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Editors

Milorad Vidović
Milorad Kilibarda
Slobodan Zečević
Momčilo Miljuš
Gordana Radivojević

Proceedings of the 2nd LOGISTICS INTERNATIONAL CONFERENCE



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Dražen Popović

Belgrade, 2015

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Preface

The idea of organizing a logistics conference was in correlation with the Logistics department alumni's meeting, that is held traditionally every last Saturday in November. During the 2012 alumni's meeting, our colleagues and friends, most of which are now distinguished professionals, scientists, managers or officials in logistics and related areas, have given us a decisive impulse and encouragement to run the conference in 2013.
Thanks to one of the youngest researchers at our department, the conference holds, I believe, an impressible and penetrative acronym "LOGIC", which is at the same time associative and deeply tied with the essence of logistics.
This way, by organizing Logistics International conference we have made one step ahead in further popularization and spreading of the ideas from this emerging area, while at the same time reestablishing the practice of our department in organizing logistics conferences, which goes back to the '80s.
The conference has tried to materialize the idea of becoming a forum and a meeting place where participants from universities, institutes and companies from different logistics related fields may have the opportunity to collaborate and exchange ideas.

Preface to the 2nd LOGIC proceedings

The 2nd Logistics International conference LOGIC 2015 has been held in May under leaved trees since the conference date is moved from the late autumn to the spring period. The second conference proceedings book is now here, giving the opportunity to wider professional and academic community to have insight into our ideas, statements and thoughts on logistics. Approximately 135 authors, speakers and discussants from 9 countries have participated to the LOGIC 2015 conference. Participants were mostly from the region, giving the conference strong regional profile. The program session "Logistics – Best practice", intended to connect theoretical knowledge and academic research with the real problems in logistics has been realized through three workshops with 18 presentations and more than 80 participants. Presentations were extremely interesting and instructive, inducing lively and constructive discussion.
In my opinion, as well as on undivided opinion of the Program committee members, LOGIC 2015 conference may be evaluated as very successful!
To do that, besides the effort of participants, authors and organizers, we have received immense help from the Ministry of Education, science and technological development of the Government of Republic of Serbia, from our general sponsors, company Milšped, and Delhaize Serbia, together with special supporters: DTS and Cargo partner. Also huge number of sponsors and the conference friends has also supported this event: Nelt, Mercator, Holcim, AgentPlus, Transfera, Standard Logistics, Uniqa osiguranje, CUBE RMS, RouteHorizon, BAS, RALU logistika, LogIT, Logistika i transport, Nestle, Rauch, Knjaz Miloš, CC Hellenic, Sarantis and Carlsberg.
To be more visible we were supported from the following media: RTS, RTV, Pluton logistics, Moj transporter and E-kapija.
To all of them we would like to express our sincere thanks and appreciation!
With the same hope that the next conference will be better, we warmly invite you to meet again and exchange ideas on the 3rd LOGIC conference in 2017.

Belgrade, June 2015

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Part I

OPTIMIZATION AND MODELLING IN LOGISTICS AND TRANSPORTATION

AN EXPERT FUZZY MODEL FOR THE DETERMINATION OF THE AMOUNT OF PURCHASE

Siniša Sremac [a*], Bojan Matić [a], Miloš Kopić [a], Goran Tepić [a]

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Abstract: *In this paper an expert model for the determination of the amount of purchase has been developed on the basis of the theory of fuzzy logic. Fuzzy logic has largely become a substitute for conventional techniques in numerous applications, including the area of managing certain logistics processes. In the paper, it has been used for modeling a complex logistics system in which it is difficult to determine the interdependence of the presented variables applying classical methods. Experience of an expert and information on the operations of the company for a certain group of items have been used to form the model. Analysis of the validity of the model results was performed on the basis of the average relative error and it has showed that the expert fuzzy model for determining the amount of purchase imitates the work of the expert in the observed company with great accuracy.*

Keywords*: fuzzy logic, determination of the amount of purchase, logistics process.*

1. INTRODUCTION

The determination of the amount of purchase is a logistics process that has a significant influence on the successful operation of a company [3]. From the logical aspect, the determination of the amount of purchase requires an adequate attention, since inadequate purchase can additionally burden the company's business [1]. On the other hand, in order to achieve a high level of service for the client, all purchase should be realized independently of their value. Therefore, the determination of the optimal amount of purchase is important for the rational realization of the process of transport, manipulation and storage in the delivery chain to the final customer [2].

In the paper, an expert model for the determination of the amount of purchase (DAP model) was developed following the fuzzy logic. DAP model is used to estimate the quantity for purchase in a business practice. The software packages Matlab and Fuzzy Logic Toolbox were used to form the model.

2. DESCRIPTION OF THE EXPERT FUZZY DAP MODEL

The main problem in forming the expert fuzzy DAP model was to determine the base of fuzzy rules and membership function parameters [7]. To define rules, the data obtained by a logistics

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experts' survey were used. Expert knowledge on the process of determining the amount of purchase was expressed using a certain number of linguistic rules.

The selection of the type and parameters of the membership function was performed on the basis of the positive experience of individual authors [4] and subjective evaluation by authors. The overview of literature helped to determine that the highest precision of output values could be obtained by applying the Gaussian membership functions [5]. For that reason, that curve shape was generated in the model, while its parameters were determined using the subjective authors' evaluation. Amount intervals of the input and output variables were defined on the basis of real values in the practice. The model was established on the Mamdani fuzzy inference system and the min-max inference method, while the centroid method was applied for the defuzzification process [6].

The fuzzy expert DAP model has three input variables: value demand, stock level and price (Figure 1). The output variable is the amount of purchase. Stock level and price have three values, while the value demand and the amount of purchase have five values. The input variable value demand has the following values: very small (XS), small (S), medium (M), large (L) and very large (XL), while the stock level has the following values: small (S), medium (M) and large (L). The input variable price can be described with the following values: low (L), medium (M) and high (H). The output variable amount of purchase has the following values: very small (XS), small (S), medium (M), large (L) and very large (XL). Most of the linguistic values were not necessary due to the fact that the satisfactory output gradation and precision were achieved in changing the input values.

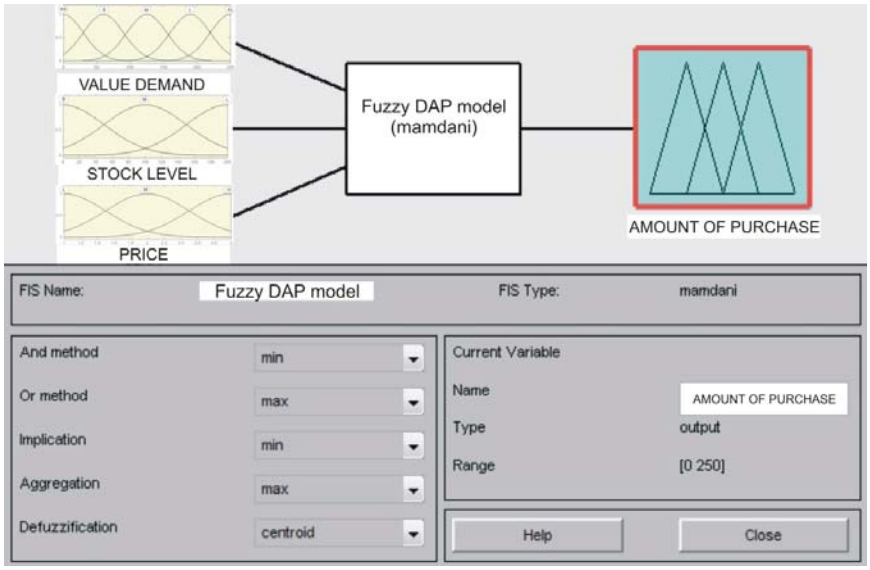


Figure 1. Expert fuzzy inference system

3. THE DEVELOPMENT OF MODEL

Real values were mapped using fuzzification into the membership functions. The input variable value demand has the values in the interval [0, 250], stock level is in the interval [0, 200], while the price is presented in linguistic values in the interval [1, 3]. The interval of the output variable amount of purchase is [0, 250]. These interval values were obtained on the basis of the company's business for the observed article.

The values of the input and output variables have the Gaussian membership functions (1) that can be defined as follows:

$$\mu_A(x) = e^{\frac{-(x-c)^2}{2\sigma^2}}, \text{for } x \in [0, c] \quad (1)$$

Gaussian fuzzy number is described with two parameters $A = (\sigma, c)$. The first number presents the left and the right distribution of the Gaussian curve along the abscissa, while the second number presents the value on the abscissa where the Gaussian curve has the value 1 on the ordinate. Membership functions of the input variable value demand (2) are defined using the parameters XS [30; 0], S [30; 60], M [30; 125], L [30; 190] and XL [30; 250] for $x \in [0, 250]$ (Figure 2 a)):

$$\mu_{VDXS}(x) = e^{\frac{-x^2}{1800}} \qquad \mu_{VDS}(x) = e^{\frac{-(x-60)^2}{1800}} \qquad \mu_{VDM}(x) = e^{\frac{-(x-125)^2}{1800}}$$
$$\mu_{VDL}(x) = e^{\frac{-(x-190)^2}{1800}} \qquad \mu_{VDXL}(x) = e^{\frac{-(x-250)^2}{1800}} \quad (2)$$

Membership functions of the input variable stock level (3) are defined with the parameters S [50; 0], M [50; 100] and L [50; 200] for $x \in [0, 200]$ (Figure 2 b)):

$$\mu_{SLS}(x) = e^{\frac{-x^2}{5000}} \qquad \mu_{SLM}(x) = e^{\frac{-(x-100)^2}{5000}} \qquad \mu_{SLL}(x) = e^{\frac{-(x-200)^2}{5000}} \quad (3)$$

Membership functions of the input variable price (4) are defined using the parameters L [0,5; 1], M [0,5; 2] and H [0,5; 3] for $x \in [0, 3]$ (Figure 2 c)):

$$\mu_{PL}(x) = e^{\frac{-(x-1)^2}{0,5}} \qquad \mu_{PM}(x) = e^{\frac{-(x-2)^2}{0,5}} \qquad \mu_{PH}(x) = e^{\frac{-(x-3)^2}{0,5}} \quad (4)$$

Membership functions of the output variable amount of purchase (5) are defined with XS [30; 0], S [30; 60], M [30; 125], L [30; 190] and XL [30; 250] for $x \in [0, 250]$ (Figure 2 d)):

$$\mu_{APXS}(x) = e^{\frac{-x^2}{1800}} \qquad \mu_{APS}(x) = e^{\frac{-(x-60)^2}{1800}} \qquad \mu_{APM}(x) = e^{\frac{-(x-125)^2}{1800}}$$
$$\mu_{APL}(x) = e^{\frac{-(x-190)^2}{1800}} \qquad \mu_{APXL}(x) = e^{\frac{-(x-250)^2}{1800}} \quad (5)$$

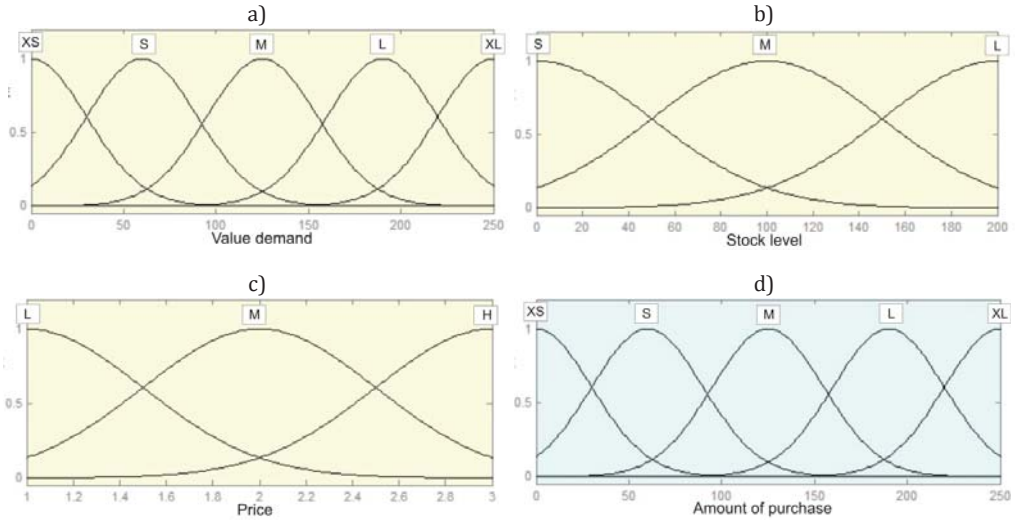


Figure 2. Fuzzy set membership functions: a) value demand, b) stock level, c) price and d) amount of purchase

In the fuzzy expert DAP model, there are three input linguistic variables, where one variable has five values, while the remaining two variables have three values each. The combination of all linguistic values provides the base of fuzzy rules with 45 rules (Table 1).

Table 1. Fuzzy rule matrix if: a) price is L, b) price is M and c) price is H

a)

		VALUE DEMAND				
		XS	S	M	L	HL
STOCK	S	M	L	XL	XL	XL
	M	S	M	L	XL	XL
	L	XS	S	M	L	XL

b)

		VALUE DEMAND				
		XS	S	M	L	HL
STOCK	S	S	M	L	XL	XL
	M	XS	S	M	L	XL
	L	XS	XS	S	M	L

c)

		VALUE DEMAND				
		XS	S	M	L	HL
STOCK	S	XS	S	M	L	XL
	M	XS	XS	S	M	L
	L	XS	XS	XS	S	M

The centroid method was applied for the defuzzification process. The result of the model defuzzification is the selection of one value of the input variable amount of purchase (Figure 3).

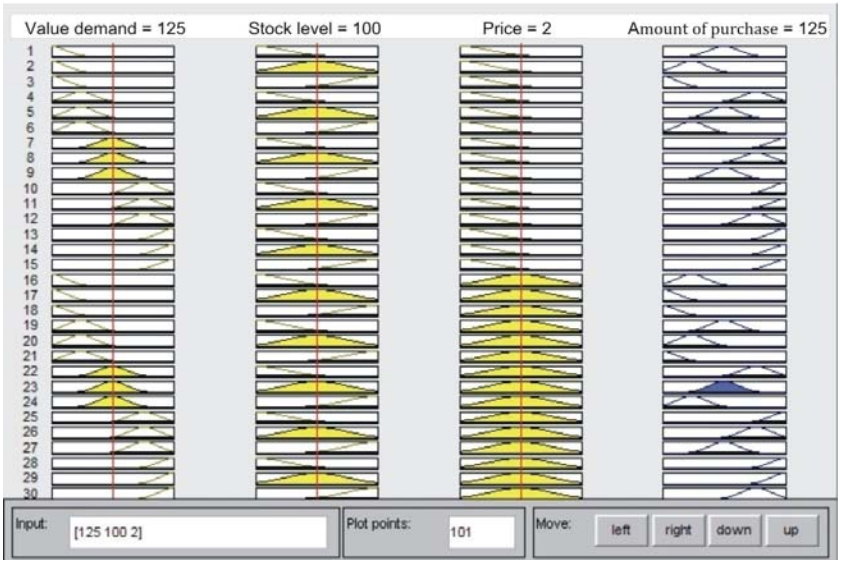


Figure 3. Model defuzzification

4. RESULTS OF MODEL

Figure 4 presents the graphic overview of the output variable amount of purchase in dependence on the input variables.

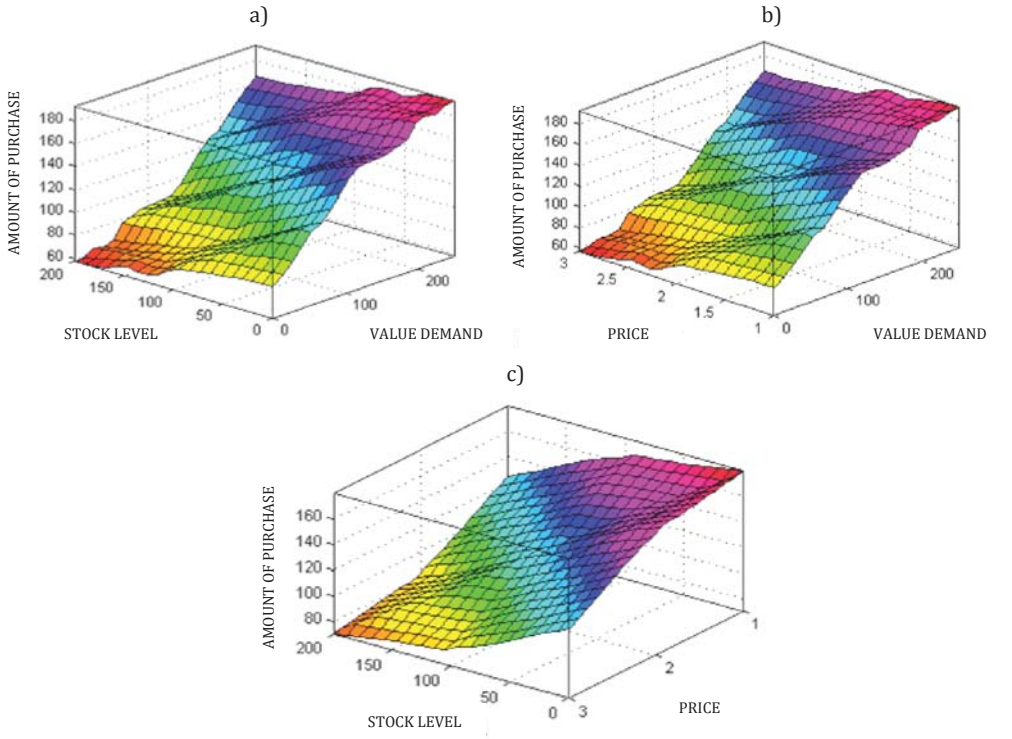


Figure 4. Amount of purchase depending on: a) value demand and stock level, b) value demand and price and c) stock level and price

The DAP model is tested on 50 examples for determining the amount of purchase for the known input values. Figure 5 presents the amount of purchase obtained by the expert fuzzy DAP model and the real amount of purchase in a company for the given input data.

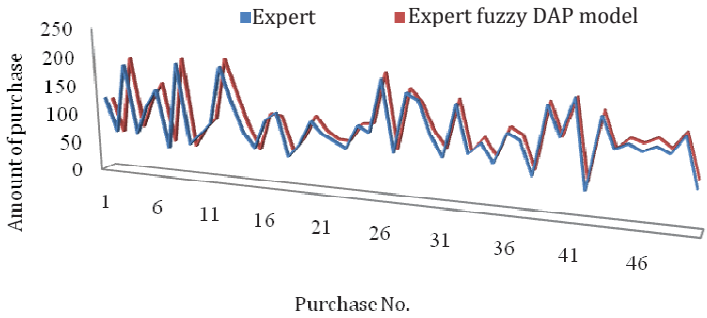


Figure 5. Amount of purchase based on the expert decision and the expert fuzzy DAP model

The evaluation analysis of the DAP model results was conducted on the basis of the average relative error of the obtained results in relation to the real results. The testing of 50 examples provided the average relative error of 5.6%. Based on the analysis, it can be concluded that there is a high compatibility between real and demanded results, and that the expert fuzzy DAP model provides valid results and can completely imitate the work of an expert.

5. CONCLUSION

The applied concept of artificial intelligence is utilized for presenting, manipulating and implementing human knowledge on the efficient management of certain logistics processes. Fuzzy logic has proven to be a valuable artificial intelligence concept in determining the amount of purchase that is designed using intuition and assessment of a logistics expert. Fuzzy logic enabled the explanation of the system dynamics via a linguistic presentation of knowledge on a logistics process. It was used for modeling a complex linguistic system in which it is difficult to determine the interdependence of the presented variables applying other classical methods. In the paper, a DAP model for solving a concrete problem in a business practice was developed, following the tendency in contemporary scientific research. The model was tested and verified, and hence it can be practically applied. The proposed model, with some minor modification, can be applied in any company dealing with the goods flow realization.

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COST ANALYSIS OF OPEN VRP

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Abstract: *Classical routing problems aim at designing the minimum cost of routes originating and finishing from a central depot for satisfying customer demand. The open versions do not consider the vehicles need to be returned. The importance of open versions of the known routing problems arises e.g. from car-hire options. Although hiring vehicles could be more expensive per unit distance traveled, their use could lead to considerable saving due to reduction of the total cost of the route. Open models of routing problems allow describing different real-world applications, e.g. considering one or more vehicles of homogenous or heterogeneous fleet structure (own or leased) starting in one of different depots that result to different logistic costs. The paper is focused on cost analysis that may aid in the decision to use own and hired vehicles based on regional data in Slovakia.*

Keywords*: Open Vehicle Routing Problem, Mixed Integer Programming, Mathematical Model.*

1. INTRODUCTION

Logistics costs constitute a major share of the total costs of almost every organization. Many variants of routing problems can be very rewarding in the field of logistics. The well-known capacitated vehicle routing problem (CVRP) is one of the most discussed problems in operations research Čičková and Brezina (2008), Čičková et al. (2013), Čičková et al. (2014), Desrochers et al. (1992), Fábry et al. (2011). The significance of that problem is evidently depended of its computational complexity, but also the importance follows from a great practical applicability, thus the problem can be applied in more general way.

This paper describes, based on regional data in Slovakia, the version of open vehicle routing problem (OVRP) that allows combining CVRP together with the possibility to realize open routes, e.g. Čičková et al. (2014). In general, OVRP is a popular problem in the field of distribution management and can be used to model many real-life problems. For example if the company deals without its own vehicle fleet and has to hire some vehicle to deliver its products to customers, it is not concerned whether the vehicle returns to the depot, and does not pay the traveling costs between the last customer and the depot. The standard OVRP can be described as follows: Consider a depot from which some products have to be delivered to a set of customers. Products are loaded on a vehicle (vehicles) at the depot and afterwards load needs to be transported to the customers. The capacity of vehicle (or fleet of vehicles) is (are) known (if more than one vehicle are used, the same capacity of all of them is supposed), so that all customers' demand needs to be served with the use of some vehicle (all the demands are met in full). It is assuming the known shortest distance between depot and each customer's location, as well as between each pairs of customer's location. The goal is to find the optimal shortest route for a vehicle (vehicles) so that each customer demand is met.

Practical applications often consider the deal to specify the number of own vehicles relative to cost of rented vehicle. The unit cost per km of own vehicles consist not only of fuel cost but also include e.g. amortization, taxes and driver's wage. On the other side, the rental cost depends on cost per km and also includes the fixed cost per car. Presented analysis is based on example of distribution in regions in Slovakia. The practical significance lies in modeling centrally controlled logistic projects that consist of two stages (e.g. organizing of vote distribution). The first stage consists in transferring elements (e.g. ballots) to regional capitals and their further distribution to relevant district towns.

2. MATHEMATICAL MODEL

The mathematical formulation based on above mentioned can be stated as follows: Consider graph $G = (N_0, A)$, where $N_0 = \{0, 1,...n\}$ is the set of all nodes in the graph, so that $N_0 = N \cup \{0\}$, where the set $N = \{1,\ 2...\ n\}$ represents the set of served nodes (customers) and the node indexed 0 represents origin (depot). The set $A = \{(i, j): i, j \in N_0, i \neq j\}$ is the arc set of G. A shortes distance d_{ij} is associated with every arc of the graph. Let the parameters $g_i,\ i \in N$ represent demand of customer and parameter g represents the capacity of vehicles. Further on, the cost (per km) of own vehicles (co) and also the cost (per km) of rented vehicles (cr) are known. The fixed cost are asociated only with number of rented vehicle and they are designated as cf. Mathematical programming formulation requires two type of binary variables: the variables $x_{ij},\ i, j \in N_0$ with a following notation: $x_{ij} = 1$ if customer i precedes customer j in a route of the own vehicle and $x_{ij} = 0$ otherwise and the variables $y_{ij},\ i, j \in N_0$ with a following notation: $y_{ij} = 1$ if customer i precedes customer j in a route of the rented vehicle and $y_{ij} = 0$ otherwise. Further on, we will apply the variables $u_i,\ i \in N$ that based on well-known Miller –Tucker- Zemlin's formulation, e.g. Miller et al. (1960), of the traveling salesman problem. That variables will represent cumulative demand of customers on one particular route.

The mathematical model can be stated as follows:

$$\min f(\mathbf{X}, \mathbf{u}) = co \sum_{i \in N_0} \sum_{\substack{j \in N_0 \\ i \neq j}} d_{ij} x_{ij} + cr \sum_{i \in N_0} \sum_{\substack{j \in N_0 \\ i \neq j}} d_{ij} y_{ij} + cf \sum_{j \in N_0} y_{0j} \tag{1}$$

$$\sum_{i \in N_0} x_{ij} + \sum_{i \in N_0} y_{ij} = 1,\ j \in N,\ i \neq j \tag{2}$$

$$\sum_{j \in N_0} x_{ij} + \sum_{j \in N_0} y_{ij} \leq 1,\ i \in N,\ i \neq j \tag{3}$$

$$u_i + q_j - g(1 - x_{ij}) \leq u_j,\ i \in N_0,\ j \in N,\ i \neq j \tag{4}$$

$$u_i + q_j - g(1 - y_{ij}) \leq u_j,\ i \in N_0,\ j \in N,\ i \neq j \tag{5}$$

$$\sum_{i \in N_0} x_{ij} - \sum_{i \in N_0} x_{ji} = 0,\ j \in N,\ i \neq j \tag{6}$$

$$q_i \leq u_i \leq g,\ i \in N \tag{7}$$

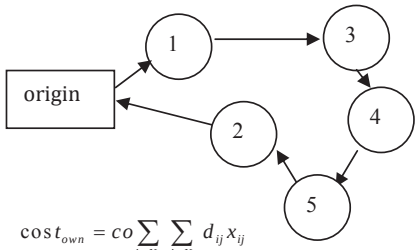
$$u_0 = 0 \tag{8}$$

$$x_{ij} \in \{0,\ 1\},\ y_{ij} \in \{0,\ 1\},\ i, j \in N_0,\ i \neq j \tag{9}$$

The objective function (1) models the total cost for all the used vehicles. Equations (2) ensure that only one of the vehicles (own or rented) enters each customer exactly once and equations (3) ensure that the vehicle does not need to depart from every customer, because the route of rented vehicle ends after serving the last of them. Equations (5) and (6) avoid the presence of sub-tour (for own and rented vehicle) and also calculates the real cumulative demands of customers of the next node on the route based on previous node. Equations (7) ensure that all demands on the route must not exceed the capacity of the vehicle. The fix values of variables u_0 are set up by equation (8).

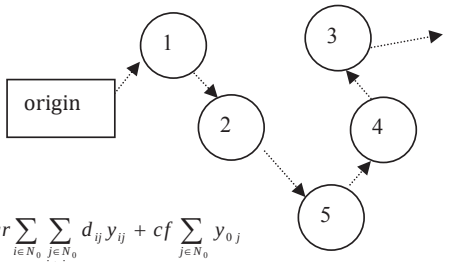
3. OPEN VEHICLE ROUTING PROBLEM IN SLOVAK REGIONS

The problem deals about the distribution scheduling in the regions in Slovakia, where origins were situated in the regional capitals. The distribution have to be assured using the own or rented vehicles with the same capacity. The goal was to determine how many own and rented vehicles must be used in each region so that demand of all district towns must be met with the minimal cost. The total cost consist of cost associated with the own vehicles (Fig. 1a) and cost of rented (Fig. 1b).



$$\cos t_{own} = co \sum_{i \in N_0} \sum_{\substack{j \in N_0 \\ i \neq j}} d_{ij} x_{ij}$$

Fig. 1a



$$\cos t_{rental} = cr \sum_{i \in N_0} \sum_{\substack{j \in N_0 \\ i \neq j}} d_{ij} y_{ij} + cf \sum_{j \in N_0} y_{0j}$$

Fig. 1b

Slovakia is divided into 8 regions: Region Bratislava (BA), Region Banská Bystrica (BB), Region Košice (KE), Region Nitra (NR), Region Prešov (PO), Region Trenčín (TN), Region Trnava (TT) and Region Žilina (ZA):

Region Bratislava (BA) is divided into 4 districts: Bratislava (0), Malacky (1), Pezinok (2), Senec (3).

Region Banská Bystrica (BB) is divided into 13 districts: Banská Bystrica (0), Banská Štiavnica (1), Brezno (2), Lučenec (3), Detva (4), Krupina (5), Poltár (6), Revúca (7), Rimavská Sobota (8), Veľký Krtíš (9), Zvolen (10), Žarnovica (11), Žiar nad Hronom (12).

Region Košice (KE) is divided into 7 districts: Košice (0), Gelnica (1), Michalovce (2), Rožňava (3), Sobrance (4), Spišská Nová Ves (5), Trebišov (6).

Region Nitra (NR) is divided into 7 districts: Nitra (0), Komárno (1), Levice (2), Nové Zámky (3), Šaľa (4), Topoľčany (5), Zlaté Moravce (6).

Region Prešov (PO) is divided into 13 districts: Prešov (0), Bardejov (1), Humenné (2), Kežmarok (3), Levoča (4), Medzilaborce (5), Poprad (6), Sabinov (7), Snina (8), Stará Ľubovňa (9), Stropkov (10), Svidník (11), Vranov nad Topľou (12).

Region Trenčín (TN) is divided into 9 districts: Trenčín (0), Bánovce nad Bebravou (1), Ilava (2), Myjava (3), Nové Mesto nad Váhom (4), Partizánske (5), Považská Bystrica (6), Prievidza (7), Púchov (8).

Region Trnava (TT) is divided into 7 districts: Trnava (0), Dunajská Streda (1), Galanta (2), Hlohovec (3), Piešťany (4), Senica (5), Skalica (6).

Region Žilina (ZA) is divided into 11 districts: Žilina (0), Bytča (1), Čadca (2), Dolný Kubín (3), Kysucké Nové Mesto (4), Liptovský Mikuláš (5), Martin (6), Námestovo (7), Ružomberok (8), Turčianske Teplice (9), Tvrdošín (10).

Input data: 8 regions (8 problems solved), number of delivery district towns and regional capital in each region (BA – 4, BB – 13, KE – 6, NR – 7, PO – 13, TN – 9, TT – 7, ZA – 11), distribution centre (regional capital) in each problem is indexed as $i = 0$, the shortest distances between all district towns and between distribution centre and each district towns is designated as c_{ij}, vehicle capacity V was set to 12, the demand of district towns was associated with number of inhabitant (0.00006 m^3 per inhabitant), cost per km of own vehicle was set to co = 0.5 €, cost for rented vehicle was set as follows: fixed cost per route cf = 15 €, cost per km cr = 0.6 €. The goal was to minimize the total costs for the distribution in each region and to determine the number of own and rented vehicles, with respect the following restrictions: the origin 0 is the initial node and also the final node for each own vehicle route, the final point in case of rented vehicle is the last served node.

The computational experiments were provided on the base of before mentioned data. The mathematical model was implemented in software GAMS (solver Cplex 12.2.0.0) on PC with Intel ® Core ™ i7-3770 CPU with a frequency of 3.40 GHz and 8 GB of RAM under MS Windows 8. The results are shown in Table 1a, 1b .

Table 1a Regional distribution

	Region Bratislava	Region Banská Bystrica	Region Košice	Region Nitra
Route 1	0-1-2-3-0	0-10-4-1-11-12-0	0-1-5-3	0-3-0
Route 2		0-2-7-8	0-2-4	0-5-0
Route 3		0-3-6-5-9	0-6	0-6-2-0
Route 4				0-4-1
Total cost	52	261.7	186	165
Cost for own vehicles	52	68.5	0	102
Total cost for rented vehicles	0	193.2	186	63
Fix cost for rented vehicles	0	30	45	15
Variable cost for rented vehicles	0	163.2	141	48

Table 1b Regional distribution

	Region Prešov	Region Trenčín	Region Trnava	Region Žilina
Route 1	0-7-0	0-1-3-4-0	0-2-0	0-1-4-2-0
Route 2	0-4-6-3	0-2-8-6-0	0-4-3-0	0-6-9-5
Route 3	0-9-1-11-10-5	0-5-7	0-1	0-8-3-10-7
Route 4	0-12-2-8		0-5-6	
Total cost	255.2	159.1	158.1	198.7
Cost for own vehicles	14	104.5	58.5	38.5
Total cost for rented vehicles	241.2	54.6	99.6	160.2
Fix cost for rented vehicles	45	15	30	30
Variable cost for rented vehicles	196.2	39.6	69.6	130.2

The Table 1 provides the solution in each region in Slovakia. The first 4 rows of the table show the obtained routes in region (if last node is of the route is the node indexed 0 than the route is realized by own vehicle and otherwise by rented vehicle) and 5th row shows the total cost of distribution (objective function) in selected region. The distribution system is depicted on Fig.2, where the solid lines represent the routes of own vehicles and dotted lines represent the routes of rented vehicles.



Fig. 2

4. CONCLUSION

This paper considers the version of open vehicle routing problem (OVRP) that allows combining CVRP together with the possibilities of open routes. The mathematical formulation was provided on the base of mixed integer programming (MIP) with linear objective function and constraints. So that formulation allows the use of standard software for solving MIP problems. The computational experiments were based on regional data in Slovakia. The distribution has to he assured from regional capital to district towns in each region using the own or rented vehicles. The goal was to determine how many own and rented vehicles must be used in each region so

that demand of all district towns must be met with the minimal cost (the total cost consist of the cost of own vehicles and of the cost of rental). Software implementation was realized in GAMS (solver Cplex).

ACKNOWLEDGEMENTS

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FACILITY LOCATION DECISION UNDER DEMAND UNCERTAINTY AND TRAVEL TIME FLUCTUATION

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Abstract: *This study solves the facility location problem of an IT service company whose main problem is to arrive at the customer's site in the shortest time when support is needed. This problem should consider both the demand of the customers and the distance and/or travel time between the customers and the company. Travel times and demand are not constant since they are affected by many factors. Therefore, one should take into account uncertainty. This study formulates the problem by considering the demand as fuzzy and travel time as varying based on different time intervals, which are defined hourly, daily and seasonally. Moreover, we consider the cases of minimum speed, average speed and maximum speed for travel time. We illustrate the application of the proposed framework using data of a company. We compare the proposed framework with the traditional distance based optimization approach and show the advantages of the proposed method.*

Keywords: *transportation-location problem, fuzzy demand, travel time fluctuation.*

1. INTRODUCTION

Considering the previous literature, this study contributes to the literature widely by deciding on the optimal facility location and route selection at the same time. It is based on both uncertainty of the travel time from facility node to the demand node and demand uncertainty. Moreover, the uncertainties are defined hourly, daily and seasonally, which covers all the time intervals that the company provides service in a year. Thus, all possible conditions of traffic and demand variability are taken into account. When the transportation literature is examined, it can be seen that effects of weather conditions have been commonly modeled in the transportation forecasting literature [1], [2] and [3].

Moreover, time of day is treated as a significant factor that represents the level of demand for the transportation services and the traffic situation during different hours of the day [4], [5], [6], and [7]. Similarly, many studies have demonstrated the variation of traffic volume in different days of week and vacation times [2], and [7]. Besides this, the travel time is modeled in 3 levels, i.e. worst, best and most likely, in order to handle the uncertainty better.

For illustration, the proposed approach solves the transportation location problem for a service company which provides information technologies (IT) support for its customers. The problem considers a "one facility and many customers" case. The company's main problem is to arrive at the customer's site in the shortest time when support is needed. Therefore travel time and

demand variability should be considered while selecting the optimal facility location and optimal routes from the facility to the customers. The company and the customers are in Istanbul and Istanbul is one of the most crowded cities in Europe with high traffic density, which makes the problem necessary to be solved.

The paper consists of three more sections. The second section introduces the proposed framework while section 3 presents the application of the proposed framework. Conclusion and further research finalize the paper.

2. PROPOSED FRAMEWORK FOR THE TRANSPORTATION-LOCATION PROBLEM UNDER TRAVEL TIME FLUCTUATION AND DEMAND UNCERTAINTY

This study proposes a framework for the transportation-location problem involving travel time and demand uncertainties. The travel time varies for each route based on time, hence it is uncertain. Moreover, the demand of the customer is not known since there is no past data and it is a subject of uncertainty, too. However, it is apparent that it varies based on time intervals for companies that serve their customers on call. In the problem setting that is considered in this study, the number of facilities to be located is one, but the number of customers is more than one. The company serves the customer at their location and when a call from a customer comes to the company, an agent in the company drives to the customer. The customer does not have a constraint about the arriving time; however, the agent should be at the site of the company as soon as possible. The assumption in the problem setting is that, there is no capacity limit and the company always has enough employees to send to the customers for service. When all these facts are considered together, the following framework is proposed to solve the facility location problem:

Step1: Determine alternative facility locations.

Step2: Find the routes that connect the customers to the alternative facilities

Step3: Determine the number of time intervals (r) that will cover all the service hours of the company.

Step4: Find the probabilities of demand from customer i at time interval k
These probabilities show the probability of customer demand. In this study, the case that there is no past data about the customer demand is considered. However, the experts in the company have some experience about the customer demand. Therefore, FRBS supported by expert opinion is used in order to model the data. After constructing FRBS, the demand probabilities corresponding to each time interval k is derived from this system.

Step5: Find the travel time to customer i when route j is selected at time interval k
This information can be found from the traffic data and Geographic Information Systems (GIS).
Step6: Formulate the problem as a mathematical model and solve the problem minimizing the travel time x demand. Find the optimal routes that should be followed at specific time intervals.

Given that there are n customers, m routes, r time intervals, and u alternative facilities, the problem can be formulated as an integer programming model by the following equation set (1):

$$\min \sum_{l=1}^{u} \sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{k=1}^{r} \left(p_{ik} * t_{iklj} * y_{iklj}\right) \tag{1}$$

subject to

$$\sum_{j=1}^{m} y_{iklj} = 1 \quad \forall_i \forall_k \forall_l \,, \; \sum_{l=1}^{u} z_l = 1 \,, \; y_{iklj} \leq z_l \quad \forall_l, \qquad y_{iklj}, z_l \in \{0,1\} \tag{2}$$

where

p_{ik}: probability of getting a call from customer i at time interval k

t_{iklj}: travel time to customer i at time interval k from facility l when route j is selected

y_{iklj} : binary variable which denotes whether route j is selected in order to go to customer i from facility l at time interval k

z_l : binary variable which denotes whether facility l is selected

The first constraint in the model ensures that only one route is selected from facility l to customer i at time interval k. The second constraint is to make sure that only one alternative facility is selected. The above mathematical model can be solved optimally by using integer programming solution techniques.

Step7: Compare the results with the distance based approach where traffic density is not considered.

3. APPLICATION OF THE PROPOSED FRAMEWORK

The illustration of the proposed framework is performed for an information technologies (IT) support company in Istanbul.

Step1: The alternative facility locations are determined by the experts in the company. The alternative facilities are selected by considering available office locations, the closeness to the customers, commercial areas, and closeness to the main transportation roads. There are 3 alternative facility locations, two of the alternative locations are in the Asian side of Istanbul and one is in the European side of the Istanbul. Two of them are chosen from the Asian side since most of the customers are there.

Step2: The company has six customers and there are 43 alternative routes in total that connect the 3 alternative facility locations to the 6 customers. Since Istanbul is a city that connects two continents (namely, Europe and Asia), the customers and alternative facility locations are on both side of the city, and there are two bridges that connect the two continents, there are several alternative routes for each combination.

Step3: Determine the number of time intervals (r) that will cover all the service hours of the company.

The number of these time intervals is determined as 160, which covers all the days in a week, all hourly time intervals in a day and all seasons in a year. There are five weekdays, 8 hourly time intervals that the company serves (10.00-11.00, 11.00-12.00, 12.00-13.00, 13.00-14.00, 14.00-15.00, 15.00-16.00, 16.00-17.00, 17.00-18.00) and 4 seasons. Hence the combination results in 160 different time intervals. The aim was to cover all possible time intervals since the traffic conditions differ substantially among weekdays, hours in a day and weathers. For instance, during rush hours, traffic is really crowded in Istanbul. Moreover, in winter the severity increases due to increased number of accidents and necessity of driving slow.

Step4: FRBS is used to find the demand probabilities. In order to identify the variables in the FRBS and to fuzzify the variables, experts are consulted. The fuzzy inference system offered by MATLAB 7.6.0 fuzzy logic toolbox is used in this study. Using the IF-THEN rules, the probability of getting a service demand at a specific time interval is estimated based on the input variables of weather condition, day of week and time of day. The determined variables have effects on both the demand of the customers and traffic conditions. The experts state that demand of the customer varies across day of week and time of day. It also varies with seasons since in summer, most of the people are on vacation and demand decreases relatively.

In the fuzzification step, the membership functions of the input variables are defined using expert opinion. Time of the day is represented by the linguistic variables of early, mid and late. Early is standing for the beginning of the week and late for the end of the week (weekend is not considered since the company does not work at weekends). Demand is also related to the time of the day so the discrete hours of the day have been defined by four levels of linguistic variables namely early, mid, late and very late. Finally, the numerical value of "probability of getting a call from the company" has been used as the demand level, which is the output of the model. Demand levels are represented by the very low, low, medium, high and very high terms. Using the rule-based system, demand probability derivation is achieved and used in the optimization model. In the literature, triangular and trapezoidal fuzzy numbers are frequently utilized for fuzzy applications. In this study, both triangular and trapezoidal fuzzy numbers are used to consider the fuzziness of the decision elements. The membership functions are defined by the experts working in the company. Functions of one of the input variables and output variable are given in Figure 1.

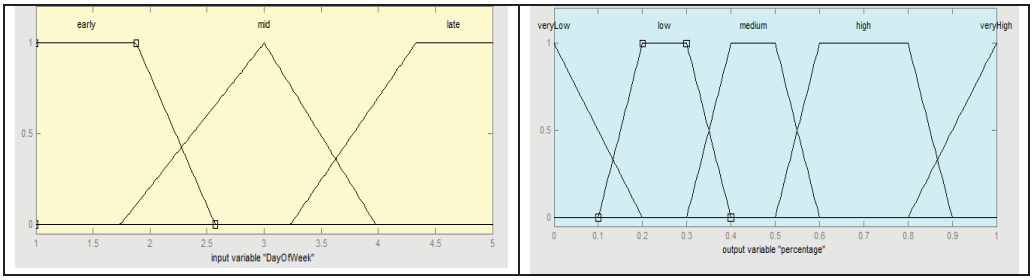


Figure 1. Membership functions of one input variable: day of week (on the left) , and output variable: demand level (on the right).

The rules are defined for each customer and for each season (summer, fall, winter, spring). The main difference among these customers is that, the demand level is never very high for Customer 4. After constructing FRBS, the demand probabilities corresponding to each time interval k for each customer are derived from this system.

Step5: We find the travel times for each route at time different time intervals from the past traffic data of Istanbul Metropolitan Municipality. We consider the cases of minimum, average and maximum travel time for each route in order to make a sensitivity analysis. Hence, we can make the decisions under the worst case, best case and the most likely case.

Step6: Having the above explanations and motivation, we use the travel time data (taken from Istanbul Metropolitan Municipality for last three years) and demand data (from FRBS) to solve the mathematical model. For all the scenarios, the results show that AF_3 (Alternative Facility 3) has the minimum objective function value (best scenario: 87. 4 most likely scenario: 95.9, worst scenario: 111.2). In fact it is expected to select either AF_2 or AF_3, since they are roughly in the middle of all the customers. The resulting optimal routes for AF_3 are shown in Figure 2. The explanations about the optimal routes at different time intervals from AF_3 to the customers are given below.

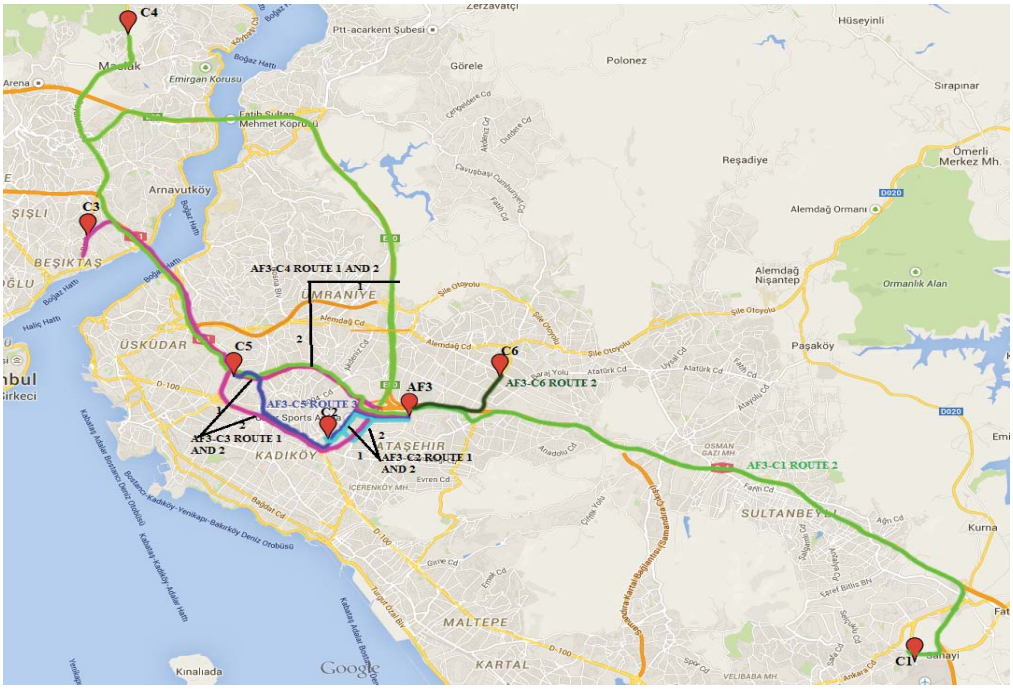


Figure 2. Alternative routes from alternative facility 3 (AF-3) to customers

From AF_3 to C_1 (Customer 1), the advantageous route is route 2 in all time intervals and in all scenarios while the optimal route from AF_3 to C_2 is route 1 in all time intervals for all scenarios. However, for the best scenario for AF_3 and C_2, in summer route 1 and route 2 have the same values which yield to alternative solutions for this season. This result is due to the fact that most of the people are on vacation in summer and the roads are less busy, so travel times on the routes are close to each other.

For the worst scenario, the optimal route from AF_3 to C_3 in spring and in winter is route 2 in the middle hours of the day, but in other time intervals, route 1 is optimal. However, in summer in all time intervals route 1 is optimal. In fall, it is advantageous to use route 2 in late hours of day. However, for the best and most likely scenarios, the optimal route is route 1 in all time intervals.

For all scenarios, the results show that in spring from AF_3 to C_4, the advantageous route is route 1 in the middle hours of the day while it is route 2 in other time intervals. The optimal route is usually route 2 in summer for all scenarios. For the worst scenario, for fall and winter, it is difficult to make a generalization since the optimal route changes among days and hours. However, for the best and most likely scenarios, in fall and winter the optimal route is route 2.

For all time intervals and for all scenarios, the optimal route from AF_3 to C_5 is route 3. Therefore independent from being pessimistic or optimistic, the driver can select route 3 at all times. Again for all time intervals and for all scenarios, the optimal route from AF_3 to C_6 is route 2.

Step7: When we solve the problem by using solely the distances instead of travel times (as in the traditional approach), we find that again AF_3 is the optimal location. We see that the optimal route for C_1 is route 2, for C_2 it is route 1. These results are similar to the results in the proposed approach. However, for the best case and for summer sometimes using route 2 is also advantageous for C_2 in the proposed approach. For C_3, the shortest distance belongs to route

1. In the proposed approach the optimal routes were selected as route 1 and route 2 for different time intervals. The proposed approach shows the optimal routes for C_4 are sometimes route 1 and sometimes route 2. However, route 2 is shorter than route 1. In fact these two routes use different bridges that connect the Asian side and European side of Istanbul, and since the first bridge that is used in route 2 is usually busier, it is sometimes advantageous to use the other route (route 1). The shortest routes are the same as the optimal ones in the proposed approach for customer 5 and 6.

4. CONCLUSION AND FURTHER RESEARCH

The results revealed in the study show that the optimal route and facility location decisions are time dependent. It is also seen that travel time volatility and uncertainty has a significant effect on the route selections. This study contributes the facility location problem with the selection of optimal routes for different time intervals simultaneously. The results show that, time dependent traffic conditions significantly affect the optimal route decision and uncertain demand is also an important factor. Additionally, FRBS is seen as a useful technique for the demand prediction. Moreover, the optimal routes change for different time intervals for different scenarios and the optimal facility location is robust to these scenarios.

Best, worst and most likely scenarios are considered in this study in order to address the uncertainty and fluctuation. In the best scenario, the travel time on a route at that specific time interval is the minimum realized travel time in the real dataset. In the worst scenario it is the maximum and in the most likely scenario it is the average.

Nowadays, technology offers us the availability of traffic data, therefore we should make use of it more. This study is an attempt to achieve this, by using the past data on the traffic conditions on different routes in a very big and highly-populated city, namely Istanbul. Further research can be carried for many locations to many customers case. The implementation is limited in this article and it can be solved for a bigger case in order to see significant results. Moreover, the study can be widened by adding the return routes, too.

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FORECASTING THE INVENTORY LEVEL OF MAGNETIC CARDS IN TOLLING SYSTEM

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Abstract: *Forecasting the inventory level of magnetic cards is an important prerequisite for the functioning of a tolling system. This paper presents the approach to forecasting the required number of magnetic cards in the tolling system on the Belgrade – Niš highway section in Serbia, as a prerequisite for purchasing and forming an optimal inventory level. The* $ARIMA(1,1,2) \times (1,1,0)_{12}$ *model was developed and applied for forecasting the monthly inventory level of magnetic cards needed for the years 2015 and 2016.*

Keywords*: time series, forecasting, magnetic cards inventories, tolling system.*

1. INTRODUCTION

The tolling system is a complex system which enables the highway owner toll charging on various sections, and fast and high-quality usage of highways to the users. Toll charging in the Republic of Serbia is within the competence of Public Enterprise "Roads of Serbia", which is responsible for organization of work, supervision, management and technical provision for functioning of the system.

Toll charging is carried out on three sections of highways in the Republic of Serbia: Belgrade – Niš, Belgrade – Šid and Belgrade – Subotica. The Belgrade – Šid and Belgrade – Niš sections have a closed system of toll charging in which the toll amount depends on vehicle category and travel distance (PE "Roads of Serbia", 2015). A highway user gets a magnetic card at entrance toll plazas and pays toll at the exit plaza, after card reading. The users get the magnetic cards at entrance plazas from distributors (automatic regime) or pre-magnetized cards from operators (manual regime). At collecting plazas, the cards are put aside, namely put in storages until they are destroyed. The entrance plazas must have an adequate level of card inventories to enable undisturbed functioning of vehicle entrance and traffic on highway.

PE "Roads of Serbia" deals with the organization of toll collection and accordingly has to plan the following: magnetic card acquisition, making sufficient amount of pre-magnetized cards, organization of workers at collection stations, the number of entrance/exit lanes at plazas as well as regular maintenance of toll collection system. It is necessary to precisely forecast the number of magnetic cards in the toll collection system for these plans to meet the future

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requirements of the system. The forecast is based on the number of issued magnetic cards in the previous time periods, namely in analyzing the monthly time series of the number of issued magnetic cards.

A Multiplicative Seasonal ARIMA class of non-stationary time series was applied in this paper for the analysis of time series. The used time series includes data on the number of magnetic cards from January 2000 till November 2014 on the Belgrade – Niš highway section. The obtained model was applied for forecasting the required number of magnetic cards for the period December 2014 – December 2016.

The paper has been organized in the following way. The second part describes the theoretical basis and Box-Jenkins methodology for analyzing and modelling time series. The third part shows application of the Box-Jenkins methodology for modelling the inventory level of magnetic cards for toll collection system on the Belgrade – Niš highway section. The conclusion and possible directions of future research are given in the fourth part.

2. TIME SERIES ANALYSIS

Time series can be described as a set of temporal ordered realizations of a random variable during a series of successive time periods. By analyzing changes in the random variable in time, it is sometimes possible to define a performance model which enables forecasting future states.

Seasonal time series consist of periodical changes which repeat in certain time intervals. The smallest repetitive time period is called seasonal period (s). When realization of a random variable repeats after seasonal period with certain regularities, it may be expected that the values in seasonal periods will correlate mutually. High values of autocorrelation function on seasonal realizations are indicators of seasonal non-stationary process. Seasonal difference operator$(1 - B^S)$ is used eliminating seasonal non-stationarity.

By combining seasonal difference operator with ARIMA model, Box and Jenkins defined the Multiplicative Seasonal ARIMA model (Box et al., 1994; Brockwell, Davis, 2002; Cryer, Chan, 2008) as:

$$(1 - B)^d (1 - B^s)^D \varphi_p(B) \Phi_P(B^s) X_t = \theta_q(B) \Theta_Q(B^s) \varepsilon_t \quad (1)$$

In this relation B is lag operator, $\varphi_p(B)\Phi_P$ and $\theta_q(B)$ are autoregressive polynomial and moving average polynomial, and $\Phi_P(B^s)$ i $\Theta_Q(B^s)$ are seasonal autoregressive polynomial and seasonal moving average polynomial. Multiplicative Seasonal ARIMA model with seasonal period s is marked as ARIMA$(p, d, q) \times (P, D, Q)_s$, where p and q are orders of non-seasonal autoregressive polynomial and seasonal moving average polynomial, P and Q are orders of seasonal autoregressive polynomial and moving average polynomial, d is non-seasonal and D is seasonal differencing degree (Box et al., 1994; Wei, 2006; Cryer, Chan, 2008).

Box and Jenkins proposed a methodology for analysing and modelling time series which includes four stages (Box et al., 1994):

- Model Identification,
- Model Estimation,
- Model Validation, and
- Forecasting.

Model Identification consists of a series of procedures over time series data, in order to chose the corresponding model from ARIMA model set. These procedures include the following (Tsui et al., 2014):

- Time series plotting – enables detecting trend occurrence and seasonal changes in time series. If it is noted that mean value is not constant then logarithmic data transformation is applied.
- Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) – based on theoretical characteristics of ACF and PACF functions for ARIMA models, p and q orders of ARIMA model are assumed. These diagrams can indicate seasonal changes in time series.
- Unit root tests (Augmented Diskey-Fuller test, Philips-Perron test) – tests are carried out by changing length of lag operator until stationary series is obtained. Existence of unit roots indicates to the necessity of series differencing.
- Seasonal HEGY test – if there are seasonal unit roots then seasonal differencing is applied.

The described procedures give the set of values of ARIMA model (p, q, d, P, Q, D) parameters.

Model Estimation implies that coefficients of autoregressive polynomial and moving average polynomial are determined for every possible parameter (p, q, d, P, Q, D) namely fitting of model is in question. In this phase the methods of non-linear least squares and maximum likelihood estimation are applied. The best model is the one which has the lowest information criterion, which may be (Kirchgässner and Wolters, 2007; Cryer, Chan, 2008):

- Akaike information criteria: $AIC = T\ln(MSE) + 2k$
- Baesian information criteria: $BIC = T\ln(MSE) + k\ln(T)$
- Normalized Baesian information criteria: $Normalized\ BIC = \ln(MSE) + \frac{k\ln(T)}{T}$
- Hanan-Quin information criteria: $HQIC = T\ln(MSE) + 2k\ln\big(\ln(T)\big)$

Model Validation involves checking residuals – the differences of realized and forecasted values. ACF and PACF residual functions are used for this or some of the formal approaches (eg. Ljung-Box Q-statistics). If there is no autocorrelation in residuals, the model is adequate. On the contrary, model is inadequate and it is necessary to go back to identification stage.

