graduates as possible the way to approximate to the ideal profile of graduate who will use in practice the knowledge acquired at the university.

4. Conclusion

Knowledge is part of the flow of information acquired by students every day, further processed, and possessed by them. The role of university teachers is to provide students with the knowledge that can be used in practice after graduation. Therefore, it is important to respect the didactic principle of interdisciplinary relations. Observing and respecting this principle may result in changing the view of the possibility of applying the acquired knowledge in other areas, which will undoubtedly increase student motivation. An important assumption of durability is that the student learns in depth, understanding the meaning and logic of the issue.

The aim of the paper was to highlight the importance of the didactic principle of respecting the interdisciplinary relations between the subjects Statics and Physics taught at the University of Security Management in Kosice. Combining teaching methods we can stimulate students‘ interest in studying Physics and Statics. We create the appropriate conditions for the development of interdisciplinary relations and for improving the quality of higher education at the University of Security Management in Kosice.

A suitable combination of the traditional and modern teaching methods can stimulate students‘ interest in learning; create conditions for the development of interdisciplinary relations and for improving the quality of higher education. The didactic principle of respecting interdisciplinary relations should be applied by educators of all types of schools, those wishing to motivate their pupils and students properly and purposefully for their further education. Because only properly and purposefully motivated student has the desire to learn, expand his knowledge and is able to apply the acquired knowledge in practice.

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Petr Hanzal - Roland Beranek *

APPLICATION OF ACCOUNTING DATA FROM ERP SYSTEMS OF BUSINESS ENTITIES IN LOGISTICS

The aim of this paper is to introduce the methodology for application of accounting data of ERP systems, gained from business entities in the Czech Republic, in logistics.

Every accounting file provides information about realized sales and purchases of each entity. With the help of accounting data it is possible to determine frequency and value of all sales and purchases. From the known address of the observed entity and its supplier and customer it is possible to derive the delivery distance. This logistic information can be analyzed and evaluated in charts.

Although the result of the examination cannot be fully generalized due to a limited data source, it should be considered as the contribution to logistics studies in the broadest context.

Keywords: *Accounting data, Logistics, Enterprise Resource Planning Systems.*

1. Introduction

This article is intended to be a contribution to the application of ERP (Enterprise Resource Planning) systems of business entities to logistics sciences as a result of a several-year research. The main goal is to demonstrate the potential of using accounting data from ERP systems for logistics evaluation, e.g. for identification of frequency and value of sales and purchases depending on delivery distance. The theoretical framework contains theoretical grounds for application of accounting data from ERP to logistics evaluation. The practical part then deals with identification of frequency and value of sales and purchases depending on the delivery distance, based on accounting data from the years 2007 to 2013 of 30 randomly selected business entities with operation in the Czech Republic regardless business subject classification.

2. ERP Accounting Data

Accounting data represent an essential element of each ERP system. They bear the recorded facts related to company activities and are transferable, interpretable and can be processed. They include all the facts of the organization's micro and macro environment like recorded data of economic facts and other factors affecting the chain of the company value chain [1]. The basic function of accounting is to provide all its users with reliable information on the company economic situation. Accounting information is intended for both managers and various external users that are interested in the company for various reasons. We can thus differentiate between two basic groups of accounting information users [2]:

- Entities directly involved in company financing (company owners and creditors – e.g. bond holders, banks, suppliers);
- Entities that are somehow interested in the company financial results (revenue offices, state administration, employees, competitors, potential investors, the public).

Financial accounting data are formed by the facts in the field of asset situations, receivables from customers, debts to suppliers, and they also monitor incomes and costs from the point of view of the accounting unit as a whole. They include all transactions in the field of purchasing and selling goods, material, own products and services, including the stem data of suppliers and customers [3].

3. Logistics and Accounting Data

Today logistic firms need to provide information to their vendors and customers. Resources for processing complex information and communication are required in the business world to assist global logistics. It is very important to plan

* [1]**Petr Hanzal,** [2]**Roland Beranek**
[1]Department of Applied Mathematics and Informatics, Faculty of Economics, University of South Bohemia, Ceske Budejovice, Czech Republic
[2]BMD Akademie, Steyr, Austrian Republic
E-mail: phanzal@ef.jcu.cz

a framework to manage materials, services, information and also capital flows of business. To increase the productivity of providing goods and/or services to the clients in Supply Chain Management (SCM) system, planning, organizing and managing activities become a vital issue [4]. It is believed that adoption of new technologies, especially information technologies, not only improves operating efficiencies, but also generates competitive advantage in logistics industry [5].

Effective operations of enterprises in almost every sectors of the economy require a well- functioning transport. It plays a very important role in logistics, because of the goods movement and the creation of ancillary services. In the past, the former economic information systems in the enterprises were used very marginally due to lack of competition. Currently, at the market there are a lot of competing firms, which led to invent new technologies and techniques [6]. The role of information systems in logistics increased. Organizing and managing information flows is done mostly using electronics means, both with the same company and between it and companies in upstream and downstream supply chain. In this way large volumes of data can be analyzed and effective and efficient decision can be taken, saving time and costs [7]. Information systems and knowledge flows play a decisive role in confirming the knowledge based economy as belonging to contemporary reality, both as a determinant of professional and managerial activities, as well as a scientific research object [8].

Economists' interest in activities and mutual transactions of companies, also from the point of view of locations where the companies are based, is very important [9]. The networked economy is, besides customer expectation, cost pressure, globalization, one of the main trends of logistics and supply chain management today and in the future [10]. Allocation of resources and selection of a suitable place for a particular activity is a strategic question for each business entity [11]. Individual authors approach its solution with accent to different factors – foreign investments [12] and [13], cluster evolution [14], urbanization aspects [15], etc.

Economies with high agglomeration rates are those external economies, where a company localized at the same place as more companies can benefit from them. This factor is traditionally supported by the two following mechanisms. At first, it is a reduction of operating costs with the possibility to share certain social and physical infrastructure resources, and secondly, it is the reduction of transport cost as a result of extended interaction between suppliers and customers that are located next to each other [11] and [16]. Economy of scale is the basic component of all models emphasizing the role of diversity of outputs and inputs. Companies having the possibility for a higher degree of economies of scale are looking for functional regions with high market potential where they can exploit their advantage. Some types of goods and services are connected with high geographic transaction costs, which determine whether production in the region will or will not be profitable. This is why products should be classified with regard to their sensitivity in relation to transaction costs. Specific product categories with development potential in small or medium or large functional regions may be defined based on this approach [16] and [17].

Figure 1 illustrates schematically the network of business entities and their suppliers and customers. Entities E_1 up to E_i represent the investigated business entities whose accounting data are available. S_1 up to S_j are the suppliers of the entities E_1 up to E_i. C_1 up to C_k are the customers of the entities E_1 up to E_i. The value and number of sales of goods, own products and services to the customer C_1, C_2, whose address is saved in accounting master data of entity E_1, $E_{2,}$ can be traced by means of accounting data of entity E_1, E_2. Similarly, the value and number of purchase of material, goods and services from supplier S_1, $S_{2,}$ whose address is saved in accounting master data of entity E_1, $E_{2,}$ can be traced by means of accounting data of entity E_1, E_2.

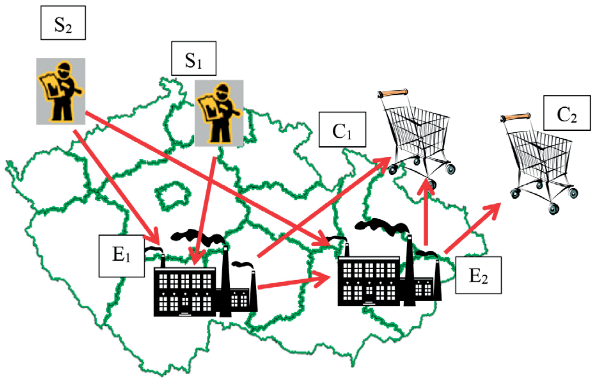


Fig. 1 The network of business entities and their customers and supplier - own source

The supplier's and customers' master data contain information on the registered office and postal code from which not just jurisdiction to the region but also geodetic geographic width and length can be deduced.

Therefore, it can be stated that the corporations accounting data are not only the bearers of information on time as well as on spatial arrangement of business transactions they record. It implies also the fact that corporate information systems' accounting data can be used for logistics statistics.

4. Methodology of Work

These partial goals were defined for fulfilment of the main goal:

- Definition of an indicator of intensity of economic relations based on business cases of business entities, which will be used in the next part of the work;
- Demonstration of the possibility to identify dependencies upon ERP accounting data from selected business entities.

Definitions, calculation and data sources of the individual items (own source) Table 1

Intensity	Mathematical definition	Description of variables	Data filter criteria	Unit
I_{hpz} Intensity of the values of sales of goods & own products for delivery distance *d*	$\frac{1}{n}\sum_{i=1}^{n}\frac{B_i}{Y_i}$	B_i – total value of all sales of goods & own products by business entity *i* for delivery distance *d*	Synthetic account 604 for goods 601 for own products	CZK / employee
I_{ppz} Intensity of the number of sales of goods & own products for delivery distance *d*	$\frac{1}{n}\sum_{i=1}^{n}\frac{C_i}{Y_i}$	C_i – total number of all sales of goods & own products to target distance by business entity *i* for delivery distance *d*	Synthetic account 604 for goods 601 for own products	Number / employee
I_{hps} Intensity of the values of sales of services for delivery distance *d*	$\frac{1}{n}\sum_{i=1}^{n}\frac{D_i}{Y_i}$	D_i – total value of all sales of services to target distance by business entity *i* for delivery distance *d*	Synthetic account 602 for services	CZK / employee
I_{pps} Intensity of the number of sales of services for delivery distance *d*	$\frac{1}{n}\sum_{i=1}^{n}\frac{E_i}{Y_i}$	E_i – total number of all sales of services to target distance by business entity *i* for delivery distance *d*	Synthetic account 602 for services	Number / employee
I_{hnz} Intensity of the values of purchases of goods & material for delivery distance *d*	$\frac{1}{n}\sum_{i=1}^{n}\frac{F_i}{Y_i}$	F_i – total value of all purchases of goods & material from source distance by business entity *i* for delivery distance *d*	Synthetic account 131 for goods 111 for material	CZK / employee
I_{pnz} Intensity of the number of purchases of goods & material for delivery distance *d*	$\frac{1}{n}\sum_{i=1}^{n}\frac{G_i}{Y_i}$	G_i – total number of all purchases of goods & material from source distance by business entity *i* for delivery distance *d*	Synthetic account 131 for goods 111 for material	Number / employee
I_{hns} Intensity of the values of purchases of services for delivery distance *d*	$\frac{1}{n}\sum_{i=1}^{n}\frac{H_i}{Y_i}$	H_i – total value of purchases of services from source distance by business entity *i* for delivery distance *d*	Synthetic account 518 for services	CZK / employee
I_{pns} Intensity of the number of purchases of services for delivery distance *d*	$\frac{1}{n}\sum_{i=1}^{n}\frac{I_i}{Y_i}$	I_i – total number of sales of services from source distance by business entity *i* for delivery distance *d*	Synthetic account 518 for services	Number / employee

5. Methods Applied to the Research of dependencies

The indicators of intensity of economic relations based on business cases of business entities were defined, which characterizes the situation in mutual transaction from the viewpoint of purchases and sales of goods, own products and services transacted in the monitored business units. They were calculated from a sample of accounting data, gained from 30 randomly selected business entities with countrywide operation, from 2007 to 2013.