Forecasting implies using the obtained model to forecast values for h step ahead. By comparing the obtained values with h past values of series realization, which were not used while estimating model parameters, it can be evaluated whether the chosen model has good quality forecast. Model estimation can be done according to any of the following criteria:

- Mean absolute deviation $MAD = \frac{1}{n}\sum_i \left|X_i - \hat{X}_i\right|$
- Mean absolute percentage error $MAPE = \frac{100}{n}\sum_i \left|\frac{X_i - \hat{X}_i}{X_i}\right|$
- Mean square error $MSE = \frac{1}{n}\sum_i \left(X_i - \hat{X}_i\right)^2$
- Root mean square error $RMSE = \sqrt{MSE}$

3. ARIMA MODEL FOR FORECASTING NUMBER OF MAGNETIC CARDS

In order to forecast the necessary inventory level of magnetic cards for toll collection on the Belgrade – Niš section, the time series of total number of issued magnetic cards was used from the period January 2000 – November 2014 (PE "Roads of Serbia", 2000-2014). The time series consists of 179 monthly realizations, out of which the first 168 were used for estimating model parameters and the last 11 for model performance estimation.

3.1. Identification of time series model

Time series plotting of issued magnetic cards is shown in Figure 1. An analysis of the time series plot shows non-stationary time series with an increasing trend and seasonal variation. Seasonal

variations are justified by the fact that the largest number of highway users is in the period July-August during the holidays, with heavy transit of traffic from Western European countries towards Turkey, Bulgaria and Greece, and vice versa, and that the lowest traffic on the highway occurs during winter weather conditions, especially in months with a great number of exceptionally cold days and snowfall.

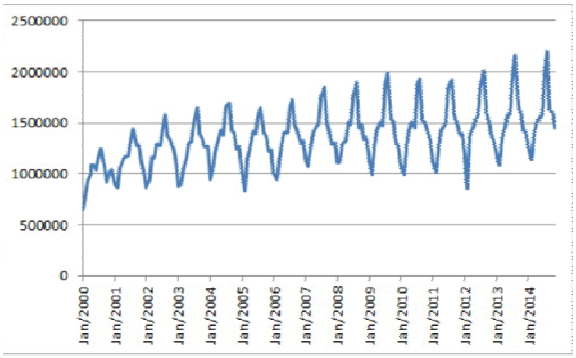
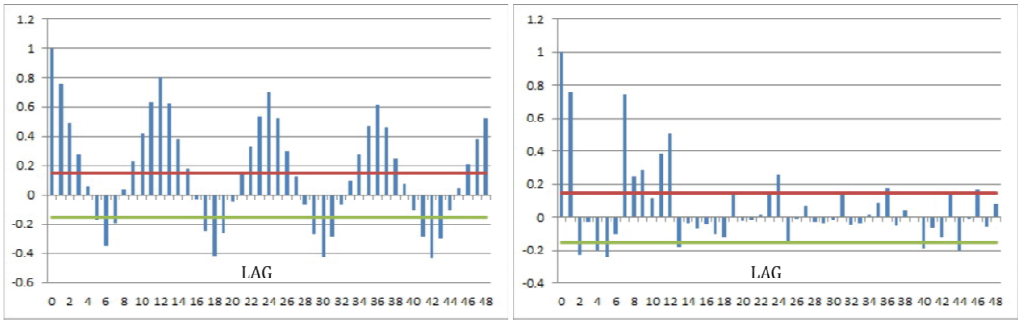


Figure 1. Time series of total number of magnetic cards for the period 2000–2014.

In order to stabilize variance, a logarithmic time series transformation was carried out. The transformed series in this paper is titled ln time series. An autocorrelation function (ACF) and partial autocorrelation function (PACF) were formed for ln time series, shown in Figures 2(a) and 2(b).



(a) ACF (b) PACF

Figure 2. Autocorrelation and partial autocorrelation function ln time series

Great correlation function values were marked in all time periods. Gradual decrease of autocorrelation function values indicate to the existence of a long-term trend, and points out to the fact that ln time series differencing is necessary to be carried out when making model, namely that $d = 1$ in ARIMA model. High autocorrelation function values on annual periods indicate to the need for seasonal differencing on model. By applying differencing operator $(1 - B)(1 - B^{12})$ stationary time series was obtained. In the model identification phase, formal tests for unit roots presence were carried out. The results of Dickey-Fulle test and Philips-Person test confirmed stationarity.

3.2. Model Estimation

Model identification showed that ARIMA$(p, 1, q) \times (P, 1, Q)_{12}$ models proved to be most suitable for the observed ln time series. In the model estimation stage, all possible models from

alternative model set, where $p, q = 0, 1, 2$ and $P, Q = 0, 1$, were considered. By using MATLAB Econometrics Toolbox®, the autoregressive polynomial and moving average polynomial coefficient were estimated as well as seasonal autoregressive polynomial and moving average polynomial coefficient for all observed models. For each of these models, Akaike information criterion (AIC) and Bayesian information criterion (BIC) values were found and Ljung-Box Q-test carried out. ARIMA$(1,1,2) \times (1,1,0)_{12}$ model represents the best model for ln time series, because the lowest AIC and BIC criterion values was obtained. The parameter values of this model for ln time series are shown in Table 1, and the model relation is given by equation (2):

$$(1-B)(1-B^{12})(1+0.354878B)(1+0.715782B^{12})X_t = (1+0.109707B+0.416844B^2)\varepsilon_t \qquad (2)$$

Table 1. ARIMA model parameters values for ln time serie

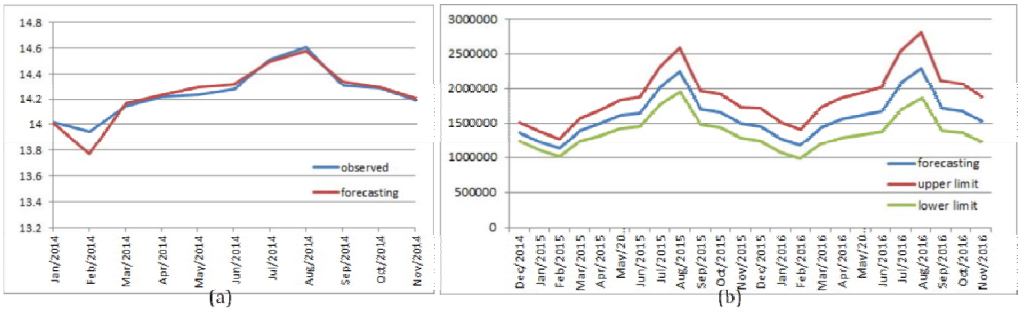
Parameter	Value	Standard deviation	t-statistics
AR{1}	-0.354878	0.210124	-1.6889
SAR{12}	-0.715782	0.0409527	-17.4783
MA{1}	-0.109707	0.210714	-0.52065
MA{2}	-0.416844	0.134475	-3.09978
Variance	0.00240232	0.000191872	12.5204
AIC	-522.4981		
BIC	-500.6303		
MAPE	0.2614		
RMSE	0.0579		
R-squared	0.9433		

3.3. Model Validation

Diagnostic checking confirms that the chosen model is stationary and that there are no redundant parameters. Residuals analysis (Ljung-Box Q=11.6542, p-value 0.92747>0.05) indicate residuals are strictly random and that no significant autocorrelation exists between residuals on different time periods.

3.4. Magnetic Cards inventory level forecasting

The differences between anticipated values obtained by model and realized values of time series for the period January-November 2014 are given in Figure 3(a).



(a) (b)

Figure 3. Inventory level of the magnetic cards forecast

As the mean absolute percentage error (MAPE) and root mean square error (RMSE) values are small (MAPE $\leq$ 10%) (Tsui et al., 2014), it may be concluded that the obtained model is good enough for forecasting the inventory level of magnetic cards on the Belgrade – Niš highway section.

By using the obtained model, the number of magnetic cards for the period December 2014 – November 2016 was forecasted. Forecast value and 95% confidence interval are given in Figure 3(b).

4. CONCLUSION

The aim of this paper was to forecast inventory level of magnetic cards needed to serve demand of PE "Roads of Serbia". High quality forecasting enables the company to properly plan acquisition of magnetic cards, the making and distribution of pre-magnetized cards, the required personnel and organize regular maintenance of toll charging system. The Box-Jenkins methodology was applied for the choice of the adequate ARIMA model based on time series of monthly number of issued cards. The obtained ARIMA$(1,1,2) \times (1,1,0)_{12}$ model for the Belgrade-Niš highway section showed high performance and may be used for high-quality forecasting of the magnetic cards inventory level. Forecasting of the required number of magnetic cards for the years 2015 and 2016 was effected by applying model. For further improvement of the model, it is necessary to also include other variables which affect traffic intensity on highway (gross national product, real wages rate, gas prices, etc.).

ACKNOWLEDGMENT

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MODELING DELAY OF LOADING GOODS ON RIVER TRANSPORT VESSELS

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Abstract: *Transport and handling operations performed in cargo transport terminals can significantly influence speed and efficiency of loading. Loading of goods has its own spatial and temporal dimension. Managing temporal dimension contributes to a more efficient realization of the loading operation and affects the performance of transport and rational handling operations in freight transport terminals. The analysis of parameters which influence the time of loading may contribute to efficient solution of practical problems that slow down loading of goods. In this paper, a simulation model of the process of delay in loading bulk cargo is developed. The model was tested on the roasted iron pyrite in the marine terminal port Sabac. The test results have shown that delay is a significant factor which influence loading of goods. Measuring of delay duration for each loaded vessel was carried out in real conditions of loading and handling operations. As the output of this method, the arrangement of regular duration of delays and disorders is observed. Further analysis shows link between regular duration and disorders and opportunity to predict and control disorders during loading of cargo.*

Keywords: *loading, delay, orderly, disorder, model*

1. INTRODUCTION

Transport of goods by inland waterways is the most capacious and most cost-effective mode of transport. Besides, environmental pollution is incomparably lower, which is very important fact in the planning of sustainable transport network as seen from the view of today's climate disturbances. Pan-European transport corridor VII is a natural, highly capacious waterway that allows the formation of large river transport structures for the transport of mass and containerized cargo [6]. Rational managing and planning of reloading operations in port terminals are an important segment in business of port terminals. Possibility of predicting duration of loading operations is certainly an important organizational and pricing dimension. The objective of the paper is to model and predict delays and their duration on loading of bulk cargo onto vessels.

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2. SIMULATION MODEL

2.1 Description of the model

The model encompasses a river terminal for bulk cargo where times of loading and delays were measured out for river vessels. At the river terminal loading place there is a conveyor of 400 t/h capacity with three to five trucks for serving it. Loading times were measured continuously during one year and 250 open type river vessels were included. Measuring was performed for one type of goods, which is massive bulk cargo - roasted iron pyrites [7].

On the duration of times of loading and delays unfavourable weather conditions, such as precipitation, moisture of goods, high water level, availability of trucks serving the conveyor, etc. have significant impact. Delays also included technical operation for loading cargo. The delays were recorded from the moment the loading was interrupted till the loading of the same vessel was continued. Where loading was stopped more than once, the delay was calculated as the sum of all breaks.

In the analytical part of the research, the statistical parameters and border of disorders in delays were established, respectively [3]. The delays that are measured out on loading have extremely high values as a consequence of disorder due to unfavourable impacts.

The occurrence of these values cannot be controlled because of unforeseeable circumstances. For this reason disorders were analyzed as a particular delay category. Namely, the delays are divided in two categories: regular duration and disorder.

On the basis of hypothesis of exponential distribution for the two categories of delay due to their own randomness, the simulation was carried out for both regular duration of delay and disorder. The simulation part implies implementation of Monte Carlo numerical method and use of software to simulate great number of iterations [4]. Further analysis will show linear dependency between regular duration of delay and disorder, as well as the possibility of predicting disorders.

2.2 Delays from the aspect of disorder size

The delay in loading of bulk cargo at the freight terminal was measured out in real conditions for each loaded vessel. Measuring included all influential factors and they are included in final duration of delay. The results of measuring, where delay is a continual random variable *(X),* have continual distribution and may take random value. Statistical data processing was performed and it showed wide range of the measured values [3]. The Figure 1. shows the histogram containing the measured delays compared with normal distribution.

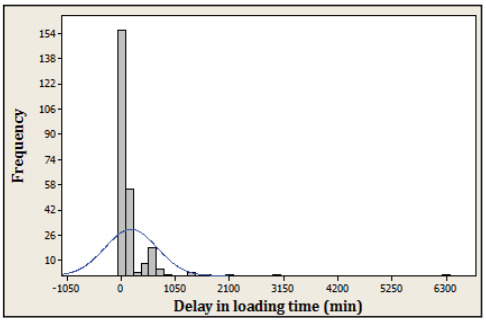


Figure 1. Histogram with measured out delays

In the Table 1. the output results of the statistical delay processing are given.

Since the frequency of the duration of delays measured for all vessels is concentrated on lower values (statistical analysis given in the Table 1. shows that the median is $\tilde{x}$ = 50 min, and the maximum value of the measured delays is *max* = 6360 min), the Figure 2. is obviously really small percent of extreme high duration of delays. These have led research on the conclusion that there are disorders in the duration outages.

In determining classes where border of disorder will be defined, the optimal relation between squared mathematical expectation, $E(x)^2$ and variance, σ^2 was searched. As the disorder classes, the values of delay above 350 min, 450 min, 550 min, 600 min were taken into consideration.

Table 1. Descriptive statistic of delay

Statistical parameters		Obtained values
Number of samples (n)		250
Central tendency	Mathematical expectation, *E(x)*	182,8
	Median, $\tilde{x}$	50
	Standard error, ε	32,6
Dispersion of values	Srandard deviation, σ	510,2
	Maximal value, *max*	6360
	Minimal value, *min*	0
Shape of distribution	Skewness	8,44
	Kurtosis	92,16

In determining of disorder borders in delays the following relation is taken as optimal:

$$E(x)^2 / \sigma^2 = 0{,}82 \qquad (1)$$

and delays in time with duration over 450 min are declared as disorders. Duration of delays below 450 min is regular duration.

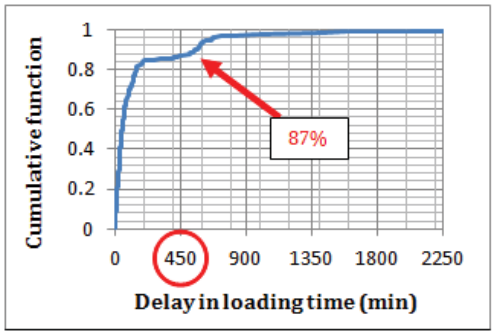


Figure 2. Cumulative function of measured out delays

Observing the cumulative function at the Figure 2. it can be concluded that 87% of all delays have duration below border of 450 min. On this way it is defined participation of all disorders in delays with 13%. Disorders above 650 min are taking only 5% in total number of measuring.

In order to assess matching with mathematical distribution, goodness of fit test is performed. The Anderson – Darling test (*p>0.05*) is carried out using probability plots with 95% confidence

interval [1]. The Table 2. shows Anderson – Darling (AD) statistic and the associated power of test (p - value).

Table 2. Anderson – Darling (AD) statistic for mathematical distributions

Specify of mathematical distribution	AD statistic	p - value
Normal	49,581	<0,005
3-Parameter Lognormal	3,295	no data
2-Parameter Exponential	51,761	< 0,010
3-Parameter Weilbull	8,144	< 0,005
Smallest Extreme Value	73,494	< 0,010
Largest Extreme Value	31,722	< 0,010
3 – Parameter Gamma	12,969	no data
Logistic	33,022	< 0,005
3 – Parameter Loglogistic	5,524	no data

From the Table 2. it is obvious that loading delays have feature of random variables and there is no matching with any mathematical distribution (AD statistic is larger than 0 and p – value is not > 0.05).

2.3 Implementation of Monte Carlo method

As the statistical verification confirmed that delays does not match any mathematical distribution, it is assumed that the first category of delay (regular duration) match exponential distribution, while disorders match Erlang distribution. Both category of delay will be presented by probability density function (pdf) of related assumed distribution and will be simulated.

To perform simulation parameter of probability, the density function is determined [5]:

$$\lambda = {}^{1}/_{E(x)} = 0{,}02 \qquad (2)$$

as a border parameter between regular duration and disorder. Regular duration of delay in simulation contains value of the parameter $\lambda>0{,}02$, while disorder contains value of density function parameter, $\lambda<0{,}02$.

On the basis of the measured values of delay for vessels, the calculated mathematical expectation of regular duration is $E(x) = 62{,}94$ min, and of disorders, $E(x) = 991{,}88$ min. Standard deviation for regular duration is $\sigma=75{,}57$; and for disorders, $\sigma=1093{,}91$. Mathematical expectation is the crucial parameter for further evaluation of efficiency of simulation.

Monte Carlo simulation is performed for $n=10^4$ iterations of randomly chosen values, $x= [0,1]$ of function argument [2].

In simulation of regular duration of delay, it was used probability density function of exponential distribution, while disorders were simulated by probability density function of Erlang distribution of the second order.

After $n=10^4$ iterations the simulated mathematical expectation of regular duration takes values that are extremely close to mathematical expectation of the measured values (approximate relative error is 0.003%). Statistical goodness of fit test shows power of test ($p = 0{,}75$) more than 0,05 according to condition $p>0{,}05$ to accept assumed hypothesis. Probability density function of regular duration shows exponential distribution (Figure 3.).

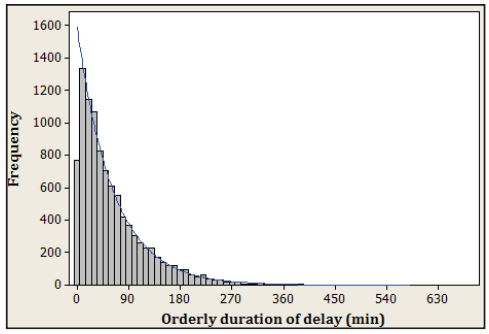


Figure 3. Histogram of probability density function for regular duration

The category of disorder was simulated according to the probability density function of Erlang distribution of the second order. Also, it shows insignificant discrepancy of the simulated mathematical expectation in regards to the mathematical expectation of the measured values (approximate relative error is 0.017%). Statistical goodness of fit test shows power of test (*p = 0,250*) more than 0,05 according to condition *p>0,05* to accept assumed hypothesis and the assumed distribution is valid (Figure 4.).

3. MODEL FOR PREDICTING DISORDERS

After simulation of probability density distribution for both categories of delay, the question is whether the disorders can be managed? How to assess potential duration of disorders?

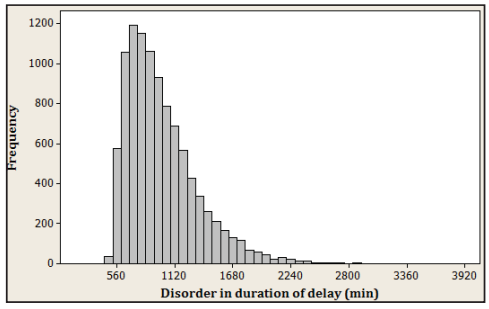


Figure 4. Histogram of probability density function for disorders

The answers to these questions are given through the analysis of disorders in percentage in regards to regular duration of delay. Disorders were analyzed in ranges of 5% beginning from the mathematical expectation of regular duration (E(x) = 63 min, disorder is 0%) till the mathematical expectation of disorders (E(X) = 992 min, disorder is 100%). The average mathematical expectation (AME) in the Table 3. was estimated from 10 measurements of simulated mathematical expectations for regular duration and disorders, and represents total duration of delay.

Table 3. Calculated AME in regards to size of disorders in percentage

Percentage (%)	0	5	10	15	20	25	30	35	40	45	50
AME (min)	63	109	155	201	248	294	340	386	432	478	525
Percentage (%)	55	60	65	70	75	80	85	90	95	100	
AME (min)	571	617	663	709	755	801	848	894	940	992	

On the basis of the measured AME given in the Table 3. the mathematical model for duration of delay is developed:

$$T_d = (T_{disord} - T_{order}) * p + T_{order} \quad (3)$$

Where:

T_d – is the duration of delay;

T_{disord} – is the duration of disorders (AME = 992 min);

T_{order} – is the regular duration (AME =63 min);

p – is the percentage of disorders.

4. CONCLUSION

Every reduction of delay in loading time has direct influence on reduction in total loading time per transport unit and more efficient utilization of conveyor and staff. Modelling of disorders and their prediction is important element of rational business in freight transport terminals.

In second part of the research, the model for prediction of disorders was developed. The linear regression model with extraordinary correlation was obtained. Control of unpredictable duration of potential disorders is an important factor in efficient organizing of reloading operations in freight terminals.

The proposal for further research is to analyze the delay impact on total loading duration. It is necessary to take into consideration the possibility to predict loading delay, as well as to prognoze loading duration on the basis of potential delays. Also, further analysis of impact should include the trucks available to serve at river terminal, the time of truck turnaround, number of working machines and technology of goods preparation for loading. On the basis of these analyses the model for delay predicting could be upgraded.

ACKNOWLEDGMENT

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MULTI CRITERIA DECISION MAKING FOR DISTRIBUTION CENTER LOCATION SELECTION- SERBIA CASE STUDY

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Abstract: *The process of location selection for distribution center can be analyzed as a multi-criteria decision problem and has a strategic importance for many retail companies. The conventional methods for facility location selection are inadequate for dealing with the imprecise or linguistic nature of assessments and measurements. To overcome this difficulty and allow including quantitative and qualitative criteria, fuzzy multi-criteria decision-making method is proposed. The aim of this paper is to use fuzzy analytic hierarchy process (AHP) for the selection of distribution center location. The presented method has been applied to location selection problem of a retail company in Serbia. After determining the criteria that affect the facility location decisions, fuzzy AHP is applied to the problem and results are presented.*

Keywords*: distribution center, location selection, fuzzy AHP*

1. INRODUCTION

Distribution center plays a vital role in modern supply chains and it location could affect to the success, or failure of logistic company's business. It presents an organizational unit that allows differentiating between various types of stock in a site. Selecting appropriate location of distribution center is very important decision for retail firms because they are costly and difficult to reverse, and they entail a long term commitments. Decisions related to distribution center's location have an impact on operating costs and revenues. For instance, a poor choice of location might result in excessive transportation costs, a shortage of qualified labor, loss of competitive advantage, inadequate supplies of raw materials, or some similar condition that would be detrimental to operations (Stevenson 1993).

The common procedure for making decision about the best location usually consists of the following steps (Stevenson 1993): 1) Decide on the criteria that will be used to evaluate location alternatives; 2) Identify criteria that are important; 3) Develop location alternatives; 4) Evaluate the alternatives and make a selection.

There are many criteria that influence the location decisions of a distribution center. In our paper, we take into account six groups of criteria based on expert opinion and literature review, qualitative and quantitative. These are: capital (investment) costs, transportation costs, operating costs, strategic factors, supply chain and logistics factors and other factors (social, demographical, geographical, and political). Each of those criteria has their own subcriteria, and

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in total we consider 24 factors. These criteria are used to choose the best location among four alternatives (Novi Sad, Šimanovci, Novi Beograd, and Niš).

As can be seen from relevant literature, the conventional methods for facility location selection are inadequate for dealing with the imprecise or linguistic nature of criteria and analyzed factors. To overcome this difficulty and allow including variety of criteria, fuzzy multi-criteria decision-making method is proposed. In this paper we use fuzzy AHP, where the ratings of various alternative locations under various subjective criteria and the weights of all criteria are represented by fuzzy numbers.

The rest of this paper is organized as follows. Brief literature review is given in Section 2. Then in Section 3, fuzzy AHP approach is introduced. A numerical example is given in Section 4 to illustrate the proposed method. And finally, Section 5 contains concluding remarks.

2. BRIEF LITERATURE REVIEW

This section contains brief literature review on facility selection problem in supply chain. In a discrete facility location, the selection of the sites where new facilities are to be established is restricted to a finite set of available candidate locations. The simplest setting of such a problem is the one in which p facilities are to be selected to minimize the total (weighted) distances or costs for supplying customer demands. This is the so-called p-median problem which has attracted much attention in the literature (Daskin 1995, Drezner and Hamacher 2004, ReVelle and Eiselt 2005).

Significant literature review of facility location models in the context of supply chain management is given in paper (Melo et al. 2009). They identified basic features that such models must capture to support decision-making involved in strategic supply chain planning. In their chapter (Daskin et al. 2005) outlined the importance of facility location decisions in supply chain design. Ertugrul and Karakasoglu, 2008 presented fuzzy AHP and fuzzy TOPSIS methods for a facility location selection problem of a textile company in Turkey. The authors of paper (Kuoaet al. 2002) developed a decision support system for locating a new convenience store. A feedforward neural network with error back-propagation learning algorithm was applied to study the relationship between the factors and the store performance. Kahraman et al. 2003 solved facility location problems using different solution approaches of fuzzy multi-attribute group decision-making. The paper (Meng et al. 2009) addressed a novel competitive facility location problem about a firm that intends to enter an existing decentralized supply chain comprised of three tiers of players with competition: manufacturers, retailers and consumers. The paper (Özcan et al. 2011) considered AHP, TOPSIS, ELECTRE and Grey Theory applied on the warehouse selection problem.

3. BASIC ASSUMPTIONS OF FUZZY AHP

The Analytic Hierarchy Process is well known multi-criteria decision making approach introduced by Thomas Saaty (Saaty 1994).Some specifics of this approach are: the hierarchical structure of a system (goal, criteria, alternatives); the elements of one level should be compared with each other based on the elements of higher level; generating the pairwise comparison matrices; Saaty scale is used for defining the relative importance of the elements; the ability for verification of the experts' consistency; etc. Here are the specifics of applied fuzzy AHP approach.

Step 1: Define a goal, criteria, subcriteria and alternatives. Then, the importance of one criterion to the other based on the goal, subcriteria to the other based on criterion which they belong to, and finally, the importance of one alternative to the other based on each subcriterion separately. After the pairwise comparison matrices are developed, consistency validated (with eventual

adjustment of importance), the alternatives rank can be determined. For comparison between these elements, the Saaty scale is used (Table 1).

Table 1. Saaty scale

Crisp value	Importance	Fuzzy value	Reciprocal crisp value	Fuzzy reciprocal value
1	Equal	(1,1,1)	1/1	(1,1,1)
2	Intermediate values	(1,2,4)	1/2	(1/4,1/2,1)
3	Weak	(1,3,5)	1/3	(1/5,1/3,1)
4	Intermediate values	(2,4,6)	1/4	(1/6,1/4,1/2)
5	Strong	(3,5,7)	1/5	(1/7,1/5,1/3)
6	Intermediate values	(4,6,8)	1/6	(1/8,1/6,1/4)
7	Demonstrated	(5,7,9)	1/7	(1/9,1/7,1/5)
8	Intermediate values	(6,8,10)	1/8	(1/10,1/8,1/6)
9	Absolute	(7,9,11)	1/9	(1/11,1/9,1/7)

With the aim to present the basic equations for application of the fuzzy AHP approach, here will be consider the fuzzy matrix **R**. The element of this matrix is fuzzy triangle number $a_{ij}=(a_{ijl}, a_{ijm}, a_{ijr})$ and shows a preference of one element to the other (i=1,2,..q, j=1,2,..q, where q is the number of criteria). Let us assume that this matrix **R** is the pairwise comparison of criteria, based on the goal of a model.

$$\boldsymbol{R}=\begin{bmatrix} (1,1,1) & (a_{12l},a_{12m},a_{12r}) & \cdots & (a_{1ql},a_{1qm},a_{1qr}) \\ (\frac{1}{a_{12r}},\frac{1}{a_{12m}},\frac{1}{a_{12l}}) & (1,1,1) & & (a_{2ql},a_{2qm},a_{2qr}) \\ \vdots & \ddots & \ddots & \vdots \\ (\frac{1}{a_{1qr}},\frac{1}{a_{1qm}},\frac{1}{a_{1ql}}) & \cdots & \cdots & (1,1,1) \end{bmatrix}$$

Step 2: Overall weight of elements, criteria, based on matrix **R** is calculated by following equations (Jie et al. 2006):

$$c_1=\sum_{i=1}^{q}\sum_{j=1}^{q}a_{ijl},\quad c_2=\sum_{i=1}^{q}\sum_{j=1}^{q}a_{ijm},\quad c_3=\sum_{i=1}^{q}\sum_{j=1}^{q}a_{ijr} \tag{1}$$

$$d_1=\sum_{j=1}^{q}a_{ijl},\ d_2=\sum_{j=1}^{q}a_{ijm},\ d_3=\sum_{j=1}^{q}a_{ijr} \tag{2}$$

$$z_{it}=\frac{d_t}{c_4-t}, t=1,2,3;\ i=1,2,\ldots,q \tag{3}$$

Where: c_1, c_2, c_3 are the sum of all left, middle and right values of fuzzy triangle number a_{ij}, respectively; a_{ijl}, a_{ijm}, a_{ijr} are left, middle and right value of fuzzy number a_{ij}, respectively; d_1, d_2, d_3 are the sum by columns of all left, middle and right values of fuzzy matrix **R**, respectively, z_i is the overall weight of criteria i, and z_{i1}, z_{i2}, z_{i3} are left, middle and right value of z_i, respectively.

Step 3: Based on certain equations (Jie et al. 2006), the matrix of weighted performance of each alternative, P with fuzzy elements p_k, is defined (k=1,2..,n, where n is the number of alternatives). Thence, the matrix of total weighted performance, **S** with fuzzy elements s_k, is obtained by following relation:

$$s_k=\sum_{k=1}^{n}p_k \tag{4}$$

Step 4: Defuzzification is a procedure of choosing a particular output value. The matrix of total weighted performance, **S**, is obtained by equation (4). A variable is defined by fuzzy set which have to be transformed into crisp value. The process of transformation of fuzzy number $\sim s=(s_l, s_m, s_r)$ into crisp number is presented below (Lious and Wang 1992).

$$s = \lambda * \left[\alpha * (s_m - s_l) + s_m\right] + (1-\lambda) * \left[s_r - \alpha * (s_r - s_m)\right], \text{where } \lambda, \alpha = [0,1] \quad (5)$$

Where λ and α are the preferences and risk tolerance of decision makers, respectively. The pessimism and optimism of decision makers can be expressed by these values.

4. FUZZY AHP FOR DISTRIBUTION CENTER LOCATION SELECTION -CASE STUDY

Retailer A that operates in Serbia for over 10 years has a retail stores in dozen of major cities but not in all. Among others, cities with stores are Beograd, Niš, Čačak, Valjevo, Šabac, Zaječar, and Obrenovac. In order to support further expansion on the market, company has decided to investigate the possibility to setup a distribution center (DC) from which retail stores will be supplied. With doing so, company is looking to achieve several benefits such as being able to negotiate better conditions with suppliers (e.g. volume and logistics rebates), reduce the stock holding costs and benefit from risk pooling, increase responsiveness of supply chain, etc. Pre-selected locations for setting up a DC are: Novi Sad, Šimanovci, Novi Beograd and Niš. Each location has some advantages and disadvantages. Since locations have many different and specific attributes, experts agree that they should be all taken into consideration and that it is not possible to relay solely to quantitative criteria. In order to support such decision making, fuzzy AHP approach is selected to support it. Based on experts' opinion all relevant elements of the model are defined (Figure 1).

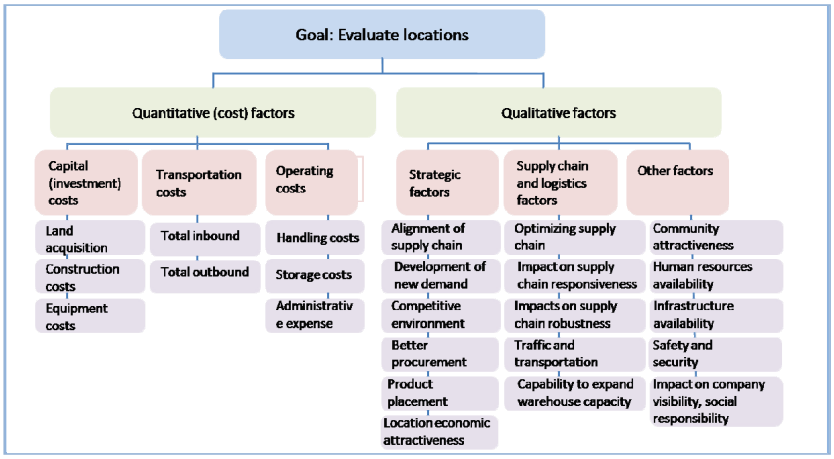


Figure 1. Quantitative and qualitative factors

4.1 Results and Discussion

After described methodology had been applied and experts had evaluated all scores, Šimanovci has shown to be the best alternative (Figure 2). This result is obtained for λ=0.5 and α=0.5. It is very closely followed by alternative-Novi Beograd, while Niš and then Novi Sad are less preferred locations although very close to each other. Speaking of criteria, experts have decided that quantitative indicators account for 2/3 of importance for making decision, and qualitative have 1/3 of importance. Figure 3 displays sorted criteria by their global weights.

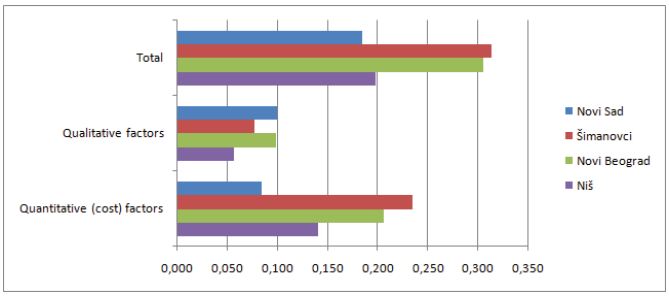


Figure 2. Final alternatives rank

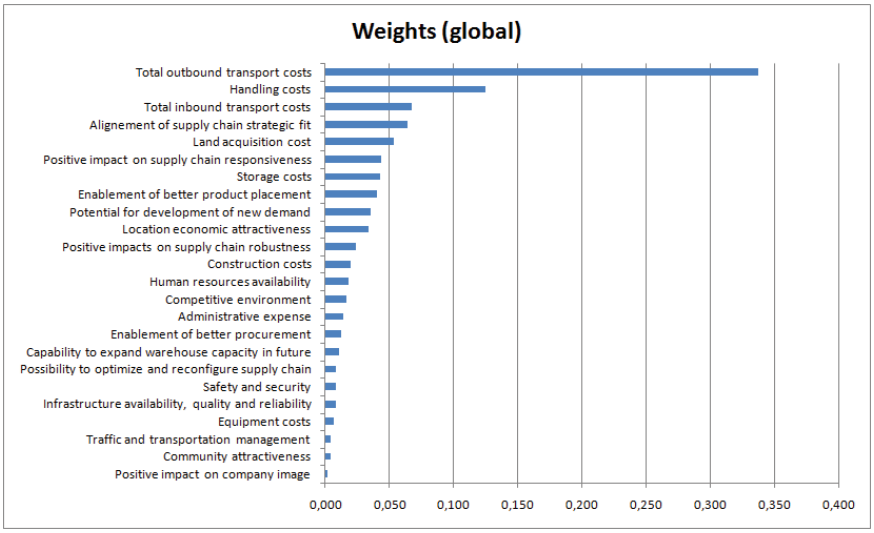


Figure 3. Final subcriteria weights

Without doubt, total outbound transportation costs are by far the most important criteria. This criteria alone accounts for 1/3 of importance for total decision. It is followed by handling costs and inbound transportation costs, so the three criteria bear together 50% of importance. Then the fourth criteria is qualitative one, which is support of location for overall supply chain strategic fit, which depends on how company wants to compete on the market, and similar to sixth ranked criteria of responsiveness improvement, thus we could say that the responsiveness of supply chain is important criteria for decision makers. Fifth is price of acquiring land, and these 6 criteria together account for 70% of importance, while the remained 30% is spread between others. Regarding the alternatives, although Novi Beograd surely optimizes the transportation costs, which is the most important criteria, but due to lower operating costs and less capital needed for investment, Šimanovci gained the overall advantage. The strategic, supply chain/logistics and other factors have very close values for both locations.

5. CONCLUSION

The model for distribution center location selection is developed in this paper. Authors suggested the fuzzy AHP for solving the proposed problem. After defining the potential locations, as alternatives, and all relevant factors in the process of selection, i.e. criteria and subcriteria, the proposed approach is applied to location selection problem of a retail company in Serbia. Finally,

the best alternative compared to other four, is obtained. Proposed model selected Šimanovci as the best solution. From managers' point of view this location can decrease transportation costs, increase competitive advantages, etc. Moreover, proposed framework can help managers in making future DC location decisions, by using this intuitive and effective approach. In order to take both quantitative and qualitative factors into consideration, as well as the preference and risk tolerance (optimism/pessimism) factors, presented fuzzy AHP model gives a solid basis for analytical but practical decision making and its application.

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SOLVING VEHICLE ROUTING PROBLEMS VIA SINGLE GENERIC TRANSFORMATION APPROACH

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Abstract: *We present a simple data structure capable to solve a broad class of vehicle routing problems. Our modeling approach involves vehicle capacity constraints and extends to the tactical location decisions of location routing problems. The unique data structure accompanied by a single generic transformation allows an effective search of the solution space. We provide simulated annealing results for standard benchmarks that confirm the quality of the proposed algorithm.*

Keywords*: Vehicle routing, Location routing, Simulated annealing.*

1. INTRODUCTION

Heuristic approaches prevail as the solution approaches for various vehicle routing problems (see e.g. [7]). Although invented to be simple, fast and generic it is often the case that applying heuristic to a specific vehicle routing problem required new data structures and iteration steps design, or at least some significant adjustments.

On the other hand, supply chain practice required optimization of the entire logistics value chain, and thus led to a new group of problems that combines facility location problems with vehicle routing problems. These problems, known as location routing problems, according to [3], needed redesign of the neighborhood search techniques of the solution spaces.

In this paper, we present a simple data structure accompanied by a single generic transformation which leads to an effective search of the solution space. The power of the transformation is that most of the classical transformations like insertion, swap, 2–opt, and some others, can be seen as its special cases. Our modeling approach involves vehicle capacity constraints and extends to the tactical location decisions of location routing problems.

The paper is organized in 5 sections. The introduction is followed by data structure presentation and transformation description in Section 2. In Section 3, we show how vehicle routing problems can be modeled with the new data structure, and in Section 4 we present some results on capacitated location routing problems. In the last section we provide some final remarks.

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2. ROUTES AND TRANSFORMATIONS IN CIRCULAR BUFFER

Every vehicle routing problem has a depot, a vehicle and a customer. We add a depot, a vehicle and/or a customer as markers to the positions of a circular list.

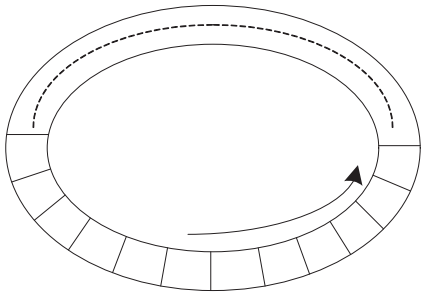


Figure 1. Circular list.

If a position in the list is marked as a depot D, then all positions before the next depot position, where the counter clockwise direction is assumed, are associated with the depot D. If a position is associated with a vehicle V, all positions before the next vehicle position, where the counter clockwise direction is assumed, belong to the vehicle V, i.e. all customers on those positions should be served by vehicle V (Figure 2).

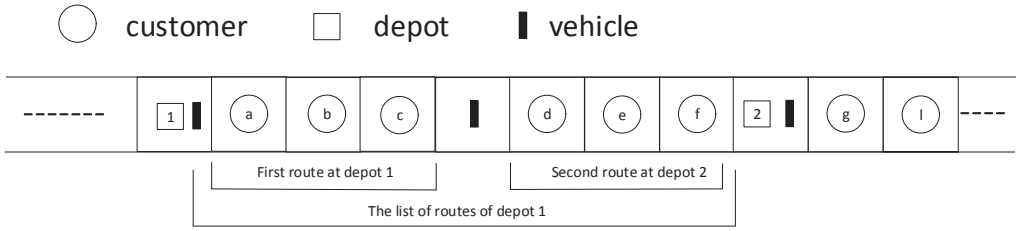


Figure 2. Positions and markers in a list.

Note that depot positions contain vehicle markers, which we interpret as the first routes starts.

We next define a generic transformation. The power of this transformation is that most of the classical transformations like insertion, swap, 2–opt and some others, can be seen as its special cases. In order to perform transformation one should choose 2 'outer' positions, A and B in the list, and two 'inner' positions C and D (Figure 3). The first step in the transformation is to invert the sub-list between A and B. In the second step, we invert the sub-list between C and D.

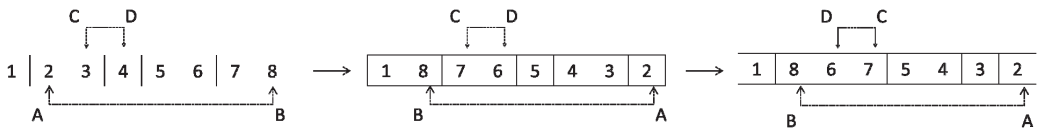


Figure 3. Generic transformation.

It can be easily observed that makes traditional insertion transformation if A coincides with C and D and B are consecutive positions. If A and C on one side and D and B on the other side are

both pairs of consecutive positions, the transformation is simply the traditional swap transformation.

3. MODELING ROUTING PROBLEMS

In this section we show how several known vehicle routing problems can be modeled via our approach. We use capacitated location routing problem (CLRP), considered in [] as our reference problem. As all routing problems, it contains customers, vehicles and depots. Each customer ordered a certain quantity of a product that needs to be delivered. The main goal is to make a routing plan such that the overall warehousing and transportation costs are minimized.

More formally, we consider that the set of locations of customers and depots, accompanied with the cost matrix containing all pair-wise traveling cost is given. Each depot has its opening cost of opening and the capacity, while customer has its demand. The fleet of vehicles is homogeneous, hence each vehicle has the usage price and the capacity. The total cost of a capacitated location routing plan is the sum of the costs for opening depots, using vehicles and total traveling cost. The ultimate goal is to make a plan such that all capacity constraints are satisfied, while the total costs are minimized.

We can model CLRP using a framework presented in the previous section. If D is the number of depots, C the number customers and V the number of vehicles ($V \geq D$), we create a circular list with $V+C$ positions, where D positions are marked with both depot and vehicle markers, $V-D$ with only vehicle markers and C positions with customer markers. The scenarios of closed depots or not activated vehicles are given in the Figure 4.

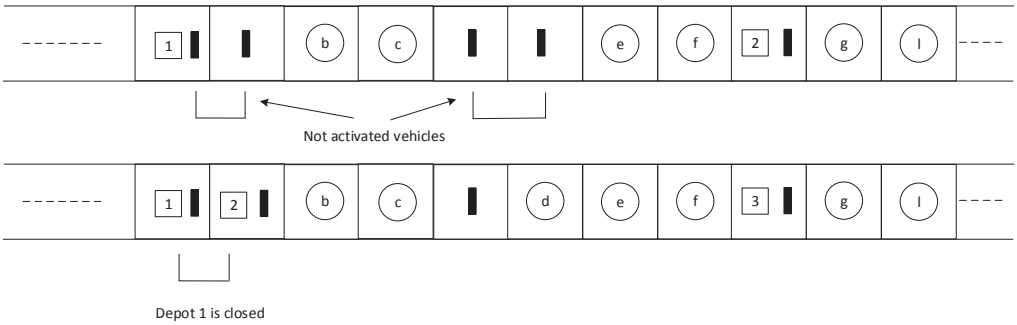


Figure 4. Scenarios with empty vehicles and closed depot.

Finally, various routing problems can be considered as special cases of CLRP, and their modeling is boils down to simplification of the circular buffer. For example, multi-depot VRP problems are obtained when depot opening costs are set to zero, and vehicle usage costs set according to multi-criteria priorities. On the other hand, one can consider adding time constraints, without adding complexity in the given structure, and thus capture vehicle routing problems with time window or working time constrains.

4. CALCULATION RESULTS FOR CLRP

We give some test results on standard benchmark problems for CLRP in this section. In Table 1 our algorithm that uses presented framework and relies on simulated annealing approach is named SIMPGEN (from simple and generic). The algorithms GRASP. MAPM, LGRST and SALRP, together with the results in the corresponding column are the results from [6], [2], [5], and [9] respectively.

The benchmark problems are described in [1], [6], and [8]. In Table 1, the columns 'Problem', 'Cust', 'Dep', 'BKS' contain the names of instances, the number of customers, the number of depots and the best know solution result, respectively. For each of the 5 algorithms the total cost, the gap towards the best known solution and the CPU times are given. The comparison of the CPU times is not relevant since tests for different algorithms were performed on different machines.

Table 1. Comparison results for CLRP

Algorithms				GRASP			MAPM			LRGTS			SALRP			SIMPGEN		
Problem	Cust	Dep	BKS	Cost	Gap	CPU	Cost	Gap	CPU	Cost	Gap	CPU	Cost	Gap	CPU	Cost	Gap	CPU
Christ50	50	5	565.60	599.1	5.92%	2.3	565.6	0.00%	3.8	586.4	3.68%	2.4	565.6	0.00%	52.8	565.60	0.00%	43.062
Christ75	75	10	844.40	861.6	2.04%	9.8	866.1	2.57%	9.4	863.5	2.26%	10.1	844.4	0.00%	126.8	848.85	0.53%	129.81
Christ100	100	10	833.40	861.6	3.38%	25.5	850.1	2.00%	44.5	842.9	1.14%	28.2	833.4	0.00%	330.8	833.43	0.00%	238.61
Das88	88	8	355.78	356.9	0.31%	17.3	355.8	0.00%	34.2	368.7	3.63%	17.5	355.8	0.00%	226.9	355.78	0.00%	157.33
Das150	150	10	43919.90	44625	1.61%	156	44011.7	0.21%	255.0	44386.3	1.06%	119.2	43919.9	0.00%	577.0	43919.90	0.00%	328.28
Gaspelle	21	5	424.90	429.6	1.11%	0.2	424.9	0.00%	0.3	424.9	0.00%	0.2	424.9	0.00%	18.3	424.90	0.00%	9.609
Gaspelle2	22	5	585.10	585.1	0.00%	0.2	611.8	4.56%	0.3	587.4	0.39%	0.2	585.1	0.00%	16.6	585.11	0.00%	5.703
Gaspelle3	29	5	512.10	515.1	0.59%	0.4	512.1	0.00%	0.8	512.1	0.00%	0.4	512.1	0.00%	23.9	512.10	0.00%	11.078
Gaspelle4	32	5	562.20	571.9	1.73%	0.6	571.9	1.73%	0.8	584.6	3.98%	0.6	562.2	0.00%	27.0	562.22	0.00%	3.579
Gaspelle5	32	5	504.30	504.3	0.00%	0.5	534.7	6.03%	1.0	504.8	0.10%	0.5	504.3	0.00%	25.1	504.33	0.01%	4.546
Gaspelle6	36	5	460.37	460.4	0.01%	0.8	485.4	5.44%	1.4	476.5	3.50%	0.7	460.4	0.01%	31.7	460.37	0.00%	61.218
Min27	27	5	3062.00	3062	0.00%	0.4	3062.0	0.00%	1.0	3065.2	0.10%	0.3	3062.0	0.00%	23.3	3062.02	0.00%	1.297
Min134	134	8	5709.00	5965.1	4.49%	49.6	5950.1	4.22%	110.5	5809.0	1.75%	48.3	5709.0	0.00%	522.4	5709.00	0.00%	346.36
Average	61.23	6.62	4487.62	4569.07	1.63%	20.28	4523.25	2.06%	35.62	4539.41	1.66%	17.58	4487.62	0.00%	154.05	4487.97	0.04%	103.11

3. CONCLUSION

We presented a framework for modeling various vehicle routing problems. It uses positions in a circular list and accompanied with generic transformation offers powerful tool for searching the solution spaces of considered problems. We tested it on CLRP benchmark problems and obtained promising results that are comparable to other approaches.

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THE CAPACITATED TEAM ORIENTEERING PROBLEM: BEE COLONY OPTIMIZATION

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Abstract: *In this paper the capacitated team orienteering problem have been applied as a tool for carriers to avoid empty returns when trucks do not work with full load. The software based on bee colony optimization technique is developed for solving the problem. Numerical example is solved and the result is shown to depict the possibility of the proposed algorithm.*

Keywords*: orienteering problem, bee colony optimization, electronic auction.*

1. INTRODUCTION

Orienteering is a sport which is a mixture of cross-country running and navigation through a forest, using a map and compass. A number of control points each with an associated score are placed in the forest and their locations are marked on the competitors' maps. Competitors start at intervals of, for example, a minute and are required to visit a subset of the control points from the start point (node 1) so as to maximize their total score and return to the end point (node n) within a prescribed amount of time (Golden et al. 1987, Tsiligirides 1984).

There is analogy between sport orienteering and the problem which consists of determining a path, limited by T_{max}, that visits some of the vertices (each with a score) of a graph, in order to maximize the total collected score. Due to the analogy, the problem was named the orienteering problem (OP). In the literature (Laporte and Martello 1990, Gendreau et al. 1998) the orienteering problem is also known as the selective traveling salesman problem. In addition, the same problem in the literature (Fillet et al. 2005) can be found as a variant of the traveling salesman problem with profits in which the cost is referred to the constraint and the collected profit to the objective function. Orienteering problem (Kim et al. 2013) is the special case of team orienteering problem (TOP) in which there are teams of several competitors, each collecting scores during the same time span. The TOP is also known as the multiple tour maximum collection problem (Butt and Cavalier 1994) or the vehicle routing problem with profits. The capacitated version of TOP was studied by Archetti et al. (2009, 2010). The authors tried to develop method as a decision support when demand and offer of transportation service did not match.

In this paper the capacitated team orienteering problem is solved by applying the Bee colony optimization. The proposed algorithm is used for solving the problem when carriers try to avoid empty returns because the fleet of vehicles they own does not work with full load. The problem was successfully solved by the developed metaheuristic algorithm. The proposed algorithm might be a tool for carriers when consider bids of potential customers through the electronic auction process.

2. THE CAPACITATED TEAM ORIENTEERING PROBLEM

Given a complete undirected graph $G=(V, E)$, where $V=\{1,...,n\}$ is the vertex set and E is the edge set. Vertex 1 is a depot for m identical vehicles of capacity Q, while the remaining vertices represent potential customers. An edge $(i,j) \in E$ represents the possibility to travel from customer i to customer j. A non-negative demand d_i and a non-negative profit p_i is associated with each customer i ($d_i=p_i=0$). A symmetric travel time t_{ij} and cost c_{ij} are associated with each $(i, j) \in E$. Each vehicle starts and ends its tour at vertex 1, and can visit any subset of customers with a total demand that does not exceed the capacity Q. The profit of each customer can be collected by one vehicle at most. In the following we suppose that $t_{ij}=c_{ij}$ for each edge (i, j). In the capacitated team orienteering problem (CTOP) a subset of the potential customers available has to be selected. The objective is to maximize the total collected profit while satisfying, for each vehicle, a time limit T_{max} on the tour duration and the capacity constraint Q.

Let $\Omega=\{r_1, \ldots, r_{|\Omega|}\}$ be the set of possible routes for a vehicle, that is, the set of routes starting and ending at vertex 1, visiting at most once each potential customer, satisfying the capacity constraint Q and the time limit T_{max}. Let $a_{ik} = 1$ if route $r_k \in \Omega$ visits customer i, $a_{ik} = 0$ otherwise. Let c_k be the total profit generated by route $r_k \in \Omega$: $c_k = \sum_{i \in V} a_{ik} p_i$. The CTOP can be stated as follows:

$$max \sum_{r_k \in \Omega} c_k p_k \tag{1}$$

$$\text{Subject to:} \quad \sum_{r_k \in \Omega} a_{ik} x_k \leq 1, \quad i \in V \setminus \{1\} \tag{2}$$

$$\sum_{r_k \in \Omega} x_k \leq m \tag{3}$$

$$x_k \in \{0,1\}, \quad r_k \in \Omega \tag{4}$$

The decision variables x_k indicate whether route $r_k \in \Omega$ is used or not. Constraints (2) ensure that each customer is visited at most once. Constraint (3) limits the number of vehicles used to m. Solving the linear relaxation of model (l)-(4) necessitates the use of a column generation technique, due to the size of Ω. Column generation is based on two components: a restricted master problem and a subproblem (Archetti et al. 2009).

Golden et al. (1987) prove that the OP is NP-hard. The TOP is also NP-hard (Chao et al. 1996). This implies that exact solution algorithms are very time consuming and for practical applications heuristics and metaheuristics would be necessary.

There are some interesting applications of the OP and the TOP in the literature: the case when truck fleet delivers fuel to consumers on daily basis (Golden et al. 1984), application in tourism (Souffriau et al. 2008), military applications (Wang et al. 2008).

As it is said before, the CTOP was studied by Archetti et al. (2009, 2010). Several heuristics and exact algorithms for solving the problem are presented in both papers. Archetti et al. (2007) proposed two variants of a generalized tabu search algorithm and a variable neighborhood search algorithm for the solution of the TOP.

3. BEE COLONY OPTIMIZATION

The bee colony optimization metaheuristic (Teodorović 2008) was developed and used by Lučić and Teodorović (2001, 2003). Artificial bees represent agents, which collaboratively solve complex combinatorial optimization problems. Each artificial bee is located in the hive at the beginning of the search process, and makes a series of local moves, thus creating a partial solution. Bees incrementally add solution components to the current partial solution and

communicate directly to generate feasible solutions. The best discovered solution of the first iteration is saved and the process of incremental construction of solutions by the bees continues through subsequent iterations.

Artificial bees perform two types of moves while flying through the solution space: forward pass or backward pass. Forward pass assumes a combination of individual exploration and collective past experience to create various partial solutions, while backward pass represents return to the hive, where collective decision-making process takes place. It is assumed that bees exchange information and compare the quality of partial solutions created, based on which every bee decides whether to abandon the created partial solution and become again uncommitted follower, continue to expand the same partial solution without recruiting nestmates, or dance and thus recruit nestmates before returning to the created partial solution. During the second forward pass, bees expand previously created partial solutions, after which they return to the hive in a backward pass and engage in the decision-making process as before. Series of forward and backward passes continue until feasible solutions are created and the iteration ends.

4. SOLVING THE CAPACITATED TEAM ORIENTEERING PROBLEM BY BEE COLONY OPTIMIZATION

Drenovac et al. (2014) developed the algorithm based on the BCO for solving the orienteering problem. The algorithm was modified and adapted for capacitated vehicle fleet. Description of the algorithm follows.

The hive with artificial bees is located in node 1. Bees bounce from the hive and begin search process of area of allowable solutions. Let V_i be the bee's benefit of choosing the i^{th} node to serve. It is accepted that the bee's benefit when selecting a node is even greater if the score is greater and the travel time is shorter. Namely, it could be presented in the following way:

$$V_i = \frac{S_i}{t_{li}} \tag{5}$$

where S_i is score in node i, t_{li} is the time required to reach node i, from the last selected node l.

Let p_i be the probability that a bee will choose the i^{th} node. Each route has to start and end at node 1. Before the node selection, a subset of those nodes that satisfy the maximal length of the route (their inclusion does not exceed the maximal length) as well as the maximal capacity (when demand of potential node is added to the partial demand, the sum does not exceed the maximal capacity of vehicle), has to be determined. Later, nodes are being chosen randomly from the subset.

Logit model was adopted as a model of choice and the probability of selection is:

$$p_i = \frac{e^{V_i}}{e^{V_1} + e^{V_2} + \ldots + e^{V_m}} \tag{6}$$

where m is the cardinal number of the subset.

During the first forward pass each bee chooses a predefined number of nodes for each route. Having returned to the hive, bees start to communicate. They calculate values of the objective function as the ratio of the total score and the total time required to visit chosen nodes and compare their partial solutions. In the proposed algorithm, the objective function of each bee comprises time because the greater route efficiency the greater number of included nodes and the greater achieved score. Then, bees make decision about their loyalty to the solution (whether to keep the solution or to abandon it).

Let Π_j be the objective function value generated by the j^{th} bee ($j=\overline{1,b}$, where b is the number of bees). Let Π_{norm_j} be the normalized value of the objective function value. It is calculated as follows:

$$\Pi_{norm_j} = \frac{\Pi_j - \Pi_{\min}}{\Pi_{\max} - \Pi_{\min}},\ \Pi_{norm_j} \in [0,1],\ j=\overline{1,b} \tag{7}$$

Where $\Pi_{\max}$ and $\Pi_{\min}$ are the minimum and the maximum value of the objective function.

The probability that the j^{th} bee will be loyal to its partial solution at the beginning of the next forward pass is calculated as follows:

$$p_j^{u+1} = e^{-\frac{\Pi_{norm_{\max}} - \Pi_j}{u}},\ j=\overline{1,b} \tag{8}$$

where u is ordinal number of the forward pass and $\Pi_{norm_{\max}}$ is maximal normalized value of the objective function.

After making decisions about the loyalty to their solutions, bees gather in the dance floor area. The bees that decide to keep their partial solutions start dancing and thus recruit uncommitted bees. Uncommitted followers choose which of the loyal bees to follow in the next forward pass.

During the search process time is updated and when bees can no longer expand the solution, the search ends. Having coming back to the hive after an arbitrary forward pass, the bees can create partial as well as final solutions. Despite of that, all of them participate in information exchange, evaluation of solutions and decision-making concerning the loyalty to solutions.

If the number of loyal bees is equal to r before the next forward pass, the probability that the uncommitted bee will join the k^{th} loyal bee in the next forward pass is equal to:

$$p_k = \frac{e^{\Pi_{norm_k}}}{e^{\Pi_{norm_1}} + e^{\Pi_{norm_2}} + \ldots + e^{\Pi_{norm_r}}},\ k=1,\ldots,r \tag{9}$$

Based on these probabilities, uncommitted bees are coupled with committed bees. Bees then start a new forward pass flying together to the last node of partial solutions generated by committed bees. After that, each bee individually extends its partial solution.

Each iteration gives a particular solution containing tours for vehicles. The best solution obtained during the pre-specified number of iterations is selected.

5. NUMERICAL EXAMPLE

Spreading of markets forces carriers to look for customers wider than their traditional service area. Usually, long-term contracts are settled through electronic auctions (using the Internet), where selected set of carriers submit a bid to cover a given set of lanes. The aim of carriers is to reduce their costs and to decrease seasonal effects when fleet of vehicles is non-optimally used (when trucks travel without any load or have a partial load). Carriers have to make effort to expand their market area and to attract new customers. Through the web carriers can find a number of spot loads to fill up trucks or to avoid empty returns. They decide whether to pick up or not according to the compatibility with the remaining capacity of a truck. The additional cost for serving the customer must be compensated by profit. For planning potential customers the entire fleet of vehicle has to be considered (Archetti et al., 2009).

This problem can be modelled as a routing problem with profits where a fleet of capacitated vehicles is given as well as a set of customers that have to be served. In addition, a set of

potential customers is available. The problem is to decide which of these potential customers to serve and how to construct routes for vehicles in such a way that a suitable objective function is optimized. In this paper the objective is the maximization of the collected profit, given limited time available for vehicles.

In order to demonstrate the proposed metaheuristic approach, the following numerical example was solved. The benchmark problem, 21-node network was taken from the following internet address and modified: www.mech.kuleuven.be/cib/op. A time limit on the tour duration is 22. The capacity constraint is 25. Demands equal to 5 are associated with the nodes except node one, which is the depot and has demand equal to 0. The 21st node is replaced by the coordinates of the first node in order for each vehicle to start and to end its route at the depot. Nodes from 6 to 13 represent long-term contracts. There are three vehicles. Each vehicle starts and ends its tour at depot. Solving vehicle routing problem of regular customers gives the following result:

Table 1. Tours with regular customers

	tour	tour length	demand	score
Vehicle 1	1, 7, 6, 13, 1	7.9968	15	120
Vehicle 2	1, 12, 10, 8, 1	11.5067	15	
Vehicle 3	1, 11, 9, 1	10.0119	10	

It could be seen that all of vehicles are poorly exploited as well as the time available for service. Nodes from 2 to 5 and from 14 to 20 are potential customers that might be considered to serve. Regular customers that need to be visited are modelled with scores 10 times bigger than real ones. Solution obtained by the proposed algorithm is given in table 2.

Table 2. Tours containing both regular and new customers

	tour	tour length	demand	score
Vehicle 1	1, 11, 10, 9, 17, 14, 1	21.2215	25	290
Vehicle 2	1, 13, 12, 8, 2, 4, 1	20.0413	25	
Vehicle 3	1, 7, 6, 5, 3, 20, 1	20.1056	25	

It could be seen that all regular customers are included in tours. Remaining, unvisited nodes are 15, 16, 18, 19. Capacity of vehicles are fully used and the available time is almost completely used, while the score is higher. It could be said that the new, better transportation plan for carriers could be obtained by the proposed algorithm.

6. CONCLUSION

In this paper capacitated team orienteering problem is solved by applying the Bee colony optimization. Here the problem is considered when the carrier has a fleet of capacitated vehicles for the set of customers but it does not completely use the time available for the service or capacity of vehicles. Finding new customers may be modelled with the CTOP. The developed algorithm, used for solving capacitated team orienteering problem for the first time, yields acceptable results. It might be considered as a support tool for decision making of carriers when choosing new customers from databases available on the Internet.

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THE IMPACT OF THE LOW COST CARRIER PRESENCE ON THE DATA ENVELOPMENT ANALYSIS EFFICIENCY OF AIRPORTS

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Abstract: *The present paper aims to fill the apparent gap in existing literature and propose proper methods for determining an impact the presence of low cost carriers has on airport efficiency. The impact of the low cost carrier presence on the efficiency of chosen airports was calculated by simple linear regression. The number of low cost carriers operating from certain airports was considered and independent variable while the calculated data envelopment analysis efficiencies were considered as dependent variables. The results clearly indicate that there is a positive correlation between the number of low cost carriers and the airports efficiency.*

Keywords*: Airport efficiency, Data Envelopment Analysis, Low Cost Carriers*

1. INTRODUCTION

Low Cost Carriers (LCC) in Europe first appeared in the late nineties with the help of deregulations of airspace that were put in place through the European Union. They lowered the services provided to the customers and started selling the tickets over the internet. Despite all this the LCC trend managed to succeed and still sees rapid growth in the last decade (Francis, 2005). Modern LCCs enable the customer to travel cheaply with low fares to an ever increasing number of destinations. The growth can be best seen in numbers of short haul passengers carried in Europe. In 2003 LCCs were responsible for 10% of short haul passenger traffic in Europe (Francis, 2003). By year 2013 this share has increased to 26% according to traffic analysis made by Eurocontrol (EPRS, 2014). This number falls short of the predictions that LCCs would control 33% of the market share by year 2010 but they are none the less showing the trend towards the growth of LCC passenger traffic.

While there were numerous studies conducted on LCC impacts towards competition, fare prices and traffic numbers as claimed by Graham (2013), the subject of LCC effects on airport efficiency and airport performance remain few and far between. Most of existing work material is further limited to major European tourist areas and bigger well known airports.

Aim of this research paper is to fill the apparent gap in existing literature and propose proper methods for determining an impact the presence of LCCs has on airport efficiency in the Adriatic region. The airports we have chosen for this sample study are considered small but the region itself is very dependent on their existence. One of the reasons for the dependence is the fact that the region set its future goals in developing tourism, therefore efficiency and development of said airports is one of the key factors in success of the region in the future.

2. LITERATURE REVIEW

Air traveler satisfaction has been noted to constantly drop in the past decade. In order to combat this problem a constant effort has been made in measuring and comparison of airport performances of competing airports while at the same time another trend of Airport congestion growing has been noted. Operational efficiency of airports is therefore becoming one of the important determinants of the system's success in the future (Schaar & Sherry, 2008).

Pyrialakou and coauthors proposed to assess the operational efficiency of airports where high levels of low-cost carrier traffic can be seen using a nonparametric method called Data Envelopment Analysis (DEA) (Pyrialakou, Karlaftis, & Michaelides, 2012). Using this method two models have been developed. The first model is used in order to assess the terminal services and the other is used in order to assess the airside operations. Data inputs for both methods consist of the number of gateways used, number of runways used and the number of aircraft movements on the airport, while number of enplaned passengers was used as data for output part of the model. The results of this model show high correlation between enplanements, terminal efficiencies and hours of operation of chosen airports. Impacts of LCC services on efficiency of major U.S: airports have been addressed in the study done by Choo and Oum (2013). The study was conducted using the Index Number Approach as the primary method for determining the efficiency of chosen airports but in addition, the SFA approach was used to ensure the robustness of obtained results. In contrast of the previously mentioned study the research determined, that the LCC presence on major U.S. airports has shown a negative effect on operating efficiency of the chosen airports.

Schaar and Sherry have exposed the differences in results using various different DEA methods (Cooper-Charnes-Rhodes (CCR), Banker-Charnes-Cooper (BCC), and Slacks-Based Measure of efficiency (SBM)) (Schaar & Sherry, 2008). Results were obtained using the data from 45 airports in the time frame between 1996 and 2000. Further analysis has shown a wide variation in results, which prompted the discussion of the need for guidelines for selection of proper DEA models and proper interpretation of DEA results in the paper. Research conducted by Yoshida and Fujimoto focused on testing the criticism of overinvestment in Japanese regional airports (Yoshida & Fujimoto, 2004). Researchers employed two distinctly different methods, Data Envelopment Analysis and endogenous-weight Total Factor Productivity method (TFP). Results of both methods indicated that the regional airport efficiency of Japan airports is not as high as the others. At the same time the research exposed an interesting fact that the airports constructed in the 1990s were relatively inefficient compared to airports built in different points in time.

3. METHODOLOGY

In previous section we established the most commonly used methods for measuring airport efficiency and productivity. Methods in question are Index Number Method, Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). First method (INM) is used for direct measurement of productivity as output index over the input index. The productivity factor of airport can be determined as the ratio of aggregate output and input indexes. The second method in question is DEA. Its deterministic approach is based on the assumption that all observed deviations are the result of inefficiencies. The last method noted is SFA. The method is using a stochastic approach to modelling which enables the model to account for both deviations caused by inefficiencies and deviations caused by measurements errors, random errors and statistical discrepancies.

The method chosen for the efficiency calculations in this paper is the DEA method. One of the main advantages of the chosen method is the fact that it does not require more data than input and output quantities. The efficiency is calculated relative to the highest observed performance

and not the average observed performance (Kamil, Baten, & Mustafa, 2012). According to Schaar & Sherry (2008) the choice of the appropriate DEA model is key for the study. We have decided on the usage of the output oriented Constant Return of Scale model which is not usually suitable for usage in cases where the Decision Making Unit (DMU) does not reach optimum operation. We support this decision due to the fact that the usage of competing Variable Return of Scale model the largest and the smallest airport in the sample would become vastly overstated in terms of efficiency. We calculated the impact of the LCC presence on the efficiency of chosen airports using the method of simple linear regression. The number of LCCs operating from certain airports was considered and independent variable while the calculated DEA efficiencies were considered as dependent variables.

4. DATA

The data sample for this paper was chosen from the airports operating in the Adriatic Sea region. Not all airports are located in the coastal region but all of them are commercially connected the coast. For purposes of this research paper five of the airports were chosen. The selection can be seen on the Figure 1.

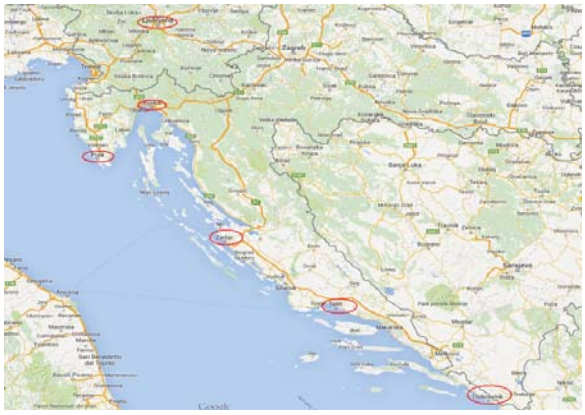


Figure 1: Selected airports in Adriatic region

Criteria for airport selection demand that the selected airport must provide scheduled flights with at least one airline and process at the very least 15000 passengers in a year. We limited the data selection in the time frame between year 2006 and year 2013. Our primary sources of data consist of Air Traffic Reports provided by ACI (2014). Other sources of data are Airport-data.com (2014) web page and data collected directly from the airport authorities. Using the procured data we built three distinct Output Oriented DEA models based on CRS algorithm. The model considers the extent in which outputs could be increased while using the same inputs, relatively to the standards set by the competing units. The inputs and outputs used are presented in the Table 1.

Table 1: Inputs and outputs

Inputs	Outputs
Flight Efficiency Model (output oriented CRS)	
Number of runways	Aircraft movements
Length of the longest runway	
Number of destinations	
Passenger Efficiency Model (output oriented CRS)	
Number of operating carriers	Passenger throughput
Car park capacity	

Table 1: Inputs and outputs (continued)

Distance to city center	
Number of passenger terminals	
Number of gates	
Overall Efficiency Model (output oriented CRS)	
Number of operating carriers	Passenger throughput
Car park capacity	Aircraft movements
Distance to city center	
Number of passenger terminals	
Number of gates	
Number of runways	
Length of the longest runway	
Number of destinations	

The same type of analysis could also be used to analyze the efficiency of airports while handling cargo as we can see from the already established analysis measuring the technical efficiency of airports in Latin America. The study used similar data set compared to our research paper with the added freight movements as an output category as well (Perleman and Serebrisky, 2012). Due to the fact that Low Cost Carriers focus is moving passengers we decided to eliminate this output variable from our study. Air companies considered as LCC and involved in our study are the following: Air Berlin, Air One, Blue air, Blue express, Blue Panorama airlines, EasyJet, Flybe, Germanwings, HOP!, Intersky, jet2.com, Monarch airlines, Norweigian airline, Pegasus airline, Ryanair, Smart wings, Transavia airline, Volotea, Vueling, Wizz Air, Sky Europe, Eurolot and Edelweiss. The number of airlines at distinct airports over the years is presented in the Table 2.

Table 2: The number of LCC at distinct airports.

	2006	2007	2008	2009	2010	2011	2012	2013
Ljubljana	2	2	2	2	1	2	2	2
Pula	1	2	3	3	3	3	4	4
Zadar	0	2	2	2	2	2	2	2
Split	2	2	3	4	5	5	9	9
Dubrovnik	1	3	4	7	8	8	9	9

5. RESULTS

The DEA efficiency numbers were obtained with the help of LIMDEP 10 software using the FRONTIER function with ALG=DEA and CRS limiters.

5.1 DEA Efficiency

In the Table 3. we can see the calculated Flight Efficiencies for selected airports over eight years, from 2006 to 2013.

Table 3: Flight Efficiency

	2006	2007	2008	2009	2010	2011	2012	2013
Ljubljana	1	1	1	1	1	1	1	1
Pula	0,26398	0,266678	0,287911	0,294223	0,23532	0,26086	0,298703	0,32706
Zadar	0,077127	0,078691	0,085384	0,094276	0,103199	0,114264	0,149574	0,163177
Split	0,546255	0,482707	0,468695	0,488964	0,533392	0,57406	0,643143	0,693237
Dubrovnik	0,362408	0,323483	0,309278	0,315274	0,365042	0,408753	0,463077	0,492216

We can see that Slovenian airport is relatively much more Flight Efficient than Croatian ones.

The calculated Passenger Efficiency is shown in the Table 4.

Table 4: Passenger Efficiency

	2006	2007	2008	2009	2010	2011	2012	2013
Ljubljana	1	1	1	1	1	1	1	1
Pula	0,68734	0,872912	0,860893	0,74044	0,682456	0,69237	0,664775	0,617474
Zadar	0,168036	0,267714	0,343728	0,529231	0,657782	0,664192	0,875956	1
Split	1	1	1	1	1	1	1	1
Dubrovnik	1	1	1	1	1	1	1	1

Here, efficiency is not geographically dependent, but yet, some airports are still much more effective than the others.

The Overall Efficiency is calculated with respect to two outputs (passenger throughput and aircraft movements). The results are presented in the Table 6.

Table 6: Overall Efficiency

	2006	2007	2008	2009	2010	2011	2012	2013
Ljubljana	1	1	1	1	1	1	1	1
Pula	1	1	1	1	1	1	1	1
Zadar	0,259897	0,275256	0,343728	0,529231	0,657782	0,664192	0,875956	1
Split	1	1	1	1	1	1	1	1
Dubrovnik	1	1	1	1	1	1	1	1

5.2 The impact of LCC presence on Efficiency

The impact of LCC presence on efficiency of airports is estimated by simple linear regression using LIMDEP. The number of LCC flights from certain airports over the years was considered as an independent variable while the calculated defined DEA efficiencies were considered as the dependent variable. The correlation coefficients, explaining the impact of LCCs, are listed in Table 7.

Table 7: Calculated correlation coefficients

	Flight Efficiency Coefficient	Passenger Efficiency Coefficient	Overall Efficiency Coefficient
Ljubljana	0	0	0
Pula	0,56186	-0,37052	0
Zadar	0,3877	0,54531	0,46351
Split	0,88393	0	0
Dubrovnik	0,6454	0	0

The results shown in the last table clearly indicate that there is a positive correlation between the number of low cost carriers and the airports efficiency. The negative number in Pula segment was caused by a rapid decline of number of the passengers due to economic crisis. In instances where optimal efficiency has been calculated thorough the whole time of observation the correlation shown is 0 due to the way the correlation coefficient is calculated. Further research featuring more airports and more data is required to further explain the correlation between LCCs and airport efficiency. After further analyzing, the impact the LCC could have on freight cargo we discovered that most LCCs based in Europe do not think pursuing the freight market is a good idea and they tend to stay on the familiar territory of passenger transport. Airlines such as Norwegian claim that they will not compete with established carriers in prices despite trying to succeed in freight transport as well (Lennane, 2013). As such, we can conclude that current day LCCs do not pose a significant factor in changing the efficiency with the inclusion of freight flows. This however might change in the future as more aggressive tactics could be used by the LCCs.

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THE VEHICLE REROUTING PROBLEM WITH TIME WINDOWS AND SPLIT DELIVERY

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Abstract: *Many logistics company use the same set of vehicle routes every day. Unexpectedly high customers' demand in one or more nodes can cause a disruption in vehicle operations. Disruption occurs since, for one or more planned routes, capacity constraints can be broken. In such a situation, dispatchers must decide how to organize a distribution in the way to minimize negative effects of disruptions. The mathematical programming formulation for the vehicle rerouting problem in the case of split delivery is proposed in the paper. Performed numerical experiments show that split delivery concept of distribution, in the case of disruptions in vehicle operations, outperform distribution approaches without split delivery.*

Keywords*: Vehicle routing problem, disruptions, split delivery*

1. INTRODUCTION

Many logistics companies, on a daily basis, deliver various goods to the customers. In many cases, companies deliver goods to the same set of the customers every day. In such a situation, dispatchers usually decide to use the same set of vehicle routes every day. The benefits of performing the same vehicle routes on a daily basis are obvious. During the time, drivers become familiar with the routes where they make deliveries. It is also easier for companies to plan fleet size and fleet usage. Simultaneously, the costs can be planned for a longer period of time.

Sudden changes in customer demands can cause situations where the planned vehicle routes are not the best possible. Significantly increased customer demands can make that some vehicle capacity constraints are broken. The disruptions in vehicle operations can produce the following negative effects: there is a need to engage additional vehicles; the delivery cost could be increased; some customers cannot be served, etc.

We consider in this paper the case when split delivery is allowed in the situation when disruption occurs. We propose, for this case, the mix-integer linear programming mathematical formulation. We clearly show that the split delivery can significantly decrease negative consequences of disruptions.

The paper is organized in the following way. The literature review and statement of the problem are given in the Section 2. Mathematical formulation of the problem is described in the Section 3. Numerical experiments are presented in the Section 4. Finally, the conclusions and directions for future research are given in the Section 5.

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2. LITERATURE REVIEW AND STATEMENT OF THE PROBLEM

The area of disruption management has been studied since 1984 (Teodorović and Guberinić, 1984). In distribution systems different disruptions can occur, such as: vehicle breakdown, changes in customer demand, traffic jam, changes in delivery locations, etc. There are several papers in the literature devoted to the vehicle rerouting problems. Li et al. (2009a,b) considered the vehicle routing problem which arise when one or more vehicles have breakdown. The authors proposed insertion heuristic based on Lagrangean relaxation. Mu et al. (2011) considered similar problem and proposed model based on Tabu search metaheuristic. Wang et al. (2011,2012) proposed mathematical formulation as well as, heuristic algorithms for the case when few disruption events occur. Hu and Sun (2012) proposed knowledge-based approach to mitigate disruptions during distribution process, while Hu et al. (2013) proposed local search algorithms and object-oriented modeling. Mu and Eglese (2013) analyzed the problem when the delivery to central warehouse is in delay. The authors proposed the model based on Tabu search metaheuristic.

We consider the case when companies use the same set of vehicle routes every day. The problem arises when the customers significantly increase demand and consequently, some vehicle routes become infeasible. This problem was studied by Spliet et al. (2014) and Nikolić and Teodorović (2015). Spliet et al. (2014) based their model on the capacity vehicle routing problem. They proposed the mathematical formulation, as well as heuristic algorithm. Nikolic and Teodorović (2015) studied the vehicle rerouting problem in the case of time windows and proposed multi-objective mathematical formulation.

In this paper, we further expand the research performed by Nikolić and Teodorović (2015). We consider the case when split deliveries are allowed. In other words, we consider the case when nodes could be served by more than one vehicle.

3. MATHEMATICAL PROGRAMMING FORMULATION

Let us denote by $G=(N,A)$ an oriented graph, where V is a set of nodes $[V=\{0,1,\ldots,n,n+1\}]$, and A is a set of edges $[(i,j)\in A]$. We denote by 0 and n+1 the central depot.

We also introduce the following notation:

- Binary decision variables:

$$\xi_i=\begin{cases}1, & \text{if node } i \text{ will not be served}\\ 0, & \text{otherwise.}\end{cases}$$

$$z_{ik}=\begin{cases}1, & \text{if the vehicle } k \text{ will make delivery to node } i, \text{ although this node is not in its original route}\\ 0, & \text{otherwise.}\end{cases}$$

$$y_{ij}^k=\begin{cases}1, & \text{if vehicle } k \text{ travels from node } i \text{ to node } j\\ 0, & \text{otherwise.}\end{cases}$$

- The other decision variables are:

w_i^k - time when start service at node i by vehicle k

f_{ik} – the fraction of demand of node i delivered by vehicle k

- The following are the input values:

x_{ij}^k - is equal 1 if in the initial set of routes vehicle k, after servicing node i, goes to node j

w_i - importance (weight) to serve the node i

u_i – importance (weight) that node i will not be serviced in the route that is not the original route of the node i

c_{ij} – the cost for travel from node i to node j

q_i – demand at node i

Q – vehicle capacity

t_{ij} – travel time from node i to node j

s_i – duration of service at the node i

M – large positive number

Mathematical formulation of the vehicle rerouting problem in the case of split delivery, based on Nikolić and Teodorović (2015) and Ho and Haugland (2004), can be given in the following way:

$$\min \quad F_1 = \sum_{i \in N} w_i \, \xi_i \tag{1}$$

$$\min \quad F_2 = \sum_{k \in K} \sum_{i \in N} u_i \, z_{ik} \tag{2}$$

$$\min \quad F_3 = \sum_{k \in K} \sum_{(i,j) \in A} c_{ij} \, y_{ij}^k \tag{3}$$

subject to:

$$\sum_{k \in K} \sum_{j \in \delta^+(i)} y_{ij}^k + \xi_i \geq 1 \quad \forall \, i \in N \tag{4}$$

$$\sum_{j \in \delta^+(0)} y_{0j}^k = 1 \quad \forall \, k \in K \tag{5}$$

$$\sum_{i \in \delta^-(j)} y_{ij}^k - \sum_{i \in \delta^+(j)} y_{ji}^k = 0 \quad \forall \, k \in K, \, j \in N \tag{6}$$

$$\sum_{i \in \delta^-(n+1)} y_{i,n+1}^k = 1 \quad \forall \, k \in K \tag{7}$$

$$w_j^k \geq w_i^k + s_i + t_{ij} - M\left(1 - y_{ij}^k\right) \quad \forall \, k \in K, (i,j) \in A \tag{8}$$

$$a_i \leq w_i^k \leq b_i \quad \forall \, k \in K, i \in V \tag{9}$$

$$\sum_{i \in N} g_i \, f_{ik} \leq Q \quad \forall \, k \in K \tag{10}$$

$$\sum_{k \in K} f_{ik} = 1 \quad \forall \, i \in N \tag{11}$$

$$\sum_{j \in \delta^+(i)} y_{ij}^k \geq f_{ik} \quad \forall \, i \in N, k \in K \tag{12}$$

$$\sum_{i \in \delta^-(j)} \left(y_{ij}^k - x_{ij}^k\right) \leq z_{jk} + \xi_j \quad \forall \, k \in K, \, j \in N \tag{13}$$

$$\xi_i \in \{0,1\} \quad \forall \, i \in N \tag{14}$$

$$z_{ik} = \{0,1\} \quad \forall k \in K, i \in N \tag{15}$$

$$y_{ij}^{k} \in \{0,1\} \quad \forall k \in K, (i,j) \in A \tag{16}$$

The objective function (1) that should be minimized represents the total number of unsatisfied customers. The total number of customers that will be served in the routes which are not their original routes is calculated by objective function (2). This objective function should be minimized. The objective function (3) that should be minimized represents the total travel costs.

Constraints (4) guarantee that if node *i* will not be served, the decision variable ξ_i must take value 1. All vehicles leave the depot, visit some nodes and return to the depot. This is guaranteed by the constraints (5), (6) and (7). Time windows must be satisfied according to the constraints (8) and (9). Constraints (10) and (11) guarantee that the vehicle capacity will not be exceeded by the total demand that will be delivered through the route. Because of constraint (12) if node *i* will not be served by the vehicle *k* , the decision variable f_{ik} must take value 0. If the vehicle *k* makes the delivery to the node *j*, and node *j* is not included in the initial route of the vehicle *k*, then variable z_{jk} will take the value 1 according to constraints (13). Constraints (14), (15) and (16) define decision variables as binary.

4. NUMERICAL EXAMPLES

To evaluate the effects of allowed split delivery, we have used benchmark examples, based on C101 Solomon benchmark example, given in (Nikolić and Teodorović, 2015). Nikolić and Teodorović, 2015 used lexicographic method to solve the problem instances. Their results, related to the case when the split delivery is not allowed, are given in Table 1. The results are given for the cases when the number of customers are 25 and 50 respectively. All instances have been solved by the CPLEX software.

Table 1. The results obtained when split delivery is not allowed (Nikolić and Teodorović, 2015)

The number of nodes	Increase in demand	C101					
		Fleet size: 3			Fleet size: 4		
		F1	F2	F3	F1	F2	F3
25 nodes	10%	0	1.12	249.00	0	1.12	249.00
	20%	0	1.15	239.33	0	1.13	251.92
	30%	1.02	1.15	239.27	0	2.16	271.29
	40%	1.30	2.22	257.76	0	3.27	272.84
	50%	2.34	1.12	243.47	0	3.29	273.30
	60%	3.60	1.09	220.37	0	4.31	265.00
	70%	4.78	0	185.81	1.04	3.37	271.48
	80%	4.78	0	185.81	1.04	3.37	271.48
	90%	6.04	2.21	192.02	2.30	5.55	284.41
	100%	6.04	2.21	192.02	2.30	5.55	284.41
50 nodes	10%	0	2.43	480.79	0	2.43	480.79
	20%	0	3.68	469.92	0	3.66	488.66
	30%	0	6.01	496.3	0	6.00	505.1
	40%	1.04	7.23	563.66	0	7.16	556
	50%	2.62	7.5	492.68	0	8.59	527.25
	60%	4.92	8.99	610.38	1.04	11.16	552.46
	70%	7.54	6.63	516.52	3.46	9.04	561.14
	80%	7.54	6.63	516.52	3.46	9.04	561.14
	90%	10.34	9.16	613.72	5.78	12.18	584.09
	100%	10.34	9.16	613.72	5.78	12.18	584.09

In this paper we have solved all instances considered by Nikolić and Teodorović (2015). We also use Lexicographic method and the CPLEX software. The obtained results are given in Table 2. In the case when there are one central depot and 25 customers, when the fleet size is equal 3 vehicles, for the six instances we obtained the better results than in the previous research. In the case when the fleet size is equal 4 vehicles, we obtained better results in two cases. Similar results are obtained for the cases where there are one central depot and 50 customers. In these cases, when the fleet size is equal 6 vehicles, we obtained better results for six instances, while in the cases where the fleet size is equal 7 vehicles, three times we discovered the better solution. The better results are denoted by bold and italic letter in Table 2.

Table 2. The results obtained in the case when split delivery is allowed

The number of nodes	Increase in demand	C101					
		Fleet size: 3			Fleet size: 4		
		F1	F2	F3	F1	F2	F3
25 nodes	10%	0	1.12	249.00	0	1.12	249.00
	20%	0	1.15	239.33	0	1.13	251.92
	30%	***0***	***2.21***	***257.28***	0	2.16	271.29
	40%	***1.3***	***2.18***	***256.60***	0	3.27	272.84
	50%	***2.3***	***3.37***	***253.52***	0	3.29	273.30
	60%	***3.46***	***2.38***	***288.07***	0	4.31	265.00
	70%	***3.66***	***2.07***	***229.53***	***0***	***4.39***	***278.66***
	80%	4.78	0	185.81	1.04	3.37	271.48
	90%	***5.16***	***3.2***	***258.49***	***1.3***	***6.55***	***304.73***
	100%	6.04	2.21	192.02	2.3	5.55	284.41
50 nodes	10%	0	2.43	480.79	0	2.43	480.79
	20%	0	3.68	469.92	0	3.66	488.66
	30%	0	6.01	496.30	0	6.00	505.10
	40%	***1.02***	***7.21***	***531.07***	0	7.16	556.00
	50%	***2.30***	***7.59***	***567.93***	0	8.59	527.25
	60%	***3.66***	***8.96***	***600.50***	***0***	***12.14***	***590.62***
	70%	***5.78***	***8.36***	***514.64***	***1.30***	***11.12***	***540.34***
	80%	7.54	6.63	516.52	3.46	9.04	561.14
	90%	***9.08***	***9.13***	***669.01***	***4.78***	***12.68***	***559.52***
	100%	***10.34***	***8.01***	***615.03***	5.78	12.18	584.09

5. CONCLUSIONS

Many logistics companies use the same set of vehicle routes every day for delivery goods to the customers. These routes sometimes can become unfeasible in the cases of very high customers demand.

When solving vehicle rerouting problem, we proposed and analyzed the split delivery concept. It has been shown, that by allowing the split deliveries the negative consequences of the disturbances can be significantly reduced.

We will explore various heuristic approaches in the future research that will enable us to attack the vehicle rerouting problems of big dimensions.

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Part II INTERMODAL TRANSPORTATION

CHALLENGES IN THE RAILWAY YARDS LAYOUT DESIGNING REGARDING THE IMPLEMENTATION OF INTERMODAL TECHNOLOGIES

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Abstract: *This paper provides a survey on railway freight yard classification and presents the challenges in designing and planning of railway yards regarding the ongoing transformation and changes. Transport service in railways can be achieved through the conventional concept of wagonload transportation or within intermodal transport chain. In both concepts, railway yards are recognized as key factors for the smooth functioning of the freight transportation. At the same time, yards are facing problems relating to layout designing and operation planning. The railway yard under the study, Vršac railway yard, has a strategic position in the transportation network and for that reason is recognized as a potential location for establishing intermodal service. The paper proposes the layouts designed for the reconstruction of the existing classification yard and the construction of a new rail-road transshipment yard.*

Keywords*: railway freight yards, layout designing, intermodal transportation technology*

1. INTRODUCTION

The accomplished transport service in railways can be achieved through the conventional concept of wagonload transportation or within intermodal transport chain. In both concepts railway yards play a decisive role for improving the efficiency and quality of transport service. At the same time, yards have been faced with a whole array of problems relating to layout designing and operation planning.

Wagonload transportation, also called Single Wagon Load Service (SWL), consolidate loads composed of single wagons and wagon groups. These wagon loads are less than full train loads which are collected at different customer sidings and assembled in yards to full trains on the same routes throughout the railway network. Wagonload transportation is based on the system of marshalling yards which are comparable with hubs in the logistic Hub and Spoke System. In this way, marshalling yards obtain a certain degree of economies of scale benefits and reduce the wastages of the system. On the other hand, the overall operating efficiency is limited by the capacity of the yards and their utilization.

The intensification of railway yard efficiency can be achieved within intermodal ''door to door'' principle application. The essence of the technology of combined rail-road transport is in the combination of the advantages of the fast, cheap and safe railway transport of freight in long

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distances and fast and efficient final distribution by trucks. This, as well, enables a sustainable modal share within transport chains. The sustainable modal share assumes the contribution to the whole transport system by shifting from one to another, more favorable transport mode. From the aspect of sustainable modal share, railways advantages are high capacities reserves, reliability and safety, reduction in specific energy consumption and pollution.

Railway yard management tries to reduce redundancy costs and to strengthen the role of yards in the transport chain by implementing the intermodal transport technologies. Only in that way, railways can increase its market share and reach the targets set by the White paper in the European transport area. Direct intermodal trains have the potential to be the basis of a novel railway freight transport service. They directly connect intermodal terminals while loading and unloading costs are allocated outside the railway service. Direct trains connect two terminals without intermediate stops in the most economical and fastest way. In addition to transport technology development, it is important to establish a more efficient freight handling and train operating in railway yards.

This paper presents the challenges in designing and planning of Vršac railway yard regarding the ongoing transformation and changes. The railway yard has a strategic position in Serbian railway network but due to years of lack of maintenance it is in an inadequate state to perform the service relating consolidation of wagonloads and to serve as interface in the novel intermodal transport technologies. The paper proposes layouts designed for the reconstruction of the existing classification yard and construction of the new rail-road transshipment yard.

2. RAILWAY FREIGHT YARDS: OVERVIEW AND CLASSIFICATION

Yards as nodes in networks have the key role for the smooth functioning of the freight transportation. Railway yards should be more used as transshipment points inside the railway system or between the railways and an alternative mode of transportation. Currently, railway yards mainly consolidate the movements of freight trains on the network. Railway yards concentrate resources, such as track sidings and various track installations, shunting locomotives and freight handling equipments in order to receive, operate and depart freight trains for the sake of provided service.

The most of railway freight yards execute classification procedures: disassembling and reassembling trains. It can generally be acknowledged that the most of classification freight yards are inefficient and that their layouts and disposition in networks does not satisfy contemporary needs. The most of the unproductive time railcars spend in the yards, approximately about two-thirds of their turnover system time. Petersen (1977) identified three types of classification freight yards: flat yards, hump yards and gravity yards. Flat yards are the yards where the railcars are pushed and pulled by a shunting locomotive which sorts them into the assigned track. These tracks lead into a flat shunting neck at one or both sides of the yard (for a detailed description of flat shunting yard operation and layout see Marinov and Viegas (2009)). Hump yards are the largest and most complex railway yards which feature the hump over which the railcars are pushed by the shunting locomotive. Early analytical queuing models (see e.g. Crane et al. (1955), Petersen (1977)) have been generally used in analyzing and evaluating the complex yard operations. Due to the dynamic and stochastic yard operation, the application of exact optimization methods is quite limited. The application of simulation tools enables the analysis of different yard layouts and operation strategies in real-time working conditions by varying different environmental parameters. The usage of simulations and their efficiency to estimate capacity requirements are pointed out in several papers (see e.g. Ivić et al. (2010) and Belošević et al. (2012)). Gravity yards, the third type of conventional railway yards, are designed with a continuous falling gradient and a distinct type of layout. Gravity yards have a very large capacity but with lots of the difficulties related to safety issues and for that reason only few remain in operation today. Typically, classification freight yards consist of:

- Arrival yard to receive freight trains in the railway yard system;
- Classification yard to disassemble received freight trains and to sort railcars;
- Departure yard to depart freight trains from the railway yard system and
- Maintenance yard and depot to serve railcars and locomotives.

On the other hand, the railway yards may serve as an interface between railways and other mode of transportation, mostly as rail-road transshipment yards. In such a system, trains perform only the long haulage while pre-haulage and end-haulage is performed by trucks. For this purpose, trains are not decomposed and only loading units are transshipped by means of handling equipment (gentry cranes, reach stackers or forklifts et.). The rail-road transshipment yards were in details analyzed considering layout planning and operational problems by e.g. Ballis and Golias (2002). To process freight trains and loading units, the rail-road transshipment yards are consisted of:

- Track sidings for train arrival/departure and inspection purpose;
- Transshipment tracks for the train loading/unloading operation;
- Loading and driving lines for the trucks ;
- Storage area for loading units and
- Handling equipment.

Besides the conventional rail-road transshipment yards fully automated rail-rail transshipment yards are designed to increase the exchange of loading units between trains. In order to ensure the rapid transshipment, the yards are designed without floor storage areas which are replaced with some of the automated systems for sorting. Although this novel transshipment technology is still under development some of these yards have already been constructed (see e.g. Boysen et al. (2013)).

3. CASE STADY: VRŠAC RAILWAY YARD

3.1 Motivation

The current role of Vršac flat yard is to rearrange freight trains passing through the yard and to classify railcars for further distribution over railway network in Serbia and border crossing to Romania. Furthermore, it is expected that Vršac yard obtains additional role in Serbian transportation network through the development of intermodal transportation. The establishment of the intermodal terminal and revitalization of railway infrastructure are defined as top priorities for further development of transport service in the Municipality of Vršac. In this sense, the existing railway yard in Vršac should be redesigned to fulfill the additional requirements for implementation of rail-road transshipment.

3.2 The current state

The flat-shunted yard Vršac is located in the industrial zone of Vršac and serves the following rail lines: Pančevo – Vršac – State border to Romania and Zrenjanin – Vršac – Bela Crkva. Vršac yard is open to entire passenger service and the service of part-load and wagon-load consignments. The yard is divided into the group of main tracks (the tracks for the arrival/departure of trains and the tracks for freight train classification) and a few groups of sidings. The yard has 28 tracks, 7 out of 28 tracks can be used for the arrival and departure of trains, while other tracks are handling, loading, depot and other sidings. The current layout of Vršac railway yard is outlined in Figure 1.

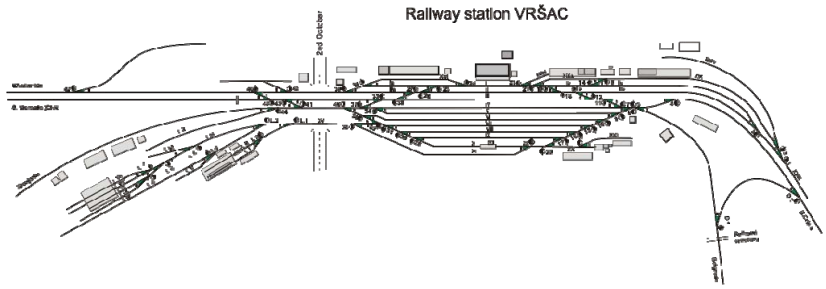


Figure 2. The current layout of Vršac railway yard

3.3 Reconstruction of Vršac railway yard

The initial framework for designing the intermodal terminal and its connection to the public railway network is based on the orientation to retain the existing location of the railway yard, which is proposed in the Master Plan of Vršac and in the Development Program of Serbian Railways. Under the current state, the railway yard in Vršac functions as a flat-shunted yard. Conducted current-state analysis has shown that the yard is able to serve trains with intermodal loading units. It has also noted the deficiencies of the sidings' conditions in the terms of the existence of the insufficient design of track ladders, unequal track lengths and poor superstructure.

Layout of the flat yard

Within the reconstruction (see Figure 2), the group of main tracks should be extended considering the requirements for serving intermodal trains with the maximum lengths of 600-650 m. This extension of main tracks requires the realignment of Belgrade railway line leading a yard and the complete reconstruction of the corresponding yard ladder. The expected intensification of the freight railway transport requires additional capacity, so the yard should be widened with two main tracks. Also, two shunting necks would be constructed to realize smooth and parallel disassembling and reassembling operations on the each side of the yard. Upon the reconstruction, the yard would deal with the 12 main tracks and two shunting necks. The first three tracks should be the platform tracks and the remaining nine should be used for freight service. The arrival group should be composed of 5 tracks, while the last 4 should be used for classification. The arrival group of tracks is intended for receiving the trains for complete or partial disassembling or other shunting operations (such as locomotive exchange, technical inspection or customs clearance). The arrival group of main tracks in the yard should be also used for receiving in-going/out-going trains for or from the intermodal terminal and the logistic center. All currently used handling sidings would be allocated from the yard and aligned over the logistic center and nearby industrial zone.

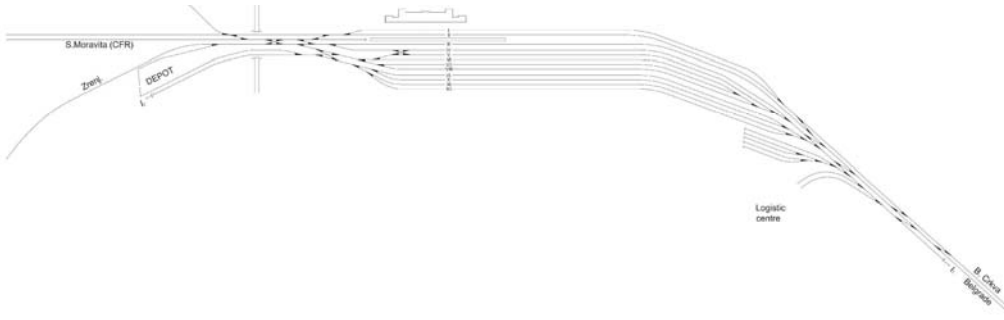


Figure 3. The reconstructed layout of Vršac railway yard

Layout of the rail-road transshipment yard

The construction of the intermodal terminal could be carried out independently of the reconstruction of Vršac yard. In the beginning, the intermodal terminal could be constructed and launched under the current state of the railway infrastructure in Vršac. Initially, the transshipment yard would be designed with three tracks in the area of the intermodal terminal (see Figure 3). Two tracks would be used as transshipment tracks for the train loading/unloading and one track would be used as a passing track for the run-around operation of shunting locomotives. The minimum usable length of handling tracks would amount 650 m in order to ensure the smooth reception of complete intermodal trains. For the purpose of accompanied transport, the RoLa loading ramp would be installed on track T1. Furthermore, after the establishment of logistic centre and initiation of intermodal transport it is possible to expand the capacity of the transshipment yard in terms of extending existing tracks or increasing the number of tracks.

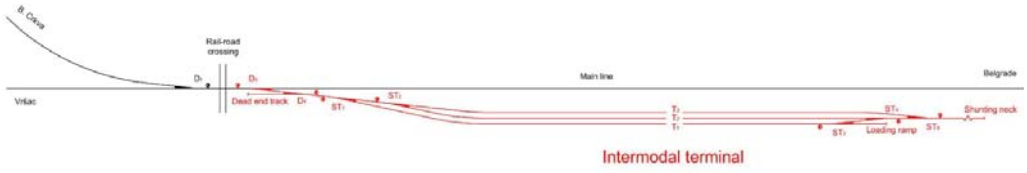


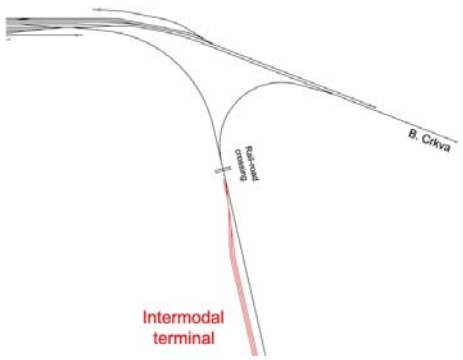
Figure 4. The layout of the rail-road transshipment yard

Layout of the rail-road transshipment yard connection with the flat yard

To ensure the full and effective operation of the intermodal terminal it is necessary to enable its connection with the public railway infrastructure (see Figure 4). The connection to the rail network would be carried out indirectly using Vršac railway yard. Connecting Vršac yard to the transshipment yard could be implemented in phases, which would be in line with the reconstruction of Vršac yard.

Under the current state, the transshipment yard could be connected from the main passing track in the railway yard. For the reason of increasing safety on the main line, the terminal connection would be designed with the short dead-end track (see Figure 4a).

a) Before the reconstruction of the railway yard



b) After the reconstruction of the railway yard

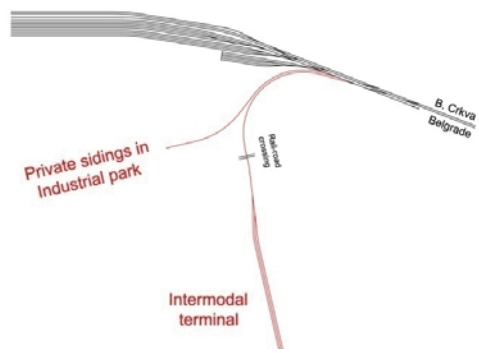


Figure 5. The rail-road transshipment yard connection with the flat yard

The allocation of the entrance of the railroad from Belgrade (in the final phase of Vršac yard reconstruction) revokes the allocation of the previous connection to the main passing track in the yard, (see Figure 4b). The connection of the terminal to the arrival group of the yard would be performed independently (using the track of existing triangle). This connection results in an indirect arrival and dispatch of the compositions to and from the terminal. Parallel to this connecting track it is possible to align another connecting track and to spread the network of private sidings within the industrial park.

4. CONCLUSION

This paper provides a survey on railway freight yard classification and presents the challenges in designing layouts of railway yards regarding the establishment of novel intermodal technologies. Railway yards are recognized as key factors for the smooth functioning of the freight transportation. The most of railway freight yards execute only the classification of railcars which do not satisfy contemporary needs. Therefore modern railway yards should be more oriented on the transshipment procedure either inside the railway system or between the railways and alternative modes. In the shape of case study we analyzed the railway yard in Vršac which mainly performs the conventional rearrangement of freight trains over railway network in Serbia and border crossing to Romania. In addition, it is expected that Vršac yard obtains more significant role in Serbian transportation network through the development of intermodal transportation. The catchment area of the potential Vršac intermodal terminal widely exceeds borders of the South Banat District because of its favorable position in Serbian transportation network, near Corridors X, IV and VII. In this paper we propose the layouts designed for the reconstruction of the existing rail classification yard and the construction of the new rail-road transshipment yard.

ACKNOWLEDGMENT

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IMPACT OF CROATIA ACCESSION TO THE EU ON THE CROATIAN RAILWAY INFRASTRUCTURE, RAILWAY AND MARITIME FLOWS

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Abstract: *The goal of this paper is to try to portrait the current state of the railway infrastructure in Croatia, main freight railway flows in the country, the state of infrastructure regarding the Croatian accession to the European Union and the future potential of the railway freight flows especially flows from the Adriatic ports and flows on the so called east-west corridor (the former Pan-European corridor X).*

Keywords*: railway infrastructure, railway flows, maritime flows*

1. INTRODUCTION

Croatia currently has 2.722 kilometres of the railway network. The entire network is managed by Croatian railway infrastructure Ltd company which is 100% owned by the Republic of Croatia. A unique company called Croatian Railways (HŽ) "lived" until 2008 when it was divided into five companies and in 2012 a new restructuring left only three independent companies. One of them is HŽ Infrastructure Ltd which manages the railway infrastructure in Croatia today. States Slovenia, Croatia and Serbia form a space which links south of Europe with the East and South East parts of Europe. The freight route that passes through these three countries is the shortest connection between Italy, France, Germany and Austria with Romania, Bulgaria and Greece and the seas like the Black Sea and the Aegean Sea. These two axes have the potential to form main freight flows.

The freight flows generated from the Croatian industry is very hard to expect in the following years due to a hard decline of the industrial production in Croatia. Worth mentioning are the potential flows from the port of Ploče towards the Bosnia and Herzegovina and possibly towards Hungary. In the end the port of Vukovar should be mentioned. It is the only freight port on Danube River in Croatia. There is a possibility that some goods can be transported from Adriatic ports to the port of Vukovar and then onwards by Danube river into Hungary, Austria and into southern Germany. The importance of Vukovar was recognized with latest TEN-T network revision and the extension to the Western Balkans. Vukovar was designated as the core port and the Danube River in the Balkan states became a TEN-T corridor. Also, Sava River from Sisak downstream to Belgrade became a part of TEN-T.

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2. CROATIAN RAILWAY INFRASTRUCTURE – FACTS AND FIGURES

Croatia has an overall of 2.722 kilometres of the railway network. Only 254 kilometres of these tracks are double track. In overall 977 kilometres of the network is electrified with 25kV AC system. Main nod in Croatia is Zagreb with its railway station. Central nods are Zagreb Main station for passenger transport and Zagreb marshalling yard for freight traffic. First railway line in Croatia was passing trough north of Croatia, it was a railway line from Hungarian Nagykanizsa to Slovenian Pragersko. It was the line which connected Budapest Nagykanizsa main line with the Vienna – Graz – Ljubljana – Trieste main line.

2.1 Infrastructure and the capacity on the Zagreb – Rijeka main line

The line Rijeka – Zagreb – Koprivnica – Hungarian border is entirely electrified with the 25 kV AC system and it is 332 kilometres long. Except of 20 kilometres in the Zagreb nod which is double track all the other parts of the line are single track. The axle load on line is 22,5 tons per axle. On the part from Moravice through Zagreb until Hungarian border there an automatic block system of signalling, while on the 90 kilometres long stretch from Moravice to Rijeka there is only clearance between vehicles (between the train stations) which significantly reduces capacity. The line due to its hauling characteristics can be divided into five sections. Two sections Hungarian border – Koprivnica – Lepavina and Križevci – Zagreb – Karlovac are the sections built on flat terrain allowing good speeds and gradual inclines. That gives the opportunity to haul very heavy trains with only one locomotive. This sections could allow speeds from 140 to 160 kilometre per hour or even higher but the current state of infrastructure limits this from 60 to 140 kilometres. Some parts that pass through Zagreb are limited to only 60 kilometres per hour due to bad track condition. The stretch from Lepavina to Križevci is only 29 kilometres long but offering inclines up to eleven per mile which adds a need for two locos when trains heavier than 1.200 brute tons need to be hauled. The similar hauling conditions apply on the 86 kilometre Karlovac – Moravice. Speeds on these sections vary from 80 – 140 km/h. The last section from Moravice to Rijeka is the most difficult ones. The line climbs there to more than 900 meters above the sea. Many parts of the line offer steep inclines from 20 to even 27 per mile. One of the hardest parts of the track is an incline from Rijeka to Plase station. More than 95% of this 29 kilometre long section has a 25 per mile incline at some parts reaching even 27 per mile. One electric locomotive can haul only a 500 brut tons trains here. Modern 6 Mega Watts locomotive can haul up to 750 tons here. On this stretch adding a pushing locomotive to the rear end of the train can significantly increase the tonnage of the train. Unfortunately, although this hauling technique was used before, during the last ten years Croatian railways didn't allow adding a pushing locomotive. Hopefully, this can be changed allowing heavier trains to leave Rijeka. Speed on this section is from 60 to 80 kilometres per hour. The current assessment of the Rijeka main line full capacity differs depending on different section of the line. The Rijeka – Moravice section has the maximum capacity around 5 million net tons (12 million brut tons) of goods per year. This can be also expressed with a figure around 60 trains per day. The sections of that line that lie in a flat terrain can allow almost up to three times this capacity reaching around 16 million net tons (40 brut tons) per year with some 80 freight trains per day. A higher capacity is not possible to reach due to only single track and mixed passenger/goods traffic.

2.2 Infrastructure and capacity on the Zagreb – Vinkovci – Belgrade main line

A part of the railway line Ljubljana – Zagreb – Vinkovci – Belgrade is also entirely electrified. Out of its 320 kilometres that passes through Croatia 216 kilometres is double track. Also from Zagreb to Novska to single track exist, one 105 and the other is 117 kilometres long.

All the line passing through Croatia was built in a flat terrain with most of the curves with long radiuses allow speed for 160 or more km/h on most of the line. Some small radius curves can be found restricting speed between 80 – 120 km/h. All the line is equipped with automatic block

system signalling. Double track parts have a very high capacity for transporting freight. A limiting fact is that the section between Dugo Selo and Novska a single track line. This can be alleviated by using another line parallel to this one which runs from Zagreb to Sisak and then to Novska. It is 117 kilometres long which is only 12 kilometres longer than the line Zagreb – Dugo Selo – Novska. It is also electrified, in flat terrain and allowing speed from 100 – 140 kilometres per hour.

3. CROATIAN MARITIME AND RAILWAY FLOWS

3.1 Maritime flows

Port of Rijeka handles all kind of goods. General cargo, wood and cereals come and go to the port. Main inland destinations are Hungary, Serbia and Croatia. TEUs (twenty feet equivalent unit) are also being mostly delivered to the same countries and also in Austria. Out of almost 160.000 TEUs per year most of them are delivered by trucks, around three quarters of them. The rest goes to rail. In port of Split the main type of goods are general cargo, wood, cereals, cement and fuels. Most of these good are transport by trucks. Most of the cereals and cement goes by rail. In port of Ploče alumina, fuels, ore and some other kind of bulk cargo arrives. Most of these good are transported to Bosnia and Herzegovina and about half of the goods travel by rail. In the port of Šibenik mostly bulk cargo is being delivered from inlands of Croatia and Hungary. Large shipments of phosphates for Hungary and Petrokemija in Kutina were also recorded in the recent years. Phosphates are practically 100% delivered by rail. In the port of Zadar small quantities of general cargo and fuels are being recorded. Up to two trains per day drive these good while most of it goes inland by road.

3.2 Railway flows

Goods traffic flows changed significantly in the last thirty years in Croatia. Today in Croatia there is only one railway freight operator and this is HZ Cargo Ltd, which was established in 2008 after a division of a single railway company, Croatian railways. HZ Cargo is 100% owned by the state. Today it has around 80 diesel and 50 electrical locomotives and somewhere around 6.000 wagons. If we compare the data from 1996 where the former Croatian railways still had 430 locomotives and almost 12.000 freight wagons and that number dropped to 280 locomotives and 7.000 wagons in 2005 we can see a clearly bad policy towards the modernisation and extension of the fleet. That is also one of the reasons why the rail numbers declined significantly.

Currently it is clear that the number of goods carried inland in Croatia is declining. One of the reasons for that is the decline of the industrial production and the economical activities in general.

Table 1. Inland transportation in Croatia in 2010, 2011, 2012 by road and rail

		Overall transport			Market share				
	Measure	2010	2011	2012	2010	2011	2012	Index	
Overall goods carried	in millions of tons	87.170	86.439	76.527	100	100	100	99	89
Railway transport	in millions of tons	12.203	11.794	11.088	14	13,64	14,49	96,65	94,01
Road transport	in millions of tons	74.967	74.645	65.439	86	86,36	85,51	99,57	87,67
Overall TKM	millions of TKM	11.398	11.364	10.981	100	100	100	99,7	96,63
Railway transport	millions of TKM	2.618	2.438	2.332	22,97	21,45	21,24	93,12	95,65
Road transport	millions of TKM	8.780	8.926	8.649	77,03	78,55	78,76	101,66	96,9

From the table 1 it is more than obvious that the inland transportation of goods is declining while the market share road/rail remains the same. It is obvious that the most railway transport in Croatia is transit through the country. This transit includes also the goods transloaded in Croatian ports and then carried over the country borders and vice versa.