Transaction dependencies were localized by means of a coordinated approach where the above indicator of intensity of economic relations based on business cases of business entities was calculated for each distance, leading to identification of relations.

6. Indicators of Intensity of Economic Relations Based on Business Cases of Business Entities Dependent on Delivery Distance

The indicators were designed as an annual average value or the average annual number of sales / purchases all considered entities per employee, depending on the sale / purchase distance carried.

The definition itself, calculation and data sources of the individual partial intensities are summarized in Table 1, while the meanings of the individual variables are as follows:

- number of employees in a business entity i, where i = 1...n.
- number of business entities (here 30).
- delivery distance.

7. Research Input Data Sources

Database of Business Entities

A set of 30 randomly selected unnamed monitored entities from the Czech Republic with countrywide operation regardless the business subject (NACE) is the primary data source. All the involved business entities were monoregional, i.e., all their units were located in the same place as the administration unit.

Database of Accounting Cases

Consolidated accounting file for the years 2007-2013, containing 4,35 million sentences, is the key data source for the research. Each accounting case includes the following information:

Account number, CREDIT and DEBIT sides, date and number of a document, accounting period, customer/supplier number, accounting text information, document symbol and a code specifying to which of the 30 monitored business entities each transaction belongs.

Supplier accounting cases may be chosen easily by means of the CREDIT side of synthetic account 321 – trade payables. The following prevailing main types of transactions may be distinguished by synthetic classification of accounts on the DEBIT side:

111 – cost of material (or also 112), 131 – cost of merchandise (or also 132), 518 – rendered services.

Customer accounting cases may be chosen by means of the DEBIT side of synthetic account 311 – trade receivables. The following prevailing primary types of transactions may be distinguished by accounting synthesis of the given operation on the CREDIT side:

601 – manufactured goods revenue, 602 – service revenue, 604 – merchandise goods revenue.

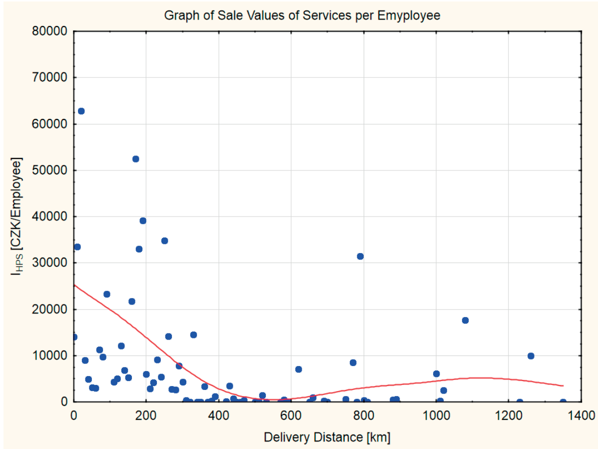
Database of Customers and Suppliers

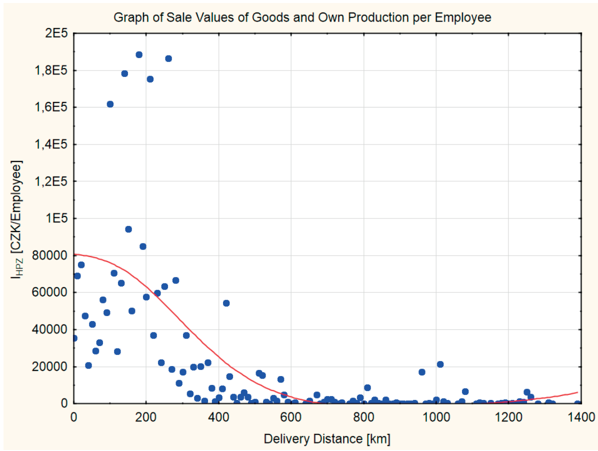
A data file of 27,900 items of legal entities and individuals, each with the number and address of the customer/supplier, country and post code, was gained by combining lists of customers and suppliers of all the 30 monitored business entities.

8. Results

In following Figs. 2 - 9 are illustrated research results.

The curves of sale and purchase values and numbers of goods and services supplied, depending on the delivery distance, have almost regularly repeating similar shape.





Figs. 2 and 3 Graph of sales values of services per employee and year and goods and own production per employee and year (own source)