The biggest amount of the railway transport in Croatia is done on the East-West corridor that includes the railway lines Slovenia – Zagreb – Vinkovci – Serbia and the main line Zagreb – Sisak – Novska. The second busiest line is the one connecting port of Rijeka with Zagreb and Hungary. Two main types of transport can be mentioned here, the first is the one from port of Rijeka towards Hungary and Serbia and the second one is the transport from Bosnia and Herzegovina to Zagreb and then onwards to Slovakia and Poland. This transport mostly includes ores from northern Bosnian territory. So called Dalmatian lines are third with the amount of transport. This does not come as a surprise since three Dalmatian ports depend on these lines, Zadar, Šibenik and Split. Although the amount of goods transported on the former Vc corridor seems small, we must realize that the section between port of Ploče and Bosnian border is only 24 kilometres long. This line serves the port of Ploče taking each year almost two million tons of different goods. The lines in Podravina and Slavonia are next in line serving many enterprises and mostly transport agricultural goods. On these lines there is "Viro" sugar refinery in Virovitica and "Nexe group" factory Našice and they both on the list of 10 biggest companies that use rail in Croatia. Largest users of railway transport are AGIT d.o.o. and C.K.T.Z. Both these companies are logistic operators. First company is owned by HZ Cargo, the other is private. Third largest user is Petrokemija from Kutina which is situated on the East-West railway corridor adding a lot to its transport. It is also important to notice that eight largest users of railway transport increased their transport in 2012 the overall amount of transported goods in decreasing. This might indicate that the so called small users have started using railway services even less. Twenty biggest users of the freight railway services in Croatia transport 88,1% of all the goods transported by rail. Small users therefore transport only 11,9% of all the goods transported by rail and this percentage is getting smaller every year. This might indicate that a transport of goods by rail by current conditions is very unattractive for many smaller users, some of them even with the potential use rail much more than today. That indicates a problem that is been present not only in Croatia, but in the other European countries as well and that is that the railway transport companies are getting further away from small users. But serving only big users in the end gives us less and less quantity of the goods transported by rail every year. This clearly indicates that although the main corridors (like Trans-European Transport Network -TEN-T network) is very important, it is vital that corridor lines are very well connected with regional and local lines, local transport centres and industrial sidings of various scale of transport. This can easily be compared with large rivers which definitely would be so huge if there weren't a large numbers of small rivers and creeks upstream.

4. EXISTING TRAFFIC FLOWS ITALY/AUSTRIA – SLOVENIA – CROATIA AND THE POSSIBILITIES FOR MAKING A NEW TRANSPORT FLOWS AMONG THESE COUNTRIES

The existing railway connection between Rijeka and Venice/Trieste goes over Pivka and Sežana in Slovenia and it is significantly longer than the road connections. In order to make competitive passenger and passenger operation a new railway line from Rijeka to Trieste is planned. This line should be a logical extension from the new Hungary – Zagreb – Rijeka high speed high-capacity line. The initiative called NAPA – North Adriatic Port Associations is an initiative that joins together four North Adriatic ports in order to boost their cooperation, common marketing and by that to boost potential of all the ports. These ports are Venice, Trieste, Koper and Rijeka.

The possibilities of NAPA are growing even stronger after the 1st of July when Croatia joined the EU. The transport of goods from Rijeka towards the European destinations is now even simpler. This initiative is a good basis for further deeper cooperation among these ports. This alliance

will in the future definitely need a better railway link between each other. Therefore a high capacity and a high speed railway link Rijeka – Koper – Trieste are needed in the future. Since these ports transload the amount of cargo very close to the amount that for example a port of Hamburg does, with common operations, better infrastructure and a good marketing these four ports can become the leading intermodal area in Europe.

East-west corridor in Croatia forms a very good potential link of Italy and Austria towards Romania, Bulgaria, Turkey and Greece. The growing Turkish economy had bigger and bigger need to drive the goods towards the middle and Western Europe and this corridor is one of the best solutions.

In the freight operations the east-west corridor in Croatia can also be a very good link between the NAPA ports and the Black Sea ports in Romania and Bulgaria. Further intermodality options appear when these rail traffic flows are combined with the Sava and Danube rivers and the ports of Vukovar, Belgrade, Slavonski Brod, etc. A great possibilities can be seen with a suggested new high-capacity and high-speed line between Zagreb and Maribor. This line railway line, together with the new Zagreb – Rijeka high-speed line and with the new Semmering basis tunnel in Austria could form the shortest and the fastest both passenger and freight connection between the port of Rijeka, Graz and Vienna. This railway partially new railway line could offer very gradual inclines which makes a possibility to haul heavy freight trains all the way with only one locomotive. This kind of operation saves energy, nature and of course offers lower costs of transport as well.

Unfortunately, new Zagreb – Maribor railway corridor was not recognized in the latest TEN-T revision in May 2013. Also, by "Regulation (EU) No 913/2010 of the European Parliament and of the Council of 22 September 2010 concerning a European rail network for competitive freight Text with EEA relevance" on the first page it is clearly stated "In order to be competitive with other modes of transport, international and national rail freight services, which have been opened up to competition since 1 January 2007, must be able to benefit from a good quality and sufficiently financed railway infrastructure, namely, one which allows freight transport services to be provided under good conditions in terms of commercial speed and journey times and to be reliable, namely, that the service it provides actually corresponds to the contractual agreements entered into with the railway undertakings." This new railway line would cut the travelling times both for passengers and the freight to one third of today's time and finally make him competitive with the road transport.

Into the regulation EU No 913/2010 regarding the freight corridors there is a need to add new corridors and connections to the existing corridors in order to boost the freight connection between Italy, Austria, Slovenia and Croatia. On the page 12 on the list of initial freight corridors under corridor number 5 there is a branch listed Graz – Maribor – Ljubljana – Koper/Trieste. Another branch should be added Graz – Maribor – Zagreb – Rijeka – Koper/Trieste. Under number 6 with the branch Koper – Ljubljana – Budapest – Zahony another branch should be added: Ljubljana – Pragersko – Čakovec – Nagykanisza – Budapest. Also two new freight corridors should be added to this list, the first is Ljubljana – Zagreb – Sisak – Vinkovci – Belgrade and the other Rijeka – Zagreb – Koprivnica – Gyekenyes – Budapest.

5. CONCLUSION

Croatia has 2.722 kilometres of the railway network and out of those only 254 kilometres of double track railways. In overall 977 kilometres of the network is electrified. This clearly shows that the railway network in Croatia was newer built to a satisfactory extent. Boosting promotional activities, more research and more legislative support is needed to boost transit transport, transloading in ports and intermodal transport in general. Besides these activities a new infrastructure capacities must be planned in order to help the boost of the railway transport and intermodal transport. Ports definitely need better connections towards inland, but

these new railway infrastructure capacities should not avoid the possibilities to serve as long-distance and local passenger links and local freight links also. In cross border operation a huge potential for interoperability already exists. Links between Croatia and Slovenia is possible to overcome by using multiple system electric locomotives and links between Hungary, Serbia, Bosnia and Herzegovina and Croatia can be achieved by the existing fleet of mono system locomotives. Further legislative and organisational steps are needed to make this possible. Croatian Adriatic ports already have large possibilities in transloading goods. This especially works for the ports Rijeka and Ploče which even today transload a significant amount of goods. Port of Rijeka is already making possible to transload around 600.000 TEUs per year but better organisation of rail transport and better railway infrastructure is needed. The strongest railway flows can be recognized in three areas. Hungary – Zagreb – Rijeka axis, Slovenia – Zagreb – Vinkovci – Serbia axis and Dalmatian ports – Zagreb axis. A lot of freight transport also goes from port of Ploče to Bosnia and Herzegovina. All these flows can be boosted even with the existing railway infrastructure by promotional and organisational measures. The existing legislative in Croatia today allows the excess of all the European operators to the network. Since Croatia only joined the EU and the new legislative measures just took the first steps in cannot still be seen that other operators than Croatian HŽ Cargo is running the railway freight operations. But the concessionaires in the port of Rijeka already announced the possibilities to engage the other operators for the operation of transporting goods from and to the port. It would be also very good that the planned new railway line Zagreb – Maribor enters TEN-T in the next revision. This would offer the shortest, fastest and most economical railway connection between Rijeka, Zagreb, Maribor, Graz and Vienna. Also, a new branches and corridors should be added into the list of initial freight corridors (EU No 913/2010). The branches are Graz – Maribor – Zagreb – Rijeka – Koper/Trieste and Ljubljana – Pragersko – Čakovec – Nagykanisza – Budapest. Two new freight corridors should be added as well: Ljubljana – Zagreb – Sisak – Vinkovci – Belgrade and Rijeka – Zagreb – Koprivnica – Gyekenyes – Budapest.

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INTERMODAL TRANSPORT IN THE POLICY DOCUMENTS CONTEXT

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Abstract: *It is the policy analysis and policy-making processes, along with the structure and content of the resulting documents that make strategic transport planning different from one country to another. A national transport policy, as an umbrella strategic planning document, should meet multiple goals the relative importance of which changes over time. A need for intermodal solutions emerged as far back as the 1970s, and political interest in intermodal transport has grown considerably since. To promote intermodal transport has become one of the key goals in national and European Union transport policies alike. Strategic planning objectives and key elements have been analysed against the backdrop of several European national transport policies, and the summary presented in the paper.*

Keywords*: strategic planning, transport policy, public policy instruments, intermodal transport*

1. INTRODUCTION

Strategic documents for transport development constitute a prerequisite for coordinated investment activity, paving the way to the growth of a national transportation system. In different countries, however, they are named differently: (national) transport strategy, transport development strategy, transport policy, strategic plan, master plan etc. They are invariably structured differently, even if the name is the same. The differences in the structure and contents of transport policy strategic documents arise from different approaches to *strategic transport planning* (STP), but also from a regulatory framework in which policy is created, economic, social, cultural and other social divides. They are the result of the current situation, capacities and needs of transport infrastructure, institutions and human resources; the existing opportunities to define specific plans for a country's economic and social development; the potentials and interests of scientific and research institutes in the sector, but, more than anything, the priorities of the government and relevant ministry. These differences, which in principle exist in all transport modes, are also incorporated in strategic documents related to *intermodal transport* (IT).

In order to get an IT overview in the STP process, and to identify the policies and instruments the countries are using today to shape the IT sector, the transport strategic documents of more than 20 European countries have been reviewed. Three different approaches have been identified to the role of intermodal transport in those documents: (1) intermodality has been incorporated in STP as a principle (in the countries with developed IT); (2) intermodality is treated as a formal objective, and the STP is actually based on transport modes; (3) the approach

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brought into line with the EU policy, but only as a matter of convenience, most often to benefit from the EU funds.

The paper has defined and described a national transport policy as a document. It overviews and discusses the objectives and instruments of IT national transport policies in several European countries and Serbia, offering conclusions, too.

2. INTERMODAL TRANSPORT IN NATIONAL TRANSPORT POLICY

National Transport Policy (NTP) is a document adopted by the government or the parliament, defining clear objectives and general guidelines as to how to achieve them. It should be quite generic, but with clear courses of action to apply in different circumstances in the future. This is a landmark document for all parties and their strategic plans. Together with the NTP, follow-up strategic documents are the elements of a state transport policy, too. The policy instruments (laws, regulations, programmes, and actions resulting from the policy) used to materialize the policy should reflect and reinforce its purposes.

A NTP is expected to meet multiple objectives the importance of which changes over time. With a shifting focus though, problems in the field of infrastructure development topped the list of priorities in the past. Different transport modes have been considered separately. To boost efficiency, a need for intermodal solutions to make a better use of different modes of transport emerged as far back as the 1970s, but a satisfactory level of interoperability within the transport modes is yet to be achieved. The transfer process at terminal and a multilateral legal framework which is still adapted to all modes separately is just one of the typical examples.

The EU *Common Transport Policy* (CTP) has a strong impact on the NTPs of the European countries, both EU members and acceding countries. Each one of the four White Papers (1992, 2001, 2006 and 2011) defined objectives and instruments of CTP. They constantly reaffirm the integration across all modes, interoperability and coordination as key preconditions for the development of IT. Practice is still modal though, but multimodal issues are now taken into account in the process of planning. The domination of road transport and the restructuring of railways in order to increase their competitiveness will for a long time remain a challenge for all IT actors, especially in the context of a single market policy and transport as a commercial activity, based on a free choice by service users.

The challenges of IT strategic planning have been addressed in different ways, depending on strategic planning and the structure of objectives. In some cases there are explicit NTP goals, objectives and policies to be used for action, but sometimes they are incorporated in freight transport or logistics development documents. The differences are also visible in the wording of the objectives. Some are defined as general objectives, and others as specific objectives or even indicators (Table 1, Hungary: ratio of combined goods transport). Objectives as they are defined in NTP are presented in Table 1.

The vision of transport system development, along with general NTP objectives, shape the approach to strategic planning of freight transport and, therefore, IT. In some countries, the approach is still modal, with, possibly, formal commitment to IT. This is usually happening in the states that established their NTPs years before the adoption of CTP 2011, such as Slovakia (MoTPT, 2005). In the NTPs adopted shortly before or after the adoption of CTP the approach has changed considerably; freight transport is a separate issue and there are specific objectives related to intermodality. On the other hand, they usually fail to offer the explicit policies and instruments to carry out the objectives. The objectives are merely formal, like in Hungary (MoTTE, 2007) or focused on the use of the EU funds, like in Bulgaria (MoTITC, 2010). There are countries which have defined their objectives not only for different transport modes, but also for IT (Russia (MoT, 2008) and Serbia (GovSRB, 2008)).

Table 1. Overview of the NTP goals concerning intermodal transport

COUNTRY	GOALS/PRIORITIES/OBJECTIVES
Bulgaria (MoTITC, 2010)	- Development of the logistics infrastructure - Fulfilling the European infrastructure and services standards along the TEN-T axes - Assuring transparent and harmonized conditions for competition between and within the different transport modes
Croatia (MoMTI, 2014)	- Improvement of transport connectivity and coordination with neighbouring countries - Improvement of freight accessibility inside Croatia
Finland (MoTC, 2007)	- Maintaining competitiveness in logistics: The trunk network development programme and high-quality logistics services
Germany (FMoTDI, 2008)	- Avoiding journeys - ensuring mobility - More transport to rail and inland waterway - Upgrading more transport arteries and hubs - Good working conditions and good training in the transport sector
Hungary (MoTTE, 2007)	- Increasing the ratio of combined goods transport - Improve efficiency of intermodal logistic centre
Spain (MoPW, 2013)	- Boost the Spanish logistics sector as an engine of our economy - Develop an intermodal network that allows shuttling between nodes and provide complete and integrated logistics services - Maximize Spain's role as a gateway
United Kingdom (DfT, 2011)	- Leveraging short term private sector investment - Improving the longer term capacity, performance and resilience of our congested road and rail networks - Reducing unnecessary regulation; - Attracting and retaining high calibre recruits

Croatia, which adopted a NTP in 2014, defines all objectives as an intermodal list of objectives. These objectives constitute the main goal - to establish a sustainable and efficient Multimodal Transport System (MoMTI, 2014). Spain, which defines its policy both in terms of different transport modes and IT, has a more specific approach. It defines activities for all modes so as to promote intermodality, first of all through a system of stimulations and support. It favours transformation of operators of different transport modes into logistic and intermodal operators, integration of smaller operators in transport chains and strengthening of intermodal operators or expansion of their role on the European and international market (MoPW, 2005).

The countries which have been the first to abandon the modal approach, such as Great Britain, Finland and Sweden, are being focused on the analysis of transport chains, not the analysis of the condition of different transport modes. Great Britain shifted its attention to the movement of different types of goods, and now has a more active overview of the future needs, sources, objectives and influences of the flows of goods, including the key routes. It also examines the possibility of supporting the logistics. Strategic document *Delivering a Sustainable Transport System: the Logistics Perspective* (DfT, 2008), following the NTP, provides a detailed analysis of movement of goods within the national transport corridors and examines the possibility of facilitating effective movement of goods and reducing negative effects by joint efforts made by the government and economic actors. This document is followed by the *Logistics Growth Review* (DfT, 2011) including a diverse package of measures to target real barriers to growth identified by businesses across the sector - from freight transport operators to logistics users in the manufacturing, wholesale, retail, postal services and waste sectors.

Although they have a similar approach – a long distance transport development trend is to be concentrated on specific routes and transport corridors - Finland and Sweden's NTPs place a stronger emphasis on innovative solutions, exploiting the potential provided by communications technology to create an intelligent transport system (ITS). The follow-up strategic documents, Finnish and Swedish ITS Strategies (MoTC, 2013; SRA, 2010), are the first of intermodal nature in Europe. In the Finnish ITS Strategy the long-term goal is to digitize logistics.

Over the past ten years, five documents related to IT strategy, policy or other form of IT development have been produced in Serbia. The umbrella document is the Strategy (GovSRB, 2008), with a separate chapter on the development of IT. In a nutshell, at this point in the IT development an emphasis should be placed on institution building, eliminate infrastructure bottlenecks, build a terminal network and logistic centres, improve the organisation of actors in the IT chain. The role and assistance of the state are vital in this, especially in terms of funding and proper conditions for financing the IT infrastructure. Even though it came out together with a proper action plan, it remained a dead letter.

Besides the Strategy, another two projects have been carried out within the framework of IT development and terminal networks. These are IMOD X (The Project Intermodal Solutions for Competitive Transport in Serbia, 2004-2006) and The General Master Plan for Transport in Serbia 2008/2009. A strategic document no. 4 is the Serbia Intermodal Transport (G2G), dealing with the education of IT actors in Serbia. However, it's just one of the five projects, the last one, which treated a specific problem - the introduction of a Serbia-Austria intermodal train.

3. POLICY INSTRUMENTS FOR INTERMODAL DEVELOPMENT

Regardless of the approach taken to strategic planning, the different leverages used to influence freight transport are similar to one another, as well as to those used in the past. Although most countries still act based on the infrastructure investment policy, fiscal policy and encouraging a change of behaviour, there is an increasing support to training programs, new regulatory frameworks and regulatory reforms, and a tighter supervision of the enforcement of regulations. In order to give a systematic presentation of policy instruments defined in the analysed strategic documents, they have been classified in different areas of activity and followed by specified objectives and policies whose realization they have been defined for (Table 2). Such an approach gives the same importance to all of the elements of the control cycle. A minimum group of elements includes objectives and instruments, as well as indicators, which have not been addressed by this paper, while further developments should include laws, competent authorities and financing, which are indispensable in the realisation of a policy.

Table 2. Overview of the NTP instruments concerning intermodal transport

GOAL	POLICY	MEASURE/INSTRUMENT
Area of activity: **Atmospheric pollution**		
Environmentally-friendly transport	Encourage the use of rail and water transport	Continue with low duty on red diesel; zero duty on bunker fuels; tonnage tax for shipping companies; and the exclusion of electric rail freight from the climate change levy
		Financial incentives through mode shift programmes
		Increased funding for combined transport
Area of activity: **Public finance**		
Efficient public finance in infrastructure	Better accessibility	Improving and developing railway connections with other modes
		Improving inland access to major ports
	Funding as the basis for service level	Adaptation of the main rail corridors to international standards
		Equip infrastructure for multimodal interconnection with advanced ITS technologies
		Interoperability on the rail by ERTMS
		Redesign transport services funding and discontinue separate funding for modes of transport
		Facilitating access to capital for commercial investment
		Support the equipping of terminals with progressive trans-shipment technologies
		Support the establishment of public terminals
		Create conditions for the private sector to build logistics centres

Table 2. Overview of the NTP instruments concerning intermodal transport (continued)

GOAL	POLICY	MEASURE/INSTRUMENT
Area of activity: **Transport market**		
Transparent and harmonized competitive business environment	Equalize conditions of competition	Improvement of the quality/price ratio of the port offer
		Creating a national ports strategy
		Review of regulatory framework for the Freight transport in intermodal competition
	Improve conditions of competition	Completing the Restructuring of the Railway Transport System
		Ensure available information systems to plan and manage supply and demand of transport services
		Create a programme for the support of an expansion of the fleet for combined transport
		Create a programme for subsidies in the initial stage of operation of regular multimodal transport lines
Area of activity: **Transport services**		
Competitiveness in logistics	Secure qualified and professionally skilled employees	Provide funding for establishing new and innovative approaches to training
		Regular Summit on labour and education in freight and Logistics
		Invest in logistics competence and related research and development
	Improve efficiency of logistic chains	Simplification and homogenization of the existing procedure in different modes to perform administrative and customs controls
		Review regulatory requirements for all freight sectors on a regular basis to ensure that they remain appropriate
		Conduct an assessment of business logistics competitiveness in each government term
		Make logistics services available to small and middle-sized businesses
		Integrate the ITS concept of Green corridors and intermodal terminals
		Border bottlenecks elimination
		Facilitate bundling of goods flows by the agro-logistics pilot and the consolidarity programme
		Promote the implementation of electronic operating procedures and fid a way to encourage small transport operators to use electronic solutions
		Integration and improvement of existing codes of good practice in the sector of Logistics and Transport
	Intelligent logistics	Create a national Single Window System capable of processing multimodal electronic data
		Fully automated data transfer within the transport chain

4. CONCLUSION

The conclusion is that the approach, form and content of NTP documents differ significantly from country to country, as well as objectives, policies and instruments related to the development of IT in these documents. Consequently, the countries can be classified in different ways. The most obvious are the divisions into (1) the countries that have incorporated intermodality as a principle within their strategic planning; (2) the countries addressing intermodality at the level of a formal objective, while in practice transport planning remains separate for each transport mode; (3) the countries whose approach follows the policy of the EU, but only as a matter of convenience and a way to use the EU funds.

As for the countries with an insignificant IT share in the transport market and limited IT potentials, as well as the countries in transition or those in the EU integration process, like Serbia, it is vital to take into account the experiences regarding inconsistencies, the characteristics of the environment, realistic possibilities of the public administration, the genuine capacity of institutions and their potential for growth. It is unrealistic to expect the NTP to contain all the elements as defined in literature, or based on the practical experience of developed or larger states. Strengthening the economic and institutional potentials of a country

allows for the external definition of general objectives and the creation and adoption of an indispensable umbrella document. These elements should be included in the next cycle of planning and drafting a NTP. Likewise, the order of specification of elements, as well as their application, should be flexible, which will make it possible for the different elements to be added and defined in phases, in order to achieve consistency and comprehensiveness.

ACKNOWLEDGMENT

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REGIONAL LOGISTICS AND INTERMODAL TRANSPORT SCENARIOS

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Abstract: *With the continuous growth of the international trade, transportation to the hinterland is gaining ever growing importance with the aim of raising the competitiveness of ports, regions and economic systems. Stable growth in the international container flows creates the pressure on ports and terminal network in the hinterland. Seaports are facing problems of insufficient storage space, long retention time of containers and poor transport and logistics system in the hinterland. These situations generate demands for new distribution and logistics solutions in the ports hinterlands, which are based on a combination of different modes of transport and the development of multi-modal logistics systems. This paper presents the scenarios of logistics and intermodal transportation in Montenegro, with the aims of expanding the hinterland of the Port of Bar, achieving the logistics sustainability, improving the economy and efficiency of supply chain services, integrating the logistics activities and stimulating the regional economic growth.*

Keywords*: regional logistics, intermodal transport, concentration, integration, network*

1. INTRODUCTION

Logistics and intermodal transport are the key words in the development strategies of modern and developed social and economic systems of the leading countries in the world. The successful concept of logistics and intermodal transport involves the formation of logistics, i.e. intermodal transport networks with logistics centers that represent capable and modern places of connection of the various modes and technologies of transport. Logistics, i.e. multimodal transport network is largely developed in the area of Europe. There are significant terminals with the developed infrastructure of maritime, rail, inland waterway and road transportation in the region. However, in Montenegro, Serbia and the closer region, there are certain disadvantages in terms of logistics and transportation networks, which represent a real limitation for the application of the intermodal transport technologies.

The paper deals with the regional logistics and intermodal transport scenarios which would, within the economic system of Montenegro and the region, create the preconditions for the inclusion into the most important international trade and economic trends. The scenario needs to offer solutions which would support the "extended gateway" concept (Iannone, 2012), logistics susstainabillity, economy and efficiency of the supply chains, integration of the logistics activities and the economic growth of the region. In order to identify the win-win solutions, the scenarios of regional logistics and intermodal transport should be based on the fundamental

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principles of the modern logistics: concentration, consolidation, cooperation, integration, inter-modality, outsourcing, synergy, sustainable development and the quality of logistics services.

2. DECENTRALIZED LOGISTICS SYSTEM

Traditional development of regional and national economic units of Montenegro and neighboring countries has a characteristic of decentralization and spatial dispersion, without the presence of integrative institutional links. The consequence of such situation is the large number of systems, institutions, i.e. transport and logistics enterprises (distribution systems, port terminals, transport companies, forwarding and agency companies, etc.). These systems often occupy large areas valuable for the development of profitable programs, use the outdated and inadequate technology and do not offer integrated services in the logistics chain (Tadic et al., 2013). Lack of cooperation and consolidation affects the increasing number of road transport vehicles, poor utilization of cargo space, large number of empty trips, low efficiency of transport and high costs of logistics. This has a negative impact on the environment, possibility of the roads, traffic safety, consumption of the non-renewable natural resources, and it impedes the economic and social development at the sectoral, national and regional level in every way.

Existing plans and development tendencies of logistics systems, traffic infrastructure and economic entities are characterized by the decentralization from the spatial, organizational and institutional aspects. A decentralized logistics system is based on the existing system of the Port of Bar and planned road-rail intermodal terminals in Podgorica and Bijelo Polje, with the aim of developing an intermodal transport on the corridor Bar-Podgorica-Bijelo Polje-Belgrade. However, logistics centers, i.e. warehousing and distribution systems, retain the concept of decentralization or spatial dispersion in all economic regions of Montenegro (northern, central and maritime region) (Figure 1).

The concept involves the development of regional transport infrastructure and connection to the Corridor X and the so-called Corridor XI – Motorway of the Seas. Apart from the promotion of intermodal transport on the route Bar-Podgorica-Bijelo Polje-Belgrade, the construction and linkage of the road infrastructure of the regional and international significance is also planned. However, systems configuration, in the spatial and institutional terms, as well as the degree of cooperation and consolidation of flows, are not appropriate for the development of strong integrative functions between the public transport companies and the other operators in the transport and logistics market of Montenegro.

Existing and planned storage and distribution systems are in the function of the individual public and private companies, while in the spatial and organizational terms they relate to their parent companies and situate next to the production facilities, sales outlets, shopping centers, industrial areas and major traffic routes. Decentralization and the individual development programs represent a limiting factor for the overall optimization and upgrading of the warehouse and distribution systems (van den Heuvel et al., 2013; Wagner, 2010).

Logistics of the transportation, warehousing, inventory, packaging and manipulation processes is characterized by the insourcing strategy or the in-house logistics, 1PL (First Party Logistics). In the individual cases, the relationship between users and providers of logistics services is based on the traditional 2PL principles (Second Party Logistics). Due to the lack of equipment and infrastructure and the reduction of costs or investments, companies mainly leave the execution of the traditional logistics services (transport and storage) to the logistics service provider. In the strategy of the decentralized system, the logistics partnership is expected to develop at the level of the 3PL (Third Party Logistics).

3. LOGISTICS INTERMODAL NETWOR SCENARIOS

Based on trends and possible real and visionary solutions, two regional transport and logistics system scenarios are proposed (Institute of Faculty of traffic and transport engineering, 2009; Tadić et al., 2013):

- The scenario of regional concentration
- The scenario of complete concentration and integration

Plans of regional logistics encourage the economic growth (Zing et al., 2008). Concentration, collaboration, cooperation and vertical integration in the transport chain of the port hinterland, expand its catchment area and enable "door to door" services. Inland intermodal terminals take a more active role in the supply chain, leading to extended gates and extended distribution centers (Notteboom & Rodrigue, 2009; Rodrigue & Notteboom, 2009).

3.1 The scenario of regional concentration

The scenario of the regional concentration involves the integration and concentration of logistics and transportation systems in the three spatial economic regions. It is based on the development of the integrated logistic intermodal centers in all three regions, with smaller centers or terminals for the reception and delivery of goods, i.e. the development of a network of logistics centers in Montenegro (Figure 2).

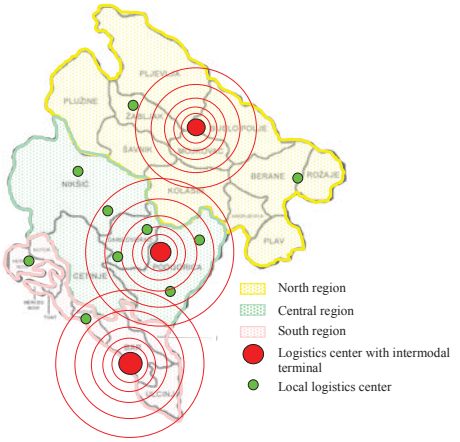


Figure 1. Decentralized logistics system

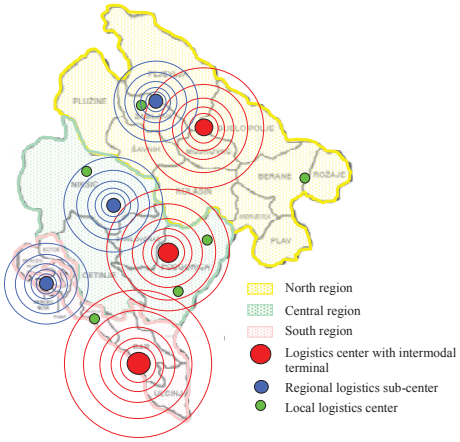


Figure 2. Scenario of the regional concentration of transport and logistics system

Podgorica, Bar and Bijelo Polje are in a function of the important intermodal terminals with a distinct aspect of the spatial centralization of logistics systems. The warehouse and distribution systems of the major companies remain at the current locations, while the logistics subsystems of small and medium sized enterprises are directed towards the concentration and location within the regional logistics centers near the developed economic centers of Montenegro. Systems with advanced technologies which will offer the high-quality logistics services will be built and developed in the area of the logistics center.

The scenario is focused on the transport corridors, intermodal transport, greater participation of the railways in the realization of the cargo flows and the development of cooperation between the transport and logistics companies and the companies from the industry, trade and other service-providing sectors in the field of logistics. In addition, scenario supports the development

and integration of large public and private transport companies with small and medium-sized enterprises and intensifies the development of the transport and logistics service exchange.

Regional concentration and development of intermodal logistics networks enable intensive development of logistics outsourcing on the 3PL level. 3PL provider has better offers, a greater number of service functions, and besides logistics activities, it performs the exchange of information, risks and benefits between 3PL providers and companies. With the aim of promoting and increasing the market share of the intermodal transport, the concept supports the development of intermodal integrators, i.e. the operators, which promote, build and manage the logistics chains. Railways of Montenegro have to identify solutions which are based on the customer requirements and which have a higher value than the services of its competitors, but also to become irreplaceable for road transport companies and freight forwarders. Through the integration and strategic partnerships with the specialized logistics service providers, railways would expand their distribution network, the volume of transport and the number of clients.

3.2 The scenario of complete concentration and integration

The scenario of complete concentration and integration of transport and logistics system fits the concept of "extended gateway", and it is based on the logistics centers of different structures, sizes and functions. The scenario involves the development of the logistics platform that integrates logistics and supporting systems and activities in a defined, i.e. arranged space, and represents a place of concentration of the transport and logistics flows. Within this platform, the functions of the dry port terminals, cross-docking terminals, city-logistics terminals, and other terminals, warehouses and distribution systems is being developed (Figure 3).

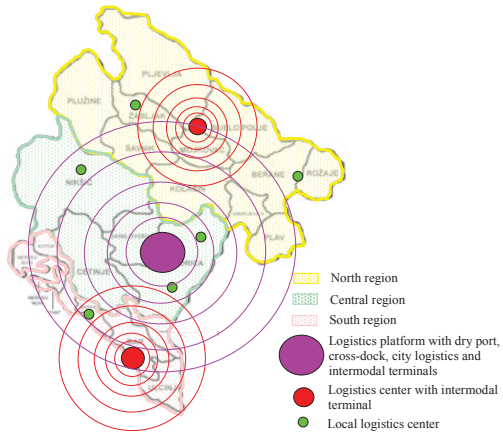


Figure 3. Scenario of complete concentration and integration of transport and logistics system

Dry port is a complex of logistical systems and activities in the hinterland of the seaports (Roso, 2008). The concept was developed in order to keep the high quality of the port services and answers to the demands of the ever growing cargo flows. Dry port terminal is located in the hinterland and connected with one or more ports by railway and/or road transport. The task of the dry port is to collect the goods for the maritime transport over long distances and the distribution of goods on the local, regional and international level. These terminals provide some additional services such as customs clearance, warehousing, packing, repacking, update data, information services etc. In the scenario of complete concentration and integration of transport and logistics system of Montenegro, the development of the dry port terminal has the function of the spatial relaxation of the Port of Bar. The terminal would be multimodal oriented and it would contain all services, facilities and equipment required by the shippers and forwarders from the

port. Port of Bar and the dry port would be the unified functional and technological system. The integration of the port and the dry port enables the "extended gateway" concept and larger share of the railways in the transport operations, thus improving the overall cost effectiveness of the entire system (Iannone, 2012).

Logistics platform may have a broader regional importance with settlement of the systems that would expand the logistics service offer with the value added service (VAL, value added logistics), such as: labeling/marking of the goods, packing and repacking, sterilization, filling, mixing, painting, final assembly, installation, Merge in Transit (MIT), etc. In the logistics center, as the point of connection, reconsolidation of the components without holding inventories is being done. This could become very profitable service concept for all freight flows which gravitate towards the countries of the region through the Port of Bar. Within the logistics platform and the Port of Bar, the cross-docking and the city logistics terminals are being developed with the primary function of centralized and integrated supply of the urban areas.

All warehouse systems of Montenegro gravitate towards the logistics centers, i.e. logistics platform in the central part of Montenegro. In spatial terms, Luka Bar relieves of the large warehousing systems and orients towards the transit-transshipment systems, i.e. cross-docking terminals, and performs the function of the city logistics. Intermodal transport terminals remain at three locations (Bar, Podgorica, Bijelo Polje), and the micro location of the logistics platform in the central part of Montenegro should be carefully defined.

Concept of the port and dry port is based on a strong transport connection, primarily by the railway, which requires the highest degree of integration between the ports and the railways. Transport by the heavy freight vehicles is limited to the connections between the terminals, and transport within the urban areas to the small and eco-friendly vehicles. The warehousing systems are fully transferred onto the outsourcing strategy. In order to reduce the required area, modern warehousing technologies and transshipment systems are being applied for certain types of goods. In relation to the existing situation, the concept of concentration provides significant savings, reduction of logistics systems and the required surfaces.

Given that scenario represents the highest level of cooperation and integration between the public and private sectors, the development of the logistics outsourcing, i.e. 3PL and 4PL (Fourth party logistics) strategies are being stimulated. In institutional and organizational terms, the port and the dry port may constitute a single unit, open to the highest level of integration with the railway of Montenegro and other public and private transport and logistics companies. The partnership concept between the 3PL and 4PL logistics service providers and the companies from the other economic fields provides multiple effects, such as the efficiency improvement, reduction of the operational, transportation and inventories costs, improvement of the technologies and the quality of services, reduction of the investment in the non-profit systems, the development of core activities of the client company, division and reduction of the risks, etc.

4. CONCLUSION

Transport and logistics system of Montenegro and the region lags behind the modern trends. The gap is not only in technical and technological, but often in the planning, organization, marketing and qualitative terms. The logistics of the region is without the necessary degree of concentration and consolidation of flows and providers of the logistics services, while the transport and traffic systems are characterized by an extremely low level of intermodal transport development. The causes are different, and they are manifested through: insufficient flows volumes, a lack of investment, poor organization, poor marketing and lack of the awareness of the importance of logistics and the application of modern transport technologies.

The described scenarios of transport and logistics system development belong to the group of solutions with which Montenegro can be placed among well-organized and planned European

countries. Application of the dry port system or the regional intermodal terminals, with the aim of connecting the port with the shippers and receivers within the region, enables the growth of competitiveness and sustainability of the multi-modal distribution in the hinterland of the Port of Bar, i.e. the development of Montenegro and the region. The proposed solutions have the elements of openness, multi-functionality, multimodality, with special emphasis on the possibility of cooperation between all forms of organization, ownership and size of the corporations that participate in the realization of logistics services. In some of the proposed solutions, the partnerships between the small and medium sized enterprises and the public and private companies may represent the most efficient form of economic, organizational, functional and technological cooperation. In addition, the development of a network of logistics centers and a higher degree of the system integration allows the expansion of the hinterland of Port of Bar.

The successful development of logistics and intermodal transportation in the territory of Montenegro and the region can be expected after adopting one of the scenarios of centralization of logistics systems. However, it is necessary to adopt and implement an integrated package of recommendations and measures related to the (Tadić & Zečević, 2012; Iannone, 2012): infrastructure policy, development of a network of logistics centers, improvement of the rail transport services, legislation, alteration of the customs processes and procedures, removal of the technical and legal barriers with the aim of fair competition in the transport market, new business models for the logistics systems integration, establishment of national associations and bodies, provision of the financial measures and support.

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THE SELECTION OF THE LOGISTICS CENTER LOCATION USING AHP METHOD

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Abstract: *The aim of this paper is selection of the most acceptable location throughout the state of facts: the ability to prove the purpose of this geographical area to form one complete and complex logistics system where the logistics center (LC) would be an interconnection between production and consumption. The multi-criteria analysis, i.e. AHP method (Analytic Hierarchy Process) was used for the choice of location. Apart from the hand calculation, the "Expert Choice" software was used for better presentation of results, as well as for their validity. Based on a set of criteria and their evaluation, then the evaluation of alternatives according to these criteria, the application of the AHP method leads to the most acceptable solution.*

Keywords*: logistics center, AHP method, location, multi-criteria analysis.*

1. INTRODUCTION

The theme of this work is chosen in accordance to the needs of the economic system of a country, and the needs of all participants in that system because, as the Germans say: "Logistics is like fuel to every economic system" and it is common knowledge that logistics centers are a key element of the entire logistics network. The functioning of the entire logistics system depends on the existence of logistics centers, which have, so to speak, the role of an "umbilical cord" in logistics, since they connect and integrate all logistics systems, subsystems, activities and processes.

German agricultural economists J. H. Thun and A. Weber are considered to be the pioneers of the development of location theory, while in terms of mathematical formulations it is believed that Ferma began the consideration of location problems. Vidović and Miljuš (2004).

From methodological point of view, a multi-criteria analysis is a systematic approach, and thus the most effective and most functional methodological approach to problem solving. Since this is a multi-criteria problem, systematic approach to its solution requires the use of methods of multi-criteria analysis to optimize the solution of the identified problem. Kovačic (2008).

AHP is especially suitable for complex decisions which involve the comparison of decision elements which are difficult to quantify. It is based on the assumption that when faced with a complex decision the natural human reaction is to cluster the decision elements according to their common characteristics. It involves building a hierarchy of decision elements and then

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making comparisons between each possible pair in each cluster. This gives a weighting for each element within a cluster and also a consistency ratio. Saaty (1980)

AHP is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales. Saaty (2008)

AHP is used extensively for decision making in the areas of management, allocation and distribution. Konstantinos (2014)

2. THE PROBLEM POSTULATE AND THE METHODOLOGY

According to Zečević (2006) development of a network of LC at national and international level is a prerequisite for optimization of transport and logistics chains. The ideal solution would be the formation of the network, where all three sites under consideration had logistics center, however, the paper discusses the selection of the most acceptable solution out of a given criteria set, because in the beginning it is very important thing to have it, if only one logistics center.

Application of a multi-criteria analysis method in solving location problems is very common and there are a number of works dealing with this issue, for example solving site selection, where more methods were applied, out of which one is the AHP, as in Yildirim and Önder (2014). AHP stands out as one of the main methods of MCDM (multiple criteria decision making), when it comes to solving approach to these problems as evidenced by Tomić et al. (2014). More recently the increasingly extended AHP method is being used, ie. fuzzy AHP whose application is solving the problems of logistics nature such as in Kayikci (2010) and Tadic et al. (2015).

The choice of the logistics center location is based on an integrated decisions and risk methodology for the selection of the best locations which involves general steps as listed below: the initial step forms a schedules collection and acceptable spatial alternatives. Step 1 defines a set of criteria for decision making, step 2 identifies the initial weight of the relevant criteria, step 3 uses the AHP as one of the techniques (MCDM), step 4 establishes a ranking list of alternatives.

One of the most relevant part of the AHP, is related with to give a structure to the problem to be solve through the hierarchy. In this phase, the decision group involved should divide the problem on his fundamental components. (Saaty 1980)

AHP consists of four steps. One, define the problem and state the goal. Two, define the criteria that influence the goal. Three, use paired comparisons of each factor with respect to each other that forms a comparison matrix with calculated weights, ranked eigenvalues, and consistency measures. Four, synthesize the ranks of alternatives until the final choice is made. Melvin (2012)

Theoretically the AHP is based on four axioms given by Saaty; these are: Axiom 1: The decision-maker can provide paired comparisons aij of two alternatives i and j corresponding to a criterion/sub-criterion on a ratio scale which is reciprocal, i.e. aji=1/aij. Axiom 2: The decision-maker never judges one alternative to be infinitely better than another corresponding to a criterion, i.e. aij $\neq\infty$. Axiom 3: The decision problem can be formulated as a hierarchy. Axiom 4: All criteria/sub-criteria which have some impact on the given problem, and all the relevant alternatives, are represented in the hierarchy in one go.

2.1. Relevant criteria

There is a number of criteria that can be studied in relation to the choice or ranking of alternatives. In order to define the relevant criteria, hierarchical structures were established, defining the group of high-level and lower-level criteria. The hierarchical structure of criteria used in this research for the choice of logistics center's location consists of 3 group criteria and 6 criteria (table 1). Criteria were chosen in accordance with the standards for defining a set of criteria to be used in solving these problems.

Table 1. The hierarchical structure of the relevant criteria

Group criteria	Criteria Level	Type
Spatial	available surface	Numerical
	Land price	
Geographic	geographical location	Linguistic
	macro-micro level of location	
Traffic	affiliation to the form of transportation	Numerical
	approach ways accessibility of transport equipment to the logistics center	Linguistic

2.2. The initial mass of relevant criteria

One of the main features of multi-criteria decision-making is that the each criteria may not have the same importance. To avoid subjectivity in the process of determining the relative weights, the criteria standardization is for the purposes of this paper, carried out by Delphi method Linstone (1975) used to identify the initial weight of the relevant criteria. The procedure for determining the initial weight was carried out in three phases, as defined by the hierarchical structure of criteria: determining the relative weight of every criteria group (g_k, $k=1..3$), determining the relative weight of every relevant criterion (c_i, $i=1..6$), corrections of relative weight of criterion with its group weight (w^i_i, $i=1..6$).

The Delphi method is based on structural surveys and makes use of the intuitive available information of the participants, who are mainly experts. Therefore, it delivers qualitative as well as quantitative results and has beneath its explorative, predictive even normative elements. There is not the one Delphi methodology but the applications are diverse. There is agreement that Delphi is an expert survey in two or more 'rounds' in which in the second and later rounds of the survey the results of the previous round are given as feedback. Therefore, the experts answer from the second round on under the influence of their colleagues' opinions. Thus, the Delphi method is a 'relatively strongly structured group communication process, in which matters, on which naturally unsure and incomplete knowledge is available, are judged upon by experts'. Häder and Häder (1995)

This research included traffic engineers, construction engineers and spatial planners, which determined criteria weighting through a survey: w_1=0.181; w_2=0.421; w_3=0.227; w_4=0.080; w_5=0.050; w_6=0.040.

3. THE SELECTION OF THE LOGISTICS CENTER LOCATION

This paper took into consideration three alternative sites: Doboj, Banja Luka and Šamac as areas that with their characteristics and geographic position are suitable places for the formation of a logistics center. Given locations are part of total number of locations, which were discussed in the study of intermodal transport for Bosnia and Herzegovina in 2008. Defined criteria are of course common to all three locations in order to make their comparison. The research represent only illustration of applying AHP method on an arbitrary set of locations for given criteria set. Hierarchical postulate of AHP method for given location problem is shown in Figure 1.

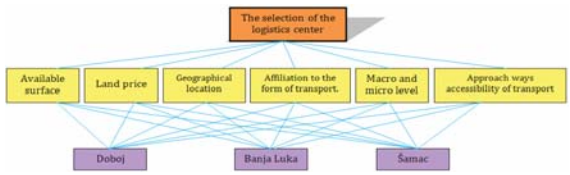


Figure 1. Hierarchical postulate of AHP method for given location problem

Comparison of alternatives in relation to the criteria on the basis of Saati 's scale Saaty (1980) is shown in table 2 where you can see their importance. For example, relation A2→A1 for K1 = 1/3 means that alternative one has low dominance compared to other alternative in relation to the first criterion.

Table 2. Comparison of alternatives per criterions

	K_1			K_2			K_3			K_4			K_5			K_6		
	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3
A_1	1	3	1/5	1	7	2	1	3	4	1	1	1/9	1	4	3	1	1/3	1/3
A_2	1/3	1	1/7	1/7	1	1/5	1/3	1	3	1	1	1/9	1/4	1	1/3	3	1	2
A_3	5	7	1	1/2	5	1	1/4	1/3	1	9	9	1	1/3	3	1	3	1/2	1

In the next step a table is formed that represents the vector of eigen values of comparing alternatives with respect to the first criterion, (table 3), which is prepared as follows: a_{11}=1/(1+0.33+5)=1/6.33=0.158; a_{12}= 3/(3+1+7)=3/11=0.273; a_{13}=0.2/1.343=0.149 etc.

Table 3. Vector of own value comparison of alternatives in relation to the first criterion

	A_1	A_2	A_3	Σ
A_1	0.158	0.273	0.149	0.58
A_2	0.052	0.091	0.106	0.249
A_3	0.79	0.636	0.745	2.171

Table ΣK represents the sum of vectors of own values and in order to commence lines normalization, sum is being divided with number of columns ie. in this case with three (since we have three alternatives):

$$\frac{1}{3}\begin{bmatrix}0.58\\0.294\\2.171\end{bmatrix}=\begin{bmatrix}0.193\\0.083\\0.724\end{bmatrix};\begin{bmatrix}1 & 3 & 0.2\\0.33 & 1 & 0.143\\5 & 7 & 1\end{bmatrix}x\begin{bmatrix}0.193\\0.083\\0.724\end{bmatrix}=\begin{bmatrix}0.587\\0.25\\2.27\end{bmatrix};\begin{bmatrix}0.587/0.193\\0.25/0.083\\2.27/0.724\end{bmatrix}=\begin{bmatrix}3.041\\3.012\\3.135\end{bmatrix}$$

To calculate the maximal mean value of comparisons' matrix $\lambda_{max,}$ matrix is to be multiplied with vector of comparisons, what was represented by the last matrix.

$$\lambda_{max}=\frac{1}{n}\sum\lambda_i=\frac{3.041+3.012+3.135}{3}=3.063;\ C_I=\frac{\lambda_{max}-n}{n-1}=\frac{3.063-3}{3-1}=0.0315$$

$$C_R=\frac{C_I}{R_I}=\frac{0.0315}{0.58}=0.054$$

R_I (random index) is taken from Saaty table (1980) on the base of number n which represents the alternative. Here we have three alternatives, ie. n=3 and random index value is 0.58. Here it is very important to mention that consistency degree C_R is 0.054 what means that the result is valid, because results are valid if this degree is smaller than 0.10.

When it comes to the first criterion, i.e. the available area for the location of the logistics center, the greatest significance has the number three alternative, ie. Šamac location because it has an area of about 40 ha, while second alternative has about 6 ha and the first alternative has about 10 ha, and so they are evaluated by the size of their fields. The method of evaluation of alternatives in relation to other criteria is the same and the results are given below.

If comparing of alternatives is done by the second criterion ie. the land price, the cheapest one is location number one followed by third location and at the end the second one. Such a sequence of results is a consequence of the position of locations themselves ie. location number two (Banja Luka) as the capital of the Republic of Srpska has, of course, the most expensive land as the result of a slightly higher standard than the rest of the entity. When it comes to location number three the land price is more expensive slightly compared to the price of the land at

location number one, primarily because it is a land along the Sava River. When it comes to the third criterion, alternative one has the best result and that is primarily because of crossing roads - road and railway. Affiliation to the form of transportation is the fourth criterion of a given location problem, and an alternative number three has the highest priority vector according to this criterion because of the location of the port of Šamac, which has affiliation to the three aspects of transport: road, rail and waterways, while the remaining two sites only have the road and rail transport. In relation to the fifth criterion location number one has the highest priority vector because it's basically a site that has such geographical location that can serve with great success in both, micro and macro environment.

After previously completed steps, result is obtained by multiplying vectors priorities obtained by mutual comparison of criteria with alternative priority vectors according to the criteria and summing up their multiplication products.

$A_1 = WK_1 * WA_1 + WK_2 * WA_1 + WK_3 * WA_1 + WK_4 * WA_1 + WK_5 * WA_1 + WK_6 * WA_1 = \underline{\mathbf{0.467}}$
$A_2 = WK_1 * WA_2 + WK_2 * WA_2 + WK_3 * WA_2 + WK_4 * WA_2 + WK_5 * WA_2 + WK_6 * WA_2 = 0.142$
$A_3 = WK_1 * WA_3 + WK_2 * WA_3 + WK_3 * WA_3 + WK_4 * WA_3 + WK_5 * WA_3 + WK_6 * WA_3 = 0.391$

Based on commenced comparison of all input data, location number one was selected. Check of methodology was commenced with assistance of software package „Expert Choice", and result is shown in Figure 2. It is obvious that the alternative number one ie. location Doboj has the biggest priority vector, when observed generally and in total in relation with all commenced comparisons, as well as in basic postulate.

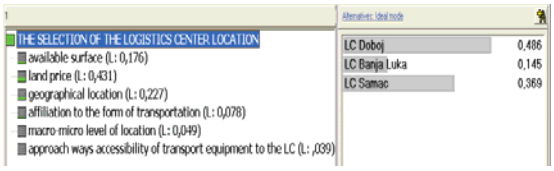


Figure 2. Final result of location selection

4. SENSIVITY ANALYSIS

The software also provides certain charts which are enabling us to perceive differences between evaluated solutions. Figure 3 makes it possible to see how the priorities of alternatives are sensitive to the weight changes of individual criteria. Increase in the weight of the second criteria (price of land - the most influential of all) causes growing of priority of the alternative number one ie. location Doboj, while priority of the remaining two locations decreases.

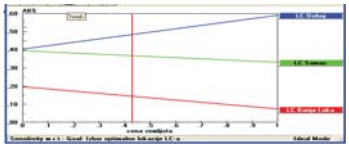


Figure 3. Gradient diagram

Figure 4. a) shows the criteria by which one alternative is preferred over the other. Selected alternatives are one and three because they have the highest priority vectors by all criteria. For instance Šamac location has the advantage when it comes to available land, belonging to the form of transport and accessibility approach of TS, while Doboj location supersedes other criteria and in the end, an overall advantage was given and highlighted in gray.

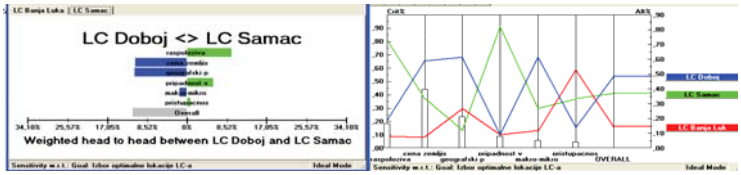


Figure 4. a) Differences diagram b) Performance diagram

Figure 4. b) shows values of alternatives per each criterion ie. per priority vector of alternatives by a single criterion. The variation of alternatives according to the criteria is clearly visible.

5. CONCLUSION

Data available during the development and the implementation of AHP as the multi-criteria analysis method, leads to solution which represents the most acceptable solution of criteria sets for the construction of the LC. It is the alternative number one in the applied method ie. location of Doboj that showed as the most acceptable for the construction of the logistics network's key element, ie. LC. Doboj as a potential location for the construction of LC has been recognized at the time of the former Yugoslavia when the top experts have made projects of LC in the territory of former republics, and among them Doboj had found its place. Then, ten years later project was re-made for the same location, which means that it is justified to construct the LC in this very much urban area.

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Part III MATERIAL HANDLING AND WAREHOUSING

COMPETITIVE ACCESS AND SERVICE ARRANGEMENTS OF CONTAINER MOVEMENTS: PORT BOTANY CASE

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Abstract: *The paper analyses New South Wales (NSW) Government role in supply chain and network efficiency as a new model that ensure competitive access and service arrangements of container movements between stevedores and transport carriers at Port Botany. The paper further analyses Operational Performance Measures (OPMs) set by the Government body that ensures that the port supply chain's stakeholders are made accountable to each other for their performance. Logistic chain participants are penalized, by paying a financial penalty to the other party, for performance that fails to meet the Operational Performance Measure (OPM) standards. The paper further analyses the impact on DP World Sydney - Port Botany container terminal operational requirements, changes of Key performance indicators (KPI) related to landside operations and strict monitoring of terminal performance, both landside and waterside, in very tight timeframe, decision making process for reallocating resources from waterside to landside operations and vice versa in order to minimize possible financial penalties or to gain financial benefits).*

Keywords*: Container terminal, Operational Performance Measures*

1. INTRODUCTION

Government role in the logistic and cargo movement task in particular shall be also focused on delivering network capacity that enables supply chain efficiency. This includes removing obstacles for achieving best practice, creating capacity and, where necessary, becoming involved in the marketplace to ensure the network operates efficiently (Ferreira, Bunker, 2003).

Cargo movement is a basic element of logistics. In New South Wales (NSW), as in most other states and areas, the cargo movement is mainly undertaken on a transport network where both the movement of cargo and the movement of people compete for space. The government primarily provides the physical network, and access to it; however there is an inexorable link between the actions of government and the performance of logistic tasks across the economy. In NSW the logistics industry accounts for approximately 13.8 per cent or $58 billion of NSW's economy; where more than 67 billion tonne kilometres of cargo is moved annually and the value of the products carried exceeds $200 billion (Transport for New South Wales, 2015).

The Government of NSW has made Freight and Ports Strategy that was released in November 2012, with aim to enhance productivity and efficiency in cargo flows realization. The NSW Freight and Ports Strategy identifies where government intervention is justified to enhance productivity and economic efficiency. Government intervention was defined in the form of the

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provision of physical infrastructure, coordination and control, market structure reforms, co-investment with the private sector, regulatory reform and other economic incentives.

The objective of the paper is to analyze the impact on DP World Sydney - Port Botany container terminal operational requirements, changes of KPI related to landside operations and strict monitoring of terminal performance, both landside and waterside, decision making process for reallocating resources from waterside to landside operations and vice versa in order to minimize possible financial penalties or to gain financial benefits.

Remaining of the paper is organized in following way. The section 2 presents landside improvement strategy and NSW government regulatory reform. Section 3 discusses operations protocols, KPI and practice of PBLIS regulations application in DP World Port Botany container terminal ands section 4 gives some concluding remarks.

2. PORT BOTANY LANDSIDE IMPROVEMENT STRATEGY – NSW GOVERNMENT REGULATORY REFORM

Port Botany is essential infrastructure asset that serve as the primary import and export gateways to NSW. NSW is Australia's largest economy and home to approximately one third of the Australia's population. Port Botany is located 12 nautical miles south of the entrance to Sydney Harbor and is well serviced by road and rail networks. The facilities at Port Botany (Figure 1) currently consist of 3 container terminals with 12 container vessel berths and 2 bulk liquids berth, container support businesses, bulk liquid berth storage facilities and private berths. The volume of containers through Port Botany has approximately doubled over the past 11 years, from about 0ne million TEU in 1999 to more than two million in 2014 (Transport for New South Wales Strategy, 2015).

Container volume growth is forecast to continue at between 5 – 8% per annum over the next 25 years (Source: Sydney Ports 30 Year Vision). Using a growth rate of 7%, the volume of containers through NSW ports will be about 11 million TEU by 2036-37 (Transport for New South Wales Strategy, 2015).



Figure 1. Locations of Port Botany container terminals

Independent Pricing and Regulatory Tribunal's (IPART) Report (IPART Report, 2008) in March 2008 highlighted an inefficiency of the landside operations at Port Botany. In response to this report NSW Government has established the Port Botany Landside Improvement Strategy (PBLIS), which is led and coordinated by Sydney Ports and now by Transport for New South Wales (TfNSW). The main goal of the PBLIS is to improve the competitive access and service arrangements of container movements between stevedores and transport carriers at Port Botany.

The PIBLIS Regulation provides performance standards relating to access by road carriers to the Port Botany Container Terminals, the performance of road carriers at those terminals and the performance of stevedores in providing services to road carriers at those terminals. The Truck Marshalling Area (TMA) has been developed as part of expansion of infrastructure in Port Botany; TMA is a component of the Operational Performance Measures framework and is fundamental to moving vehicle congestion off public roads; and to provide a safe and secure area, for early arriving trucks to be staged before they are serviced by the stevedores.

2.1 PBLIS – operational performance measures (OPMs) and mandatory standards

Operational Performance Measures (OPMs), defined in PBLIS with industry financial penalties, commenced on Monday 28 February 2011. Logistic chain participants are penalized, by paying a financial penalty to the other party, for performance that fails to meet the OPM standards. The OPM standards that are measured for truck carriers include: Early Arrivals, Late arrivals, No Shows and Cancellation of bookings (listings). The operational performance standards that will be measured for stevedores include: Minimum Number of Slots Offered per Hour, Truck Turnaround Time, Truck Non Service and Time Zone Cancellations. The OPS integrates the stevedores' processing data and truck tracking data, to provide an independent and comprehensive data record of the operations of the landside interface. PBLIS Mandatory standards cover (Transport for Wales, 2012):

- Carrier Mandatory Standards, which sets mandatory standards regarding Carrier performance in respect of access by their Trucks to the land-based facilities and services at the Terminals at Port Botany;
- Stevedore Mandatory Standards, which sets mandatory standards which apply to Stevedores in respect of the operation and provision of land-based facilities and services at their Terminals at Port Botany;
- Regulation of Charges, which regulates the extent to which a Stevedore may impose certain charges, including by increasing certain charges, in relation to the operation or provision of land-based facilities and services at its Terminal;
- Determining Certain Matters (Definitions) such as: when Truck Arrives, when a Truck joins, or fails to join, a Service Line, Truck Turnaround Time, Minimum Number of Slots.
- Records and Information, which contains directions to Stevedores regarding the keeping of records and the provision of information by Stevedores and Carriers
- Invoicing of Financial Penalties, which prescribes certain matters with respect to the invoicing of Financial Penalties payable under the Regulation.

2.2 Mandatory standards and penalties related to DP World Sydney – Port Botany Terminal

PBLIS Performance Standards for Truck Carrier and Stevedore performance standards are presented in table 1 and table 2 respectively.
Operational Mandatory Standards also include regulations, rules and definition of terms and conditions such as (Transport for Wales, 2012):

- All truck carriers visiting Port Botany are required to register their details with the Transport for NSW Cargo Management Control Centre (CMCC).
- All trucks servicing Port Botany must be fitted with an RFID truck tracking tag. This tag is used to capture the movements of each truck when in the Port Botany precinct and records arrival time, queue time, TTT, the time taken to be serviced by the stevedore.
- The Stevedore notifies the Carrier that a Container is available for collection.
- The Stevedore notifies the Carrier less than 4 hrs prior to the commencement of the Time Zone in which the Booking is scheduled to occur that the Container is no longer available for collection. The Carrier makes a Booking in respect of that Container.

Table 1. PIBLIS Performance Standards for Truck Carrier

Truck Carriers Performance Standard	Description	Industry Financial Penalty
1) Early Arrival	No trucks to arrive before booked time slot. Trucks may be accepted into the terminal at the stevedore's discretion without penalty. Truck Turnaround Time (TTT) applies from start of time zone	$100 per trip Payable to the stevedore
2) Late arrival	No trucks to arrive after booked time slot. Trucks may be accepted into the terminal at the stevedore's discretion with "Late Arrival" penalties to apply. If truck is not accepted by the stevedore then a "No Show" penalty will apply	$50 per slot Payable to stevedore
3) No show and extended late	Truck fails to arrive within booked time slot and is not accepted by the stevedore	$100 per slot Payable to stevedore
4) Cancellation of bookings	Restrictions and penalties apply to cancellation of bookings for a slot within 24 hours of the commencement of that time zone	Less than 12 hours not ice, penalty is $50 per slot. Between 12 – 24 hours notice, penalty is $50 per slot unless slot is booked by another carrier Payable to stevedore

Table 2. PIBLIS Stevedore performance standards

Stevedore Performance Standards	Description	Industry Financial Penalty
Truck Turnaround Time (TTT)	Gate In to Job Complete 50 minutes for first container plus 10 minutes per additional container	Payable to the truck carrier Increments of $25 per each 15 minutes If a truck is affected by poor terminal performance during the specified period, (for subsequent trips the same truck may be eligible for extended arrival time (up to the same number of minutes that the truck was previously delayed).
Minimum slots offered	Minimum of 50 slots per hour must be offered 24/7 (min 1200 slots per day) Stevedores have the flexibility to offer, and are currently offering more than the minimum number of slots	Stevedore is subject to inf ringement (fine) and prosecution
Truck non-servicing	Stevedore fails to service a truck that has a slot booking. Truck Turnaround Time (TTT) also applies Stevedore must provide a replacement slot within 24 hours	$100 per slot plus TTT penalties apply Payable to the truck carrier
Cancellation of time zones	Closer the stevedore gets to the time zone the more restrictions apply	Greater than two hours notice, penalty is $50 per slot Less than two hours notice, penalty is $100 perslot Payable to the truck carrier

- For each Truck that Arrives at a Stevedore's Terminal pursuant to a Booking and for the purpose of receiving Truck Services a Stevedore must perform the Truck Services in full within the applicable Truck Turnaround Time.
- A Stevedore must not prescribe a Time Zone which is less than 60 minutes.
- A Stevedore must not cancel an entire Time Zone unless it is due to an Unforeseen Event or is necessary to do so to address reasonable concerns regarding the safety of a person or persons.
- A Carrier must not cancel a Booking for a Slot less than 24 hours prior to the commencement of the Time Zone in which that Booking occurs Stevedore must immediately make a cancelled Slot available to all Carriers for Booking.

- If a Carrier cancels a Booking after the commencement of the Time Zone in which that Booking occurs the Carrier will fail to comply with the mandatory standard relating to the arrival of Trucks.
- Each Stevedore must make available no less than the Minimum Number of Slots each Hour, 24 hours a day, in respect of which all Carriers can make Bookings.
- The Minimum Number of Slots to be made available by a Stevedore each Hour must be made available by that Stevedore for Bookings at least 2 Working Days prior to the commencement of that Hour unless it has received the prior approval of TfNSW to make one or more of those Slots available for a period that is less than 2 Working Days prior to the commencement of that Hour.
- A Stevedore and, if applicable, its Vehicle Booking System (VBS) must not make a Booking, or accept a Booking, for a Container to be loaded or unloaded onto or from a Truck at that Stevedore's Terminal unless that Booking has been made through that Stevedore's VBS. VBS is a web-based online slot booking system designed for facilities to organise the receipt and delivery of shipping containers. Truck Carriers utilise the VBS to create bookings in any of the 24 Time Zones (per day).
- Each Stevedore must create, collect and retain the records and data specified OPM and each Stevedore must provide to TfNSW the records and data specified in OPM.
- Financial penalties are issued via the stevedores' invoicing process for which they are responsible. Stevedores send an invoice to truck carriers that have not met OPM standards detailing penalties they owe. Stevedores are also responsible to self-invoice for financial penalties they owe to truck carriers.
- These invoicing processes are monitored and audited under the CMCC.

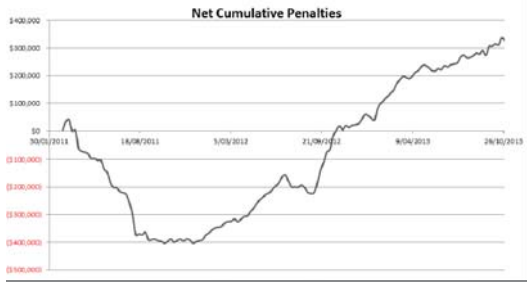
Financial penalties are issued via the stevedores' invoicing process for which they are responsible. Stevedores send an invoice to truck carriers that have not met OPM standards detailing penalties they owe. Stevedores are also responsible to self-invoice for financial penalties they owe to truck carriers. These invoicing processes are monitored and audited under the CMCC. If the CMCC find that a party has not issued a penalty, issued a penalty incorrectly or has not paid a penalty, they may be liable to an infringement.

3. DPW SYDNEY – PORT BOTANY LANDSIDE IMPROVEMENT STRATEGY FOLLOWING PBLIS REGULATIONS

In response to PBLIS regulations DP World Port Botany terminal has amended the operations protocols, KPI and practices with increased focus on landside operations and balancing and improving efficiency of both landside as well as waterside operations. Prior PBLIS regulations the terminal was not financially penalised for failing to meet expected landside performance level and during period of restricted resources availability, the focus was usually shifted to waterside operations, as the penalties would be imposed by vessel operator if vessel failed behind agreed target. Close monitoring of landside operations becomes important as penalties paid to truck carriers, as presented in Figure 2, can quickly rise to substantial amounts.

Servicing trucks within PBLIS mandatory standards is essential task for landside operation and Truck Turnaround Time is calculated for each truck based on number of containers transactions booked for the truck visit (Figure 2) and based KPI is to keep TTT below the standard.

Truck Turnaround Time is calculated under PBLIS regulation from the time truck "Queue In" at Service Line, rather than at "Gate In", to the time truck leaves the terminal - "Gate Out" time. Service Lane starts about 800m from the terminal gate and therefore DPW Sydney terminal has adjusted respective KPI that includes time truck spent in service lane outside the terminal gates.



Cont. Trans. / TTT(min)		DROP OFF				
		0	1	2	3	4
PICK UP	0		1/50	2/60	3/70	4/80
	1	1/50	2/60	3/70	4/80	5/90
	2	2/60	3/70	4/80	5/90	6/100
	3	3/70	4/80	5/90	6/100	7/110
	4	4/80	5/90	6/100	7/110	8/120

Figure 2. DP World Sydney – Net Cumulative Penalties and Mandatory Standards TTT in relation to number of container transaction per truck visit

4. CONCLUSION

The Operational Performance System (OPS) integrates the stevedore's processing data and the carriers' truck tracking data, to provide an independent and comprehensive data record of the operations of the landside interface. This allows PBLIS to comprehensively analyze the performance of the landside interface, including booking information, carrier listings, etc. The data will also be possible to view at the complete industry level or at the single operator level, across all time periods i.e. time zones, days, weeks, months or years. This information provide the PBLIS team with technical insights as to how efficiently and consistently all the components on the landside interface are performing. Then, this knowledge can be used to improve the efficiency, consistency and transparency of the landside interface (Transport for NSW, 2015).

The regulations introduced in DP World Sydney appear to continue to have positive outcomes, particularly in terms of truck turn times and carrier arrival patterns. A significant improvements are reached can easily recognized if look at trucks arrivals schedule showing that almost there is no vehicles more than 1 minute late.

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IDENTIFICATION OF CONTAINER HANDLING PROCEDURES

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Abstract: *Considering that container ships represent the most dominant transportation mode in globalized supply chain networks, the identification and protypation of effective container terminals' management processes is critical for the reliable and efficient operation of these networks. Furthermore, the identification and protypation of containers' handling procedures is a critical success factor for the development of sea transportations and especially the container transportation which is growing in global maritime business. Under this context, the purpose of this paper is two-fold: first, to identify the key container management processes, second, the appreciation of the necessary ICT systems that should be used by any terminal's management in order to provide general guidelines for establishing effective container management operations.*

Keywords*: Maritime logistics, Containers handling, Process / logistics standardization.*

1. INTRODUCTION

Improving the efficiency of container terminals (CTs) is critical for the development of effective door-to-door supply chain networks, as these constitute the start point of responsive and resilient hinterland connections. On this basis, the optimization of their operations may have significant value added effects throughout the whole supply chain. As the optimization of CT operations can be mainly achieved through the optimization of container management procedures and the employment of Information Technology (IT) systems, the purpose of this paper is to map: (i) the critical container management processes, and (ii) the necessary IT systems that should be employed by the port's management, in order to develop general guidelines for the design of effective container management operations.

2. CONTAINER TERMINAL OPERATIONS

This chapter will provide an analysis of the container management operations associated to: (i) conventional cargo containers, (ii) empty containers, and (iii) hazardous cargo containers as these are, depicted in the following Figure 1:

2.1 Conventional Cargo Container Management

The management of conventional cargo containers represents a range of 50-80% of the terminal's total operations and thus, their effective management may significantly improve its overall performance. These operations are classified into the operations associated to their exports and their imports. The operations associated to their exports are the following:

- Pre-gate recording of the truck and container's weight.

- Pre-gate confirmation of the container's shipping and customs related documents.
- Pre-gate recording of the container's export information into the Terminal's IT system.
- Physical inspection of the container (inspection of its stamp, physical condition etc.) at the terminal's gate.
- Consistent checking of whether the truck and container's identity comply with the pre-check stage.
- Indication to the truck driver, of the containers' discharge position within the terminal's interchange area according to container's size/type/height, departure vessel, weight and port of discharge (If the terminal receives however instructions from the customs office to scan the container, the container passes through the scanner first and its discharge position is then indicated to the truck driver).
- Issuance of the container's discharge and storage command and its transmission to the straddle carriers (or to other alternative equipment).
- Determination of the export container ship's berthing location at the terminal's quay.
- Development of a specific container sequence, based on the order that these will be loaded onto the ship (that is based on the Master Bay Plan).
- Weighting of the empty truck at the exit (Aqaba Container Terminal, 2015).

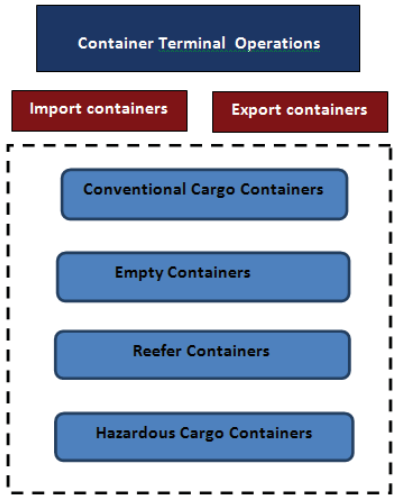


Figure 1: Container Terminal Operations

In some container terminals, its management already has preliminary information on its arrival and has thus determined its stacking position. Moreover, and If the terminal's management has instructions from the customs office for scanning, the container passes through the scanner first and is then discharged at the designated place. Specifically in the case of the container's physical inspection, and under the orders of the customs office, the terminal's staff can assist the performance of physical control (checks) of the cargo in the container. Then, the ship loading order is issued and countersigned by the customs office. The Terminal's operations associated to the import containers are the following:

- Receipt of the ship's import manifest.
- Berth allocation to the vessel.
- Discharge of the vessel's containers on the quay and further inspection of the containers in order to identify whether: (i) each container's number is correct, and (ii) its stamp is not infringed (The scanning of a container after the Customs Office's request may be performed even during ship discharge operations or subsequently.

- Electronic recording of the container's receipt.
- Generation of a delivery sequence list based on the stacking of the container in the container yard.
- Delivery of the containers to the terminal's container yard.
- In the case of partial cargo loads (groupage), their receipt is conducted by the terminal's warehouse, based on the mailing list supplied by the cargo's agent and after their inspection with respect to their brands, and their quantity stated at the bill of lading.
- After the containers' and the partial cargo are received, an "Execution Report" is formed and passed to the cargo's agent and the Customs Office.
- When the importer's agent carries out customs formalities and receives the delivery order of each container, sealed by the customs office for release, the cargo is delivered to the Port Authority.
- The importer then pays the General Port and Warehouse Rights, and an invoice is issued by the Port Authority.
- The terminal's documentation staff releases "hold" in EXPRESS for import delivery after relevant payment is cleared.
- Documentation staff updates the weight and B/L number in EXPRESS and scans a copy of B/L into a designated network share folder with the B/L number as file name.
- The truck that will receive the imported container goes through a weighbridge in order to obtain a weight ticket that shows the weight of empty truck.
- Truck driver presents its entry permit to the pre-gate staff.
- The pre-gate staff then prints a "gate pass" to the truck driver.
- The in-gate staff checks the consistency of the truck number with that on the entry permit and gate pass and makes a gate-in.
- The yard dispatcher dispatches equipment to load the import container onto the truck.
- The weigh staff will weigh the truck with the container and print the weight on the same weight ticket.
- The pre-out gate staff will check the weight of the container and compare it with the scanned B/L in the network folder.
- The truck will be sealed by Customs and its entry permit will be recorded.
- Out-gate staff will compare the truck and container number with that on the entry permit.
- Truck has to wait if it is over loaded, or else it departs (Aqaba Container Terminal, 2015).

For both import and export containers that employ rail transportation, the terminal's operations are the same as those for trucks, with the difference that we now have wagons instead of trucks. In some container terminals, after the container discharge from the ship, the port issues documents for the customs cffice and the agents of the imported containers, namely: (i) The General Act, (ii) The Notification Act for differences in seals, and (iii) The Container Interchange Report. Moreover, the Scanning of a container at the customs office's request may be performed even during ship discharge operations or subsequently. Customs-cleared containers can be shipped on trucks or can be stripped. Loading of full containers on trucks for further shipping is done on the basis of previously submitted by the agent numbers of cars. Finally, at the container release stage, the numbers and the integrity of seals are checked.

2.2 Empty Container Management Procedures

The required procedures associated to the export of empty containers are the following: In Gate – gate staff will check the container's condition, In Gate – staff will check the agent's request note and entry permit, and register it into the system, Yard staff will inform the empty container handler to unload the container to the projected position according to the line operator, the container's size and type, Out Gate – gate staff will confirm that the container is discharged, and

stamp on the entry permit. (Aqaba Container Terminal, 2015), and the empty containers will be then stored in the Terminal's empty container slots until loading on the ship. The required procedures associated to the import of empty containers are the following: The exporter sends trucks to collect the empty imported containers. The exporter's agent sends an EDI message to the Port's management indicating the number of empty containers he intends to receive. After relevant payment is cleared, the Terminal approves the empty container's release, and the yard dispatcher loads it on the transportation mode employed for its re lease.

2.3 Hazardous Cargo Container Management Procedures

Hazardous cargo can be classified to the following categories: Petroleum in accordance with Annex I of the International Convention Marpol 73/78, Gases as defined in GC Code, Noxious liquid substances/chemicals, including waste, as defined in the BCH Code and Annex II of the International Convention MARPOL 73/78, Solid bulk cargoes which exhibit chemical risk in accordance to the BC Code, Harmful substances in packaging covered by Annex III of the International Convention MARPOL 73/78, and Packed hazardous goods: substances, materials and articles as defined in the IMDG Code. The packaging and transport unit of hazardous cargo should carry warning labels, depending on the category of the cargo's risk, in order to communicate the potential dangers throughout all stages of the supply chain and thus handled accordingly. The empty uncleaned packages should be also treated as hazardous cargoes, sufficiently purged by residues of their dangerous cargo and evacuated from hazardous vapors.

2.3.1 Legislation for Hazardous Cargoes

The management of hazardous cargo should cope to the following international legislative frameworks: International Maritime Dangerous Goods Code (IMDG Code), International Bulk Chemical Code (BCH Code): International Code for the construction and supply of ships carrying dangerous chemicals in bulk, International Bulk Gas Carrier Code (GC Code): International Code for the construction and equipment of ships carrying liquefied gases in bulk, International Convention for Safe Containers (CSC Code), International Ship and Port facility Security Code (ISPS Code), International Convention for the Safety of Life at Sea (SOLAS) and International Convention for the Prevention of Pollution from Ships 73/78 (MARPOL 73/78).

2.3.2 Important Issues on Hazardous Cargoes for Port Authorities

The port authorities must be informed in advance regarding the characteristics of the hazardous cargo. Specifically, the shippers or consignees must submit the following information to the Port Authority. Specifically about: Technical name (Proper shipping name), Class and subsidiary danger, UN Number, Packing Group, Number and kind of packages, Total quantity of dangerous goods, Auxiliary descriptors such as : Marine pollutant, elevated temperature, etc. Specific information for classes: 1, 6.2 and 7, for some cargo types of classes 4.1 and 5.2 and for fumigated units (Minimum flashpoint, if the temperature drops below ≤61 Celsius, indication of uncleaned packaging that contained dangerous goods, and any information that is necessary for the safe handling of the cargo in the terminal's area.

2.3.3 General Principles for the Management of Hazardous Cargoes

The management of hazardous cargo requires the adoption of measures for its safe loading and discharge. Such measures involve:

- Identification of specific positions for the ship's discharge and loading, which further meets safety distance requirements from sites of industrial facilities, residential regions, shipbuilding areas, and any other work site that could be affected by these dangerous cargoes.

- Safe mooring of ships at piers.
- Responsive information sharing on the dangerous cargoes that will be loaded / discharged or remain in the harbor area.
- Emergency response plan in the case of an explosion, fire, and water or gas or solid dangerous goods leaks.
- Constant monitoring of the hazardous cargo storage areas along with appropriate warning signs on potential dangers.

Specific hazardous cargo classes require special treatment. Regarding explosive cargoes (Class 1) the following shall apply: 1) The explosive substances and cargo types (other than class 1.4s) should be accepted only for immediate delivery / receipt,2) Their residence in terminal's area requires special facilities, and Their loading and discharging should be: monitored by specially authorized personnel, conducted with extreme caution, made with the of use explosion-proof equipment (e.g. electric forklifts) and the appropriate workers' gear and clothing. For radioactive cargoes (Class 7), the following processes should be followed: They should be accepted only for immediate delivery / receipt, their residence in the terminal's facility, even for a few hours, requires a special storage area, which must be isolated and not accessible by unlicensed individuals and their loading and discharge should be monitored by specially authorized personnel, and conducted with care, along with the use of appropriate gear and clothing. For temperature controlled cargo, such as automatic ignition substances (Class 4.1), organic peroxides (Class 5.2), and some infectious substances (Class 6.2), the following should apply: These cargoes should be accepted only for immediate delivery / receipt and their storage in the terminal should be made in specific, specially designed areas that incorporate temperature-control devices for dealing with exceptional cases of high temperature increases.

3. IT SYSTEMS FOR EFFECTIVE CONTAINER MANAGEMENT

Effective container management procedures require the installation of Integrated Information Systems, in order to diffuse the necessary information between the terminal's staff. The most critical IT systems, as presented by Sxoinakis and Koukouloudi, (2004), are the following:

- Centralized Information Management System: This system supports the dynamic movement of data and information between the terminal's subsystems. The purpose is the collection and distribution of data between different sources.
- Official Document Filling System: This system supports the downloading process of the necessary documents for the delivery and receipt operations of containers.
- Administrative work system: This system supports the issuance of exit, loading and transit permits, the maintenance of records and the submission of customs clearance documents.
- Pricing system: This system supports the estimation, publication and management of invoices, with respect to the terminal's storage and loading/discharge rates.
- Entry/exit control system: This system supports the automatic control of containers and its vehicle using a smart card and by automatically releasing the gate after a successful cross-check of the vehicle's necessary documentation.
- Control of loading/discharging: This system supports the management of loading/discharge operations through the employment of wireless terminals, and by electronically monitoring the loading and discharge movements performed.
- Geographical information system: This system supports the graphical representation of container's movements within the terminal in real time.
- Inventory system: This system supports the electronic confirmation of the position of the container in the terminal's stowage area.
- Stowage planning system: This system supports the distribution of container's in the stowage area.

- Equipment Management System: This system supports, via wireless terminals, the stowage plan system, while passing the necessary instructions to the straddle carriers for container movements.

4. SUMMARY

Considering that container ships represent the most dominant transportation mode in globalized supply chain networks, the development of effective container terminals' is critical for the reliable and efficient operation of these networks. Under this context, the purpose of this report is to identify key container management processes, along with the necessary IT systems that should be used by any terminal's management in order to provide general guidelines for establishing effective and sustainable container management operations.

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OPERATOR SCHEDULING USING MIN-CONFLICTS AND TABU SEARCH BASED HEURISTIC IN CONTAINER TERMINALS

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Abstract: *In this paper a new approach to the operator scheduling problem in container terminals is presented. The problem is related to assigning operators to handling equipment while satisfying requirements for operators over shift and work regulations. It is considered in a case of disruption, when it is impossible to make a schedule so that all requirements for operators and work regulations are satisfied. In that situation the least bad solution is needed. For that purpose the problem is considered like a maximum constraint satisfaction problem (Max CSP) and solved by a heuristic based on Min-conflicts heuristic and Tabu search.*

Keywords*: operator scheduling, container terminals, Min-conflicts heuristic.*

1. INTRODUCTION

Resource scheduling in container terminals is a very important activity due to a great impact on the efficiency and the quality of service, and thus on the terminal business. It is especially related to scheduling of handling equipment, but also to workers (operators) who operate with them. In fact, operators are highly qualified workforce and cause a big expense for terminals. On the other hand, for the sake of their safety and safety of goods, their work is regulated by numerous strict work regulations.

Kim at al. (2004) pointed out that operators are usually scheduled after determining their number in each shift and scheduling of the operation time of the equipment. Accordingly, they defined operator scheduling as the problem of assigning the certain number of operators to time slots of equipment usage while satisfying the requirement for the number of operators in a specific time slot, various regulations for workforce utilization, and the requirements of operators for assignments. Considering that definition, the problem corresponds to a CSP and Kim at al. (2004) solved it using ILOG Solver. However, in that case the possibility of obtaining a schedule that does not meet all regulations and requirements is eliminated. Consequently, if some disruptions occur such as an unplanned operator absence or an increased workload, there would be a chance that non schedule could be made i.e. non solution could be found.

For that reason in this paper operator scheduling is considered as the problem of assigning operators to the equipment with the aim of satisfying as many requirements for operators and work regulations as possible. That means that the sum of intervals in which the required number of operators is satisfied and satisfied work regulations is maximized, where satisfying each work regulation are observed for each operator separately. According to that, the problem corresponds to a Max CSP, because its aim is actually meeting as many constraints as possible. In

order to solve that Max CSP, a heuristic based on Min-conflicts heuristic (MCH) and Tabu search (TS) is developed.

The rest of the paper is organized as follows. In the next chapter the problem is described and related literature is given. The third chapter is dedicated to MCH, whereas the fourth to the developed heuristic. The fifth chapter presents the result of the application of developed heuristic to an operator scheduling problem in the port container terminal, and the last gives concluding observations.

2. PROBLEM STATEMENT AND LITERATURE REVIEW

Environment in which the problem is considered involves the following: 1.) The handling equipment is related to machines such as container cranes, yard cranes and yard trucks; 2.) The shift is composed of a known number of one hour time slots. 3.) For each piece of equipment in each time slot is determined whether it is used or not, based on the schedule of the operation time of equipment. 4) Work regulations are the same as those in the container terminal in Pusan (Republic of Korea) and they are presented in Kim at al. (2004). They specify the minimum and maximum operating time allowed per shift (S, L), the minimum and maximum consecutive operating time (session) allowed for every operator (S_1, L_1), types of equipment that can be assigned to each operator, the minimum length of the rest period (F), necessity for the rest after a session. They also involve disallowance of assigning one operator to multiple pieces of equipment in one time slot. 5.) Given the great complexity of the problem, in this paper an assumption with the aim of the problem relaxation is introduced. It is assumed that each operator can handle any type of equipment. Accordingly, types of the pieces of equipment, which work in a specific time slot are no longer important, but the total number of them. That number represents the requirement for operators in a specific time slot.

Considering these characteristics of the problem, the input data for the problem are the total number of time slots in the shift *N*, the total number of pieces of equipment *M,* the total number of pieces of equipment which work by time slot e_i ($i = 1,2, \dots, N$), the total number of operators in the shift *R* and parameters in the work regulations. The output of the problems is the schedule that defines for each operator when and on which piece of equipment work.

It is adopted that it is equally important to satisfy every requirement for operators and work regulation, except of the last regulation that takes precedence over all others. In mathematical terms the problem consists of constraints that represent the work regulations and the requirements for operators. Here, all constraints are expressed by variable formulated as x_{ij} ($i = 1,2, \dots, N; j = 1,2, \dots, M$) whose value r ($r = 0,1,2, \dots, R$) represents the operator number assigned to time slot *i* on equipment *j* (the decision variable); and $x_{ij} = 0$ when no operator is assigned to time slot *i* on equipment *j*.

In addition to the paper (Kim et al., 2004), Legato and Monaco (2004) dealt with this problem too. They solved it for a longer period in which they determine days off for the operators, and for a shorter period in which they assign operators to the shifts, tasks and resources. However, the operating rules apply only in determining the days off, free time between shifts, etc. Murty et al. (2005) dealt with determining the number of workers by shifts in the horizontal transport processes, while respecting the rule of break during the shift. Zampelli at al. (2013) carried out the assignment of group of workers to the cranes during a specific time period. Operators group (gang) was viewed as a workforce "consumed" by the crane, except during the break period.

3. MAX CSP AND MIN-CONFLICTS HEURISTIC

Generally, CSP is a problem that involves a set of constraints and a set of variables, where each variable has each own domain of values. It is solved by using various types of search, and the

solution is found if each variable has a value and all constraints are satisfied. A CSP becomes a Max CSP if a solution which does not satisfy all constraints is acceptable. In that case the objective of the problem solving, and hence of the search, is finding a solution which satisfies as many constraints as possible. According to that, methods of local search are naturally suitable for Max CSP, because Max CSP can be considered like optimization problem with optimization objective of minimizing the number of violated constraints. Therefore, most local search algorithms for CSP can be directly applied to Max CSP, since their evaluation function directly corresponds to the optimization objective of Max CSP (Rossi at al., 2006).

Probably the best known and most widely used method of local search for solving CSP (hence Max CSP) is MCH, due to good results which are obtained by its application to the complex CSPs. Particularly good results were obtained for the well-known problems: "Telescope Problem" and "N-Queen Problem" (Russel and Norvig, 2003). It represents an iterative improvement algorithm which changes the value of a randomly selected variable located in the conflict set in each iteration. The conflict set consists of variables present in the constraints violated by the solution of the previous iteration. Each variable in the conflict set has a certain number of conflicts, which is equal to the number of violated constraints which contain a specific variable. A total number of conflicts is obtained by adding up conflicts of every variable from the conflict set and being updated along with the conflicts set after each iteration. The new value that is assigned to the chosen variable should provide a minimum total number of conflicts in comparison to other values from the variable domain. If more than one value from the domain has this feature, the choice between them is random again. The searching process is stopped when the values for all variables are found so that the total number of conflicts is equal to zero, i.e. all constraints are satisfied, or after reaching a predefined number of iterations.

Like most iterative improvement methods, MCH can get stuck in a local optimum of the underlying evaluation function; and therefore it is essentially incomplete (Rossi at al., 2006). In order to overcome that problem the rules such as “restart” or “random walk” or some metaheuristics are usually used. A metaheuristic that is often used in a combination with the MCH is TS. It help the search process escape from a local optimum by forbidding moves which take the solution, in the next iteration, to points in the solution space previously visited (hence "tabu").That is implemented by putting tabu on each new pair of variable-value, for a fixed number of iterations.

4. HEURISTIC

For problem solving, a special heuristic based on MCH and supported by TS is developed. MCH is chosen because it is generally one of the best methods of local search for CSPs, but also due to the feature that tends to provide a solution that is the least different from the initial one. This can be useful for the problem discussed in this paper if the schedule is made a day before. Min-conflicts heuristic is therefore described as a "repair" or "online" technique (Russel and Norvig, 2003).

Variable formulated as y_{ir} (i=1,2,...,N; r=1,2,...,K) is introduced for the implementation of the heuristic. Its value represents the number of constraints in time slot i which are unsatisfied because of an operator r, i.e. the number of conflicts that the operator r has in time slot i. Variable y_{ir} increases its value by one if the operator r is assigned to a piece of equipment in the time slot i, i.e. value r is assigned to one of the variables x_{ij} (j=1,2,...,M), and it causes some constraints to become unsatisfied. Also, variable y_{ir} increases its value by one if the operator r is not assigned to any piece of equipment in the time slot i, and it causes some constraints to become unsatisfied. If one of these constraints relates to the last regulation it is defined that the corresponding variable y_{ir} enormously increases its value. Hence, it is impossible for it to be violated in a solution. Therefore, the number of conflicts of each value r in each time slot is considered in this case, and not the number of conflicts of each x_{ij} variable. This is done due to

the fact that all constraints regulate operators work in time, and it is easier to make algorithm of the heuristic with variable defined as y_{ir}.Though, in this way a slightly deviation of MCH is made.

Because of using TS, variable formulated as a_{ir} (i=1,2,…,N; r=1,2,…,K) is also involved in the heuristic. It demonstrates the value of tabu for the corresponding y_{ir} variable. The value of tabu is assigned to a_{ir} variable when one of the variables x_{ij} (j=1,2,…,M) obtains a new r value. Due to that, the number of conflicts that the operator r has in the time slot i is not considered during the next iterations whose number is equal to the value of tabu.

The end of heuristic consists of several steps which attempt to improve the best solution obtained by the part of heuristic based on MCH (if there are conflicts). It is performed through exchanging positions (pieces of equipment) between an operator r that causes conflicts in a time slot with other operators who also work in that time slot. This part is introduced because the previous implies only changing a chosen value r. However, it may only be needed to replace that value with the corresponding value from the same time slot, in order to avoid conflicts.

The algorithm of heuristic is presented in the following subsection. It involves 16 steps, where the part for improving begins from the step 11. In order to facilitate its explanation, three matrices **X**, **Y** and **A** are introduced. The matrix **X** (*NxM*) contains values r of the variables x_{ij} and represents a solution of the problem in an iteration. Matrix **Y** (*NxK*) contains values of y_{ir} variables. The sum of the values of all y_{ir} variables represents the number of conflicts that a solution **X** has, and at the same time the value of the objective function in the heuristic. Matrix **A** (*NxK*) contains tabu values that are related to y_{ir} variables, i.e. values of a_{ir} variables. In addition to the matrices, the sets I = {1,2 ..., N}, J = {1,2 ..., M} and R = {0,1, ..., K} are also introduced.

4.1 Algorithm of heuristic

1.) Set the *global minimum* on a sufficiently big value (bigger than the maximum number of conflicts), equate the *iteration number* to zero and define the tabu value and maximum number of iterations. Assign value from the initial solution to each x_{ij} variable, or zero if the initial solution does not exist, remember that set of values (matrix **X**) as the best solution. Go to the next step.

2.) Increase the *iteration number* by one. If the *iteration number* is smaller than or equal to the defined maximum number of iterations then go to the next step, otherwise go to the step 10.

3.) Calculate values of all y_{ir}variables. Set the *number of conflicts in iteration (nci)* = maximum (maximum > the maximum possible number of conflicts) and go to the next step.

4.) Among y_{ir} variables choose the one which has the biggest value (let it be variable $y_{\boldsymbol{ir}}$), for which the corresponding variable $a_{\boldsymbol{ir}}$=0. If there are more than one such variable, choose the first and go to the next step.

5.) Find variables x_{ij} ($j = 1,2, \dots, M$) which have the $\boldsymbol{r}$ value. If none has that value go to the 6a step, otherwise go to the 6b step.

6a.) For each variable x_{ij} ($j = 1,2, \dots, M$) check how many conflicts would have a solution if the $\boldsymbol{r}$ value would be assigned to that variable. Assign the $\boldsymbol{r}$ value to the variable for which the solution has the smallest number of conflicts (let it be $x_{\boldsymbol{ij}}$ variable). If that number of conflicts is smaller than the current value of *nci*: remember $x_{\boldsymbol{ij}}$ variable and the $\boldsymbol{r}$ value as its *new value*, forget the previously remembered and its *new value*. Go to the step 7.

6b.) Choose the first x_{ij} variable which has the $\boldsymbol{r}$ value (let it be $x_{\boldsymbol{ij}}$ variable). For each value $r_1 \in R \setminus \{\boldsymbol{r}\}$, check how many conflict have a solution if that one would be assigned to $x_{\boldsymbol{ij}}$ variable. Assign the r_1 value for which the solution has the smallest number of conflicts to the $x_{\boldsymbol{ij}}$ variable (let it be the $\boldsymbol{r_1}$ value). If the solution with a smaller number of conflicts than the

current value of *nci* is reached: remember that number of conflicts as a new value of *nci*, remember x_{ij} variable and the $\boldsymbol{r_1}$value as its *new value,* forget the previously remembered and its *new value*. Go to the step 7.

7.) If there are still some y_{ir} variables which should be checked (which have the same value as the previously checked y_{ir}, and for which the corresponding tabu values are equal to zero), choose the next and go to the step 5, otherwise go to the next step.

8.) Assign the *new value* to the remembered x_{ij} variable. Update matrix **X**. Mark the y_{in} variable as tabu, i.e. assign the tabu value to the a_{in} variable, where *n=new value.* Update matrix **A** and go to the next step.

9.) In the matrix **A** decrease each value bigger than zero, by one. If the value of *nci* is smaller than value of the *global minimum* then: set the new value of *global minimum* to be equal to the value of *nci*: forget the previously remembered best solutions and remember the matrix **X** as the best solution. If the value of *nci* is equal to the value of the *global minimum*, remember the matrix **X** as the second found best solution. Return to the step 2.

10.) If *global minimum*=0, mark the first best solution as final and go to the step 16. Otherwise choose the first best solution and go to the next step.

11.) Choose the first y_{ir}variable which has the value bigger than zero (let it be y_{ir} variable) and go to the next step.

12.) Among x_{ij} variables ($j = 1,2, \dots, M$) find the ones which have the $\boldsymbol{r}$ value, choose the first (let it be x_{ij} variable) and go to the next step. If there are no such variables, go to the step 14.

13.) Check the total number of conflicts which is obtained by replacing values between variable x_{ij}=$\boldsymbol{r}$ and every second variable x_{ij_1}, ($j_1 \in J \setminus \{j\}$). If one of the replacements provides solution which has the total number of conflicts smaller than the value of the *global minimum*: set that number of conflicts as value of the *global minimum;* carry that replacement out; Update the matrix **X**; forget the previous improved solution and remember matrix **X** as the improved solution. If the value of the *global minimum* is equal to zero, mark the improved solution as the final and go to the step 16, otherwise go to the next step.

14.) If there are still some y_{ir} variables with values bigger than zero, choose the next and go to the step 12. Otherwise go to the next step.

15.) If there are still best solutions, choose the next and go to the step 11. Otherwise, mark the improved solution as the final one, if exists, and go to the step 16. If does not exist, mark each best solution as the final and go to the next step.

16.) Finish the algorithm.

5. EXAMPLE

Problem selected for the example is similar to the solved one in Kim at al. (2004). It differs only in the number of pieces of equipment which work in the last time slot. It is set that three of them work instead of two. Before its solving with the developed heuristic, it was checked whether it can be solved as a CSP by using Microsoft Solver Foundation (MSF). A Constraint Programming Solver within MSF did not manage to solve it, which means that there isn't any solution that meets all constraints. Solving the problem as a Max CSP, using the developed heuristics in the Visual Basic environment, the solution with one conflict, i.e. one violated constraint is obtained. It refers to the work regulation that regulates the minimum number of consequent time slots which an operator has to operate when starts. The solution, together with the problem parameters, is given in Table 1. In the solution the numbers are referred to the operators, the columns to the pieces of equipment, whereas the rows to the time slots. The underlined number

indicates the operator who violates the regulation, i.e. the r value which generates the conflict. Therefore, the operator three violates the regulation by working on the second piece of equipment in the sixth time slot.

Table 1. Example of the problem with solution

Problem parameters	Search characteristics	The solution
N=6, M=4, K=6, tabu=25,e_1=3, e_2=4, e_3=4, e_4=3, e_5=4, e_6=3, L=4, S=2, L_1=3, S_1=2, G=1, F=2;	The smallest number of conflicts reached during the search: 2; Total number of solutions with the same number of conflicts: 8; They occur in iterations: 120, 165, 175, 477, 584, 974, 1040, 1128; The final solution is obtained through improving the third best solution and has one conflict.	1 4 3 0 1 4 3 6 5 2 3 6 5 2 0 6 5 2 1 4 0 3 1 4

6. CONCLUSION

Using the new approach, the operator scheduling problem in container terminals is considered as Max CSP. In order to be able to solve it, the heuristic based on MCH and TS is developed, which is therefore the major contribution of this work. In this way it is ensured that the problem has a solution in a situation when it is not possible to meet all work regulations and requirements for operators. That solution has the smallest number of unsatisfied requirements and regulations, which can be found by the heuristic. Also, in this way the approach used in Kim et al. (2004) is extended. The problem could be also solved as a Weighted Constraint Satisfaction Problem (WCSP) by using the developed heuristic. It would only require defining a larger number of conflicts for the violation of constraints related to the more important regulations and requirements. Although it is not applied here, this option would very likely be useful in the real life conditions.

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POSSIBILITY OF APPLICATION OF REMOTE CONTROLLED ORDER-PICKER FORKLIFTS

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Abstract: *Warehouses and warehousing processes, as a significant component of the supply chains, are places where the possibilities of rationalization are being continuously explored. Order-picking, that generates main warehousing costs, is an especially interesting process in terms of rationalization. As such, order-picking is a subject of permanent research in the field of development and use of equipment, design, management, optimization, etc. One approach to this goal is increasing the productivity of the workforce by using remote controlled forklifts in the manually realized order-picking process in order to reduce order-picker's engagement time. This paper gives an overview of this technology with the evaluation of potential points and the level of savings in order-picker's labor time for a set of typical order-picking tasks.*

Keywords*: warehouse, order-picking, remote controlled forklift*

1. INTRODUCTION

With the aim of time rationalization of order-picker engagement, different kinds of more or less efficient solutions in the technology domain are present, applicable for the purpose of rationalization of elementary order-pickers' activities. Some of them are related to: technologies of receiving/sending of information about ordered SKUs (Stock Keeping Units) to be picked, selection of order-pickers' routes, determination of picking locations, technology/place of picked SKUs put off, etc. [1].

Although the spectrum of applied order-picking technologies is very wide, [2, 3, 4], in praxis solutions based on the method „man to goods" are mostly dominant. Also, in this method so called „low-level" principle is the most applied – so that the zone of picking goods is in ergonomically suitable area available to order-picker while moving through of the floor of the warehouse area [1]. This is very important during labor-intensive activities, where huge number of ordered SKUs have to be picked in short time window. This type of tasks require significant activities of order-pickers, where order-pickers' traveling time has the greatest share (5). Therefore, the moving phase is one of the focuses of research of rationalization possibility of order-pickers activities, and this paper presents one of the possible approaches with this aim, based on new technology – by use of remote controlled order - picker forklift (OPF).

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Having that in mind, this paper consists of several sections. After introduction with problem description, the second section shows short review of the most applied manual order-picking technologies with the analyze of the time structure of order-pickers' working cycle. The third section presents the characteristics of the new technology based on the appliance of OPF: it includes work principle, time working structure and difference between this and the technology of AGV system. The fourth section gives review of potential effects through overview of important measurers – possibilities of time savings, advantages and disadvantages of appliance of this technology. In this section, some effects of the use of the new technology are presented. The conclusion gives consideration of up-to-day, relatively small experiences in this area, as well as discussions about potential researches related to the use of OPF in the order-picking processes.

2. BRIEF OVERVIEW OF TYPICAL MANUAL ORDER - PICKING TECHNOLOGIES

Regardless of high level of the development of techniques and technology in logistics processes, about 80% of the activities in the domain of order-picking technologies are based on manual work. By rule it is the consequence of the frequent adjustments to the request changes of order-picking by different kinds of parameters (type of goods, logistics unit type, order pattern, etc.), when sophisticated technologies require significant time (and costs) to adapt to the new characteristics of requests.

We can see several various categorizations when we speak about manual order-picking technologies [1, 6]. The most common technologies are based on man (order-picker) movement with the transport means (forklift or carts with or without motor drive) along aisles within order-picking area (Figure 2.1). In this paper, technology OPF presented on the Figure 2.1.c is analyzed.



a) b) c)

Figure 2.1. Some examples of the manual picking technology with different transport means

Order-picker moves to the predefined picking location, where he (by rule) steps of from the OPF and walks to the picking location, picks requested number of ordered SKUs (Stock Keeping Units), moves with goods to OPF and put them on pallet that is on OPF. The mentioned process is being repeated until the completion of the order or the fulfillment of the OPF's capacity; afterwards picked SKUs are dispatched to the location of further activities realization (eventual sorting, packing, etc.). By analyzing order-picker's work in this technology, we can see that upon defining (and receipt) of picking order-list, the order-picking task on one location consists of following set of typical elementary activities:

1. Receipt of information of picking location of ordered SKUs,
2. Order-picker's stepping on (if required) on the OPF,
3. Activation of the OPF's moving,
4. Moving the OPF with order-picker to the required location and the OPF's stopping and securing,
5. Order-picker's stepping off from the OPF,
6. Order-picker's moving from the OPF to the required SKUs' location,

7. Searching/identifying and picking of the ordered SKUs,
8. Order-picker's carrying the SKUs to the OPF and put them on the OPF,
9. Confirmation of task realization for required SKUs.

During working time, these activities are being repeated for each picking location. Considering specificities and repetition of these activities, the distribution of order-picker's engagement time in this technology was the subject of the whole range of analyzes ([3, 5, 7]). According to these sources, the most dominant participation in the order-picker's time work structure is walking/movement time (app. 50%-60%), while the searching and picking time of the SKUs participates with 20-25%. Therefore, possibilities of rationalization of this time movement were the primary area of researches. The following section gives the overview of some of the appliance of the remote controlled OPF technologies, since they provide achievement of mentioned goal.

3. SPECIFICITIES OF REMOTE CONTROLLED OPF TECHNOLOGIES

Development of remote controlled OPF technologies had the goal of the elimination or the rationalization of some of the partial times of typical elementary activities. The primary idea is based on the elimination of order-picker's time for stepping on/off the OPF as well as giving the appropriate associated commands for vehicle guidance (activities 2, 3, and 5, and partially activity 4 described in Section 2). The developed solutions based on the two primary principles of giving orders for the OPF movement (i) by the order-picker, and (ii) by WMS, will be presented in details in following chapters.

3.1 Orders for OPF movement with active order-picker's participation

The principle of this technology is based on the activation of the appropriate buttons by the order-picker. Given order (start, turn, stop) is transferred to the OPF via radio-connection. This technology has several solutions and two of them are presented as follows.

a) OPF remote unit bonded around order-picker's hand by the strip

The order-picker receives information related to the next picking location (OPF stop) based on the order-picking list. By pressing the appropriate button on the remote unit (Figure 3.1.a, www.still.de; named *"iGoRemote"*) desired order of the OPF is activated.



Figure 3.1.a – Overview of the remote unit bonded around order-picker's hand

It is necessary to note that the order-picker's hand activities can be partly reduced using this alternative, since the remote unit requires significant attention and higher level of hand's use.

b) OPF remote unit on the order-picker's glove

The order-picker receives information related to the next picking location (OPF stop) based on the order-picking list. The option with this remote unit is in the form of glove (Figure 3.1.b, http://video.tdcols.com/video/g_-V31UL4Ww; named *"Crown's QuickPick™"*). By pressing the appropriate button, desired order of OPF is activated, with the possibility of sound signal as well.



Figure 3.1.b – Overview of remote unit in the shape of order-picker's glove

In this technology, the freedom of the order-picker's hand activities is on the higher level compared to the alternative a), since the orders for the OPF require less attention and less order-picker's usage of hand. Also, greater freedom of hands usage during picking and putting off activities is achieved.

3.2 OPF remote control by WMS, without active order-picker's engagement

In this alternative, the applied WMS has double role: controls OPF and transfers instructions to the order-picker using *pick-by-voice* technology (Figure 3.2, http://video.tdcols.com/video/g_-V31UL4Ww; named *"Pick-n-Go"* by Toyota (BT)). Based on the WMS instructions, OPF moves to the location where the SKUs have to be picked and stops there. Order-picker receives information related to the picking location and the number of the ordered SKUs via headset, pick them and walk with items, putting them on the OPF. By voice – over microphone and communication system – WMS receives information related to the realization of the task for ordered SKUs. Based on it and according to the fulfillment of the order, WMS sends instruction to the OPF about the next picking location, order-picker's decides about the mode of movement (on OPF, or by foot behind it).



Figure 3.2 – Overview of OPF remote control using WMS

This technology influences a range of significant factors which increase the order-picker's productivity: complete freedom of hands; with the option of OPF with lifting forks, WMS additionally provides pallet unit lifting on ergonomically optimal height level for SKUs putting on; using AGVS elements increases work safety with the OPF, by using a lot of sensors/detectors

for noticing obstacles on the path, sound and light signals, etc. – this is very important on the transport paths/aisles/corridors in the order-picking area where the presence of people, vehicles, goods and equipment is very significant; WMS using AGV system provides elimination of order-picker's work related to movement to the OPF and driving to the disposal place of pallet unit when the order is completed.

4. POTENCIAL EFFECTS BASED ON APPLIANCE OF REMOTE CONTROLLED OPF

The influence of the presented technology on time reduction of the elementary activities of the order-picker (see Section 2) is shown in Table 4.1. Thereby, the estimations are given by authors, compared to the conventional technology.

Table 4.1 Level of the applied technologies' influence on the time reduction of the realization of the order-picker's elementary activities

	Technology	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9
1	3.1.a	○	+++	+	++	+++	+	-	++	○
2	3.1.b	○	+++	++	++	+++	+	○	++	○
3	3.2	○	+++	+++	+++	+++	+	+	+++	○

Legend: - unfavorable influence; ○ no influence; + small influence; ++ medium influence; +++ great influence

The available sources from companies-producers are used since, according to our knowledge, there are no expert papers which have explicitly analyzed this technology and potential effects of its appliance. By analyzing the available sources of several producers (Still, Crown, Toyota (BT)) potential effects which might result can be classified in several groups:

Time savings are mentioned as primary achieved effect – according to the data published in companies' materials, time of order-picker's movements is reduced up to 70 percent by the elimination of the range of the unnecessary movements, orders for the OPF operations etc.;

The reduction of the traveled path of order-picker with load – which results with less workload of order-picker, and thereby with the increase of the quality level of the basic processes realization;

The decrease of potential injuries and professional diseases – by the reduction of stepping on/off OPF at picking locations, effects can be expected in the decrease of workers' injuries/diseases, having in mind the extent of these activities during work (i.e. for several years);

Preconditions for working environment with higher order-picking density are achieved – in paths/aisles/corridors of order-picking area, it is possible for more order-pickers to work at the same time with OPF; the risk of injuries of workers and/or goods and equipment damage (due to activity density) are being reduced/eliminated by applying OPF equipment mentioned in previous Section;

Flexibility – when required, it is simple to move from semi-automatic/automatic to manual control of OPF;

Cost-effectiveness – The increase of the productivity and the decrease of the energy consumption have influence on cost-effectiveness and ROI to this technology can be expected in relatively short time period.

In less extent, some of described technology appliances can be met in praxis. Most of them outline general positive impressions and conclusions which imply to the favorable results/effects of the appliance that cannot be presented in this work due to limitations.

5. CONCLUSION

By analyzing presented technologies, it can be concluded that these are new solutions without significant experiences in praxis. Mentioned manufacturers state their observations, especially the ones referring to the range of favorable effects. It is clear that these states should pass theoretical and practical audits, having in mind series of specificities related to realistic tasks of order-picking, staff educations, appropriate information system support and others. However, potential effects of this technology are very interesting for warehouse system designers and it is required to have these technologies in mind when developing alternative technological concepts of order-picking subsystem(s). Therefore, it is necessary to perform series of research in this area, which can be related to the theoretical as well as to the practical aspects. Some of them might refer to the work and time studies in different environment/conditions (type of goods, orders' patterns, path conditions, etc.), the analysis of the specific strategies for goods assignment appliance, the use of additional devices and equipment on OPF and etc. That way, the more qualitative bases for decision-making in logistics' system design would be acquired, and through them, support for more qualitative level of supply chain solution.

ACKNOWLEDGMENT

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ST MODEL IMPLEMENTATION ON SHORT TERM OPERATIONS' PLANNING AT BULK TERMINALS

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Abstract: *This paper focuses on a bulk terminal short term operations planning problem faced by the port management in tactical decision making. Loading and discharging of ship cargo, cargo stocking, maintenance and service of facility equipment are regular operations of a sea port's bulk terminal. Their organization is subject to difficult-to-predict or unforeseen influences. The challenge that port management faces in day to day operations is in making the best possible plan with scheduled duration of operations/states and transition instants, considering various internal and external factors influencing terminal performance. A states and transitions model is used to derive effective solutions for obtaining states order and states transition time of a bulk terminal, with the objective of minimizing operational costs. Behavior of the terminal is tested with stochastic and deterministic methods.*

Keywords*: operations planning, sea terminal, general systems theory, stochastic modeling*

1. INTRODUCTION

Our understanding of the traffic phenomenon is based on empirical researches and verbal description of traffic systems. The core concept of a systemic traffic theory is not presently available in unified and formalized form. The field of traffic science and technology is extremely broad one, encompassing many different disciplines and activities, thus the unification seems impossible without application of general systems theory and methodology. The partial use of system's theories in major part of traffic literature has been only a superficial description without precise formulations derived from concept of general or generalized system. On the other side, classical analytic approach with bounded discipline-oriented researches, use their own theoretical concepts and methodologies.

Radmilović (1989) presents functioning of port facilities with discrete Markov processes and proposes the application of the model with system of differential equations, which describes technological processes of direct and indirect trans-shipment of the cargo. Radić and Bošnjak (1997) give the concept of the generalized traffic model using general system theory methodology, and derive equations from ST-diagram for stationary behavior of the subsystem. Kia et al. (2002) explore port capacity under a new approach by computer simulation. Asperen et al. (2003) propose a possible way of modeling ship arrivals in ports.

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The major objective of port operations planning is to diminish port vacancy, thus minimizing operational costs, while assuring that the service rendered to ships is in line with widely accepted standards.

Even though the wide range of planning problems within the shipping industry received significant attention from researchers so far, as in Cullinane et al. (2009), there are still problems that have to be addressed, i.e. port operations planning under uncertainty. The problem of optimization under uncertainty exists in bulk terminals too, but is of a somewhat different character, see Hess et al. (2007), Hess and Hess (2010). The limited storage capacity and facility output necessitate planning of terminal operations to prevent storage overflow and unoccupied terminal capacities.

This paper focuses on terminal behavior understanding and addresses the question whether terminal operations show deterministic or stochastic behavior. The major contribution of this work is in determination of the states and transitions model (ST model) for bulk terminal behavior observation which is based on comparison of deterministic states and transitions (DST method) and stochastic states and transitions (SST method). Worksheets of bulk terminal of Bakar port in two years period (2013-2014) are analyzed. Contribution is in conclusions on which method better fits real example. Finally, practical extensions are outlined.

2. GENERAL SYSTEMS THEORY APPLIED TO THE PORT

2.1 Fundamental traits

Highest-level generalization is axiomatic, mathematical theory of traffic system. On that level, fundamental traits and relations must be derived from a concise formal definition of traffic system. Collection of concepts and definitions for fundamental traits of system are given in Klir (1972). The general systems theory is applied in the state system analysis, forecasting and planning development of dynamic systems, in selection of optimal or at least satisfying managing actions and decisions. The state and the transitions between the states will be identified, along with the scheme (ST-diagram) on the basis of which the mathematical model is derived. Through the proposed model one can observe time varying port system operation.

Five definitions, each based on a separate trait are defined by Klir (1972). Each verbal definition is followed by a mathematical definition, the two indicated as (a) and (b). Definition 4 and definition 5 of a traffic system (Radić and Bošnjak, 1997) are as follows:

Definition 4.

a) A traffic system is a given set of elements, their permanent behaviors, and a set of couplings between the elements and between the elements and the environment.

b) A system is 2-member set (B, C), where: $B = \{b_1, b_2, \ldots, b_r\}$ is the set of all permanent behaviors of elements of the universe of discourse and $C = \{c_{ij} \,|\, c_{ij} = A_i \cap A_j; i \neq j\}$ is the set of couplings between the set of input quantities A_i and the set of output quantities A_j.

Definition 5.

a) A traffic system can be defined by its hypothetical (known) ST-structure as a set of states and a set of transitions between the states.

b) A system is a 2-member (S, $R(S, S)$), where: S is the set of states; R a relation defined on (S x S) or a system is 3-member (S, $R(S, S)$, $P(R)$), where: $P(R)$ is a probability measure defined on R such that if $(s_i, s_j) \in R$ then $P(s_j \mid s_i)$ is conditional probability of transition from state s_i to state s_j.

A minimal definition of system would have to be one of the basic definitions.