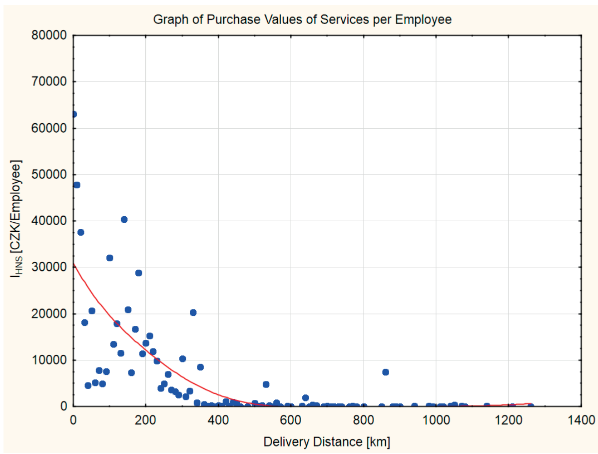


Fig. 4

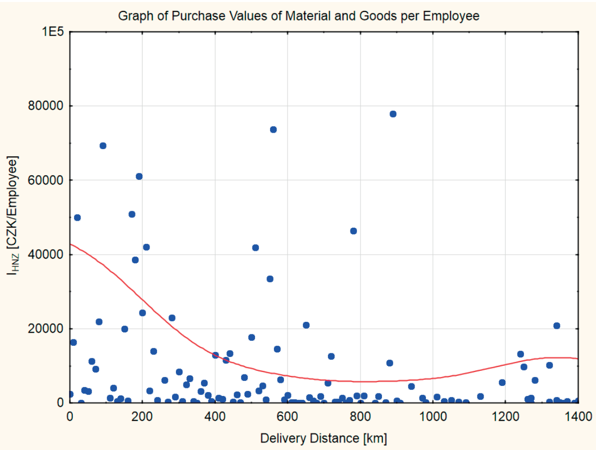
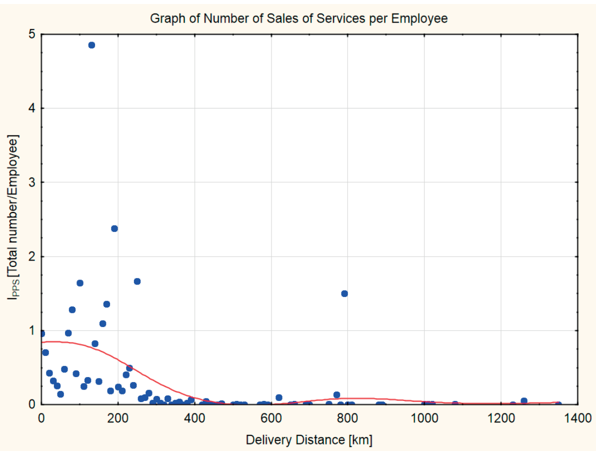
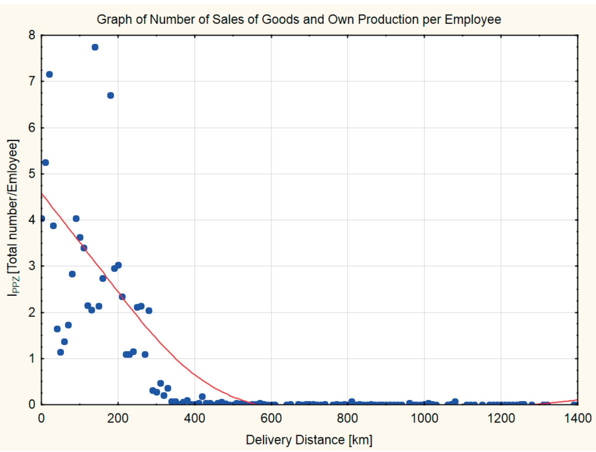
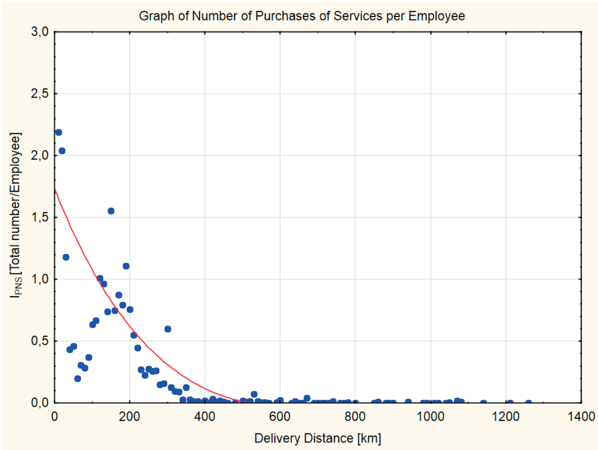


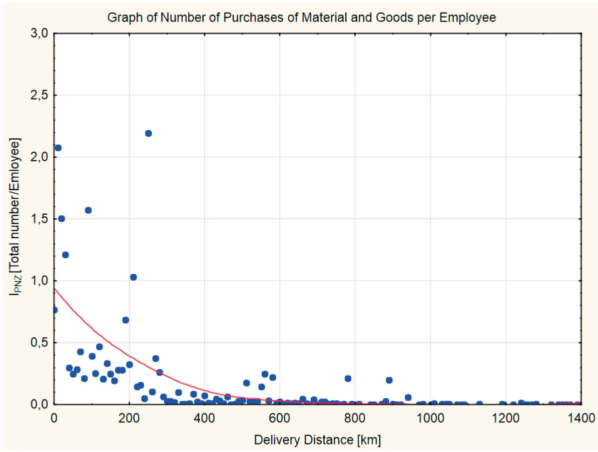
Fig. 4 and 5 Graph of purchase values of services per employee and year and purchase values of material and goods per employee and year (own source)





Figs. 6 and 7 Graph of number of sales of services per employee and year and of frequency of sales of goods and own production per employee and year (own source)





Figs. 8 and 9 Graph of number of purchases of services per employee and year and number of purchases of material and goods per employee and year (own source)

9. Summary

Research results deal with mutual geographical accessibility of economic units, which is indisputably an important aspect influencing the intensity and orientation of economic relations among them. We may observe that the interactive spatial relations between the individual spatial system elements based on the intensity of economic relations in business cases of business entities are directly proportional to the value of intensity of economic relations and indirectly proportional to their distance. Market proximity in general reduces the total costs of entrance to external markets; however, on the other hand, it usually represents larger competition in the market, which presses companies to higher productivity. From the business entity point of view the closeness of the market in the basic spatial framework represents the potential for market expansion. The shorter the mutual distance between individual units the higher the potential. In activities with more intensive cooperation in the manufacturing industry the aspect of market closeness is comparable with the aspect of the closeness of key customers. We have confirmed that accounting data enable mutual economic relations among the units to be identified and characterized despite the fact that the research data were only obtained from a limited number of business entities. The studies, dealing with various aspects of geographic economy, are gradually becoming an integral part of modern conceptions of logistics researches. They thus widen the system of economic theories, which was characterized by insufficient reflection of globalization processes, resulting from the idealized conception of lack of spatial dimensionality in the recent past. Increasing mutual dependence is a characteristic trait of global economy development. These phenomena may be described both by means of economic-logistic-statistical indicators obtained from statistic research, and by means of data from ERP systems, which bear a wide spectrum of information important for regional economy and development.