2.2 The universe of discourse and couplings of the port system

According to the Definition 4, set of all the elements and their links in the system "serving ship at quay" is shown by the UC-structure (Fig. 1).

The elements of the system "serving ship on quay" are:

- the ship (S) – the object to which the activity is directed,
- the quay (Q) – the element quay does the loading/unloading operations of the ship,
- the centre for organization the technological process (COTP) – organizes, coordinates and controls the transshipment process, does the paper-work regarding the cargo, gives possibilities for obtaining the different statistical data, transacts invoice.

The links between the elements of the system are as follows:

- L_0 – initiation – puts the system in the active state, and starts with the ship arrival at the quay,
- L_1 – two-headed arrow between the elements S and COTP, serves for informing the COTP on ship arrival and for acknowledgment transmission, and for additional communications between the S and the COTP,
- L_2 – two-headed arrow between the COTP and Q, is represented by the communication channels with purpose to coordinate the loading/unloading operations,
- L_3 – two-headed arrow between the elements S and Q, is represented by the communication channels intended for the communications between the S and the Q,

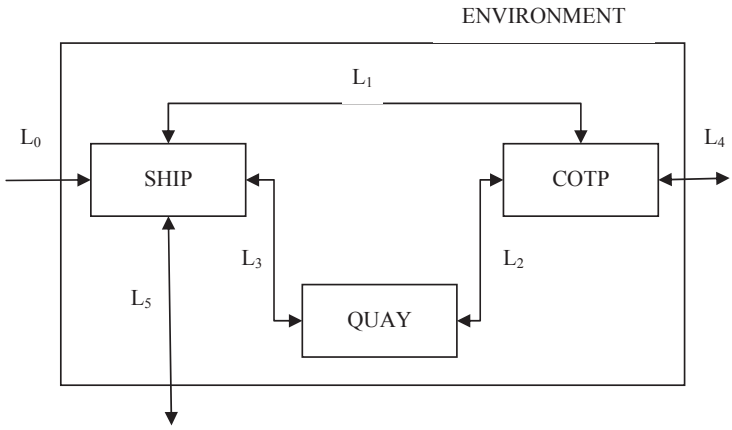


Figure 1. UC-structure of the system serving ship at quay

- L_4 – two-headed arrow between the COTP and the environment, serves for the COTP to communicate with the meteorological service, the agents, forwarders, land carrier, air and river carriers,
- L_5 – two-headed arrow between the ship and the environment, and serves for the communication between the ship and the agents, forwarders, meteorological service, and so on.

2.3 The states and transitions between states of the port system

The set of states and transitions between these states (Definition 5) for the system "serving ship at quay" is presented by the ST-structure (Fig. 2 and Fig. 3).

3. THE MODEL

The objective of the paper is to identify the particular state in which the bulk terminal will be in a given moment in the future, starting from assumption that in the beginning it was in idle state and that states' switching occurred with designated transition probabilities. The main goal is to answer the question whether the observed bulk terminal behaves as a deterministic system, i.e. according to the logical terminal's operation flow, or as a stochastic system, meaning that the influences causing state transition disorder are not negligible.

Two approaches in quantifying the state transitions are examined. The first consists of setting up a system of differential equations for terminal operations with assumption that the terminal has discrete states expressed with probabilities. The second approach, by defining the bulk terminal operations as Markov processes and setting up matrix of transition probabilities, yield state probabilities and lead quickly to acceptable solution of ST model that is essential for any practical application, Hess and Hess (2010).

The states of the ST model of terminal operations are:

- S_1 – idle state (no operations on the terminal except data processing, i.e. collection and analysis of weather reports, cargo/ships related information)
- S_2 – preparatory state (operations carried on the terminal just before ship arrival, i.e. preparation of facility/cargo/longshoremen for cargo operations)
- S_3 – transshipment state (cargo loading and/or discharging; from economical perspective the most desirable state of the terminal)
- S_4 – closing state (operations immediately after finish of ship loading/discharging, i.e. paper-work, ship departure operation)
- S_5 – repair and maintenance state (regular maintenance of equipment, repair in case of machinery breakdown).

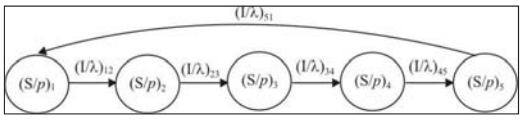


Figure 2. ST-structure of deterministic terminal behavior

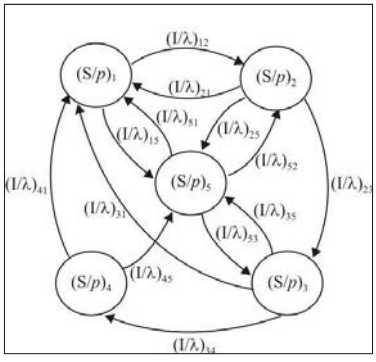


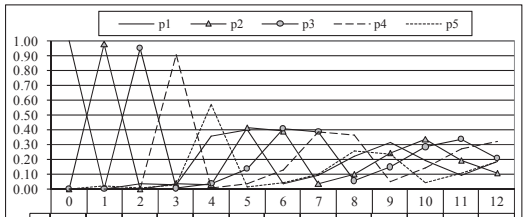
Figure 3. ST-structure of stochastic terminal behavior

A terminal has deterministic behavior if order of states and their durations are exactly known in advance, Hess et al. (2008). In DST method the set of states and transitions between these states

for a bulk terminal is formed around ST-structure shown in Fig. 2. A terminal has stochastic behavior if order of states and transitions doesn't follow logical workflow due to various internal and external unforeseen influences on regular operations. For research of such a system the SST method will be developed. In this case the ST-structure may be defined from Fig 3.

Data that were derived from a terminal work were used to assemble a problem of stochastic terminal operations. To define terminal's various operations for SST method, worksheets of bulk terminal of Bakar port in one year period (2013) have been analyzed. Those operations include transportation of bulk cargo from/to terminal, loading/discharging cargo to/from ships, inspection of ship and cargo, distribution of cargo to shore stock, maintenance and repair of facility equipment, and customs procedures. The data on frequency of machinery failure, bad weather and strike caused stoppages of operations, and congestions on the terminal were also taken into consideration. These data served as a basis for population of stochastic matrix of transition probabilities for bulk terminal behavior.

The solution was obtained with computer-assisted evaluation program WinQSB. WinQSB has an integrated Markov modeling and simulation tool, based on discrete space, continuous-time Markov model. After data entry in the transition table, defined number of periods (n=1,..., 12 steps) and initial state vector of the terminal at time t=0, $P_0 = [1,0,0,0,0]$, probabilities of the five terminal states are obtained and presented in Fig. 4. Starting from idle state, simulation shows in which state the terminal will appear most probably after each transition (step). Probability of the most notable state decreases with number of simulation steps and the terminal approaches steady state probabilities.



	0	1	2	3	4	5	6	7	8	9	10	11	12
p1	1.00	0.00	0.03	0.03	0.36	0.40	0.03	0.09	0.22	0.32	0.19	0.10	0.18
p2	0.00	0.98	0.00	0.03	0.03	0.42	0.39	0.04	0.10	0.25	0.34	0.19	0.11
p3	0.00	0.00	0.95	0.00	0.04	0.14	0.41	0.39	0.05	0.15	0.28	0.34	0.21
p4	0.00	0.00	0.00	0.91	0.00	0.04	0.13	0.39	0.37	0.05	0.14	0.27	0.32
p5	0.00	0.02	0.01	0.03	0.57	0.01	0.04	0.10	0.26	0.24	0.05	0.10	0.18

Figure 4. Probability distribution for terminal states for 12 steps

After obtaining state probabilities for 12 steps in SST method and deducing the state probabilities in DST method follows comparison of results with real-world operations flow for year 2014 and selection of best-fit method for further short term planning. For example, duration of state S_1 depends on actual time of ships' arrival and departure time of previous ship, while duration of state S_3 is influenced with size of ships and quantity of cargo manipulated. Consequently, duration of each state is determined with real situation in terminal operations.

The order of state transitions on weekly basis were evaluated and the final results showed that data obtained by SST method matched the practice in 34 cases (weeks), by DST method in 11 cases and in 7 cases the state transitions followed some other order. It was concluded that the observed terminal had stochastic behavior in 65% cases during 2014.

Comparison of the DST solution to the corresponding SST solution indicates that the later one better emulates the logic of bulk terminal operations flow. Therefore, if the port management, in existing situation and without overtaking specific measures for improvement of operational effectiveness, follows the SST method in terminal operations short term planning, the plan is expected to be more feasible. However, bearing in mind that the SST terminal operations draw

longer working procedures and therefore time lost on overcoming effects of unforeseen events and consume more resources, to perform even better the management should strive to adhere to the plan based on DST method.

3. CONCLUSION

In this paper basics of the general systems theory are presented. This theory is applied for the system states analysis, forecasting and planning the development of the dynamic systems, then choice of the optimal or at least adequately controls actions and decisions. Lack on uniformity in the case of cargo arrival at the port and impossibility to predict exactly time and the quantity of the cargo arriving to the port, are the main reasons of the stochastic property in the port operating. The port can be presented as physical systems with random changes during time which draw necessity of using probabilities in its modeling

The method, presented here, may be used for short term tactical decision making by identifying the particular state in which the terminal will be in a given instant. One of the major shortcomings of the SST compared to DST terminal operations is represented by time lost and consumption of more resources on overcoming effects of unforeseen events, resulting in operational costs inefficiency. The ST model presented can serve as theoretical base for modeling technological operations of other port terminals or traffic systems.

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Part IV LOGISTICS CONCEPTS AND STRATEGIES

AIR CARGO FLOW ANALYSIS IN THE EUROPEAN UNION

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Abstract: *Although the demand for air cargo services in the world has been showing signs of accelerated growth since 2010, the level of cargo traffic in the European Union is still below its pre-crisis 2007 level (measured in freight tones-kilometres). Notwithstanding, air cargo volume in the European Union accounts for up to 20% of the total air cargo worldwide. In this paper the authors examine air cargo network and air cargo flows on schedule routes in the European Union in 2013. Air cargo flows include flows within the European Union as well as flows from the European Union to other regions in the world. Additionally, main European Union cargo airports are identified and cargo movements between them are analyzed.*

Keywords*: Air cargo, flows, cargo airports.*

1. INTRODUCTION

The importance of air cargo to the economy and consumers could be perceived through the fact that air cargo represents less than 1% of the weight of all international cargo, while at the same time this segment represents around 35% of the total worldwide shipment value (Boeing, 2014). The air transport mode found its role on the market to ship goods between countries quickly and efficiently compared to other modes of transport, especially on the longer routes where savings in time is most noticeable. This advantage makes air transport more suitable for transport of goods which are either time-sensitive or high-value. But unfavourable economical developments in recent years have had a direct impact on people's willingness to spend and, thus, on world trade growth. A significant, negative impact of the economic crisis is noticeable on the European market because, as a mature market, it has a great number of consumers for high value products (which tend to use air freight). Thus, it has had important consequences on air freight.

Development of the airline industry was the subject of many research papers. The focus of these research papers was mainly on the passenger side of the airline industry, putting the cargo sector development aside. Only a few of the research papers deals with air cargo, Zhang (2003), Hui et al. (2004) and Hwang (2011), which focusing on the Eastern and Southern Asia markets.

In 2013, cargo airlines in the European Union (EU) took some cyclical upturn and improved profitability, after years of stagnation (IATA, 2014). But the negative effects of global economic recession that began in 2007/2008 were so strong on air cargo demand that, in terms of freight tonne-kilometres (FTKs), the traffic levels were still below the pre-crisis 2007 level (AEA, 2013). Additionally, high fuel prices and increased competition from other modes of transport and non-EU airlines still make the European market a challenging environment. However, the EU air

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cargo industry is one of the most competitive in the world. Air freight accounts for a significant share of EU cargo in terms of FTKs. Almost 20% of world air cargo FTKs are transported through the EU (World Bank, 2015). Measured in tonnes of goods, the share of EU member countries accounts for up to 30% in the total world air cargo transport (in 2013, airlines transported 49.8 million tonnes of goods) (IATA, 2014).

In spite of the slow recovery and low growth rates (IATA, 2014), air cargo is still very important in facilitating trade and economic activity of EU member countries and development of efficient and sustainable transport network should not be neglected. Analyzing transport flows within the network is very important for understanding air cargo movements and developing future strategies for airlines, airports and policy makers. This paper presents statistical data on air cargo handled at airports in the European Union (EU) in 2013. The main objective of this paper is to contribute to a better understanding of air cargo network flows in the EU. It, also, examines air cargo movements focusing on countries with the highest air cargo volumes within the EU and individual results for their main airports, as well as the strongest air cargo flows between EU members and regions in other parts of the world. The remainder of the paper is organized as follows. Section 2 consists of three parts that describe air cargo flows in EU on domestic, international and intercontinental level. This section investigates distribution of air cargo volume from EU by regions and countries and provides a review and outlook for the expected developments of main air cargo flows. Finally, Section 3 contains concluding remarks.

2. AIR CARGO FLOWS

This paper represents the review and analysis in air cargo transport in the EU by countries and airports with emphasis on main cargo flows inside and outside this region. The research is based on data collected from the Eurostat database (statistical data related to carriage of goods by air) in the period from January to March 2015. Eurostat database contains all air cargo movements in the 28 EU member countries. The total volume, measured in weight of air cargo, transported through EU member countries amounted to 14.6 million tonnes in 2013. According to this result, air cargo volume remained more or less stable from 2012 to 2013, with a 0.04 % decrease in the total gross weight of goods. The total air cargo volume based on geography allocation is distributed as follows:

- 72.64% of the total air cargo volume is traded between EU member countries and the countries outside the EU,
- 23.64% of the total air cargo volume is traded between EU member countries,
- 3.72% of the total air cargo volume represents national cargo trade.

Germany alone had nearly 4.5 million tonnes in 2013, that is 30% of the EU air cargo transport. Germany was followed by the United Kingdom (UK), France and the Netherland, with shares of 16%, 12% and 11% of the EU total, respectively. High concentration of air cargo transport in the EU is also noticeable through the fact that five member countries account for more than 75% of the total air cargo volume (Table 1). Frankfurt Main Airport is the largest airport due to the cargo tonnes moved by both belly and dedicated freighters, followed by Amsterdam's Schiphol, London's Heathrow and Paris' Charles de Gaulle that recorded more than 1 million tonnes in 2013 (Table 1). Besides Frankfurt Main Airport, there are two more airports in Germany (Leipzig and Koln) that belong to top ten EU airports in terms of tonnage throughput in 2013. Altogether those three German airports account for 25% of total air cargo tonnes in the EU. The 10 largest airports accounted for about 72% of the total tonnage of air cargo handled in the EU countries in 2013. This result indicates that air cargo in the EU is concentrated into several key airports that are close to regional centres of production and consumption.

2.1 Domestic and International Air Cargo Flows

The total air cargo that is transported within the EU comprises approximately 3.0% of the world's air cargo tonnage, but only 0.8% of the world's tonne-kilometres (Boeing, 2014). The routes inside the EU are primary short haul, mostly between 900 and 1,200 kilometers, which favors other modes of transport due to lower costs.

Table 1. EU member countries and airports by air cargo volume, 2013, (Source: Eurostat database, 2015)

Country	2013 (t)	%	Airport	2013 (t)	%
Germany	4,421,995	30.11	Frankfurt/Main	2,160,824	14.71
United Kingdom	2,362,259	16.08	Amsterdam/Schiphol	1,565,755	10.66
France	1,775,342	12.09	London/Heathrow	1,512,246	10.30
Netherlands	1,619,819	11.03	Paris/Charles de Gaulle	1,491,287	10.15
Belgium	1,004,808	6.84	Leipzig/Halle	895,270	6.10
Italy	814,024	5.54	Köln/Bonn	766,131	5.22
Luxembourg	673,445	4.59	Luxembourg/Luxembourg	673,445	4.59
Spain	580,492	3.95	Liege/Liege	560,470	3.82
Austria	221,518	1.51	Milano/Malpensa	430,342	2.93
Finland	192,421	1.31	Brussels	400,282	2.73
Other	1,020,882	6.95	Other	4,230,983	28.81
Total freight	14,687,005	100	Total	14,687,005	100

Air cargo flows in the EU can be observed in respect to domestic and international transport, separately. Freight on domestic flights account for only 4% of all EU air freight (545,988 tonnes in 2013) since narrow-bodied aircraft with minimal belly capacity are used for these flights and road and rail transport within the EU are more cost effective. A small proportion of cargo that is transported by air in domestic markets of EU countries can also be observed through its small share in the total air cargo transported within the EU borders, that is 16%. The countries with highest domestic air cargo volumes are France (156,238 t), Germany (119,485 t) and the United Kingdom (116,933 t), while main airports with domestic cargo are East Midlands (73,146 t), Charles de Gaulle (67,069 t) and Leipzig's Halle (60,985 t).

Air cargo transport within the EU achieved a very slow growth since 2011 (2% annually), after having recovered from the economic crisis in 2008. Primary routes for air freight inside the EU are the routes from Germany to the United Kingdom, France, Italy and Spain where the total tonnage by route was more than 100,000 t in 2013 (Table 2). The highest total cargo tones flown on routes within the EU were between Germany and the United Kingdom in 2013 (224,815 t). The routes within EU with lower tonnage i.e. between 50,000 t and 100,000 t were: Germany-Belgium (62,554 t), the United Kingdom-France (59,590 t), Germany-Sweden (59,567 t) and the United Kingdom-Belgium (57,692 t).

Table 2. Air cargo flows within EU member countries, 2013, (Source: Eurostat database, 2015)

Air cargo flow	Total air cargo (t)	Air cargo flow	Total air cargo (t)	Air cargo flow	Total air cargo (t)
UK-Germany	224,815	Austria-Germany	38,755	Germany-Hungary	22,528
France-Germany	177,192	UK-Ireland	38,429	Spain-Netherl.	21,829
Italy-Germany	134,524	Germany-Netherl.	36,210	Sweden-Belgium	20,143
Spain-Germany	100,244	Spain-France	32,033	Portugal-Germany	17,479
Belgium-Germany	62,554	UK-Italy	31,432	UK-Netherland	16,841
UK-France	59,590	France-Belgium	30,050	Sweden-Finland	15,743
Sweden-Germany	59,567	Denmark-Germany	29,074	Hungary-Luxemb.	15,335
UK-Belgium	57,692	UK-Spain	24,339	Ireland-Germany	13,526
Poland-Germany	47,276	Spain-Belgium	24,206	Spain-Portugal	12,860
Italy-Belgium	44,752	Greece-Germany	23,760	Germany–Slovakia	12,468
Italy-Luxemb.	43,393	UK-Luxemb.	23,347	Denmark-Netherl.	12,266
Italy-France	41,647	Germany-Finland	22,856	Denmark-France	10,503

2.2 Intercontinental Air Cargo Flows

In terms of weight, EU member countries exported (52%) more air freight than they imported (48%). In absolute numbers, they exported 5,559,173 tonnes and imported 5,109,115 tonnes. Primary routes for air freight in and out of the EU are the transatlantic routes to and from the United States of America (USA) for both imports and exports, and also routes to and from major Asian regions (Eastern Asia and Near and Middle East Asia) (Figure 1a).

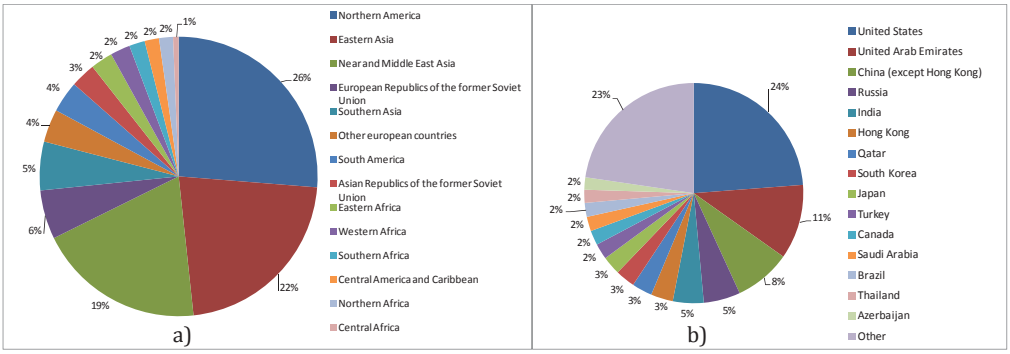


Figure 1. Total freight in 2013 by international routes between EU member countries and: a) partner world regions; b) partner world countries, (Source: Eurostat database, 2015)

After a period of declining demand (2008-2010), the EU–North America flow started to recover in 2011, but in 2012 air trade fell by 5.47% and 3.34% in 2013. The total air cargo trade between the EU and North America accounted for 2.76 million tonnes in 2013 and this volume was still below its peak of 3.3 million tonnes in 2007. However, the EU–North America flow is still the strongest air cargo flow within the regions and accounts for approximately 6.6% of

world air cargo tonnage and 8.4% of the world's tonne-kilometres (Boeing, 2014). Air cargo flows to Asian regions were more stable in the recent years. After a slight decrease in 2009, air cargo trade between the EU and the Eastern Asia, as well as between the EU and the Near and Middle East Asia, increased continuously with an average growth rates of 5.16% and 5.69%, respectively. Countries with highest air cargo trade with the EU are the United States, the United Arab Emirates, China and Russia that together account for almost 50% of the total world air cargo trade (Figure 1b). The United States had 90% share of North America's air cargo exports from the EU and 91% share of air cargo imports from this region into the EU during 2013. The total air cargo trade on the EU-to-US direction fell by 6% in 2012 and 3.25% in 2013. Analysing on a country level, the major air cargo trade routes are between the USA and Germany, the USA and the United Kingdom, Germany and the United Arab Emirates, Germany and Russia (Table 3). All these main routes between EU member countries and countries outside the EU are more or less two-way balanced (cargo volume that is exported is close to cargo volume that is imported) except the routes Germany-India and the United Kingdom-India where the import was more than 50% higher than export and the route Germany-South Korea where export was more than 70% higher than import. Air cargo volume on all main routes from Germany to other countries outside the EU decreased in 2012, except on the route between Germany and Hong Kong, where air cargo volume increased by 12%.

Table 3. Main air cargo flows between EU member countries and other countries in the world, 2013, (Source: Eurostat database, 2015)

Countries	Total (t)	Import (t)	Export (t)
Germany-USA	726,274	309,275	416,999
United Kingdom-USA	675,571	330,884	344,687
France-USA	280,756	118,544	162,212
Netherland-USA	275,553	149,152	126,401
Luxemburg-USA	162,657	76,126	86,531
Belgium-USA	144,867	84,258	60,609
Germany-United Arab Emirates	357,526	189,479	168,047
United Kingdom-United Arab Emirates	230,235	118,961	111,274
Netherland-United Arab Emirates	134,056	68,241	65,815
Germany-Russia	324,729	177,119	147,610
Germany-China (except Hong Kong)	290,017	123,569	166,448
Netherland-China (except Hong Kong)	259,922	136,113	123,809
France-China (except Hong Kong)	108,580	47,388	61,192
Germany-India	232,573	140,076	92,497
United Kingdom-India	126,510	77,137	49,373
Germany-Hong Kong	112,118	59,037	53,081
Germany-South Korea	110,802	40,699	70,103
Germany-Turkey	106,678	54,199	52,479

In 2013, flows from Germany to China and India recovered and recorded a growth of 12.74% and 4.75%, respectively. Air cargo trade between Germany and Hong Kong stayed stable in 2013 with a growth of 13.53%. The strongest air cargo flow on the intercontinental level is still between Germany and the USA, despite the repeated decline in volume tonnes recorded in 2012 and 2013 (5% and 6%, respectively).

3. CONCLUSION

The recovery of air cargo transport in EU has been very slow after a strong impact of the economic crisis in 2008. Unlike passenger airlines, airlines in air cargo transport are faced with additional problems such as low load factor that is below 50% and low yields, both caused by overcapacity in the air freight business. However, recent forecast given by reputable institutions and companies (IATA, Boeing, AEA, Airbus, etc.) are suggesting stronger performance of air cargo in the years to come (worldwide air freight volumes will expand at an annual rate of 5.2% through 2030). Carriers in all other regions already improved their transport and financial results, which is also expected for carriers in the EU despite the challenges they are faced with (the ongoing sanctions against Russia, the Eurozone economy recession etc.). The possible means, but not least, by which EU cargo airlines can improve their performances are increased connectivity and efficiency through their networks (e.i. where possible introducing connecting flights to cover airports where demand is insufficient to justify non-stop flight and better matching capacity with demand using new freighters). Moreover, results presented in this paper show that they should focus on the routes that have more even two-way balance and to become more competitive on the domestic and intra-EU routes. Significant growth of air cargo demand is expected on the routes between the EU and Asia (5.3% annually, Boeing 2014) indicating that this region will still be the key driver for shaping the pattern of EU airline networks in the future.

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AN OVERVIEW OF EUROPEAN AIR CARGO TRANSPORT: THE KEY DRIVERS AND LIMITATIONS

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Abstract: *The air cargo industry has been recording a rapid growth in last three decades with an average rate of almost 4.9% per year, thus remaining the vital component of overall globe cargo activity. Economic expansion of countries in the Far East and their intensive international trade with other regions (primarily North America, Europe and the Middle East) have boosted the demand for efficient and reliable cargo transport revealing the rising importance of air transport. In this paper, regression analysis is employed to explore the most significant factors (such as GDP, international trade, export-imports of goods, etc) that could have a crucial impact on demand for air cargo transport in the countries of the European Union. Although featured by an evident drop in the volume of air cargo traffic caused by severe economic crisis occured in 2008, Europe still constitutes an important link in the chain between the East and the West.*

Keywords*: Air cargo, air cargo demand, regression analysis.*

1. INTRODUCTION

Air cargo sector plays a prominent role in the era of rising mobility and trade of goods and services worldwide. The new economy products, consisting of small, light, compact, high value-to-weight parts and assembled components have been shipped internationally by air in a reliable and fast manner (Kasarda and Sullivan, 2006), which places air cargo sector in the first place by value of today's world trade. In its report, Boeing (2014) estimates that air cargo constitutes only a 1% of world trade calculated by tonnage, but about 35% of world trade calculated by the value of goods shipped.

However, several factors have been crucial in catalyzing air cargo's[†] consistent development through the second half of the 20th century. First, according to Air Transport World (2014) the integration of global markets followed by transatlantic and transpacific air shipments of electronics had an enormous impact on rebuilding Europe and developing Japan, South Korea, Taiwan, Hong Kong and Singapore into economic powers in the post-World War II era. Second, an economic giant such as China that has evolved from a centrally planned economy to one with a greater share of free enterprises has become a leading country around the globe by total export volume in the 1990s and early 2000s. In alignment with the profound transformation of economy, which could be characterized as market-oriented, China gradually developed from a low-income country to a higher income level one. These two changes will shape the air cargo industry in the years to come (Hui et al., 2004). The highly populated countries such as India and

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† In this research the terms "air cargo" and "air freight" will be used interchangeably.

Brazil have also adopted more open trading policies which induced substantial demand for air cargo transport.

Certainly, the challenging circumstances (i.e. severe economic crisis) prevailing in the past several years had weakened the entire world economy and trade growth which caused air cargo to stagnate, particularly during the period from mid-2011 to early 2013. Not surprisingly, along with the recovery of world economic activity (primarily in the United States and China) measured by Gross Domestic Product (GDP), IATA (2014) claims that the outlook for air cargo markets has started improving again.

The aim of this paper is to reveal major economic drivers at macro level that could affect the demand for air cargo sector in Europe, having in mind their historically fierce interdependency. A brief overview of key drivers is given in Section 2. Data and methodology used are given in Section 3, followed by subsection which explains the obtained results. Finally, concluding remarks are presented in Section 4.

2. ECONOMIC FACTORS AND THEIR IMPACT ON AIR CARGO DEMAND

Performance for air cargo transport is highly susceptible to the state of global economy and its volatile nature. For example, fuel prices have historically been a persistent problem for air cargo which diverted a large portion of general cargo to less expensive competitor mode of transport during the periods of oil crisis. Furthermore, the global economic downturn drove freight yields down to 22.4% in 2009 (Boeing, 2014). On the other hand, the positive effect of economy on air cargo demand are evident in the countries of the Far East, particularly China which domestic market will be the fastest growing with a 6.7% average annual growth according to Boeing (2014) forecast for the period from 2013 to 2033. The rising economy of China and other countries situated in the Far East with their intense international trading activities will also have a positive stimulus to world air cargo growth in the future. It is worth mentioning that the leading east-west air cargo markets are those between Asia–North America, Europe–Asia and Europe–North America, each of which accounting for 21%, 20% and 8% of total 208 billion revenue tonne-kilometers (RTK) in 2013. Air cargo traffic in a specific country highly relies on the volume of export and import with other countries, as well as on transportation cost, exchange rates and relative prices (Fig. 1). In that sense, air cargo transport constitutes one of the major facilitators to trade activities between countries, mainly the distant ones.



Figure 1. Trading activity between countries pulls the air cargo traffic (Boeing, 2014)

Conversely, the development of air cargo could boost the global economy, as it enables the connectivity of a country to other markets in an efficient and reliable manner. The relation between air cargo demand and economic activity has been very well documented in the literature (Kasarda and Green, 2005; Chang and Chang, 2009) indicating that air cargo volume and GDP per capita are mutually interdependent and causal. Although highly interdependent, air

cargo growth mostly outpaced the GDP growth and trade growth. The evidence for this can be found in the analysis by Kasarda and Green (2005) who used World Bank database for 68 countries and showed that the GDP grew by 72%, trade by 132% and air cargo by 302% in the period between 1980 and 2000. Along with liberalization of markets stipulated through a large number of bilateral agreements between countries, air cargo sector could significantly contribute to inflows of foreign direct investment (FDI) and consequently foster county's economic activity. In the near past, this was the case particularly with Dubai Airport in the United Arab Emirates that use its advantageous geographic position, placed halfway between Europe and Asia, and airport free trade zone to attract companies looking to invest in the Emirates. Nowadays, Dubai Airport is the largest air cargo center in the Middle East and one of the largest reexport hubs in the world.

3. OVERVIEW OF EUROPEAN AIR CARGO SECTOR

About 14.4 million tonnes of air freight (both national and international) were carried through airports within the EU-28 in 2013, marking a slight increase of 0.4 % when compared with 2012 (Eurostat, 2014). However, the share of air freight in the total freight transported by each country within the EU remained sufficiently low ranging between 0.01% for the countries located in the Central and Eastern Europe (Czech Republic, Slovakia, Slovenia, Bulgaria, Croatia and Romania) to almost 1% for Luxembourg. *Cargolux*, one of the major air cargo carriers in the world, has its hub at Luxembourg's Findel Airport which significantly facilitates international trade by air. On the other hand, Germany is a leading country in terms of total volume of freight transported by air accounting for 4.4 million tonnes of freight in 2013, followed by the United Kingdom (2.3 million tonnes) and France (1.8 million tonnes). These three countries together with Italy and the Netherlands have consistently accounted for approximately 70% of all European air trade with North America. Nevertheless, the intra –Europe air cargo market comprises approximately 3% of world's air cargo tonnage, but because the region is geographically compact it comprises only 0.8% of the world's tonne-kilometers (Boeing, 2014).

Europe is still an important partner for the majority of regions in the world. The European Union (EU) remains an important trade partner for Latin America, second only to the United States, and is also the region's leading source of FDI (Boeing, 2014). Furthermore, overall air cargo traffic between the Middle East and Europe has been growing over the last 10 years by an average rate of 5%, accounting for a variety of commodities shipped on both directional flows (such as telecommunication equipment, machinery, and finished goods, perishables and garments). Europe is the primary destination for African air cargo accounting for about 2/3 of the total. African exports are typically counter-seasonal cut flowers and other perishables to Europe, but there is relatively little return cargo (World Bank Group, 2009). Finally, Europe–Asia market comprises approximately 19.6% of the world's air cargo traffic in tonne-kilometers and 10.0% in tonnage (Boeing, 2014) and is expected to have steady growth in the future.

From all the above facts, it is evident that economic activity, followed by industrial activity, play a key role in generating demand for air cargo in any country. European Union countries are very diverse in terms of the level of economic development and broader commercial policy environment which strongly affect their respective international trade, and subsequently the volume of freight carried by air. For example, nominal GDP per capita that can be used as a rough indicator for the relative standard of living among member states, with Luxembourg having the highest (EUR 83,400) and Bulgaria having the lowest (EUR 5,500) in 2013. Between these two extremes, there are a number of variations across EU counties and some of them severely suffered from the European debt crisis that erupted in the wake of the Global financial crisis (Greece, Spain, Ireland, Cyprus and Portugal). On the other hand, Germany, as one of the strongest economy in the world, continues to achieve very positive financial results even in the period of crisis. Having in mind that Germany is the third larger exporter in the world, it is not

surprising that air freight sector recorded an impressive growth rate by 6.5% in the period from 2002 to 2013.

Regression analysis was employed in order to capture the impact of underlying economic factors on the demand for air cargo across the countries of the European Union. The model designed assumes a uni-directional relation between the air freight volume and several economic indicators deemed as crucial drivers.

3.1 Data and methodology

In order to create a robust model for air cargo demand on the European Union level, the importance of several explanatory economic indicators was examined. As it can be found in previous research on this issue, GDP per capita, Foreign Direct Investments and International trade (measured as the sum of import and export) have been selected as key drivers for air cargo demand. The growth rates of those four variables for the period between 2004 and 2013 are shown in Figure 2.

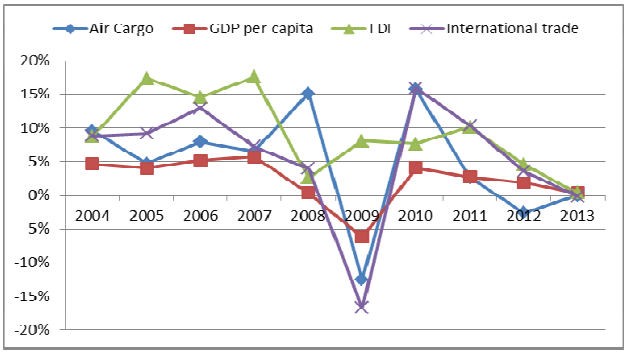


Figure 2. Growth rate for air cargo freight, GDP per capita, FDI and International trade

As it can be observed from Figure 2, growth in International trade has substantially outperformed GDP growth, which is also the case with air cargo growth (except for the last three years when air cargo in Europe has experienced a steady decline).

The cross-panel data was used to explore any differences between variables selected in terms of time period. Three temporal intersection including 2002, 2007 and 2013 were selected primarily to investigate potential changes in correlation between air cargo demand and its explanatory variables across EU member countries. The temporal intersections are in accordance with EU enlargements that have occurred in the last decades. In 2002, the EU consisted of only 15 member states followed by the entrance of former communist countries of the Central and Eastern Europe in 2004, 2007 and 2013. Since no significant changes have been recorded during these three years in terms of correlations between variables, for the sake of simplicity the model will be estimated for 2013 only.

Air freight data of the countries in the European Union originates from EUROSTAT database. Air freight statistics are collected for both freight and mail loaded and unloaded on all commercial flights in schedule and non-schedule service. Air freight data can be divided into national and international level, depending on the scope of research. Annual data are available for the most of EU member states for the period from 2003 onwards, while some countries have provided data ever since 1993. The statistics that are collected are also available for monthly and quarterly periods, but for the purpose of this research only annual data are used.

In addition to air freight data, EUROSTAT provides an abundance of historical data on economic indicators from which four abovementioned have been selected - GDP per capita, Foreign Direct

Investments (net inflows), Exports of goods and services and Imports of goods and services. The variable called International trade is derived as a sum of Exports and Imports of goods and services. All variables have been expressed in the value of current EUR.

3.2 Results

In order to avoid multicollinearity in the regression model, it is necessary to explore the correlation between each pair of variables selected. Multicollinearity is a phenomenon in which two or more explanatory variables in a multiple regression model are highly correlated causing spurious results. Table 1 presents the basic correlation between the volume of freight and mail and three explanatory variables: (1) GDP per capita, (2) International trade and (3) FDI – net inflows. Based on these results, it can be concluded that air cargo volume across EU countries highly correlates with the international trade (r=0.96) confirming the previous findings from relevant literature that countries with higher export and import activity are likely to show more needs for air cargo transport. As expected, FDI is seen as a good indicator with correlation coefficient accounting for 0.75. However, the correlation coefficient between FDI and international trade is sufficiently high (r=0.72), which is a serious indication to omit one of these two variables from the further regression model. Although GDP per capita is in positive correlation with air cargo volume, this coefficient (r=0.34) is still low which disenables this variable to be included into further consideration. This can be explained by the fact that some countries with slightly less GDP per capita (such as Germany, France, the United Kingdom etc.) have higher volume of air freight compared to those countries placed on the top of the list in terms of GDP per capita (such as Scandinavian countries and Luxembourg), but with less volume of air cargo.

Table 1. Correlation between selected variables

	Freight and mail by air	GDP per capita	International trade	FDI, net inflows
Freight and mail by air	1			
GDP per capita	0.34	1		
International trade	0.97	0.28	1	
FDI, net inflows	0.76	0.38	0.72	1

Therefore, the regression model proposed consists of only one variable– International trade. Skewness coefficient for *Air Cargo* volume and International trade (*Int. Trade*) account 2.7 and 2.5 respectively. From the statistical perspective, highly skewed variables have to be transformed into one that is more approximately normal. The convenient method to do so is logarithmic transformation which was carried out in this case. The robust model is presented by the following equation:

$$log\ Air\ Cargo = -0.92 + 1.14\ log\ Int.Trade \quad (1)$$

The accompanying statistics are the following: $R^2=0.75$, $F_{statistics}=82.36$ (with significance of 2.1887E-09). The interpretation of "log-log" regression model is given as an expected percentage of change in dependent variable when independent variable increases by some percentage. In other words, multiplying International trade by 10 will multiply the expected value of Air Cargo

volume by $10^{1.14}$. Finally, by knowing the international trade of a given country, one can easily predict the volume of freight carried by air in the future.

4. CONCLUSION

The paper provides a robust regression model to estimate air cargo demand across countries in the European Union in 2013. The results reveal that level of international trade remains the most important driver that highly contributes to generation of additional demand for air cargo transport. In other words, as long as the export and import increases, the demand for air cargo will rise. Although minor in terms of freight volume compared to other modes of transport, air cargo sector will present the vital component in the region's overall economic activity in the future. However, the economic growth in the European Union will see several major limitations such as aging populations, uncompetitive labor markets and economic crisis which will certainly have substantial influence on air cargo performance in the long-term periods. Nevertheless, it would be challenging for further researches to investigate reverse relation - the importance of air cargo expansion on economic growth across countries of the European Union.

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DELIVERY PLANNING IN CITIES FOR CEP ITEMS

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Abstract: *Planning the delivery and distribution of courier, express and parcel (CEP) items has tend more-than-current i.e. implicit connection with the development of information society inside which telecommunications progress lead to restructuring delivery time and space in a way to ensure the sustainability of classic postal services in a longer period of time. Implementation of new technologies in the delivery process of CEP items deserves more attention in urban planning and development of the information society and e-commerce. Standard delivery of CEP items is no longer satisfactory. This paper deals with planning the delivery of CEP items in cities by automated postal booths. The paper will consider examples of the application of this technology in the world. It will present the results of customer survey and it will propose location parameters for automated postal booths. The aim is to propose concrete solutions and consider the justification for using them.*

Keywords*: planning, delivery, courier, express, parcel*

1. INTRODUCTION

Global electronic market is developing rapidly. As the number of e-users grows, so does their expectations. It is forecasted that in the next three years the international electronic commerce will increase by 150%, while the sales through e-commerce will reach several trillion US dollars by 2016. Growth of e-commerce impacts surge in popularity of alternative ways of delivery and distribution of CEP items.

Alternative ways of delivery and distribution of CEP items are growing and they provide easier collection of items. According to research in the post office, users want a 24/7 solutions that are fast and affordable. Standard delivery of CEP items is no longer satisfying.

The market of e-commerce is turning toward self-service devices for the delivery of items.

These devices eliminate most common problems faced by users, postal operators and other. There is no need to wait for a courier, delivery is successful in the first attempt, shipping costs are decreased and the availability of postal services is increased because customers can collect their item on the way home or at a convenient location, within 24 hours, 7 days a week. Using modern technology to deliver CEP items resolves problems of returning items, fees and problems of reverse logistics.

This paper deals with planning the delivery of CEP items in cities by the implementation of automated postal booths. The paper will consider examples of the application of this technology in the world and present the results of a customer survey. We have analyzed the savings in: the

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cost of operators who provide this service, in the costs of operators who would use these devices on the basis of a contract which allows network access, the cost of users collecting their items due to failed delivery. The aim is to propose concrete solutions and consider the justification for using them.

2. 24/7 SOLUTION APPLICATION IN THE DELIVERY OF PACKAGES

Postal network of automated postal booths is the largest international network of self-service machines which enable dispatch and collection of packages at a convenient location for 24 hours a day, seven days a week.

These solutions can already be found in 21 countries: Australia, Chile, the United Kingdom, Ireland, Iceland, Italy, France, Latvia, Lithuania, Ukraine, Estonia, Poland, Russia, Cyprus, Slovakia, Czech Republic, Colombia, Saudi Arabia, Costa Rica, Salvador and Guatemala. There are currently more than 3,500 units of postal booths that are based on postal technology. In the near future, additional 6,000 automated postal machines will be put in Europe, Asia, America, North Africa and the Middle East (www.postaltechnologyinternational.com).

In the last 12 years, the company Keba AG has released around 3000 KePol packet machines with over 250.000 boxes. KePol machines are considered the best in the market due to the largest number of installed machines in the world, top quality and a high level of safety and value retention. The creation of automated solutions for the first and last mile is a milestone in the logistics of item transportation. Kepol system is present in Germany with more than 2,500 devices (DHLPackstation), Denmark (Doegnposten) with over 300 devices as well as in Norway (Postautomat), in Vienna, Austria, Russia, Turkey, Spain, Lithuania, the Czech Republic and other countries.

By automating item delivery, costs of delivery services are being reduced while providing a more comfortable delivery to users. The concept of this delivery system using postal booths is simple and acceptable from the standpoint of both users and the postal operators. User can order goods over the Internet and package with his goods will be delivered through a system of postal booth. Via e-mail or SMS message, the user sets requirements on how they want the package to be delivered. Collecting your package is independent of the working hours of the post office and delivery service. Systems contain compartments of various sizes, whose number can be adapted to user needs.

Automating product delivery has numerous advantages both for users and post offices:

- it complements the classic way of delivery and physically separates the courier from users;
- system is independent of the post office working hours and is available 24 hours, seven days a week;
- one system may be used by various delivery services and
- system is easily integrated into existing delivery system including track & trace system to monitor the shipments.

Almost a year ago, Austrian Post has decided to provide users with additional possibilities of their self-service with a so-called "Pick - up stations". "Pick-up station" actually represents parcel automats that are specially designed in accordance with Keba standards for indoor use. They are optimized in terms of size and design for installation in locations such as self-service areas, shopping centers or postal shops.

Denmark Post has over 300 parcel automats which mean that automated postal machines almost completely cover the country throughout. Joint cooperation between Denmark post and leading retail chain "Coop" has opened a brand new office space for Keba machines. Parcel automats in stores with 35,000 employees and sales revenue of nearly 6.7 billion euros have

made that "Coop" Denmark becomes the largest retail chain in the country. "Pakkeboksen" (Figure 1.) have been installed in 300 "Coop" stores and are managed by Denmark post, i.e. they allow users to collect and send their packages. In December 2014, they have reached an all-time high in volume of packages in transfer - more than 10,000 parcels a day at parcel automats. Clients of Danishpost can collect and send their packages during shopping in Coop, while "Coop" customers can collect products that they ordered online at their local store. "Coop" Denmark has also been clearly defined in the market through this service. The plan is to expand this system to a total of 490 locations (www.keba.com).

Following the example of Germany, Austria, Denmark, Luxembourg, Lithuania, Switzerland, the Czech Republic and France, the national postal service of Spain Correos has decided to expand its services with Kebaparcel automats. They will operate under the name "CityPaq"(Figure 2. (www.postaltechnologyinternational.com)) and a total of sixty-systems will be installed in 2015. Parcel automats will be installed in gas stations and in other similar places in Madrid and towns throughout Spain (www.keba.com).



Figure 1. "Pakkeboksen"



Figure 2. "CityPaq" (www.keba.com)

"Kouzelné Almara" (Magic Box) is the solution of the Czech Republic, which has been on the market since April 2013 and is designed for future expansion (Figure 3). It is used to deliver the products of the selected e-shop partners. The market of e-commerce in the Czech Republic is growing rapidly, which corresponds to the current increases in the volume of items. Kouzelné Almaraprovides its customers the possibility to take their products at a time that is most convenient, 24 hours a day, seven days a week.



Figure 3. "Kouzelna Almara" (www.keba.com)



Figure 4. "Alza Box" (www.logistika.ihned.cz)

This solution uses KePol FS/08 system where each cabinet is fitted with 54 boxes. The biggest internet shop in the Czech Republic (Alza) opts for Keba system. Alza is the largest store of electronic goods but also a pioneer in e-commerce in the Czech Republic. The success of Alza'sinternet shops is based on the growing market of e-commerce in the Czech Republic and

Slovakia, which strongly influenced the company to become one of the largest in Europe. Alzahas actually launched their own business model with online store for electronics, but now offers goods of all descriptions. Until recently, Alza customers had to pay for the delivery or to personally collect their packages from one of the company stores, which also have limited working hours. However, the company recently decided to offer customers the option to collect their package at package stations which are called "Alza Boxes"(Figure 4.) whenever they want (24/7). Since the beginning of 2011, the Lithuanian Post has established the largest network of 71 self-service terminals called "Express LP 24" in 41 cities in Lithuania (www.keba.com).

3. THE DEVELOPMENT OF ELECTRONIC COMMERCE IN SERBIA AND USER ATTITUDES

Assumptions about the development of electronic commerce and information technology, as specified in the paper of Tomić and Petrović (2011) can be divided into five categories. First category is based on technical assumptions, electric power supply and development of telecommunications network (speed, the Internet quality and coverage in urban and rural areas),representation of ICT devices (computers, mobile phones, etc.), availability (price) of ICT infrastructure and equipment, development of roads and logistics in the country, in the paper of Vukićević and Drašković (2014). Second category consists of legal and political assumptions in the form of laws and regulations in the field of e-commerce: adequate legal protection of participants in e-commerce, existence of the law on e-document and the legality of digital signatures, the judiciary and legislature follow the development of e-commerce, promoting e-commerce by government institutions. The third category consists of instrumental assumptions, which are realized through the prism of services. The fourth group consists of utilitarian assumptions, the usefulness of e-commerce for customers. The fifth category includes socio-cultural assumptions: personal preference of electronic communication or communicating in person; willingness to accept new trends; the existence of initiatives, willingness to take risks, trust in abstract systems, government institutions, the judiciary, people, law enforcement and confidence in the data confidentiality, age and financial capabilities of customers, need to see the live product which is being purchased.

A survey of users for this paper was conducted in order to comprehend the significance of all these categories from the view point of user himself. The aim of the survey was to analyze the attitudes of users towards the influence of certain factors on the use of e-commerce. The purpose of this survey was also to show how many of existing users of postal parcel and express services is ready to replace the traditional method of delivery with a new method of postal delivery. Based on the data obtained from a survey sample, we have obtained the estimated number of users who would use the method of delivery via automated postal booths.

Users were supposed to provide answers to 10 questions (statements). Answers took the form of Likert's 5-point scale of attitudes ("1-strongly disagree", "2-disagree", "3-neither agree nor disagree," "4-agree "," 5-strongly agree"). Questions are grouped into five categories, according to factors influencing the development of e-commerce. The results of the survey will not be displayed individually. It is important to note that statements in the category of socio-cultural assumptions have the lowest level of agreement. The statement "I am willing to take some risk of buying over the Internet," had the smallest degree of agreement, only 2.6. The statement "It is not necessary to see the live product before purchasing it," only 3.4. Users have agreed with the statement from the category of usefulness of services to users, so that the statement "Electronic commerce is a comfortable way of buying goods and services" got the score of 4.3. The answers to questions from the first category of technical assumptions are certainly worrying. Most users especially in rural areas are not satisfied with the development of telecommunications infrastructure, speed, reliability of links and services. Therefore, our research will continue its focus on urban areas of cities in Serbia. When it comes to the development of transport and logistics infrastructure, attitudes were divided, and based on the additional questions during the

direct contact with customers, it was concluded that attitudes depend on previous experiences of users and operators with whom they collaborated. Most objections relate to the deadline to deliver the item (longer than three days), the possibility of collecting shipments in the premises of operators (some operators do not have their branches in smaller towns and the delivery is done solely at the user's address at the time when it is not convenient to the user), pay extra postage for the next delivery, etc. Most of the users, namely 98% of those who use the services of e-commerce, have agreed that the use of postal booth would positively influence their decision to purchase in the future. While according to the survey of RAPUS, 90% of users have agreed that their postal item with personal delivery can be delivered to a member of the same household, however according to our research 100% of users have agreed to receive mail via automated postal booth (RAPUS, 2014).

Having completed the survey, we have concluded the following:

- it is necessary to reduce the risk of buying over the Internet;
- is necessary to provide the option of returning the product,
- is necessary to provide greater access to ICT,
- it is necessary to conduct regular quality control of postal and logistics services,
- it is necessary to increase the availability of networks and services of postal and logistics operators,
- it is necessary to reduce the cost of product delivery and introduce alternative ways of delivery.

4. DELIVERY OF CEP SHIPMENTS IN CITIES THROUGH AUTOMATED POSTAL BOOTHS

Currently in the Republic of Serbia, only PE Post of Serbia is licensed to provide the universal postal service and therefore is obliged to provide these services throughout the country. Development of alternative modes of delivery of shipments to customers has a special significance to Post of Serbia. However, the Postal Services Act does not allow delivery of shipments to be done via self-service machines, such as packet automat (Republic of Serbia, 2005). Therefore, further development of automated delivery depends on changes in the legal framework. However, recently adopted Regulations on access to the postal network (RATEL, 2014) is in favor of the application of these devices, which makes it possible for the Post to offer the resources of public network to other postal operators. Postal automated booths should be part of the public postal network, designed to deliver the package (which falls within the scope of universal service) and other items, such as express shipments or logistics shipments. The possibility that the Post of Serbia offers units of public network to other operators is in favor of the sustainability of universal postal service. The Post of Serbia has about 5.2 million express and package items per year. Other postal operators have approximately 10,800,000 express items per year. Participation of private postal operators is around 68% which is higher compared to The Post of Serbia. The cost of the first delivery of CEP shipments in cities is lower than the costs of CEP delivery of shipments in rural areas. However, successful first delivery in rural areas is almost 100%. Number of items to be delivered in repeated delivery in urban areas is over 7%. Delivery costs comprising the price of the consignment are 45%, about 50 dinars per shipment. Of the total number of items 1,200,000 parcels are delivered in repeated delivery, which annually cost operators in Serbia an extra 60,000,000 dinars. For users, regardless of whether their item was delivered in the first or repeated (second) delivery, waiting for the courier means waste of time and money. The potential market for these services and the number of end users is much larger than customers who receive shipments in the second repeated delivery. Size of the market is proportional to the number of users that receive CEP shipments. Most CEP shipments come from electronic commerce (about 70% of shipments), and in our survey these people have declared that this service was crucial for them. The conclusion is that

more than 11 million shipments per year may be delivered via packet automats, and shipping costs will be reduced to a minimum.

5. CONCLUSION

The increase in postal services has caused the constant improvement of the quality of serving customers, which is related to the development and deployment of cutting-edge technical equipment in the units of the postal network. The growth of e-commerce contributes to a growing number of parcels which requires implementation of new services, such as delivery system of parcels twenty-four hours seven days a week, which is the basis of this paper. Automation of the delivery process of postal items contributes to reducing costs and saving a lot of time which in the postal activity is the most important quality parameter. With this service it is no longer necessary to wait for courier at the home address. The package can be collected at any time at the convenient location for the user. When introducing new technologies, The Post of Serbia can take advantage of their existing network infrastructure and market coverage. The Post must adapt to the modern way of doing business, primarily by investing in new technical solutions.

ACKNOWLEDGMENT

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ECO-DRIVING AWARENESS AND BEHAVIOUR OF COMMERCIAL DRIVERS

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Abstract: *Unwanted driving routines (harsh acceleration, harsh breaking and sudden steering) are among the key issues for increased fuel consumption, maintenance cost, air pollution and greenhouse gas emissions reduction. This paper focuses on commercial vehicle drivers' awareness about eco-driving impacts on environment and costs, their current driving behaviour and application of eco-driving measures by companies in transportation and logistics sector. Eco-driving in developing countries is highly desirable and reasonable due to its low costs and almost permanent effects in comparison with other costly and time-consuming measures (fleet renewal with hybrid and electric vehicles, environmental impact strategies and green logistics concepts). For the research purpose, a questionnaire survey is conducted to collect data on eco-driving skills and strategies on in logistics and transportation sector in Serbia.*

Keywords*: Eco-driving, Fuel consumption, Green logistics, Serbia*

1. INTRODUCTION

Eco-driving programs attempt to change a driver's behaviour through general advice, such as: do not drive too fast; do not accelerate too quickly; shift gears sooner to keep engine speed lower; maintain steady speeds; and keep the vehicle in good maintenance (e.g. check for proper tyre pressure frequently) (Barth & Boriboonsomsin, 2009). Some of these actions drivers do applicate without knowing what eco-driving means. However, not all drivers are aware of all of the techniques of eco-driving. Awareness of eco-driving is the first step towards this concept implementation and further development. The aim of this paper is to estimate a level of eco-driving awareness in transportation and logistics sector and level of (un)conscious application of eco-driving techniques on roads in Serbia.

This paper is organised as follows. After a brief introduction, an insight into the eco-driving principles and benefits, as well as a brief overview of the recent eco-driving initiatives and projects are given in Section 2. The research methodology, main results and discussion are presented in Sections 3, 4 and 5, respectively. Final remarks and conclusions are given in the last section.

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2. RESEARCH BACKGROUND

Eco-driving is a term used to describe the energy efficient use of vehicles, and refers to the set of rules, techniques and behaviour that drivers can employ in order to reduce their fuel usage, emissions of CO_2 and other pollutants. Vehicle efficiency is not constant and changing driver behaviour can significantly reduce fuel consumption. Such behaviour is often described as eco-driving (Mensing et al., 2013). We have identified a few terms in use - rational driving, modern driving, smarter driving, etc. - all referring to similar actions. Additionally, "energy efficient driving" or "environmentally friendly driving" are the terms often associated with "slowing down" which is counterproductive, rather than supportive for changing driving behaviour (Schulte, 2012a). Therefore, we decided to use term "eco-driving" to describe such behaviour.

Numerous possible benefits of eco-driving are divided into four groups: environmental (reduced greenhouse gas emissions, local air pollutants and noise), financial (reduced fuel, vehicle maintenance, and costs of accidents), social (more responsible driving, less stress while driving, higher comfort for drivers), and safety (improved road safety, enhanced driving skills) (ECOWILL project, 2010-2013). The essence of eco-driving is to reduce fuel consumption and studies showed that savings are 5-10% on average in long-term period (Barkenbus, 2010).

In transportation and logistics sector, eco-driving also contributes to avoid situations when driver of the vehicle with company logo shows too aggressive driving style, which harm the reputation of the company. In order to achieve listed benefits, driving behaviour and driving techniques should be adapted to traffic conditions and to the type of vehicle. In general, there is a range of rules, tips and tricks about eco-driving that drivers should know. However, five basic ("golden") rules of eco-driving for drivers to follow are identified (Schulte, 2012b):

I Anticipate traffic flow;
II Maintain a steady speed at low rpm;
III Shift up early;
IV Check tyre pressures frequently;
V Consider any extra energy required costs fuel and money.

Eco-driving initiatives in transportation and logistics sector can be differed by levels of application: *Policy level* – creating a unified platform in order to stimulate eco-driving; *Company strategic level* – enhanced route planning and decision making; and *Company operational level* – driver education, trainings and motivation, as well as vehicle equipment and maintenance. Only the last one is considered in this paper. Also, different types of eco-driving activities can be distinguished, but the optimal scenario is a blend of these activities (SenterNovem, 2005): 1. Awareness raising; 2. Dissemination and distribution of information; 3. Training programs. We considered the awareness of commercial vehicle drivers about eco-driving as the first and necessary step towards other measures and activities.

There have been some actions in the past to stimulate eco-driving in Europe, from the legislative (Directive 2003/59/EC, 2003), to the implementation and education area. Target groups of a large number of initiatives were mainly the drivers of private (passenger) cars. Greater attention to eco-driving in freight transportation is paid in several projects (ECOEFFECT project, 2011-2013; ECOSTARS Europe project, 2011-2014; RECODRIVE project, 2007-2010). The results of those projects showed environmental, financial, social and safety benefits. The positive effects are particularly related with emission reductions, fuel consumption and costs savings.

The first steps of eco-driving in Serbia were made under the UNDP project "Support to Sustainable Transportation System in the City of Belgrade", 2011-2015 (Plevnik, 2013). However, only five truck drivers were involved into program. Training and testing of truck drivers resulted with about 7% savings of the average fuel consumption (Vuković and Đorđević, 2014). To include other positive effects and obtain more reliable conclusions, it is necessary to continue the research.

3. METHODOLOGY

A short structured interview (2-3 minutes) is used for data collection. The survey was carried out in the first week of March 2015. The drivers of all commercial vehicle types were included into the survey. The interview was conducted at two level crossings with the barriers in the surrounding of the city of Novi Sad, in periods when the barriers were closed. Once the traffic flow is stopped, random drivers were asked by trained interviewers to participate the survey. If they agreed, the interviewers asked the questions from the questionnaire, explained them, if necessary, and filled in the obtained answers fast "in situ". The interview sample size accounts the total number of 113 drivers. This method allowed the highest level of response. Only 3 questionnaires were not finished due to the opening of the barriers in the middle of interview and they are excluded from further research, so the total number of analysed answers are 110.

The questionnaire consisted of three sets of questions. At the beginning, drivers were asked about their age, driving experience, vehicle and route basic data. Further questions addressed driving behaviour, habits and skills, implementation of eco-driving measures by companies and what measures drivers prefer. Finally, drivers were asked to assess driving skills of commercial drivers in Serbia and whether they are familiar with the term “eco-driving”. The possibility that drivers could give desirable/expected answers from the viewpoint of their company is minimized, because the survey was not conducted in firms. The interviewers have also conducted a brief visual inspect of the vehicle equipment related with aerodynamic design. This was considered as an indirect supporting indicator of an overall approach of respondents' companies to environmental issues.

4. MAIN RESULTS

The survey intended to collect the data on eco-driving awareness and behaviour of commercial vehicle drivers. The basic information about drivers and vehicles is shown in Figure 1. A wide range of drivers is covered by the survey with different levels of experience – young, old, more or less experienced. About 62% of drivers has more than 10 years of driving experience and more than 68% of drivers are older than 35. A significantly high percentage of old vehicles can also be noticed. About a quarter of respondents usually drive on the long-haul routes.

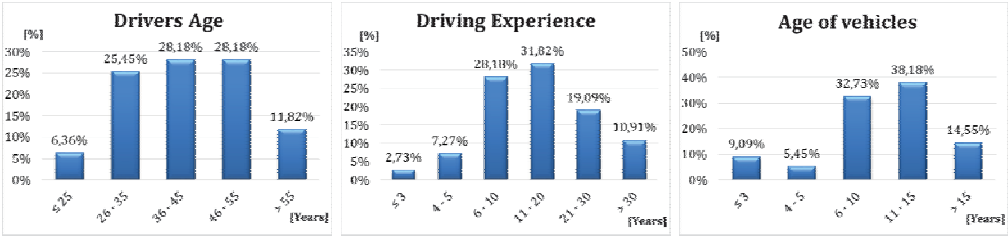


Figure 1. Basic data on drivers and vehicles included in survey

We have investigated at what amount of revolutions per minute (rpm) commercial vehicle drivers usually perform gear shifting, depending on the type of vehicle they drive (Figure 2). Drivers of vehicles equipped with tachometer (around 74%) answered about the engine speeds they usually shift gears. Twenty three percent of total number of respondents drive vehicles with automatic transmission system and a few vehicles with manual transmission are not equipped with tachometer. The two thirds of the light commercial vehicle (LCV) drivers shift gear between 2000 and 2500 rpm. Drivers of vehicles with load capacity more than 3.5 tons (middle and heavy commercial vehicles – MCV and HCV) mostly shifts between 1250 and 1500 rpm. When maintaining a steady speed drivers act different: 40% tend to maintain speed at low

rpm, other 40% maintain a certain rpm (the most at 1250, but there were answers up to 3000 rpm) and 20% maintain desired speed regardless amount of rpm.

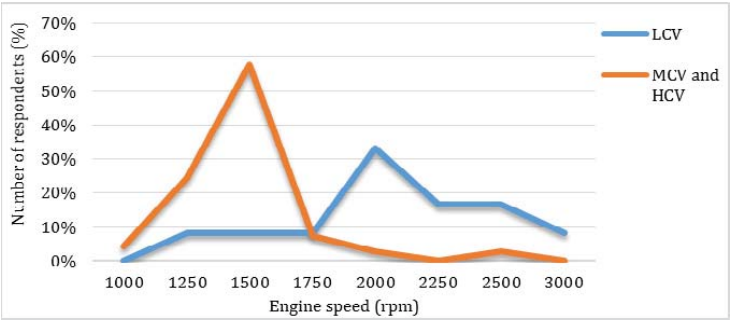


Figure 2. Drivers' opinion about preferred engine speed for gear shifting

Electrical energy is converted from extra fuel burned in a combustion engine, so electrical equipment costs extra energy. Air conditioning is basic electrical device that significantly impact fuel consumption. Drivers were asked how often they use the air conditioner – 60% never or rarely use it, 28% sometimes and 12% often or constantly.

Drivers were asked to rate driving behaviour of other professional drivers in Serbia on a scale from 1-poor to 5-excellent. The rough assessment of driving behaviour resulted with 72% of answers with average and above average rates. Also, a little more than 60% of drivers said they had heard of the term eco-driving, but only 20% of those had a good explanation of what it involves.

At the end, we have investigated level of eco-driving implementation by companies. Even 75% of drivers answered that their company do not implement any of the measures. However, 50% said that implementation of eco-driver recognition and rewarding system is highly desirable. The investment into the air drag reduction aids additionally indicate that the company care about environmental impact. Around 30% of vehicles were not equipped with air drag reduction aids at all. Roof deflectors were on 97% and side extenders on 39% of vehicles equipped with any aid. When it comes to tyre pressure checking, research results shows that 35% of drivers perform frequent checks and around 40% do it occasionally. In few cases, another person in company was responsible for vehicle operational maintenance, so drivers were not obligated to check tyre pressure.

Air drag reduction aids (roof deflectors, side extenders, side tank fairings and end fairings) and recommended tyre pressure reduce fuel consumption, especially on a long-haul routes due to higher driving speeds. Roof deflectors and side extenders are in most cases added in a vehicle production process and are not necessary a result of companies paying attention on air drag reduction. The side tank fairings had only 1% of vehicles and that there was no vehicle with end fairings attached.

5. DISCUSSION

The variety of respondents in terms of age, driving experience, company they work for and routes they usually drive gives strength to this research. Different shifting techniques for light and heavy commercial vehicles (see Figure 2) are consequence of different power sources and different designs of transmission system – HCV are mostly powered with big diesel engines with narrow power band and a lot of LCV are powered by gasoline engines with wider power band. Although the results about preferred engine speed for gear shifting are not output of testing and measurement, but the personal opinions of drivers, we can conclude that drivers of commercial

vehicles perform (or tend to perform) gear shifting in eco-driving manner. The same conclusion can be made about maintaining a steady speed. The most of the drivers which aim to maintain certain engine speed cited low number of rpm. Based on those results, we can conclude that almost 80% of drivers (of both vehicle load capacities - less and more than 3.5 tons) act with regard to eco-driving rule "low rpm at steady speeds".

A high percent of answers about never or rarely use of air conditioner (60%) indicate its use in the eco-driving manner. This is partly influenced by a high number of vehicles without air conditioner installed. It should also be noticed that survey was conducted in winter days, which might have subconscious influence on answers or question misunderstanding. Further, a purpose of commercial vehicle sometimes requires additional (special) electrical equipment. This research questionnaire was not designed to collect specific data about equipment usage of such dedicated vehicles (concrete mixers, refrigeration, waste collection, etc.).

Average and above average assessment of other drivers' behaviour leads to conclusion that professional drivers generally think their driving behaviour is good, but that there is still a room for improvements. Little familiarity with eco-driving indicates that education and dissemination of eco-driving concept should be carried out. This can be achieved in different ways: presentations, press and media, current and new driver trainings in driving schools, etc. The drivers' interesting for this matter encourages the consideration of these measures.

The average age of vehicles indicate a high level of emissions and therefore, a greater importance of the question how they are exploited. While the fleet renewal is crucially significant for environmental impact, it is in the same time the most expensive measure, hardly extensively applicable by majority of Serbian carriers. Hence, the importance of eco-driving gets an additional significance in such challenging economic environment.

The adoption of eco-driving techniques by drivers may be stimulated by their belief that company policy is eco-oriented. A systematic implementation of eco-driving initiatives and programs by companies in transportation and logistics sector in Serbia is on a low level, from drivers' point of view. However, respondents mostly agreed that company should implement some measures. Eco-driver recognition and rewarding scheme is the most wanted measure by drivers, so it is likely that this measure will be well accepted. A low level of application of added air drag reduction aids may indicate low willingness of companies to invest into the environmentally friendly measures, even if they support reduction of fuel consumption.

This research also has a set of limitations. The survey method always indicate a subjective viewpoints of respondents. Further, traffic flow anticipation minimizes harsh acceleration and harsh braking, but this aspect could not be analysed by the qualitative research. Therefore, in further research ECU or accelerometer readings should be included into the analysis to obtain a more comprehensive picture of eco-driving behaviour and obtain more exact results. Additional research could be conducted about eco-driving activities on company strategic level and national level. Dedicated vehicles should be analysed in order to assess additional electrical equipment usage and impact on fuel consumption.

6. CONCLUSION

Eco-driving reduces fuel and maintenance costs, as well as the traffic accidents costs due to a safer way of driving. Consequently, rising the eco-driving awareness contribute to the business performance improvement of companies. Due to its social and environmental significance, we have conducted a research on eco-driving awareness of commercial drivers in Serbia. The general conclusion is that drivers are not familiar with eco-driving concept, but they often use to apply one or more eco-driving techniques.

While majority of environmental measures in transportation and logistics require additional costs and efforts, eco-driving is among the rare ones which have mostly coupled cost-effective

and environmental positive effects. This point may be of crucial importance for wider involving companies into the eco-driving actions. An increasing awareness about environmental effects of eco-driving might additionally increase the motivation for wider implementation of techniques in full range from driver, to company and wider level. This is particularly important for developing countries, with weak economies, where transport and logistics industry face numerous challenges. Therefore, eco-driving concept should be disseminated in all possible ways and it should also be a part of training in driving schools.

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FACILITATING CROSS BORDER MOVEMENT OF GOODS IN THE REGION OF WESTERN BALKAN– THE EVIDENCE FROM SERBIA

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***Abstract**: The authors elaborate problems of border crossing practices in the region of Western Balkan countries with special focus on Serbia. Among the many barriers to the efficient cross-border movement of goods are the complexity of procedures, expenses in both money and time, and insufficiencies in infrastructures and operations. Customs and other border-related controls impose costs on traders and induce considerable frictions in cross-border supply chains. The paper also presents and elaborates some of results of the project Conducting surveys at border crossing points done for the Belgrade Chamber of Commerce as a partner to the ACROSSEE project. The surveys included structured interviews of truck drivers and traffic counting at border crossing points. The research was conducted in 2013 at 7 border crossings with Croatia, Bosnia, Montenegro, Macedonia, Hungary and Romania.*

***Keywords**: trade flows, transport flows, border crossing, supply chains, Serbia.*

1. INTRODUCTION

Intensifying and facilitating trade and transport flows between Western Balkan countries represents a precondition for the economic development of each of them, as well as, meeting the conditions for entry into the European Union (EU). One of the most important issues concerning trade facilitation is the relationship between trade costs and private sector growth and export competitiveness, especially for countries in transition. Regional economic cooperation, partnerships in forming industrial clusters, mutual support in meeting the requirements of candidacy and then membership in the EU are only a part of the huge agenda of mutual support and cooperation in the region of Western Balkan (WB).

The mutual interdependence of trade and transport flows points to the need for integrated, coordinated and harmonized transport policies. Greater trade integration prior to becoming part of the EU has multiple benefits: (i) countries will need to align to the EU acquis in trade-related areas (free movement of goods, services and people, customs); (ii) firms will be better able to cope with the competitive pressures within the EU; and (iii) national administrations are building up capacity in regional cooperation (Handjiski et al., 2010). Higher interregional trade would lead to, other factors being equal, to a higher level of foreign direct investment as the region would be perceived as one market with a broader potential. Export led growth is the solution for the countries of WB (Vujačić and Petrović Vujačić, 2012).

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Trade and transport facilitation addresses a wide agenda in economic development and trade that may include improving transport infrastructure and services, reducing customs tariffs, and removing non-tariff trade barriers including administrative and regulatory barriers. Business costs may be a direct function of collecting information and submitting declarations or an indirect consequence of border checks in the form of delays and associated time penalties. These costs can result in forgone business opportunities and reduced competitiveness.

2. TRADE FLOWS AND TRADE FACILITATION

Serbia, as the others WB countries (Albania, Bosnia and Herzegovina, Croatia, FYR Macedonia, Montenegro, UNMIK-Kosovo) has implemented substantial trade liberalization reforms, including reduction of tariff and non tariff barriers, the elimination of import quotas, the reduction of import licensing requirements and prohibitions, and the restructuring and simplification of customs procedures. In addition, Serbia has also introduced an updated tariff schedule to reduce trade restrictions faced by nearly all agricultural, fish, and food products imported from the EU.

The most important economic partner of Serbia is the EU and then CEFTA which absorb over 90% of Serbian exports and account for 3/4 of Serbian imports (Figure 1 and 2). In December 2006, the countries of the Western Balkans signed the Central European Free Trade (CEFTA), which substituted a network of bilateral free trade agreements. After becoming members of the EU, Romania and Bulgaria left CEFTA in 2007, and Croatia in July 2013. The countries remaining in CEFTA are: Albania, Bosnia and Herzegovina, FYR Macedonia, Montenegro, Serbia, UNMIK-Kosovo and Moldova which make up for a common market of close to 23 million consumers.

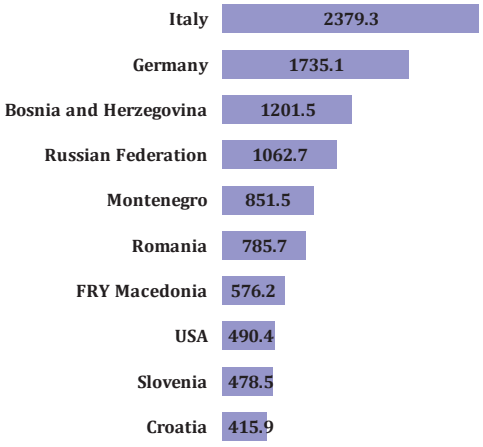


Figure 1: Imports by countries of origin, 2013, USD million

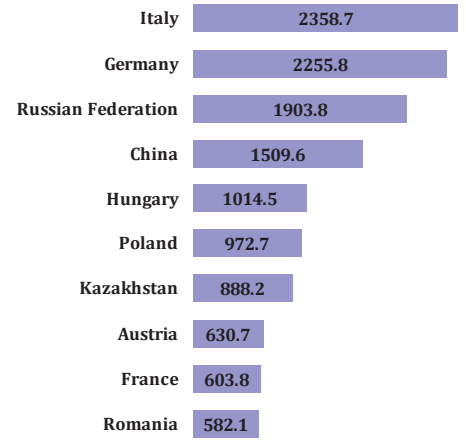


Figure 2: Exports by countries of destination, 2013, USD million

Source: Statistical office databases

The structure of the trade in goods of Serbia with these countries has been fairly constant over the last years. The exports of Serbia to the WB countries are primarily processed foods, agricultural raw materials, electric power, coated metals, chemicals and textiles. On the import side the largest share is taken by oil and derivatives, natural gas, paper, cardboard and cellulose products, vegetables and fruit, iron and steel. Serbia is represented on the WB markets with a broad array of products with which it would not be competitive on the EU markets due to higher standards required there. In this respect Serbian exports are dominated by a small number of products such as iron, steel, raspberries, corn, tires.

In trade with the CEFTA countries Serbia has a trade surplus thanks to a good market position in Bosnia and Herzegovina, Montenegro, the FRY Macedonia and UMNIK Kosovo, while the ratio of exports to imports by country decreases with the geographical distance from Serbia. Trade flows are hindered by too many different types of non-tariff barriers (complicated procedures on border crossings, cumbersome administrative procedures and uncoordinated custom and inspection activities, an inadequate number of internationally accredited certification bodies, as well as, accredited laboratories and institutions, unrecognized certificates of quality, corruption and counter band. It is necessary to upgrade the infrastructure to the level when the Serbian and the product certificates of other WB countries will be recognized in all countries of the EU and CEFTA. There is a lack of institutionalized accreditation bodies due to which it is not possible to consistently apply the CEFTA agreement (Nikolić et al., 2011).

The Enabling Trade Index (ETI) was developed within the context of the World Economic Forum's Industry Partnership Programme for the Logistics and Transport sector. The ETI measures the extent to which individual economies have developed institutions, policies, and services facilitating the free flow of goods over borders and to destination. The ETI categorizes the obstacles into four categories: market access, border administration, infrastructure and operating business environment (Drzeniek Hanouz et al., 2014). These subindexes are composed of the seven pillars: domestic and foreign market access, efficiency and transparency of customs administration, transparency of border administration, availability and quality of transport infrastructure, availability and quality of transport services, availability and use of ICTs, and operating environment.

If we compare the ETI index for 2014 (Table 1) and previous years for Serbia we can notice that the situation has became worse, especially from the point of view of market access, availability and quality of transport infrastructure and business/operating environment (Petrović Vujačić and Medar, 2012).

Table 1. Enabling Trade Index (ETI) 2014 for Serbia

Enabling Trade Index 2014	Rank (out of 138)	Score (1–7)
Enabling Trade Index 2014	89	3.7
Subindex A: Market access (25%)	112	3.2
Pillar 1: Domestic market access	107	4.0
Pillar 2: Foreign market access	79	2.3
Subindex B: Border administration (25%)	78	4.2
Pillar 3: Efficiency & transparency of border administration	78	4.2
Subindex C: Infrastructure (25%)	69	3.8
Pillar 4: Availability & quality of transport infrastructure	103	2.6
Pillar 5: Availability & quality of transport services	55	4.3
Pillar 6: Availability & use of ICTs	54	4.4
Subindex D: Operating environment (25%)	104	3.7
Pillar 7: Operating environment	104	3.7

Source: World Economic Forum, 2014, p.276.

The data from the 2014 Report show that Serbia, according to the survey, is ranked 89, while Bosnia and Herzegovina is ranked 78, Albania 69, FYR Macedonia 63, Croatia 56, and Montenegro 49.

3. TRANSPORT FLOWS AND BORDER CROSSINGS INEFFICIENCES

Road transport is the vehicle for the largest part of Serbian foreign trade. In 2013 it accounted for 46.6% of all transport in the import of goods and 60.4% of all transport in the export of

goods. The total volume of international transport of goods was slightly higher in 2013 than in 2012 and amounted to 19.5 million tons of goods: 5.65 million tons in imports, 6.75 million tons in exports (Figure 3) and 7.08 million tons in transit.

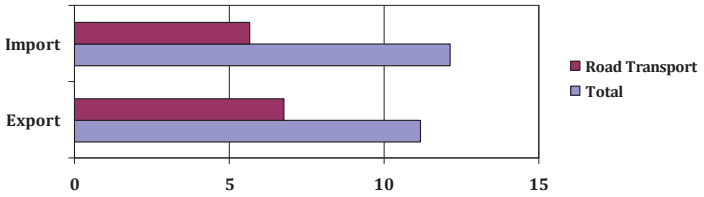


Figure 3: Volume of total trade in goods and road transport, million tons, 2013

Source: Statistical office databases and SORS (2014), p.2

The international haulage is facing many challenges with a direct impact on productivity and quality of the service. One of the most severe is considerable time losses during the transportation process. Studies done in 2007, 2008 and 2011, presented in Medar and Manojlović (2011) and Petrović Vujačić and Medar (2012), highlighted inner customs and border crossings as a major source of considerable time losses. The records of time spent in inner customs and at border crossings (hold-up times) in 2008 were: for border crossings – leaving Serbia was 1 hour and entering Serbia was 6.5 hours. Even though this was a pilot study, the results clearly indicate that hold-up times in Serbia are longer than in other countries. The results from a similar sample in 2011 show a slight improvement, i.e. acceleration of the procedure.

More improvement, specially in entering Serbia, can be detected from the reports of the study *Conducting surveys at border crossing points* (Ipsos Strategic Marketing, 2013) done for the Belgrade Chamber of Commerce as a partner to the ACROSSEE project in which the authors of this paper participated. The research included road and railway transport. The surveys done according to the defined methodology within the ACROSSEE project (ACROSSEE, 2013) included structured interviews (questionnaire) of truck drivers and traffic counting at border crossing points. The research was conducted in June 2013 at 7 border crossings with Croatia (Batrovci), Bosnia and Herzegovina (Mali Zvornik), Montenegro (Gostun), Macedonia (Presevo), Bulgaria (Gradina), Hungary (Horgos) and Romania (Vatin).

Out of more than 7000 counted trucks entering and exiting Serbia during the study period, 1823 truck drivers were interviewed. Most of them, 25.5% were at Batrovci border station (Table 2), 54% exiting Serbia and 76% driving heavy goods vehicles. Transit frequency of the same trip is: weekly 39% (average 1.8 times), monthly 46% (2.8 times), and yearly 8% (7.7 times).

Table 2. Truck driver interviews - characteristics of the sample [%]

		Border station							Total
		Batrovci	**Gostun**	**Horgos**	**Gradina**	**Mali Zvornik**	**Presevo**	**Vatin**	
Direction	Entering	20	17	14	14	12	13	10	46
	Exiting	30	15	15	12	14	8	5	54
Vehicle's classification	LGV	14	14	22	11	13	20	6	4
	HGV	25	20	15	7	16	10	7	76
	TIR	31		12	38	1	9	8	20
Total		25.5	16.1	14.6	13.2	12.9	10.2	7.4	

Source: Ipsos Strategic Marketing (2013)

Yearly average is 54.2 trips – almost one every week. For this trip the total average time from origin point to destination point is 53 hours and total approximate distance from origin point to destination point is 1048 km (Ipsos Strategic Marketing, 2013). The shortest trips are associated with crossing the border with Bosnia and Herzegovina, and the longest are crossing border with Hungary (Ipsos Strategic Marketing, 2013). On average they carry 16.3 tones of goods.

According to the methodology defined within the project (ACROSSEE, 2013) waiting times were recorded separately for the period before the beginning of the procedure and for the procedure itself and entire hold-up. The mean of the waiting time in queue before the start of the procedures is 59 minutes and the most perceived is *up to 10 minutes* – 33.1% (Figure 4). Presevo border station has the highest value – 55% of respondents stated *more than 40 minutes*. Vatin is the best with 53% answers *up to 10 minutes*. The mean for the time needed for all the controls is below the queuing time and amounts to 47 minutes. The answer *up to 10 minutes* was given by 37.8% respondents (Figure 5). The results for total waiting time at the border station during this trip reveals problems at Horgos where 70% stated more then 60 minutes. The mean for total waiting time is 69 minutes. Results for hold-ups at border crossing show a better situation compared with previous studies but some of the crossings have results that need the attention of the government.

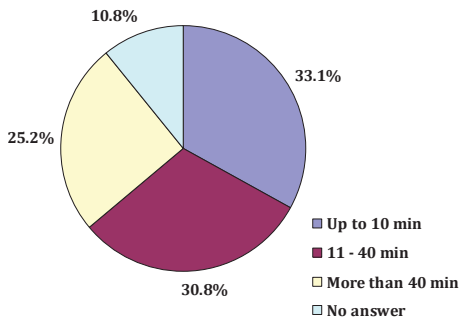


Figure 4: Waiting time in queue before the start of the procedures, %

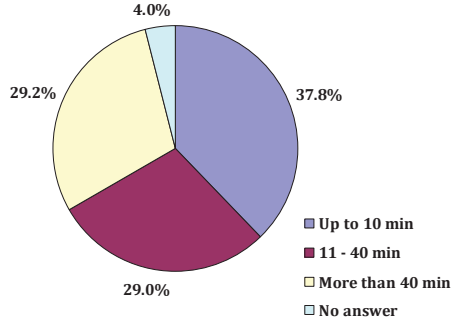


Figure 5: Time needed for all the controls, %

Source: Ipsos Strategic Marketing (2013)

The time losses certainly have an impact on the performance of individual trips, haulers and the international haulage sector, as well as on their users and society as a whole. The reasons for major hold-ups can be categorized in several groups: (i) flaws and deficiencies in the legal framework and its implementation; (ii) poor organization of the customs offices and associated inspection services; (iii) unprofessional and unmotivated staff; (iv) corruption; (v) lack of technical equipment and technology and (vi) the low capacity and poor condition of infrastructure. The interview with truck drivers shows the reasons as long lines / traffic density – 28%, procedures /paperwork/ long processing of documents –18%, slow work – 6%, inactivity/indifference/ unprofessional officers, change of officers/long change of shifts, not enough lanes, organization of work (breaks, number of officers...), inspections (procedures, slowness, working hours...), system error, small crossing capacity, congestion on the other side of the border, corruption (this question has multiple open ended answers).

All this time and money losses in border crossing cause supply chain fragmentation, weaknes links and reduce the efficiency of supply chains. Improving connectivity and reducing fragmentation of supply chains implies a renewed push for national improvements and cross-border integration in such areas as infrastructure standards, trade facilitation, and service regulation.

4. CONCLUSION

In Serbia the legislation and corresponding regulations that ease trade have been passed. Nevertheless, much remains to be done in different areas. In the period ahead until they become EU member states, the countries of the WB would benefit from some measures that would contribute to easier and faster trade and transport flows. These measures should lead to the creation of conditions for trade and transport similar to those in the EU. Substantial assistance in this regard is provided by the EU, World Bank, international donors and other international institutions. Although positive improvements have been made in facilitating cross-border practices and better cross border regional cooperation, joint projects with the goal of further improvement of trade and transport flows in the Western Balkan region are needed. There is still a lot to do in Serbia and other WB countries in the area of economic and institutional reforms which should lead to more efficient supply chains, a better business environment, trade and economic growth.

ACKNOWLEDGMENT

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MULTICRITERIA ANALYSIS APPROACH FOR HUMANITARIAN PREPAREDNESS OPERATIONS

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Abstract: *Strategic, tactical and operational decisions in humanitarian logistics require the simultaneous consideration of a number of usually mutually conflicting criteria in order to come up with optimal decisions. Our work aims to present a conceptual approach based on multicriteria analysis for the selection of the optimal location for the development of a humanitarian logistics depot. In this light, decision-makers are provided with a decision support system towards optimal preparedness for facilitating secure relief to the victims of natural disasters in a timely and reliable way. The proposed framework is implemented for the case of a specific type of natural disaster (earthquake). However, the procedure could be easily adopted in order to come up with optimal decisions in respect to types of natural disasters other than the one examined in the present analysis*

Keywords*: Location of logistics depot; relief operations management; multicriteria analysis; decision support system*

1. INTRODUCTION

The management of humanitarian logistics is a critical factor for facilitating secure relief to the victims of natural or man-made (e.g. terrorist attack) disasters in a timely and reliable way. Humanitarian logistics management is a complicated issue dealing with different situations, times and responses (Kovacs and Spens, 2007). In contrast to commercial logistics where numerous analytical optimization models have been constructed, humanitarian logistics constitute a rather unexplored field. Depending on the type of disaster, different ways of treatment need to be planned and implemented, making disaster relief management a case-specific approach with high levels of uncertainty and risk. This paper presents a multicriteria-based strategic approach towards optimal location for the development of a humanitarian logistics depot. The aim is to provide an easy-to-use decision support system that simultaneously accounts social, technical and economic concerns. The rest of the paper is organized as follows. Section 2 accommodates the proposed methodology, while in Section 3, a case study is provided. Finally, in Section 4 we provide the main conclusions of the paper.

2. METHODOLOGICAL FRAMEWORK

Strategic, tactical and operational decisions in humanitarian logistics often, if not always, require simultaneous consideration of a number of usually mutually conflicting criteria in order to decide the optimal alternative. In practice, decision-makers aim towards the best compromise between available alternatives. Towards this direction, a number of Multi-Criteria Decision Aid (MCDA) techniques have been proposed to assist decision-makers not taking decisions based only on personal thoughts, views or experiences, but on a robust and rational approach. The proposed methodological framework is divided into two phases; before (Phase I) and after the disaster strikes (Phase II). As a primary step of Phase I, potential locations for the development of a humanitarian logistics depot need to be identified. Such depots can alternatively be built within army camps or other public owned infrastructure. The methodology continues with its Phase II, which commences exactly after the disaster occurs. Operational criteria are determined according the nature and the special characteristics of the incident. It should be underlined that the exact number of both strategic (Phase I) and operational criteria (Phase II) depends on the decision-maker. Performances of all potential sites on those criteria need to be qualitatively or quantitatively quantified. Quantified performances of alternative sites over the selected criteria are entered into a performance matrix. Then the quantified parameters are preferably scaled in order to facilitate monitoring and direct comparison between individual criteria. As a last step before the formation of the mathematical model, weighting factors need to be determined for the selected criteria. This step allows the incorporation of specific strategic goals according to the decision-makers philosophy to the decision-making process. Weighting factors of the selected criteria are case specific, based on the type of incident and the severity of its impacts. However, due to the humanitarian nature of the problem under study, weightings of criteria usually "favor" social parameters followed by technical or economic concerns. The methodology concludes with the model runs and the determination of the humanitarian depot's optimal location. This is further reinforced by a sensitivity analysis which enables the decision-maker to identify the robustness of the calculated ranking, as well as which are the parameters that mostly influence the optimal selection. A critical turning point in the decision-making process is the choice of the multicriteria analysis technique to be employed. The literature lists a large number of multicriteria analysis techniques. There are no universally preferable multicriteria analysis techniques, but some techniques are more or less appropriate according to the problem under study and its specific characteristics. In the proposed method, the EliminationEtChoixTraduisant la REalité III technique (Roy, 1978), commonly referred to as ELECTRE III, is used. ELECTRE III requires the determination of three thresholds; preference threshold (p), indifference threshold (q) and veto threshold (v). With the inclusion of the three aforementioned thresholds, ELECTRE III is considered to be well-adapted for uncertainties. The technique uses three pseudo-criteria to represent all aspects of a problem, and it begins by comparing the alternatives' criteria scores. The results are aggregated, and a model of the fuzzy outranking relation, according to the notion of concordance and discordance, is built. The method, in the second phase of the fuzzy relation exploitation, constructs two classifications (complete pre-orders) through descending and ascending distillation procedures. A final classification consists of the intersection of the two complete pre-orders. A sensitivity analysis tests the result by varying the values of the main parameters and observing the effects on the final outcome.

3. CASE STUDY

3.1The incident

The applicability of the proposed methodology is demonstrated with its implementation in a virtual case study for the development of a humanitarian logistics depot after an 8.4 magnitude earthquake in Pella, Greece. The epicenter of the earthquake is located at Kromni in Mount

Paiko, 3.2 kilometers below ground, 60kilometers north east from the city of Thessaloniki. Alternative sites that are available for the development of the humanitarian logistics depot are operational army camps in Goumenisa, Giannitsa, Edessa and Skidra, and schoolyards in Aridea, Exaplatanos and Aravisos, respectively.

3.2 Determination of criteria

After identifying all alternative potential sites, the criteria to be taken into account need to be decided upon. In any study concerning site locations, the most important question is defining the criteria to be considered. In this light, a critical number of relevant stakeholders, all experts on the thematic area under study, were personally interviewed in order to decide which criteria to use in the virtual case study. As already stated in the methodological framework, those criteria can be either strategic or operational. On a strategic basis, the selected criteria included; (CS1) local population, (CS2) distance from centralized warehouse, (CS3) quality of infrastructure, (CS4) distance from closest port, (CS5) distance from closest airport,(CS6) distance from closest heliport and (CS7) local hospital capacity. As already mentioned in the previous section, all above criteria can be quantified before the incident occurs in order to come up with timely decisions in the case an event strikes in the area. Performances of the seven alternative logistics depots' sites are summarized in Table 1. References for the data is also depicted. It should be mentioned that quality of infrastructure is measured in a 1 – 10 scale, based on experts' opinions. Value "1" refers to totally inappropriate infrastructure, while "10" refers to infrastructure equipped with state-of-the-art facilities.

Table 1: Alternative sites' performance on strategic criteria

Alternative site	Population (C_{S1})	Distance from centralized warehouse (C_{S2})	Quality of infrastructure (C_{S3})	Distance from closest port (C_{S4})	Distance from closest airport (C_{S5})	Distance from closest heliport (C_{S6})	Hospital capacity (C_{S7})
	(#)	(km)	(1-10)	(km)	(km)	(km)	(# of beds)
Reference	*HSA, 2012*	*Google, 2012*	*HGSCP, 2012*	*Google, 2012*	*Google, 2012*	*Google, 2012*	*TCG, 2010*
Edessa	25,729	40	2	91	56	7	150
Aridea	19,970	60	4	98	67	13	18
Exaplatanos	8,852	63	4	91	60	24	-
Aravisos	7,509	47	8	64	33	6	-
Skidra	15,633	32	6	75	38	12	32
Goumenisa	6,677	82	9	70	42	7	-
Giannitsa	31,782	39	5	52	21	9	248

Similarly, more criteria need to be defined on an operational basis. To that end, the following operational criteria were selected; (CO1) distance from the earthquake's epicenter, (CO2) condition of local infrastructure after the earthquake,(CO3) number of missing people, (CO4) number of homeless people and (CO5) number of wounded people (Table 2). Those criteria need to be quantified after the event, thus those cannot be quantified in advance similarly to the strategic criteria. It should be mentioned that the performances of the operational criteria are based on virtual case study and are not representing real life data. As regards the condition of the infrastructure after the earthquake (CO2), in the present work this is characterized on a 1 – 4 scale with "1" referring to totally destroyed local infrastructure and "4" referring to local infrastructure in good condition and/or fully operational. The values "2" and "3" refer to major and minor destructions in the local infrastructure, respectively. Moreover, as regards the criterion referring to the number of wounded people (CO5), this is further divided into severity of wounds with Cat I to represent the number of slightly wounded citizens, while Cat III to represent the number of heavily wounded ones. Last but not least, quantification of values for criterion CS7 is based on hospital beds capacities of General Hospital of Edessa, General Hospital of Giannitsa, Medical Centre of Aridea and Medical Centre of Skidra, respectively (TCG, 2010).

Table 2: Alternative sites' performance on operational criteria

Alternative site	Distance from epicenter (C01)	Condition of infrastructure (C02)	Missing people (C03)	Homeless (C04a)	(C04b)	Wounded		
						Cat I (C05a)	Cat II (C05b)	Cat III (C05c)
	(km)	(1-4)	(#)	(#)	(%)	(#)		
Edessa	46	3	87	16,724	65%	5,000	1,000	50
Aridea	47	3	367	15,976	80%	6,000	1,000	40
Exaplatanos	39	1	458	8,409	95%	1,500	200	15
Aravisos	16	2	309	7,134	95%	1,000	90	10
Skidra	34	3	-	13,288	85%	1,000	100	15
Goumenisa	30	2	207	5,675	85%	1,200	90	10
Giannitsa	22	4	4	6,356	20%	2,000	800	30

Towards optimal site location, the values of alternatives on criteria CS1, CS3, CS6, CO2, CO3, CO4 and CO5 need to be maximized, whereas the values of alternatives on criteria CS2, CS4, CS5, CO1 need to be minimized. As discussed in the methodological section, the values of Tables 1 and 2 are scaled in a range from 1 to 10 using the aforementioned Nk(A) index (eq. 1). Scaled performances are depicted in Table 3.

Table 3: Alternative sites' scaled performances

Alternative site	CS1	CS2	CS3	CS4	CS5	CS6	CS7	CO1	CO2	CO3	CO4a	CO4b	CO5a	CO5b	CO5c
Edessa	7,8	2,4	1,0	8,6	7,8	1,5	6,4	9,7	7,0	2,7	10	6,4	8,2	10	10
Aridea	5,8	6,0	3,6	10	10	4,5	1,7	10	7,0	8,2	9,4	8,2	10	10	7,8
Exaplatanos	1,8	6,6	3,6	8,6	8,6	10	1,0	7,7	1,0	10	3,2	10	1,9	2,1	2,1
Aravisos	1,3	3,7	8,7	3,3	3,3	1,0	1,0	1,0	4,0	7,1	2,2	10	1,0	1,0	1,0
Skidra	4,2	1,0	6,1	5,5	4,3	4,0	2,2	6,2	7,0	1,0	7,2	8,8	1,0	1,1	2,1
Goumenisa	1,0	10	10	4,5	5,1	1,5	1,0	5,1	4,0	5,1	1,0	8,8	1,4	1,0	1,0
Giannitsa	10	2,3	4,9	1,0	1,0	2,5	10	2,7	10	1,1	1,6	1,0	2,8	8,0	5,5

For the case under consideration, weighting factors, indifference, preference and veto thresholds are presented in Table 4. Weighting factors and veto thresholds are calculated as averages of the corresponding views of the 13 experts that were interviewed. As regards preference and indifference thresholds, those were calculated as follows:

$$p_k = \frac{1}{n}(V_{Ak_{MAX}} - V_{Ak_{MIN}}),\ A \in (A_1, A_2, ..., A_7),\ k \in (C_{S1}, C_{S2}, ..., C_{O5c}) \quad (1)$$

(Haralambopoulos and Polatidis, 2003) and

$$q_k = 0.3 \cdot p_k,\ k \in (C_{S1}, C_{S2}, ..., C_{O5c}) \quad (2)$$

(Kourmpanis et al., 2008), where:

$V_{Ak_{MAX}}$: Maximum performance of alternative Afor criterion k,

$V_{Ak_{MIN}}$: Minimum performance of alternative w for criterion k and

n = number of available alternatives.

In that sense, indifference and preference thresholds are directly linked to the quantified values of the alternatives' performances in the selected criteria. Since values of the performance table (Table 3) are scaled (in a range1-10), indifference and preference thresholds are similar for all criteria. However, those scaled values refer to totally different actual values.

Table 4: Weighting factors and thresholds for the development of a humanitarian logistics depot in Pella, Greece

	C_{S1}	C_{S2}	C_{S3}	C_{S4}	C_{S5}	C_{S6}	C_{S7}	C_{O1}	C_{O2}	C_{O3}	C_{O4a}	C_{O4b}	C_{O5a}	C_{O5b}	C_{O5c}
Weighting factor	5.3%	4.1%	6.0%	1.6%	1.8%	4.9%	9.8%	7.7%	7.2%	14.9%	9.7%	1.4%	5.1%	7.8%	12.7%
Threshold of indifference	1.43														
Threshold of preference	0.43														
Veto threshold	-	-	6.1	-	-	-	-	-	5.7	2.8	4.8	-	-	-	5.4

3.3 Results and discussion

As a next step, following the determination of alternative sites and criteria, the mathematical The optimal location (Aravisos) can be interpreted as a result of the specific site's excellent performance in a number of different criteria. More specifically, Aravisos is the site closest to the earthquake's epicenter(CO1) among alternatives, while also the location is one of the closest to port(CS4), airport (CS5)and heliport (CS6)so that resources and human capital can be quicker and more efficiently transported. This is further reinforced by the specific site's excellent quality of infrastructure (CS3), since the specific area corresponds to a newly renovated army camp. In order to overcome subjectivity issues, the sensitivity analysis that follows, as well as the ease to re-calculate optimal solution with modified parameters, provides the decision maker with an easy-to-use tool. Sensitivity analysis is considered as a significant merit of the presented methodological approach on the grounds that in real-world applications, input data originate from estimations which, although assumed constant, are sometimes more or sometimes less reliable. Especially in times of severe incidents as the one herein described, the quality of input data is further questionable. General sources of individual uncertainties could come from data series uncertainties, synergies and idiosyncrasies in the interpretation of ambiguous or incomplete information. In any case it should be underlined that the simultaneous consequences of potential variations of parameter values, decision variables and constraints could be studied by new model runs, since the low computational time gives the opportunity for fast reformed optimal solutions. On this basis, ELECTRE III is preferable, since it is considered to better adapt to uncertainties (Roy and Bouyssou, 1993).In this light, for sensitivity analysis purposes, the problem under study is resettled with modified parameters (weighting factors and thresholds).Together with the "basic" scenario, twelve more parameter-based scenarios with differentiated preference and indifference thresholds were examined. Those scenarios correspond to increase of preference and indifference thresholds by 5%, 10%, 20%, 30%, 40% and 50%, respectively. The rest six investigated scenarios similarly correspond to decrease of preference and indifference thresholds by the same percentages. For all above scenarios, Aravisos appears as the optimal location for the development of the logistics depot, which provides the decision-maker with additional confidence on the robustness of the result. Apart from the aforementioned twelve threshold-based scenarios examined, sensitivity analysis is also conducted with the modification of criteria weighting factors also by 50% (increasing and decreasing). For all weighting factors-based scenarios, Aravisos appears the optimal location.

4. CONCLUSIONS

In cases of earthquakes, floods, volcanoes' explosions, tsunamis, as well as other natural or man-made disasters, timely and efficient organization, planning and execution of all necessary actions towards humanitarian relief is most critical. Notwithstanding the fact that all such different incidents heavily differentiate among each other in terms of the required relief operations, in all

cases those operations need to be carefully organized well ahead the incident occurs. In this light, responsible bodies need to be adequately prepared in order to efficiently cope with such disastrous situation. Towards this direction, one of the most strategic decisions is the optimal location of a humanitarian logistics depot to be developed. Such a decision may represent the cornerstone towards humanitarian relief and may further influence all other important strategic, tactical and operational actions that are required. Optimal location of a humanitarian logistics depot involves simultaneous consideration of usually mutually conflicting parameters which may be either related or not to the episode's epicenter. The latter can be assessed well ahead the incident strikes in order the responsible body to be better prepared for rapid response. On the other hand, the decision-maker needs to wait until the disaster actually happens in order to come up with the assessment of the parameters that are directly influenced by the type of disastrous incident and its epicenter. This paper presents an easy-to-use tool that could facilitate secure relief to the victims of disasters in a timely and reliable way. The proposed methodological framework is implemented for the case of a virtual earthquake incident in northern Greece. However, the procedure could be easily adopted, with slight modifications and adjustments to the special requirements of the problem under consideration, in order to surface optimal decisions in respect to types of natural or man-made disasters other than the one examined in the present analysis.

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NEW TRENDS AND STRATEGIES IN POSTAL LOGISTICS

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Abstract: *This paper will present the latest trends and strategies in postal logistics and will also give the experiences of most developed postal operators in the field of logistics. Postal business network of Serbia is the largest infrastructural and logistical network. Serbian post has a wide range of logistics services and post is a leader in the provision of logistics services. We will provide an adequate prediction of the future development of postal logistics and assess the current situation in the field.*

Keywords*: Logistics trends, logistics strategies, experiences, Serbian post, prediction*

1. INTRODUCTION

The rapid technological development has given a number of trends that have affected all areas of logistics activities. Besides the technological trends there are and social-business trends. In combination with the technological trends they create unique value for business improvement. Social-business and technology trends are the result of megatrends such as digitization, globalization and so on. Universal Postal Union monitors all modern trends, implements them and adjusts for postal logistics.

The aim of this paper is to summarize the most important trends as well as strategies which passing through from these trends in the field of postal logistics , give the experience of leading operators in postal logistics, and then analyzes the state of postal logistics provider "Post Serbia" to accept new trends as leading postal logistic provider. Through SWOT (Strength Weakness Opportunities Treats) analysis it will be determine the readiness to accept new trends and perform the appropriate conclusions.

2. TRENDS IN POSTAL LOGISTICS

According to research conducted by Kückelhaus and Wegner (2013) from the Department for Innovation of DHL in cooperation with Detecton consulting, it was concluded that logistics is influenced by a numerous of trends. The most important of them are labeled as megatrends. Some of these megatrends are:

- Digitalization
- E- substitution
- Sustainability
- Continuing globalization
- Outsorcing

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- Demographic change and urbanization.

In addition to the identified megatrends, it is important to note the impact of new technologies and their development trends that appear in logistics. The greatest impact have these new technologies:

- Mobil devices of next generation : smart devices and tablets
- Cloud based market places
- Internet of everything
- Internet of things
- Mobil application
- In-memory computing etc.

By combining the megatrends and new technologies, DHL company was able to identify trends that are present in the logistics and divided them into two categories:

- Social and business trends
- Technology trends

Heutger and Kückelhaus (2014) from DHL's sector for inovation have also conducted identical study and in the following table are given the most important trends from the aforementioned two categories, ie. trends which have the greatest impact on logistics providers (Table 1):

Table 1. Logistics trends

Logistics trends	
Social and business trends	**Technology trends**
Supergrid Logistics	Big Data/ Open Data
Real-Time Services	Cloud Logistics
Anticipatory Logistics	Autonomous Logistics
Urban Logistics	3D printing
Omni-Channel Logistics	Internet of Things

2.1 Social and business trends

Supergrid logistics is a very important logistic trend. There is a tendency in major urban areas to connect with each other and create supergrid transportation networks, and that networks will be one day connected to large international mega-cities, which will act as logistics hubs. This trend has already begun. United States Postal Service (2014) imposed one problem. Problem is the existence of "last mile links, to connect people from rural areas to the rest of the world. That segment will also be very interesting for postal logistic providers.

Heutger and Kückelhaus (2014) said that in the trend of real time services, there are two dominant influence: real time tracking services (for example, services that provides information about positions of items) and real time order management (ordering along the way). There are a variety of mobile applications for this logistic trend in postal logistic.

Anticipatory logistics is improved method for predicting request for items. It is especially applicable for military operations. Predictive logistics planning is particularly important in e-commerce. Companies analyze the user's search, shopping history, desires and prepare the order before ordering.

By resarch of Federal Ministry of Education and Research (2014), 85 percent of European population will live in urban areas in 2050. The existing infrastructure does not represent a guarantee for a sustainable supply chain of goods and services. Postal, parcel, express and other logistics companies will consider new opportunities that are special designed for uraban areas. Urban logistics will occupy a very important place in the logistics industry.

Omnichannel logistics is made of better linking shop and e-commerce opportunities. There are several options, one of them is that the user, for example, can go to the store and sees an object that he likes and to order for home delivery or to order online and pick up in store. This trend is beginning to appear in the postal logistics.

2.2 Technology trends

Universal Postal Union (UPU) over 140 years of collecting data on global postal exchange. In the postal terminology, this term has become known as big postal data. In Report of Universal Postal Union for December (2013) was concluded: "whether you make a phone call, send a letter, you leave some footprints digital character". The private sector can use this data to improve business. Postal big data is the key to global development and UPU realized that data is public good.

IBM researchers have demonstrated how big data can be used for optimization of public transport in African cities matching of bus routes with traffic from mobile phones. That allowed them to create the new routes that passengers will save 10% of the time in transit.

Postal and logistics companies can benefit by shifting IT components to the cloud across their entire value chain. Most postal and logistics companies already started their cloud migration journey. TNT uses cloud to support both front- office and back office operations. Postal and logistic companies can generate revenue from offering their service from the cloud. Services are accessible anytime and anywhere. (Deloitte 2012)

Kückelhaus and Wegner (2013) indicated that autonomous logistics is the implementation of unmanned aerial vehicles (UAVs), cellular transport systems and other similar systems that provide a variety of opportunities in the sector of storage and transport. Such systems in the coming years will become a reality and the postal and logistics sector will be impossible to imagine without their use. All companies that are involved in express delivery are considering autonomous logistics in the air. The potential application is in hard to reach areas or for medical purposes. (figure 1-DHL tested parcelcopter)



Figure 1. DHL parcelcopter*

3D Printing was presented as an automatic method that will be used for the production of prototypes. There are several technologies and most of them work on the principle of building

* http://www.aircargonews.net

up layers of material. The materials used in the 3D printing are mostly of plastics and ceramic. 3D printing is a technology that will change the lives of people. Bearing this in mind, 3D printing will have a big influence on the logistics company. Manners-Bell and Ken Lyon (2012) indicated that this trend will create new opportunities and will develop new sector that will deal with storage and movement of raw material used by 3D printers. With the available 3D printers, for operations in remote locations is only required electronic library with items and computer. Combination of 3D scanners, computers, 3D printers allow you to print the desired object.

Universal Postal Union saw the significance of the trend which is known as the "internet of things". Term "internet of things" is adapted for postal vocabulary and become "internet of postal things" (Figure 2) .When it says "internet of things" usually refers to the use of sensors that enable physical objects, for example letters and packages that collects a variety of information in real time through Internet. In this manner are obtained "big data" for analysis. This will help any company to promote their business or to develop a new set of services*.



Figure 2- Internet of postal things**

3. STRATEGIES IN POSTAL LOGISTICS

In this section it will be given some basic characteristics of strategies of leading postal logistic operator: DHL and Swiss Post.

The strategy DHL is based on three pillars: Focus, Connect, Grow. The objective is to remain in position logistics provider for the world. Each of the three pillars has very clear goals. Focus on the things that make them successful. The company continues to focus on logistics as a primary activity, and plans to 85% of revenue comes from logistics activities. They are trying to expand services for e-commerce market. Connect pillar is based on linking the organization. This is achieved by making the exchange of internal know-how expertise. Connect pillar allows to increase service quality.

To ensure the development of the company they created a grow pillar. With it, the company is expanding into new market segments, especially in the sphere of e-commerce***.

Swiss Post is a modern logistics company. Every day delivered half a million packages and 15 million letters. It strives to meet user needs, and at the same time to remain effective national company. Swiss Post is going to increase the efficiency from collection to delivery. Swiss Post's logistic strategy provides common basis for development for the company's different areas. This applies to all fields of the process chain. (Swiss post and politics 2014).

* http://news.upu.int/no_cache/nd/internet-of-postal-things-offers-food-for-thought
** http://nfpe.blogspot.com/2014/10/upu-news-forum-on-internet-of-postal.html
*** http://www.dpdhl.com/en/about_us/strategy.html

4. POSTAL LOGISTICS IN SERBIA

Post Serbia offers numerous logistical services. Services include set of postal, logistical and IT services. Post use modern technology to improve business. In this paper we deal with ability of Post Serbia to accept new trends, technological and social-business trends [*]. By analyzing the existing capacities of post and history of accepting new trends in postal sector we have summarized the most important features in the SWOT (Table 3) matrix.

Table 2. SWOT Analysis for new logistical trends in Serbian Post

SWOT analysis	
Strength • Good infrastructure and capacity to receive technological trends and social-business trends • Strategic approach to business • Educated staff who can quickly implement social-business and technological trends •	**Weakness** • Time of implementation of new trends due to regulations and laws • The high cost of new services • Cultural differences and time to customer adaptation on new trends
Opportunities • The appearance and availability of new users (by using autonomous logistic-reach hardly accessible areas, delivery of drugs etc) • Implementation of new technical and technological systems (increase company brand in eyes of customer) • New services with additional values (real time services)	**Treats** • The appearance of competitors with lower costs • The appearance of competitors with a higher level of quality • The introduction of new laws that increase the cost of business • Changes desires and habits of users

5. CONSLUSION

At the end of the paper can be summarized that the new trends in postal logistics will shape the different ways of doing business, which can lead to the creation of new services that have added value to the user, and thus increase profits for the logistic company. In Serbia, in the next period is expected development of e-commerce. Users want to have their ordered products delivery in

[*] http://www.posta.rs/default-eng.asp

the shortest possible time. This can be achieved through a combination of new trends, particularly the application of cloud logistics in the postal sector and providing various electronic services, which are attractive for users. Post Serbia has all the capacity to become a regional leader in the provision of logistics services, as well as very easy to implement certain trends such as cloud logistics, urban logistics, autonomous logistic especially in the sphere of processing shipments. Future research in this sector we will focus on the analysis of other providers of postal logistics and the development of new services in this domain.

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SOCIAL NETWORKS IN LOGISTICS SYSTEM DECISION-MAKING

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Abstract: *Social networks, such as Facebook, Twitter and LinkedIn have been becoming very popular during the last few years. Facebook is currently the world's most populous "country" with more than 1.3 billion "inhabitants". According to the statistical data, the users share their impressions daily in the form of statuses about upcoming events and present state of affairs, their problems, plans, novel experiences about the products, political stances, and alike. Having the possibility to extract the information of interest from a huge amount of hand-created data about the users' personal affinities and their usage within logistics system, it is facilitated to meet the customers' needs. In this paper we present a procedure for finding and analyzing valuable information related to the specific products, and its effect on logistics system decision-making. Filtering is being done by already developed software for neurolinguistics social network analysis - "Symbols". This software offers graphical representation of statistical data for selected brands based on the social network statuses, its implications, as well as target group demographic and territorial structure. The results obtained point out possible increasing/decreasing demands among separate user groups, therefore giving a factual basis for logistics changes.*

Keywords*: social networks, information retrieval, logistics system decisions.*

1. INTRODUCTION

Enterprises create and deliver products and services through increasingly global and complex supply chains (Binder and Clegg, 2007). Nowadays, business requests are demanding and enterprises have to continuously seek ways for business improvement. Improvement indicators are numerous and vary from decreasing operational costs, providing satisfactory customer service, to minimizing existing disruption risks. These pointers can be achieved by means of efficient supply chain design and management.

In the traditional analyses performed in logistics and supply chain management (SCM) research relationships among buyers and suppliers are observed as linear (Cox et al., 2006). The traditional approach puts an actor (individual or organization) participating in a supply chain into the focus, thus isolating a unit of the analysis. Contrarily, social network analysis (SNA) focuses on actor-actor relationship patterning. Relationships among individuals within a social network can reveal highly indicative results that a conventional survey in the field of logistics and supply chain management could never yield. These relations may be established through, for instance, friendship, liking, ''talked to over the last month'', ''sent e-mail to'', workflow,

money flow or the exchange of goods among actors (Scott, 2000). Basically, flows and transfers are the most important kinds of relations. Yet, they are rarely surveyed and are presumed from interactions or social relations. In case of real data want, since they are not collected, scrutinized or available due to company security and privacy policy, we have focused on company and fan profiles on Internet social networks, such as Facebook.

Unlike classical offline techniques, Internet offers unique and immense possibilities for market research, giving real-time data access and insight into the people's changing preferences thus providing room for innovation in the field. In this paper, we demonstrate how to use social network analysis and online communication for logistic problem investigation, advising amendment for certain supply networks, their activities and plans. Filtering of collected statuses throughout news feed was done by software for neurolinguistics social network analysis "Symbols" which is presented in more details in the fourth section. Finally, we compared our results with the results of existing surveys for beverages brands available on Internet.

The remainder of the paper is structured as follows. Section 2 gives an overview of the literature. Section 3 presents the details of our software "Symbols". Section 5 describes our research methodology. In Section 6, we provide interdisciplinary research opportunities for using our software in supply chain system (SCS) and enterprise system research. Section 7 concludes the study.

2. LITERATURE REVIEW

Inter-connected companies which are integrated into supply networks participate in procurement, use, and transformation of raw materials to provide goods and services (Harland et al., 2001). Traditional approaches in analyzing supply chains are characterized by different issues which can be overcome with viewing supply chains as a network for all actors. If we take a look at one company, its "supply network" will consists of relations to its direct suppliers and customers, and relations between them and their direct suppliers and customers, and so on, thus forming an ever more complex network.