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Petr Novotny - Jiri Markuci - David Rehak - Ibrahim Almarzouqi - Lucia Janusova *

CRITICAL INFRASTRUCTURE DESIGNATION IN EUROPEAN UNION COUNTRIES: IMPLEMENTATION OF SYSTEMS APPROACH

The contribution deals with the issue of designating critical infrastructure elements in European Union Countries. Based on approach analysis in selected countries, where sufficient attention is paid to the area of critical infrastructure, the aim of the article is to propose a systems approach to critical infrastructure designation. The aim is determined by the fact that a significant number of EU countries do not currently apply the systems approach and designating of elements is realized via sectors approach, i.e. without taking possible bonds with other sectors into consideration. Therefore, using the systems approach may be a solution to realizing further necessary steps in the area of critical infrastructure protection, for example complementing the issue of resilience and modelling dependences in the area of critical infrastructure.

Keywords: *Critical infrastructure, designation, systems approach, European Union.*

1. Introduction

The primary demand for sustaining development of EU countries´ economy and sustaining required level of society´s welfare [1] is providing continual supply of commodities and services via the infrastructure system [2]. These infrastructures may be divided according to functional specifications into technical (e.g. energy, transport) and socioeconomic such as the health service or financial market [3]. The individual infrastructures then come into effect as to expanse and value of the area for which they provide their services (European, national, regional), as well as regarding the importance or indispensability of the given services [1 and 2]. Infrastructures are growing more and more interconnected and in some cases even mutually dependent [4 and 5]. Functionality of these infrastructures and providing continual supplies of products and services is continually exposed to the impact of natural and anthropogenic threats [6]. That is the reason why significantly more attention has been paid to chosen, vital, even critical infrastructures [7 and 8], as well as to methods of its risk analysis, critical elements evaluation and their protection [9 and 10].

Building protection and resilience [11] of critical infrastructure elements is above all based on identification of critical infrastructure elements themselves, which is carried out via various approaches in the European Union and other parts of the world. These approaches are based on risk analyses [12 and 13], criticality analysis via various criteria [3], cross-section and sectoral criteria [2] or modelling and simulations [14]. The core of various approaches comparison is its evaluation from the point of view of entrusted responsibility for the critical infrastructure as well as the way of marking elements on various vertical levels.

2. Description of the system approach in selected countries

The system of critical infrastructure determination in the European Union proceeds from historical connections and the presented Green Paper [1]. The European Union member countries are bound to implement the procedures stated in the directive [2]. Since individual member countries approach the critical infrastructure determination in different ways, four countries whose critical infrastructure determination is system based were selected. System approaches of these countries will be used as the basis for proposing a system solution of critical infrastructure determination for European Union member countries which have not had the system approach yet. The key to the choice of the system for critical infrastructure determination is the following. The Swiss system of critical infrastructure determination was chosen as a model one, because specific

* **[1]Petr Novotny, [1]Jiri Markuci, [1]David Rehak, [2]Ibrahim Almarzouqi, [3]Lucia Janusova**
[1]Department of Civil Protection, VSB-Technical University of Ostrava, Czech Republic
[2]Department of Geography and Environment, Northumbria University, Newcastle upon Tyne, United Kingdom
[3]Department of Technical Sciences and Informatics, Faculty of Security Engineering, University of Zilina, Slovakia
E-mail: novotny.petr@vsb.cz

authorities are involved in the whole system. On the other hand, the British model was selected as the representative of traditional involvement of state authorities and rescue services in the choice of the critical infrastructure determination. Further, the system approach in the Netherlands has been selected as a representative of the traditional system solution, which is specific for developed European countries. Last, but not least, there is the long-term approved system of critical infrastructure determination in New Zealand. To contrast the system approach, the way of critical infrastructure determination in the Czech Republic will be presented in the following chapter.

2.1. Switzerland

The critical infrastructure system in Switzerland has undergone an evolution. The Federal Council`s Basic for Critical Infrastructure Protection [15] (also used as "CIP") was the key foundation for processing the crucial document for critical infrastructure determination process, which is the method for creating critical infrastructure protection inventory (Schutz Kritischer Infrastrukturen – SKI) [16]. The method´s aim [16] is to determine elements of infrastructure which show a high level of criticality. Criticality is connected with consequences that may occur at failure, malfunction or destruction of the relevant infrastructure element, however, the probability is not considered (this classification should enable an adequate determination of funds and measures). Besides other things, critical infrastructure elements on a national or regional level are to be identified. During the inventory preparation there are three groups of participants [16]. The basic group, which works on the inventory development and creates the basics for a thorough analysis of individual processes, is an expert committee participating in critical infrastructure elements identification. The last group of participants is represented by cantonal contact authorities of the SKI inventory that may identify objects important from the cantonal point of view as well as critical from the national point of view.

Within critical infrastructure protection, a list of objects, by the failure or damage of which the population and their living conditions may be endangered, has been created. These are objects which are of great importance for basic goods and service supplies, and objects where dangerous substances are stored [16]. Identification of critical infrastructure elements [15] follows a standardized process on the basis of three unified criteria (quantitative evaluation, qualitative evaluation, potential threat) and it is based solely on detailed process analyses in individual sub-sectors which are created by authorized national subjects. Five following steps are taken in order to identify and classify critical infrastructure subjects in individual sub-sectors [16]: (1) Creating a functional group for criticality evaluation, (2) preparation for criticality evaluation, (3) detailed data gathering, (4) objects classification, (5) amendment for cantonal subjects. Such a list of critical infrastructure elements [15 and 16] is classified as top secret from the point of view of secret information protection. The creation of the inventory is carried out and managed by the basic group only.

2.2. Great Britain

The main responsibility for the matter in question is borne by the Cabinet Office (evaluation of critical infrastructure elements vulnerability). Monitoring is continually realized by the ministries and authorities, however, once in 5 years there is an overall inspection, so called National Risk Assessment, carried out [17], the outcome of which is evaluation of the found risks (natural disasters, serious accidents, deliberate attacks) which may affect the whole country or its significant part. The National Risk Register [17] has been processed since 2008 as meeting liabilities coming out of the National Security Strategy [18]. Local rescue services are integrated into the risk evaluation system. Each local rescue service publishes its own Community Risk Register [17] for its area of interest and for the relevant territory on web pages. Measures planned by all organizations and operators should draw from the National Risk Register. The document of Strategic Framework and Policy Statement [19] for the area of improving the critical infrastructure resistance to natural threat provides instructions for how to evaluate the criticality of critical infrastructure area to all subjects involved. The document outlines possibilities for regional critical infrastructure determination (the term Vital Infrastructure corresponding with local infrastructures is used).

The national critical infrastructure in Great Britain is divided according to the Criticality Scale [19] into 9 sectors and 29 sub-sectors, including determining responsibilities for sub-sectors in the whole kingdom and individual countries. Seven categories of criticality draw from such evaluation (CAT 0 – CAT 6). CAT 3 forms the border between the Critical National Infrastructure and an infrastructure that may be interpreted as a regional critical infrastructure, since the possible impact on a geographic region or several hundred thousand people is defined here. From this level downwards we speak about Wider National Infrastructure including the above mentioned vital infrastructures providing services in certain location [19]. The level of criticality is thus determined merely for the national level of critical infrastructure. Any criticality evaluation under this level means determining the infrastructure as Wider National Infrastructure, not as critical. For that reason, only the national level is determined as critical. The risk evaluation system is also projected in the system of infrastructure criticality determination [19]. The planned measures for critical infrastructure protection draw from risk evaluation. All activities in the sphere of CIP in Great Britain strictly stick to standards of the Business Continuity

Management (BS 25999). Therefore, following all determined processes from the level of central authorities down to the local level is emphasized. At the same time, doing all pre-determined duties is ensured.

2.3. Netherlands

The Government of the Netherlands - The Cabinet is an authority responsible for the area of critical infrastructure protection in the country and this authority approved the National Safety and Security Strategy in 2007 [20 and 21]. According to this strategy, the national safety cannot be taken out of the complex safety context which proceeds from the partnership within the EU and NATO member countries. The performance of some entrusted activities in the sphere of critical infrastructure also belongs to risk management authorities across the risk management levels, including the public administration authorities. In the Netherlands, the original definition of ”critical infrastructure“ [22] included only the areas of public administration and industry (including the ICT area) and the original plan comprised the following steps: a fast analysis of the Dutch critical infrastructure, stimulation of bonds between the public administration and private subjects, threats and vulnerability analysis, analysis of safety measures gaps. After fulfilling the National Safety and Security Strategy, [20] A Quick Scan was created and used [21]. Since cross-border bonds were found out, some of the materials were given to the European Union.

The Ministry of Security and Justice and Ministry of Interior and Kingdom Relations [20] bears the primary responsibility for determining critical infrastructure elements. In order to increase the system flexibility, two working groups were appointed across the central authorities, which are Interdepartmental Working Group on National Safety and Security and Steering Group on National Safety and Security. First, the working groups evaluate the possible dangerous scenarios on a national level, based on The National Safety and Security Method, then consequences are described and probabilities of relevant scenarios are evaluated. Such scenarios are projected in the National Risk Assessment and, consequently, final summary of scenarios and its evaluation with respect to interest and consequence (territorial safety, physical security, economic security, and ecological security, social and political stability) is carried out. After evaluating the consequences it is possible to use the gained data further on, e.g. for public administration purposes [20].

For the needs of critical infrastructure determination in Netherlands, a boundary was set between services and products that are vitally important on the national level and those which are “only” very important [21]. Because of bonds and dependencies, operation-oriented analysis is required, in which the ICT sector plays an important role, as it currently connects and controls most infrastructures. The process of determining the vitally important infrastructure had not been easy until “Vital Importance” was determined within a company. According to the definition, these are products and services which [21] contribute to providing basic services for a society and define the basic level of its providing for (1) national and international law, (2) public safety, (3) economics (4) public health, (5) environment. These products and services may also reduce providing services for the population or public administration below the minimum level also in the national scale.

11 vitally important sectors with 31 vitally important products and services (an analogue of sub-sector) have been determined for the national critical infrastructure of the Netherlands. From the point of view of the national critical infrastructure of the Netherlands, it is these vitally important products and services (direct and indirect ones) which form the core of the system, while other products and services (not of vital importance) supplement the function of the whole system [21].

2.4. New Zealand

The core document for the civil protection of New Zealand is the Civil Defence Emergency Management Act 2012 [23]. This crucial document determines authorities, responsibilities and involvement of all involved services in the civil protection in the country. Based on the provisions of sections 39 and 45 of the Civil Defence Emergency Act, a new National Civil Defence Emergency Management Plan [24] has been created, in which all substantial requirements for the area of critical infrastructure defense are elaborated and stated. The aim of the plan is to increase public awareness, understanding and readiness in the field of Civil Defence and Emergency Management (CDEM), to reduce risks, to increase capacities for emergencies control and to increase the capacity for recovery after emergencies. The CDEM Plan also states tasks and responsibilities of subjects involved in protection of critical infrastructure elements, such as the Ministry of Civil Defence and Emergency Management for the national level, Local Civil Defence Groups and Local Authority for the local level. The working authority is always the group appointed for the relevant level, the so called ”CDEM Group“. Thus, there are advisory authorities called Clusters, i.e. groups comprising agencies across sector in order to cooperate effectively and reach practical outcomes. The above mentioned authorities participate in CIP.

However, the term of critical infrastructure is not used in New Zealand [23]. On the contrary, it is common to label some subjects as Health infrastructures and the term Lifelines is used instead of the term of critical infrastructure to mark basic systems for which it is necessary to remain in function, e.g. water supplies, transport (road, rail, sea and air), gas supplies, communication networks and sewage systems (water and sewage management).

The primary aim of supporting the Lifelines evidence by Central authorities is recognition, effective evaluation and evaluation of the subject´s importance [23]. Individual regions thus carry out evaluation and report data to the central level of the Ministry of Civil Defence and Emergency Management. In case some of the Lifelines shows high criticality and the consequences of its failure affect society outside the region, we speak about the national level, etc. The term Lifeline Utilities is used for the national level of critical infrastructure in New Zealand. Another option to determine such infrastructure on a national level is a direct determination in a legal regulation [23], (for example, keepers of enumerated airports, harbors, gas suppliers, etc.) or subjects mentioned in the following part that run enumerated businesses (running a national motorway network, railway network, electricity and water suppliers, etc.). In total, we can categorize the elements into eight sectors (or, as the case may be, determine specific elements) [23 and 25].

Determining the criticality of Lifeline Utilities [26] is based on the CDEM Plan. Categorizing Lifeline Utilities into relevant categories is carried out according to the outcomes of criticality determination. Criticality 1 for the national level of Lifeline Utilities, Criticality 2 for the regional level of Lifeline Utilities, Criticality 3 for the local level of Lifeline Utilities. Runners of Lifeline Utilities are obliged to abide carrying out of the prescribed activities in New Zealand, e.g. constant verifying and developing emergency plans, risk evaluation and preparation for reaction including constant reporting of the updated data to the subjects responsible [25].

In the above mentioned crucial document, [23] the need to protect the so called *Assets* is also stated. These are key elements like cultural and historical heritage. These subjects may also be determined as "critical infrastructure" elements in New Zealand. On the other hand, another commonly used term of Infrastructure Hotspots means accumulation of entries into several "critical" infrastructures on a single location (e.g. harbors) [26]. A similar term is used in other countries, e.g. in relevant literature [27] such cumulative entries are called Hubs. At the same time, dependencies were determined under the term of Infrastructure Interdependencies across sectors and currently programs for resilience improvement are being specified [26].

3. Sector approach description in the Czech Republic

Since 2010 and with effect from 2011, the critical infrastructure in the Czech Republic has been in function by implementation of Directive requirements [2] into the National legislature via the Crisis Management Act [28] and its implementing regulation [29]. The Ministry of the Interior – General Directorate of the Fire Rescue Service of the Czech Republic is the guarantor of the critical infrastructure in the Czech Republic. Thus, in the Czech Republic, critical infrastructure elements are determined at two vertical levels by law (National and European), while the national level is the implicit one. In the Czech Republic, elements at the national level are determined in nine sectors altogether (Energy, Water management, Food Industry and agriculture, health service, transport, Communication and information systems, Financial market and currency, Emergency services, Public administration). The way of determining the elements for individual levels is, in accordance with the Directive, [2] based on cross-cutting and sectoral criteria [28 and 29]. The cross-cutting criteria serve to evaluate the impact caused by potential malfunction of the evaluated element of the relevant critical infrastructure sector. These criteria serve to evaluate the impact with regard to possible casualties, economic impacts and impacts on the public [30]. Limit values of these criteria at a national level are stated by a decree of the Czech Republic government [29].

In case the critical infrastructure subject (Owner, Runner) is an organization bureau of the state, ministries and other central administration authorities send their proposals for elements to the Ministry of the Interior that prepares a list based on these proposals. In the following stage, the list is presented to the government who adopts a resolution about the critical infrastructure elements whose runner is the organization bureau of the state [31]. In case of determining the critical infrastructure elements whose runner is not an organization bureau of the state, the decision-making process is realized by entrusted ministries and other central administration authorities. These, in accordance with the law, apply relevant definitions and criteria and subsequently determine elements by general measures and immediately inform the Ministry of the Interior about their decisions.

It is the critical infrastructure subject itself who bears the responsibility for the critical infrastructure element protection [28]. For this purpose, the subject is, apart from other responsibilities, obliged to make a plan for the crisis readiness of the critical infrastructure subject [32 and 33]. Within the plan, the following areas should be considered: (1) overview and evaluation of possible risk sources, (2) threat analyses, (3) possible risk impact on the subject´s activities (4) a list of critical infrastructure elements within the subject´s control, (5) identification of possible threats of individual elements of the critical infrastructure, (6) measure overview arising from the emergency plan of the relevant risk management authority, (7) ways of securing realization of the mentioned measures, (8) ways of securing the subject´s action readiness to realize the emergency measures and subject´s activity protection and (9) procedures of solving emergency situations identified in the threat analysis. The necessity to increase the resistance and protection of critical infrastructure elements to possible risks and securing a broader involvement of critical infrastructure subjects in the process of preparation for emergency situations is one of the strategic priorities of population protection stated within the current population protection concept [34].

4. Summary, Suggestion and Discussion

This chapter summarizes the above mentioned approaches as materials for creating a system approach proposal. From the point of view of the state administration involvement there were no fundamental differences found, since in the selected countries it is always the top authority that bears the responsibility on the national level, alternatively it is the authority affiliated to the top management level. The involvement of the home rule in the critical infrastructure determination system is similar, though there are minor differences among the individual systems. In several cases the rescue services are involved, in other cases the home rule is involved. The responsibility for critical infrastructure determination is more varied – it is possible to leave the responsibility on the central level, divide it between the state administration and the home rule, leave it on the created authorities, shift the responsibility to the relevant level of management, alternatively to the owners or runners themselves, or a combination of any of the above mentioned approaches.

The initial framework of determining critical infrastructure elements differs in individual countries. It may be a clearly stated procedure according to an obviously described manual with clear outcomes, or a procedure stated only by conceptual material. It is similar with the case of the methodology used, when individual countries use their own procedures. However, there is a significant difference in the terminology used in individual countries. It is not always "critical infrastructure" that is in question; the terminology may be set in a different way. The numbers of sectors vary in a narrow interval, just as the numbers of sub-sectors on a national level do not vary significantly. The number of levels does not vary much either. In the European Union countries it is obligatory to determine the supranational critical infrastructure (or the European level). From the national level upwards, the system stays similar – in most cases it is the national, regional, or local level (in some cases with different terminology though). In the Czech Republic there is no other critical infrastructure determined but national. For this reason, the proposal for determining the critical infrastructure on a regional level is justified further on in the contribution.

On the bases of comparison of the above mentioned approaches to determining the critical infrastructure, a general proposal has been created. This proposal may be applied in countries which do not have such elaborate systems, e.g. the Czech Republic (see Fig. 1).

From comparison of the approaches to determining critical infrastructure elements it is obvious that the first suitable step to assess which elements belong to which level (e.g. the regional level) is assessing their criticality. Such assessment is based on various principles in different countries (cross-cutting and sectoral criteria, assessment of impact and vulnerability, etc.). A common aspect can be seen in assessing the extent of impacts on protected interests (lives, health, properties, and economy). Assessing criticality should not be based on probability of occurrence of those impacts, which are mainly because of the fact that a failure of a critical infrastructure element is very improbable. Nevertheless, there is still little probability of its occurrence. During criticality assessment it is also suitable to implement the issue of mutual dependencies and perceive it from

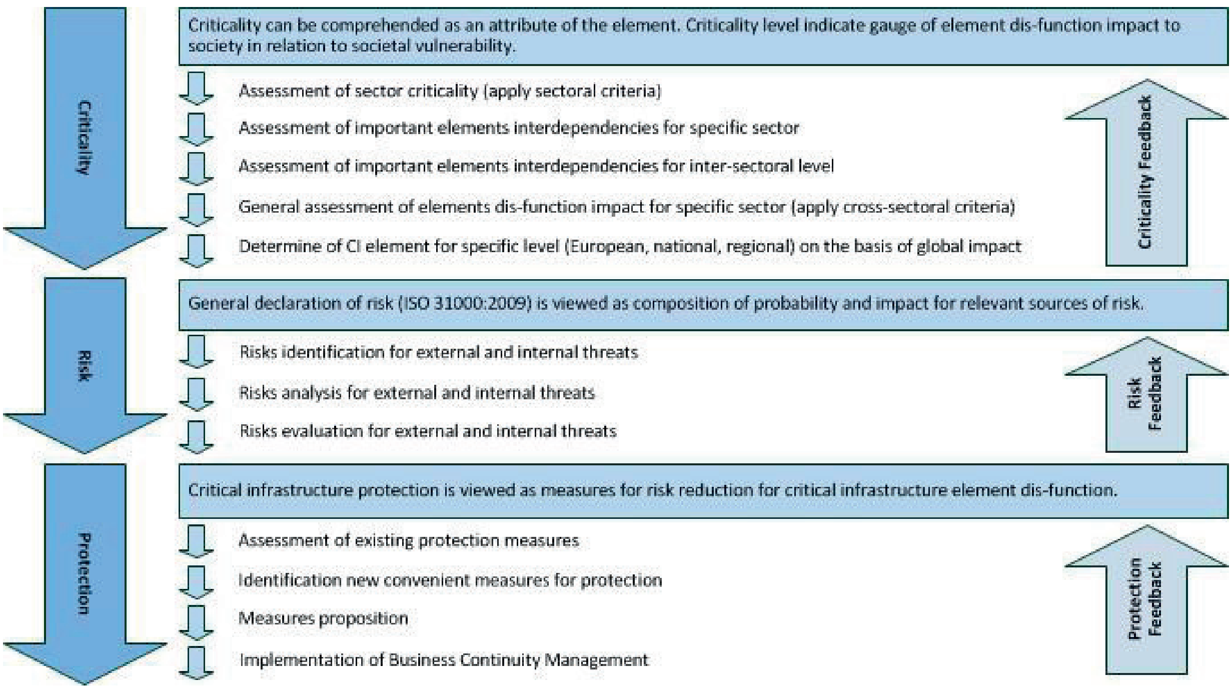

Fig. 1 Proposal of systems approach to critical infrastructure determination

the viewpoint of impacts that may be caused by bonds of the spreading disturbance among the critical infrastructure elements across the sectors (sub-sectors).

The second step is risk assessment [35] of a critical infrastructure element (determined according to step one) considering external as well as internal threats that may cause an element function disturbance. The risk extent is usually stated as a product of occurrence probability and impact extent. It is necessary to plan relevant measures based on the assessment. The planning documentation of critical infrastructure elements protection differs in individual countries (Operator safety plan, Emergency readiness of the critical infrastructure subject Plan, Business Continuity Plan). Nevertheless, the aim of all this documentation is identical – to provide a continuous supply of commodities and services [36] provided by the critical infrastructure element.

5. Conclusion

It is important to carry out critical infrastructure safety measures by relevant procedures, i.e. besides other things, make a suitable analysis, and not use common procedures without considering their suitability. Wrong usage of the Paret´s principle can serve as an example, which states that 20 % of causes bring about 80 % of all effects. In spite of that, excluding all other causes and concentrating only on some of them may be a mere overlooking other causes, which does not lead to a system solution. A similar summary is presented in the risk matrix where the most numerous incidents do not cause any significant effects; on the other hand, rare incidents may cause extreme effects. For that reason, it is not purposeful to concentrate only on the most frequent causes and effects, but we should concentrate on system solution with all its causalities.

Based on the above mentioned approaches in selected countries, it would be suitable to set a system way of critical infrastructure determination that could be used e.g. in countries that do not have a similar system approach for all levels of critical infrastructure. In the Czech Republic, there has not unfortunately been a similar system way of critical infrastructure determination stated yet. The proposed Stating such approach would undoubtedly contribute to society´s safety and at the same time, it would increase the land potential as well as possible hidden drawbacks in the current way of critical infrastructure determination in the Czech Republic and elsewhere.

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