Relative position of individual firms within network influences strategy and behavior (Borgatti and Li, 2009), therefore it is increasingly important to analyze the network structure of supply relationships. A relation between two firms can be established based on their collaboration, a product development, sharing the trade organization or money exchange for services etc. Different metrics, node-level and network-level, provide researchers with a descriptive and statistical method for positioning and connecting the SCS actors (Wasserman, 1994). Degree centrality, closeness centrality, and betweenness centrality are different types of centrality metrics and they identify nodes that are important.

Most of the existing interorganizational SNA research has occurred in the strategic management arena (Pettigrew, 1992). SNA represents a valuable tool for analyzing structures and relations in different areas which could be transformed in network, including business studies, sociology, computer science, physics, and psychology**,** knowledge transfer, and innovation. Kim et al. used social network analysis to investigate the structural characteristics of three automotive supply networks reported in (Choi and Hong, 2002). SNA use could be seen in the analysis of communication patterns in organizations involved in humanitarian and tourist logistics operations (Holguín-Veras et al., 2012; Pesonen, 2011). Generally, SNA has not been applied in an empirical study of real supply networks. A general paucity of SNA applications in supply management arise from the lack of conceptual clarification as to how the key SNA metrics can be theoretically interpreted in the context of supply networks (Carter et al., 2007).

Here we tried to overcome mentioned issues by offering additional information about the company's business. Unlike SNA, where the obligatory unit of analysis is an organization, firm, or business unit, our approach is based on Facebook profiles network. Many social networks are

extremely rich in content, and they typically contain a tremendous amount of data that can be used for analysis (Aggarwal, 2011). There are no studies employing demographic data from Facebook for product popularity improvement. Following different parameters enables us to predict demands at a location, for a target group - the need for building new warehouses or rearranging transport routes and all according to the market changes detected online.

3. "SYMBOLS" DATA COLLECTION

When analyzing Facebook data, data collection was a major challenge. In our approach, we asked a group of people for the permission to access their data. This method results in a strong sampling bias and makes it difficult to acquire large samples.

For the purposes of web application named "Symbols", we developed a Facebook application SSNA (Software for Social Network Analyze). App users have to explicitly agree that the app is permitted to access the part of their data classified into two groups, static and dynamic data, explained below. They were informed that their data will be used only for scientific purposes and that it will not be given away to any third party. The app has had 46 activated, basic Facebook profiles during the data collection period, 12.12.2009 – to the present time. One part of the asked permissions refers to the friends' data; therefore, the data of 106,434 users could be retrieved. In the background, two time-based job schedulers (CRON) are processing every core profile. One job is to deal with the static data (education, birthday, city, job, fan page, etc.), and another one with dynamic data (statuses, likes and comments, all friends' data). The data includes the *friendship network* (friendship relations) and the communication network (*Like*, *Comment*, *Post* and *Tag* relations).

4. METHODOLOGY

Sample size for mineral water brands in Serbia taken into consideration are 422 for Knjaz, 249 for Aqua Viva, 859 for Rosa and 127 for Jana. Profiles who like brands' pages on Facebook constitute samples. For instance, pages taken into account for Aqua Viva mineral water are Aqua Viva, Aqua Viva - voda sa ukusom breskve, AQUA VIVA Breskva Hydroactive, Aqua Viva Sport.

Market Network (2014) is a source of information about mineral water market in Serbia for 2014. This web site provides research findings related to mineral water consumption. Market Network enlists sale channels. This is based on standardized research in Serbia that lasts since November 2002 and it encompasses 1500 families in the country. Among others, this web site lists the most popular water brands based. Based on this, list of mineral water brands for this research has been created. Other reports about mineral waters include text written by Smit (2009). As for sodas, some of the related research findings could be seen on website "Tvoj stav" (Online istrazivanja, 2010). Although similar research inquiries to our social network stratification have not been done in Serbia, goal of this paragraph is to list some of the findings of classical market research.

5. RESULTS & DISCUSSION

Goal of this paper is to see how real time data from social networks can be used in logistics. Figure 1 depicts age, education level and relationship status of those that like different mineral water brands on Facebook. These data are different for each brand so it would be possible to conclude that elder like Knjaz (30 years old in average) while the young like Aqua Viva (Figure 1-a). This awareness can optimize marketing by being leveled to chosen target groups in order to get customers from different age groups.

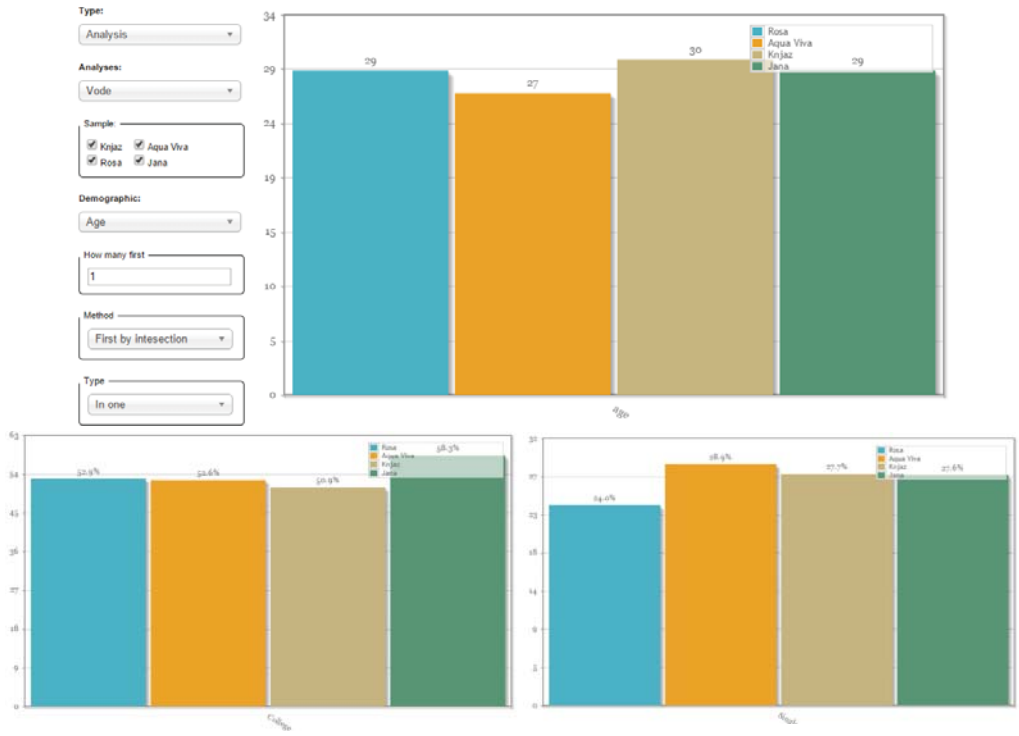


Figure 1. Statistics for a) Age b) Educational level c) Relationship status

Figure 1-b on the other hand, depicts that the most educated consumers of mineral water in Serbia are those that like Jana mineral water brand on Facebook, while the least educated are those that like Knjaz mineral water. Consequently, advertisements addressed to those people should be fittingly created. Knjaz mineral water brand manager should want to attract younger consumers by creating advertising campaigns that talk to youth more than to the aged, for example. The similar conclusion could be made when looking at Figure1-c which depicts that those who like Aqua Viva are the most "single" in terms of relationship status when compared to other mineral water consumers. On the other hand, most married people like Rosa mineral water. Additionally, we obtained that women prefer Jana mineral water while men prefer Knjaz mineral water. Similarly like in cases of first three graphs, data obtained from Figure 2 can be used in marketing. Whether this mineral water brand would go for one or the other advertising strategy it depends from decision of the company in question but the main point would be that social networks with use of adequate software can provide valuable logistics for marketing in terms of advertisements. Obviously, it is important that products in questions are mentioned online, and this is expected because they are widely consumed and they are parts of everyday life. In this way, online identification and quantification of logistics demands can be useful for brands.

Mentions of product category indicate the present needs for it. For example, water may be mentioned more times at some location because of hot weather conditions. On the other hand, water may be mentioned more in one place because of the problems in water supply. These circumstances can be registered on social networks by increased mentions of water product category, but also there might not be any apparent reason for the increase in demands. Measuring this online increase in needs would be valuable for logistics. This real-time statistics may be an input for top management in deciding for higher marketing efforts, increasing the

number of products on the market and in improving position of brands within the existing ones. These actions would result in better sales. This approach has its use in lower branches of management, as well. They would use the input for selecting where and how to implement decisions of top management (install water machines near appropriate institutions, how to organize distribution routes, design product for target population).

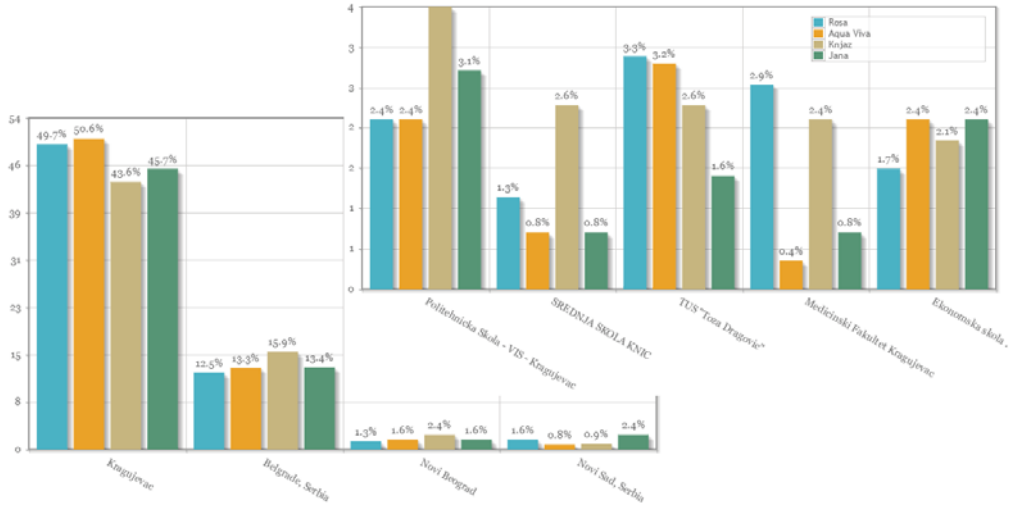


Figure 2. Statistics for location and schools in Kragujevac

Nonetheless, this method of research may have its implication in delivery logistics. When inquired into how many times people mention certain mineral water brand during a week, the findings show that water gets the most mentions from Kragujevac, which is a city in central Serbia (Figure 2). Hence, product category is talked about more in Kragujevac than in the capital city, Belgrade. This may imply that water brand should increase supply in this part of the country.

When looked more closely, Figure 2 shows which population from different schools in Kragujevac like mineral waters. Based on this graph it is possible to conclude that supply should be increased in the vicinity of the schools where pupils most like mineral waters, while for those schools in which brand in question is not so popular, advertising efforts should be increased. By gaining these pieces of information company can, for example, decide where to send promoters of mineral water as well as where to increase other kind of marketing efforts.

6. CONCLUSION

Internet social networks may be hiding an abundant source of opportunities giving space to the "parallel world" which can and in many ways does surpass the realty. Unlike SNA, in this paper we changed the focus from organization as a unit of analysis to company and fans profiles on Facebook social network. Yet, this research is not independent from previous SNA research; it only provides additional information about company's business. The result is a demographic representation offering new marketing advices for specific brands, in our particular case, for water brands. In the same time, we compared our results with some online surveys made by different marketing companies. The results presented in this study give affirmative answer to the research question whether it is possible to use Facebook demographic data for product popularity improvement, and point out the novel demands appearing in logistics.

The advantages of this approach are real-time information without conducting a survey. People impressions can be divided into information sets for different population structures such as age,

location, gender, educational level and many more. These sets influence on product design and marketing targeting. However, every new decision must be confirmed with "field" data.

Our future goal is to expand core Facebook profiles and to adapt application to the newest Facebook API 2.0. Finally, an application upgrade for Twitter news feed is real necessity.

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TRENDS IN AIRLINE CARGO FLEET

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Abstract: *Although the global air cargo industry has recorded significant increase, it is expected that it will be more than doubled in the next two decade. The fleet involved in world air cargo transport consists of freighters and passenger's aircraft carrying cargo in its belly. The fleet of passenger aircraft has a larger number of aircraft and lower belly capacity compared to freighters. Therefore it is not unexpected that more than half of world's cargo is carried by freighters. In this paper, the cargo fleet structure and changes related to fleet size and fleet types are analysed. Bearing in mind that more than half of freighters are converted passenger aircraft it is worth noting aircraft conversion/production and retirement in the cargo fleet. The authors also give an overview of air cargo fleet both worlds and European, pointing the factors that influence on freighter fleet growth.*

Keywords*: Airline Cargo Fleet, Air Cargo Transport, Aircraft Capacity.*

1. INTRODUCTION

The cargo transport plays a significant role in the world transport system due to the fact that it makes more money for a transport company in comparison with transport of passengers (Wensween, 2007). The air cargo transport has not achieved this success yet, but still is unavoidable means of transport for specific goods. The speed of air transport and the lower risk of losing or damaging of the freight make air transport favourable for carrying the perishable, time-sensitive and valuable cargo despite the high charges. The value of freight carried by air is over a third of the total value, while the tonnage represents only few percent of the total freight carried in the world by all other modes of transport (Boeing, 2014).

Aiming to achieve the ground and water means of transport, air cargo is the fastest-growth area in the world cargo transport. Its growth depends on international trade and it is easily influenced by the changes in world's economy. After few years of stagnation, during the world economic crisis and economy recovering, the air cargo traffic started to grow. Although the global air cargo industry has recorded significant increase, it is expected that it will be more than doubled in the next two decade (Airbus, 2014).

The fleet involved in world air cargo transport consists of freighters and passenger's aircraft carrying cargo in its belly. The fleet of passenger aircraft has a larger number of aircraft but lower belly capacity compared to freighters. Therefore it is not unexpected that more than half of world's cargo is carried by freighters. In this paper, the cargo fleet structure and changes related to fleet size and fleet types are analyzed. Bearing in mind that more than half of freighters are converted passenger, aircraft conversion/production and aircraft retirement also

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should be noted. An air cargo fleet overview both worlds and European is given, pointing out the factors that influence on freighter fleet growth.

2. THE HISTORY OF AIR CARGO FLEET

The aircraft is constructed mainly for carrying passengers (Wensween, 2007). Therefore, the fact that passengers transport by air is more profitable than air cargo transport is reasonable. Depending on aircraft used in the fleet for cargo transport, development of air cargo services could be divided into three parts. Taking a look back in the past it can be seen that air cargo transport started after World War II in order to use spare capacity of transport military aircraft with the piston power plant. These aircraft were characterized by low speed, small range, low payload and low available volume. Hence, they were employed to carry valuable shipment such as gems, precious metals, small packages etc.

The second part of air cargo history is related to appearance of narrow body aircraft with jet power plant. These aircraft have higher speed, larger range and larger payload. They are used for transport of passengers in the cabin while cargo is carried in their belly as supplement to full payload, enabling to make additional earnings for an airline. The narrow body aircraft offered a possibility to transport different types of cargo, while the transport cost per unit of cargo were reduced. The type of cargo that could be transported is limited due to the cargo door dimensions and belly volume, as well as due to the volume and mass of cargo consignment. The disadvantages of narrow bodies are related to the fact that there are many different units of cargo which means that the great diversity of handling equipment is needed.

The third part of air cargo history has started with the appearance of wide body aircraft (in the sixties) that gave opportunity to transport a variety of goods. At the beginning the cargo was shipped by passenger aircraft in the bellies of wide bodies as supplement to full payload. Later, the aircraft that carried cargo in both belly and main deck and allowed even the transport of unusual shipments were came. These aircraft (known as freighters) offer possibility to transport a large amount of goods (up to 250 tonnes on the same flight). They are equipped with cargo loading systems (mechanical and powered), which enables better stacking and securing of cargo and reduction of cargo loading and unloading time as well. With these improvements the unit costs of transport are further reduced. The wide body freighters provide the ability to transport a large number of containers and pallets of different sizes, as well as the transport of intermodal containers. The intermodal containers are very suitable having in mind that air cargo transport includes inter-modality because the cargo must be moved to and from the airport by surface mode of transport. Also, high capacity of freighters is convenient for transport of oversized and heavy cargo (e.g. helicopters, aircraft fuselages, trains etc.).

The wide body aircraft are produced in combi and quick change version. Both passengers and cargo are carried on the main deck of combi aircraft (passengers may occupy the front section of the aircraft, with cargo occupying the back section), while quick change aircraft are used as passengers aircraft by day and as freighter by night. The quick change aircraft are equipped with quick change systems that include passenger seats on flooring panels which are put on and off the aircraft like cargo containers.

The freighter aircraft are divided into three categories according to Boeing (2014) (large wide-body, medium wide-body and standard-body) and Airbus (large freighters, mid-size freighters and small freighters). Each freighter category corresponds to particular market. As stated by Boeing (2014), the share of wide-body freighters in the current airline cargo fleet is about 65% and they offer about 95% of the total cargo fleet's capacity. Due to the range limitation of small and mid-size freighter, large freighters are usually employed on long-haul routes with high market demand. Mid-size freighters operate the regional routes where the usage of large freighters presents a capacity risk, and demand is not small. Small freighters are versatile and

flexible, thus they are used when terrain is geographically difficult (mountains, forests or islands).

Customers that sent their shipments by air consider the speed, reliability and quality of air transportation as main advantages and crucial factors while choosing the mode of transport. According to Hsu et al. (2009) it is very important to select not only optimal transport mode but also the optimal carrier that will deliver the goods to customer. The authors noted that the logistics cost of the shipper is influenced by the charge, flight frequency and transit time of the carrier as well as by product characteristics (high pricing and/or perishable characteristics lead to a high inventory loss). They showed that the shippers forwarding the product of high value on short distance consider the shipping charge as important factor and prefer the air cargo carrier that offers higher frequencies. On the other hand, the freighter operators are sensitive to tonne-kilometre costs due to the competition with other modes of transport. They also should adjust their supply attributes to the product characteristics in order to increase the market share (Hsu et al., 2009). While choosing their fleet, airlines must take into consideration both the interest of customers and their own interests, which are usually conflicting. The art of fleet planning lies in the ability to harmonize these interests in the most convenient way.

3. FACTORS INFLUENCING THE FREIGHTER FLEET GROWTH

According to Airbus (2014) the key drivers of air freight growth are: 1) economic and trade growth that strengthen or induce cargo flows, 2) globalisation of exchanges and free trade agreements that enables smooth and easy flows of goods, 3) expanding middle class demanding higher added value products (it is forecasted that the middle class will grow from 33% in 2013 to over 60% in 2032), 4) increasing urbanisation and industrialisation that require specific goods to be delivered in right place and right time from central warehouse, without local warehousing (there is no large investments in warehousing and inventories). Also, the increase of passenger demand and its impact on air cargo demand should not be omitted, too.

The market conditions have strong influence on world freighter fleet growth. The consequence of the global downturn reflects in decline of cargo flows as well as decline of freighter demand. Freighter operators solve the problem related to surplus of capacity by parking certain number of their aircraft. According to Boeing (2014) different factors often cause contrary effects. The high fuel prices increase air cargo transport costs, which further decrease demand for services. The contrary effect is that high fuel prices and fuel costs are reason to replace old less efficient freighters (usually converted passenger aircraft that constitute more than half of freighters) with the newer ones, which further induce the demand for new freighters. This demand for freighters decreases when yields, load factor and utilization are reduced. The new wide-body passenger aircraft with large cargo compartment also affects the demand for freighters, by reducing it slightly. However, the freighters offer specific, unique advantage on the market that could not be offered by passenger aircraft. Competitive mode of transport and belly capacity could influence on demand for mid-size freighter by reducing demand for air cargo service offering lower prices. The intercontinental flights are operated by wide-body freighters.

4. WORLD'S AIR CARGO FLEET

Airbus (2014) predicts increase in air cargo fleet from 2014 to 2033 (Figure 6). They expect that 328 of 341 small freighters will be replaced, 13 will stay in service, while the fleet will be enlarged with 284 aircraft (in 2033, 625 small freighters will be in service). The fleet of mid-size freighters will be increased from 750 to 1242. Only 97 aircraft will stay in service, 653 will be replaced, while growth will be 492 aircraft. Finally, 337 large freighters will be replaced, 177 will stay in service, while the fleet will be enlarged with 264 large freighters. The total freighter

fleet will increase from 1605 to 2645 aircraft. Only 287 aircraft will stay in service, while 1318 will be replaced, therefore enlargement of fleet is 1040 freighters (Figure 1).

Considering the conversion – new-built share, it could be noted that the conversion of large freighters is not usual, because new built aircraft are more reliable and have lower operating costs. Small freighters are subject to the conversion because of the lower acquisition costs. Both manufacturers Airbus and Boeing similarly forecasted the conversion – new-build share in the total fleet in the next 20 years of approximately one third of fleet to be new built, while the rest will be conversion. Also both manufacturers noted that air cargo fleet will be doubled in the next 20 years.

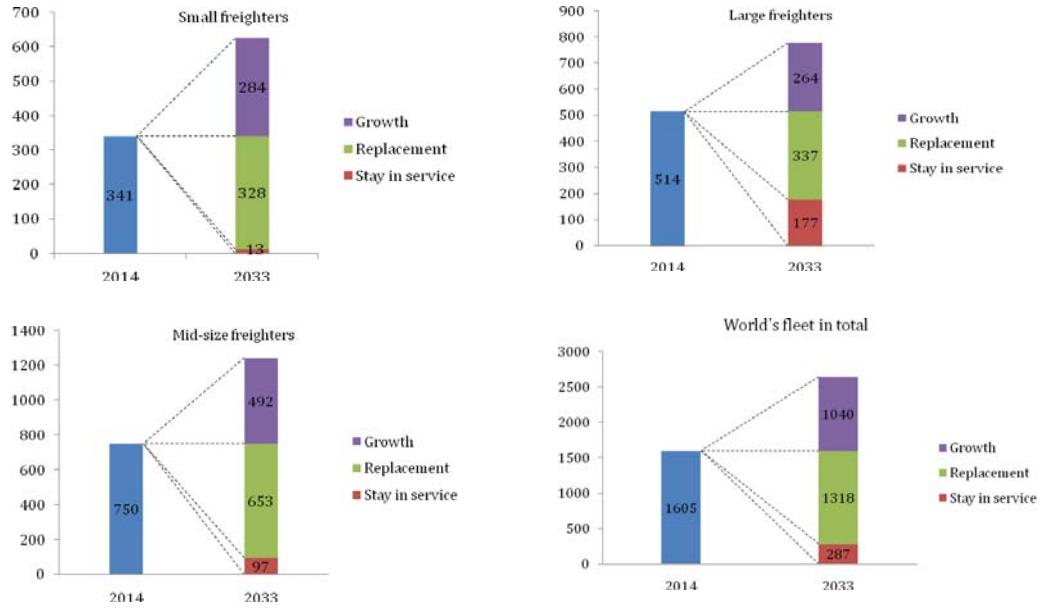


Figure 1. World's freighter fleet forecast (*Data source Airbus GMT 2014*)

Boeing (2014) expects that the world cargo capacity measured in available tonne-kilometres (ATKs[1]) will be more than doubled in the next two decade (more than 1000 billion ATKs). Capacity in combi aircraft will not be offered. Although the increase of the cargo capacity in passenger aircraft measured in ATKs is predicted, the dedicated freighters will transport more than half revenue tonne-kilometres (RTKs). The dedicated freighters are preferable due to their operating advantages, especially on long haul routes or for unusual shipment transport. It also should be noted that the belly capacity has increased with the size of aircraft, while the available belly capacity per passenger has remained stable during the last 25 years.

5. EUROPEAN AIR CARGO FLEET

The air cargo transport is influenced by economic conditions on the market. The effects of world crisis can be observed through the Eurostat data related to 32 European countries for the period from 2001 to 2012. It can be seen that the total number of cargo aircraft in considered countries

[1] Available tonne kilometres (ATKs) is a measure of an airline's total capacity. It is calculated by multiplying capacity in tonnes and kilometres flown.

is reduced from 427 in 2008 to 416 in 2012. The number of cargo aircraft by countries in 2012 is given on Figure 2, while Figure 3 presents the share of cargo aircraft in the total fleet by countries in 2012. Germany had the largest fleet consisting of 68 aircraft, while Portugal and Estonia had only one cargo aircraft (Figure 2). The eight countries (according to Eurostat data) did not have cargo aircraft in their fleet in 2012. Serbia also did not have cargo aircraft in its fleet, thus air cargo was carried in the belly of passenger aircraft. The largest fleet in total can be observed in United Kingdom and Germany, consisting of 1229 and 1146 aircraft respectively.

Considering the share of cargo aircraft in the total fleet (Figure 3) Luxembourg has the largest share of about 24%, that could be explained by the fact that large cargo airline Cargolux is originated from this countries. The share of cargo aircraft in Portugal fleet was less than one percent, while in France and Italy, the percentage was 2.3%. Although the share of cargo fleet in France in 2012 was small, the number of cargo aircraft in its fleet is not negligible (14 cargo aircraft).

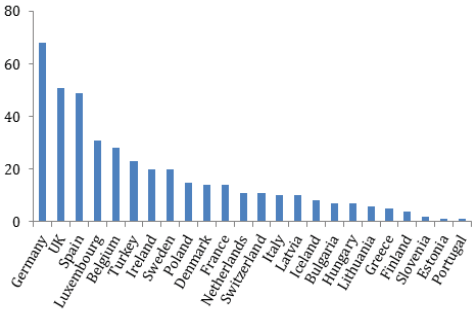


Figure 2. Number of cargo aircraft in 2012 *(Data source: Eurostat)*

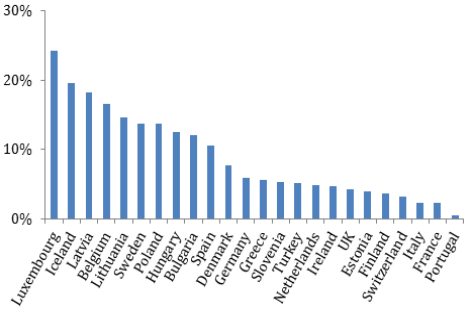


Figure 3. The share of cargo aircraft in the total fleet in 2012 *(Data source: Eurostat)*

According to Eurostat (data related to 32 European countries), the number of combi aircraft is insignificant. Unlike these data, Zhang and Zhang (2002) pointed that most passenger carriers in Asia have substantial cargo business and operate combi fleets. The quick change aircraft were used in European countries. Its number in 2012 is presented on Figure 4. The nine countries owned quick change aircraft in their fleet, and the leaders were France and UK with 15 and 14 aircraft respectively.

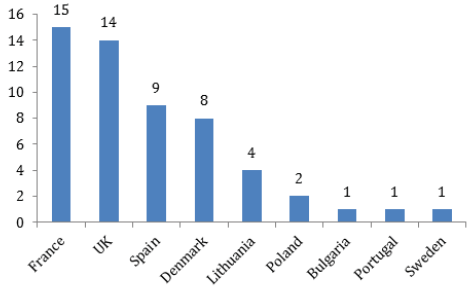
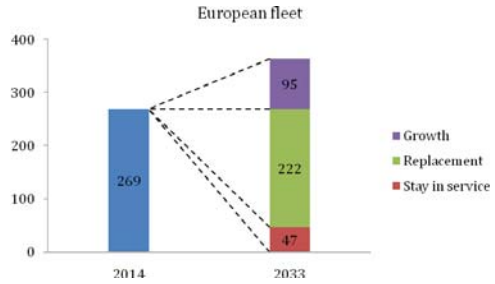


Figure 4. Number of quick change aircraft in 2012 *(Data source: Eurostat)*



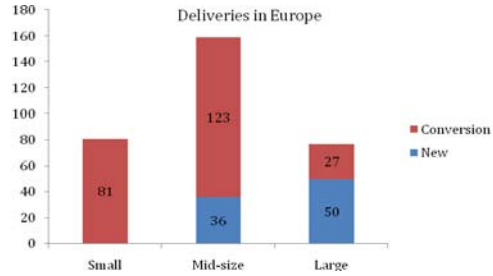


Figure 5. The growth of European fleet

Figure 6. Freighters delivery in Europe

(Data source: Airbus GMT 2014)

The forecasted growth of European freighters fleet (Airbus, 2014) for next 20 years is presented on Figure 5. The fleet will expand for 95 aircraft, 222 freighters will be replaced, while 47 will stay in service. Considering deliveries in Europe (Figure 6) it can be seen that all small aircraft will be converted passengers aircraft. The share of new mid-size freighters is 23%, while large freighters are in 65% new ones.

6. CONCLUSION

The fleet planning is the problem of strategic importance for an airline. Aircraft acquisition and fleet renewal enables an airline to reduce the costs, because newer aircraft are more flexible, fuel efficient and better match the demand on the market, especially on short-haul and medium-haul routes. New generation of freighters are designed to be more adoptable to the market conditions, therefore allowing the airline to be more competitive with other modes of transport. Forecasted trends, both in Europe and world, indicate the growth of air cargo fleets, which means that air cargo transport has been recovering from recession.

ACKNOWLEDGMENT

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Part V

INFORMATION AND COMMUNICATION TECHNOLOGIES IN LOGISTICS

APPLICATION OF REVENUE SHARING CONTRACT IN TELECOMMUNICATIONS INDUSTRY SUPPLY CHAINS

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Abstract: *Revenue sharing contracts have been used in a number of industries and play an important role in management of supply chains. This paper analyses possibility of application of revenue sharing contracts in telecommunications industry. The telecommunications industry is characterized by complex supply chain, with frequent services and tariffs introduction. In this fiercely competitive industry, new technologies and new services require high capital investments in order to provide emerging services to the customers. Other important issues in telecommunications industry are uncertainty of demand and service life cycle shortening. In such dynamic environment, supply chain management is essential. Telecommunications supply chain in delivering content from Content Provider, through Service Providers to the customers, is observed. The goal of the analysis is formulation of revenue sharing mechanism that reduces provider's incentives to increase retail price and stimulates improvement of customer base and market share.*

Keywords*: Revenue sharing, contract, telecommunications industry, supply chains*

1. INTRODUCTION

The telecommunications industry is characterized by rapid development of new technologies and new services. Large capital investments are needed in order to make content available. Market players often introduce new services and tariffs to increase their market share. Considering fierce competition, these systems need to be effective, flexible and scalable to efficiently manage an increasingly complex service portfolio. Telecommunications industry market includes residential customers, small businesses and big corporate customers, according to Gupta (2008). In the residential customers market, competitors rely heavily on retail prices to increase their customer base. Success depends on reputation and investment in billing solutions. The corporate market has different features in comparison with residential customers. Mainly, big corporate customers are less price sensitive when value added services are being considered. Telecommunications industry supply chains are very complex, dynamic systems and in general involve many different types of players and deliver different outputs by Agrell et al (2004). The roles and responsibilities in the supply chain are often changed due to the uncertainty of demand.

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Coordination of these supply chains can be achieved applying revenue sharing contracts. The main objective of this paper is obtaining the appropriate revenue sharing contract that reduces providers' incentives to increase retail prices and improves providers' market position.

The paper is organized as follows. After introductory remarks, Section 2 gives brief overview on revenue sharing coordination of supply chains. Two types of revenue sharing contracts are presented in Section 3. In this Section, we introduce two relevant parameters, provider's reputation factor and customer's willingness to pay. Numerical example is presented in Section 4. Finally, concluding remarks are given in Section 5.

2. COORDINATION OF SUPPLY CHAINS BY REVENUE SHARING CONTRACTS

Coordination of supply chains can be pursued by centralized or decentralized decision-making approach according to Giannoccaro and Pontrandolfo (2004). If there is a unique decision maker within the supply chain, decision-making approach is centralized. Decentralized decision-making approach occurs when there are several independent actors at the different stages of supply chain. Supply chain contracts are a useful tool to make several actors of a decentralized approach to behave coherently among themselves. In a centralized control mechanism, a unique decision maker possesses all relevant information on the whole supply chain and contractual power to implement such decisions. The centralized control assures the system efficiency. However, centralized control is often considered as not realistic. In such conditions, decentralized control is more convenient. It includes several decision makers, pursuing different objectives, possibly conflicting among each other. Locally appropriate behaviour is often globally inefficient. Hence, coordination mechanisms are needed in order to have local decision-makers pursue channel coordination. Such coordination mechanisms include the supply chain contracts, which control transactions between actors in supply chain. In particular, the risk and the revenue, arising from different sources of uncertainty and channel coordination respectively, are shared by all actors of supply chain. Different models of supply chain contracts have been developed, including quantity flexibility contracts, the backup agreements, the buy back or return policies, the incentive mechanisms, the revenue sharing contracts, the allocation rules and the quantity discounts by Giannoccaro and Pontrandolfo (2004). Revenue sharing contracts have an important role in the supply chains management by Krishnan and Winter (2011). These contracts can be applied to industries where their demand is uncertain, forecasting demand does not follow a well-defined trend and distributors can easily control retailer's profit. Revenue sharing contracts in which retailers pay specified amount of revenue to suppliers are widely adopted, especially in the video distribution and movie industry. According to these agreements, a retailer purchases a product from a supplier for a fixed price and shares a portion of the revenue with a supplier. The supplier offers the purchase price for the product to the retailer who defines the quantity of the product to be ordered by Parsule-Desai (2013). Considering content delivery from Content Provider (CP) to Service Providers (SPs), due to the characteristics of telecommunications supply chain, short service life cycle, and the absence of inventory, there is no difference between purchase and demand. Schematic presentation of telecommunication supply chain is shown in Figure 1. A major Electronics Manufacturing Services Provider (EMS) may support many of the Original Equipment Manufacturers (OEMs), such as Nokia, Ericsson, Alcatel, etc. Global operators often choose different OEMs to supply different countries and use more than one supplier within a country. Second and third tier suppliers are supplying not only the next step in the supply chain, but also companies downstream.

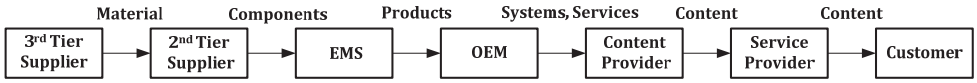


Figure 1. Schematic presentation of telecommunication supply chain

The uncertainty on the telecommunications market and the short service life cycle make reliable forecasts of supply chain characteristics more difficult. The reason lies in the uncertainty of demand, new operator emergence and introduction of new technologies.

3. PROBLEM STATEMENT

Let us consider telecommunications supply chain as shown on Figure 1. Emphasis of our research is the analysis of the last segment of supply chain, consisting of CP, SP and customer and their mutual relations. Assume that total customer population, denoted as X, is fixed during observed time interval. SPs compete on the common retail market for provisioning the same content from CP. Total number of SPs is denoted by N. Assume that contracts are being agreed among providers for a single content. Quality of Service (QoS) is assumed to be satisfactory and all SPs offer the same service class. In order to obtain appropriate revenue sharing contract among CP and SPs, such that provide market stability and ensure customers protection by reducing incentives of SPs to increase their retail prices, we analyse two types of contracts, static and dynamic. The aim of dynamic revenue sharing contract is to stimulate providers to improve their market share, to strengthen market position and thus increase their revenue, rather than by price enhancement. Relevant parameters in these contracts are customers' willingness to pay specific content by the given SPs' retail price, and SPs' reputation. Customers' willingness to pay refers to the portion of total customers' population that are able to afford themselves observed content by the retail price, p_i. Regarding to the price sensitivity, two types of customers can be distinguished, more and less price sensitive. Thus, customers' willingness to pay mathematically can be expressed as follows:

$$w_i = \begin{cases} \frac{\alpha - \beta p_i}{N}, & for\ more\ price\ sensitive\ customers \\ \frac{\rho p_i^{-\varphi}}{N}, & for\ less\ price\ sensitive\ customers \end{cases}, \quad w_i \in (0,1) \qquad (1)$$

Parameters in this equation (1), α, β, ρ and φ depend on socioeconomic structure of customers, target groups, but also on substitutability and popularity of content delivering from CP, through SPs, to the customers. Willingness to pay is inversely proportional to the total number of SPs at the market.

Figure 2 presents customers' willingness to pay for arbitrary chosen values for parameters and price. Less price sensitive customers are less flexible in terms of price variation, and the slope of their willingness to pay has slow decay in comparison with more price sensitive customers.

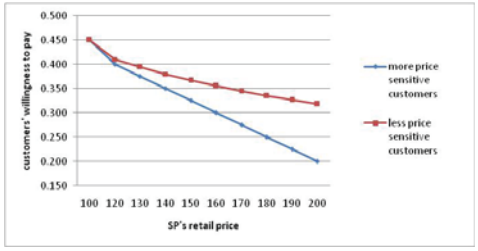


Figure 2. Price dependence of customers' willingness to pay

Price reduction leads to enhancement of customers' willingness to pay specific content for both types of customers. As a result, number of SPs' end customers will increase. Thus, one of the most important providers' business goals, improved market share, will be satisfied. Another important parameter in proposed models is SPs' reputation SP_i's reputation is denoted by $r_i, r_i \in (0,1)$. This value is established on the basis of long term business existence of SP_i on the market, and $\sum_{i=1}^{N} r_i = 1$. This means that value for SP's reputation is normalized and sum of the values for all SPs equals 1. We assume that reputation of all SPs on the market is known. Higher

reputation is reason why a number of customers are willing to pay content at higher price rate, although QoS requirements are satisfied by all SPs. Static revenue-sharing contract defines fixed, predetermined, portion of generated SP's revenue from provisioning CP's content on retail market that must be paid to CP. Thus, CP always obtains the same portion of revenue from contracts with SPs for the given content. Revenue of SP_i from provisioning content to the customers and CP's revenue in accordance with the static revenue sharing contract can be, respectively, written as follows:

$$R_i^{\ s} = \left(1 - \Phi_i^s\right) p_i w_i r_i X, \tag{2}$$

$$R_{CP}^s = \sum_{i=1}^{N} \Phi_i^s p_i w_i r_i X \tag{3}$$

where $\Phi_i^S,\ \Phi_i^S \in (0,1)$ presents fixed portion of revenue that, by the contract, SP_i pays to CP under static revenue sharing contract. Dynamic revenue-sharing contract defines flexible portion of revenue that SP pays to the CP, depending on SP's retail price. Portion of SP_i's revenue paid to CP under dynamic revenue sharing contract can be expressed as follows:

$$\Phi_i^{\ d} = \left(1 + \Delta p_i\right) \cdot \Phi_i^s \tag{4}$$

In this equation (4), Δp_i presents variation of SP_i's retail price p_i. Thus, revenue of SP_i from provisioning content to the customers and CP's revenue under dynamic revenue sharing contract can be, respectively, written as follows:

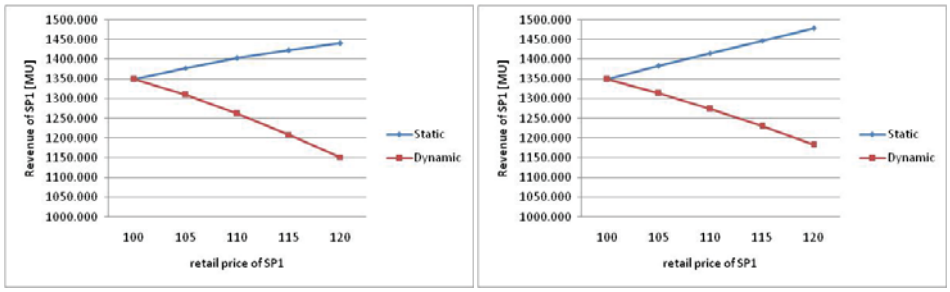
$$R_i^{\ d} = \left(1 - \Phi_i^{\ d}\right) p_i w_i r_i X, \tag{5}$$

$$R_{CP}^d = \sum_{i=1}^{N} \Phi_i^d p_i w_i r_i X \tag{6}$$

4. NUMERICAL EXAMPLE

Let us consider the situation in which revenue sharing contracts have been applied to a single CP and two SPs on the retail level. CP offers a single content and negotiates with SPs on the portion of revenue that has to be paid on the revenue sharing basis. We assumed that one SP is new entrant in the observed market, thus having lower reputation factor than other. Regarding customers' price sensitivity, we assumed two scenarios. The first scenario refers to the situation when SP1 increases its price up to the level of SP2's retail price, while SP2 remains retail price. The second scenario describes price reduction by the SP's offering higher retail price. This situation is common when promotions and discounts are being applied. Values for parameters in the expression for customers' willingness to pay are specified according to assumed market situation. We assumed that values of relevant factors for calculation of revenues are the following: $X = 200000,\ \Phi_i^S = \Phi^S = 0.5,\ p_1 = 100, p_2 = 120,\ r_1 = 0.3,\ r_2 = 0.7$. All obtained revenues are expressed in monetary units [MU].

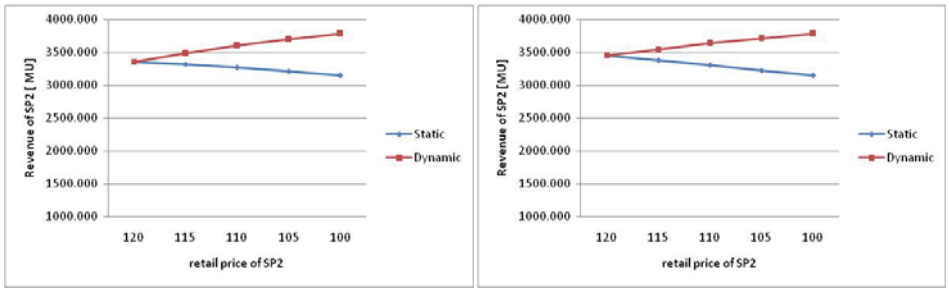
Figure 3 presents revenues of SP1 under static and dynamic revenue sharing contracts, for more sensitive customers, when SP1 increases its retail price, while SP2 remains its price at the same level. Maintaining SP2's retails price keeps its revenue the same. It can be noted that static revenue sharing increases SP1 revenue, while dynamic reduces for both more and less price sensitive customers. Hence, under dynamic revenue sharing contract, SP1 has no incentive to increase its retail price.



(a) (b)

Figure 3. Revenues of SP1 when retail price varies for (a) more sensitive customers, and (b) less sensitive customers

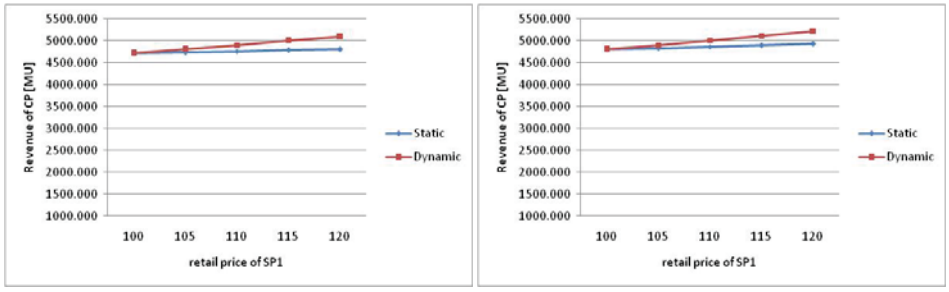
Figure 4 presents revenues of SP2 when its retail price decreases until it reaches level of SP1's retail price. For both more and less sensitive customers, dynamic revenue sharing contract enhance SP2's revenue. SP1 maintains its revenue, since there was no price variation.



(a) (b)

Figure 4. Revenues of SP2 when retail price varies for (a) more sensitive customers, and (b) less sensitive customers

Retail prices enhancement ensures greater revenue for CP. However, it leads to reduction of customers' willingness to pay and reduction of market share in long term. Also, price variation must be in accordance with price regulation in force. Dynamic revenue sharing contract ensures higher revenue in comparison with static, as shown in Figure 5.



(a) (b)

Figure 5. Revenues of CP when SP1 retail price increases for (a) more sensitive customers, and (b) less sensitive customers

SP2's price reduction leads to the reduction of CP's revenue for both static and dynamic revenue sharing contract, as well. This situation is shown in Figure 6 for both observed types of customers. Static contract ensures greater revenue in comparison with dynamic.

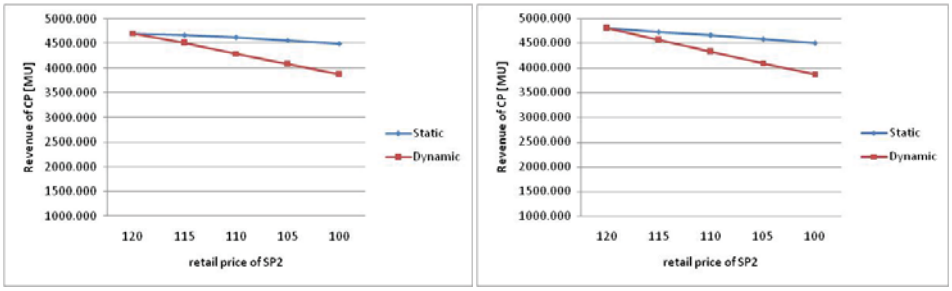


Figure 6. Revenues of CP when SP2 retail price decreases for (a) more sensitive customers, and (b) less sensitive customers

5. CONCLUSION

This paper analyses characteristics of telecommunications supply chains and possibility of application of revenue sharing contract for supply chain coordination between Content Provider and Service Providers on the given market. Two types of contracts are observed, static and dynamic. The former establishes fixed portion of revenue that Service Provider pays to Content Provider. The later depends on retail price and involves fixed portion of revenue that SP pays to CP, but involves variable part which reflects retail price variation. The aim of dynamic revenue sharing contract is to enlarge customer base by price reduction, and thus improve market position. Regarding price sensitivity, two types of customers are observed, more and less price sensitive. For all analysed scenarios, dynamic revenue sharing contract satisfies given goals. Our further research in this field will be directed towards introduction of competition at the Content Provider level, and introduction of content differentiation through content popularity distinction, as well.

ACKNOWLEDGMENT

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BIG DATA: CHALLENGES AND OPPORTUNITIES IN LOGISTICS SYSTEMS

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Abstract: *Advancements in telecommunications and computer technologies have led to exponential growth and availability of data, both in structured and unstructured forms. The term Big Data mainly refers to enormous datasets containing large amount of unstructured data that require more real-time analysis. Great potential and very useful values are hidden in this huge volume of data. The influence of Big Data is recognized in logistics services, turning large-scale data volumes into a unique asset capable of boosting efficiency in areas of the business. This paper analyses benefits and opportunities of Big Data in logistics systems. Challenges and risks that logistics systems, affected with this phenomenon deal with, are highlighted. The paper also proposes some efficient ways of exploiting the value of Big Data in logistics systems.*

Keywords*: Big Data, logistics systems, challenges, opportunities*

1. INTRODUCTION

With the permanent increase of data, scaling up to noteworthy amounts, generated by Internet-based systems, Big Data has emerged as a new research field. The core of Big Data paradigm is the extraction of knowledge from data as a basis for intelligent services and decision making systems. It encompasses many research topics, disciplines and it investigates a variety of techniques and theories from different fields, including data mining, machine learning, informational retrieval, analysis etc. Big Data has indubitably become important trend in logistics systems. Optimization of service properties, such as delivery time, resource utilization and geographical coverage, is a permanent challenge in logistics systems. Large-scale operations in logistics systems require data in order to work efficiently. Optimization results depend on information accuracy and availability. Integration of logistics providers and customer operations provides comprehensive knowledge related to supply chain risks. The transport and delivery network is important data source. Beside network optimization itself, network data may provide insight on global flow of goods. Hence, Big Data analytics emphasize a microeconomic viewpoint. Big Data concept provides multilateral analytics in order to enable the insight on customer experience and product quality.

The paper is organized as follows. After introductory remarks, a survey of some proposed Big Data definitions, tools and techniques is given.

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The third section analyses potential benefits and opportunities of Big Data application in logistics systems. Steps for efficient exploitation of the values in Big Data are also presented in this section. The forth section observes challenges and risks that logistics systems need to cope with in order to ensure efficient business platforms. Concluding remarks are given in the last Section.

2. BIG DATA DEFINITIONS, TOOLS AND TECHNIQUES

Considering vast increase of global data and advancement of information technology which enable data generation, the term Big Data is mainly used to describe enormous datasets which typically include masses of unstructured data requiring more real-time analysis by Chen et al. (2014). It provides new opportunities for discovering new values, better understanding those values, but also raises new challenges including organization and management of these datasets. Beside masses of data, there are many other features determining the difference between Big Data and "massive data" or "very big data". These differences and different concerns in scientific and technological aspect cause different definitions of Big Data. Big Data can be described as datasets which could not be captured, managed, and processed by general computers within an acceptable scope by Chen et al. (2014). In accordance with this definition, Big Data presents the next frontier for innovation, competition, and productivity by MGI (2011). It refers to such datasets which could not be acquired, stored, and managed by classic database software. This means that volumes of datasets conforming to the standard of Big Data are changing, increasing over time or with technological improvement. Also, these volumes in different applications differ from each other. Most common explanation of Big Data is 3Vs (Volume, Velocity, Variety) model by Laney (2001). Volume refers to vast data scale increasing with the generation and collection of masses of data. Timeliness of Big Data is described by Velocity. Hence, data collection and analysis must be rapidly and timely conducted in order to utilize the commercial value of Big Data. Variety indicates the various data types, including unstructured, semi-structured and traditional structured data as well. Another definition describes Big Data as a new generation of technologies and architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling the high-velocity capture, discovery, and/or analysis by IDC (2012). Thus, characteristics of Big Data can be summarized as 4Vs (Volume, Velocity, Variety and Value). This definition is wide spread since it emphasizes the meaning and necessity of Big Data including exploration of huge hidden values from data with an enormous scale, various types, and rapid generation. Adding Veracity as a key characteristic of Big Data, 5Vs model is created by Hassanien et al (2015). More detailed definition by Beyer and Laney (2012) describes Big Data as high-volume, high-velocity, and/or high-variety information asset that require new forms of processing to enable enhanced decision making, insight discovery and process optimization. Hence, data set can be referred as Big Data if it is formidable to perform capture, storage, distribution, management, analysis and visualization on it at the current technologies.

There are many proposed techniques and technologies to capture value from Big Data, analyze and visualize these data by Philip Chen and Zhang (2014). However, they are not entirely capable to meet the requirements. These techniques and technologies combine a number of disciplines, including computer science, economics, mathematics, statistics and other expertise. Multidisciplinary methods are needed for determination of valuable information from Big Data. These techniques involve many different disciplines, such as statistics, data mining, machine learning, neural networks, social network analysis, signal processing, pattern recognition, optimization methods, visualization approaches and they overlap with each other. Statistics is used to collect, organize, interpret data and to provide numerical descriptions. These techniques are used to determine correlations and causal relationships between different objectives. However, standard statistical techniques are not entirely convenient for management of Big Data. Many extensions of classical statistical techniques or completely new methods have been proposed by Di Ciaccio et al (2012). Data mining is a set of techniques to extract valuable

information from data, including clustering analysis, classification and regression. Big Data mining is more complex in comparison with traditional data mining algorithms. Machine learning is aimed to design algorithms that allow computers to evolve behaviors based on empirical data. Important characteristics of machine learning are discovery knowledge and making intelligent decisions automatically. Considering Big Data, both supervised and unsupervised learning algorithms need to be scaled up.

3. BENEFITS AND OPPORTUNITIES OF BIG DATA APPLICATION IN LOGISTICS SYSTEMS

The barriers to extracting value from Big Data can overcome through systematic plan by WEF (2014). The first step is to define responsibilities and roles for collection and analysis of data. The next step is determine how Big Data might be valuable, since the aim of Big Data is not data by itself, but discovering insights that can lead to valuable outcomes. Valuable business insight can be obtained from various sources, including social media, activity streams, machine instrumentation, operational technology feeds and data currently unused but have already been captured. These sources need to be explored in order to find new ways of capturing information, such as complex event processing, video search and text analytics. Big Data initiatives should be launched in business functions for which the potential payback is high. Functions such as marketing, customer service, supply chain management and finance are poised for the greatest growth. Another step is to match Big Data initiatives with compatible business functions. Issue of great importance is determination weather Big Data will yield valuable information unavailable through traditional business analytics. Also, complexities, priorities and technology architecture need to be assessed accordingly. Finally, multidisciplinary team of business and technology experts is the key for success.

The advancements in technological and methodological aspect of Big Data provide great benefits to the logistics sector. Logistics providers manage enormous flow of products thus creating vast data sets. Origin, destination, size, weight, content and location of shipments on every day basis are tracked across global delivery networks. There is great unutilized potential for improving operational efficiency, customer experience and creating new business models. Big Data analytics provides competitive advantage through properties which highlight where Big Data can be effectively applied in the logistics industry according to DHL (2014). Some of the most important fields of Big Data application in logistics systems are shown in Figure 1.

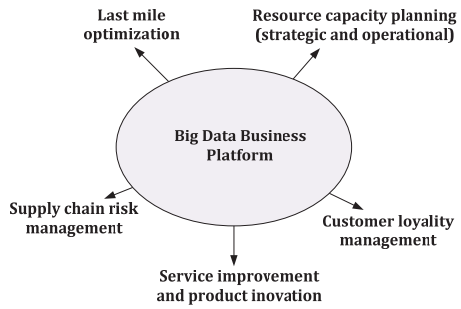


Figure 1. Big Data Application in Logistics Systems

Big Data analytics can accelerate business processes and increase the level of operational efficiency enabling last mile optimization. This goal can be achieved through real-time optimization of delivery routes or utilizing data processing in order to control an entirely new last-mile delivery model. For such purposes sensor-based detection of shipment items can be used or automatically changing of delivery routes according to current traffic conditions. The automated control of a large number of randomly moving delivery resources requires extensive data processing capabilities of Big Data techniques. This can decrease last-mile delivering costs,

especially in rural and seldom populated areas. Optimal utilization of resources is one of the most important competitive advantages for logistics providers. Hence, logistics providers must apply resource planning on strategic and operational level. Planning on strategic level involves the long-term configuration of the distribution network, while operational level planning scales capacities on a daily or monthly basis. In both cases, Big Data techniques improve the reliability of the planning and enable logistics providers to optimally match demand and available resources. In order to significantly increase predictive value, a much higher volume and variety of data is exploited by advanced regression and scenario modeling techniques. This results in a new quality of planning with greater forecast periods. Hence, the risk of long-term infrastructure investments and contracted external capacities is reduced. In the case of planning on operational level, transit points and transportation routes must be efficiently coordinated on day-to-day basis. Operational planning tasks are often based on historical averages or even on personal experience. As a result, resource utilization is inefficient. Real-time information about shipments is aggregated to predict the allocation of resources. This data is automatically sourced from warehouse management systems and sensor data along the transportation chain. Also, detection of changes in demand is derived from externally available customer information. The prediction of resource requirements enables scaling capacity in each location. In addition, it reveals upcoming congestions on routes or at transit points which cannot be addressed by local scaling. The distribution network can become self-organizing infrastructure using Big Data analytics.

Acquisition of customer insight is of great importance in the aspect of Big Data analytics. Data from the distribution network carries meaningful value for the analysis and management of customer relations. Application of Big Data techniques enables understanding of customer demand. Big Data analytics allow a comprehensive assessment of customer satisfaction by merging multiple extensive data sources. In order to achieve the insight across the entire customer base, the logistics provider must merge multiple data sources. Big Data analytics are essential in creating an integrated view of customer interactions and operational performance, ensuring satisfaction of both sender and recipient. In order to get accurate results from customer feedback evaluation, it is necessary to aggregate information from as many touch points as possible. The open research problem in logistics systems and supply chain management can be analyzed from the perspective of managerial business components and the different category of stakeholder, where main business functions are forecasting, inventory management, transportation management, transport and human resources by Robak et al (2014). Issues such as prediction of time delivery, timely response to customer experience, real-time planning of capacity availability, inventory, customer and supplier relationship management can be addressed by Big Data. Considering data not only as information asset, but also as a strategic asset, organizations in supply chain management can realize economic value in the data using Big Data analytics through revenue generating activities by Rozados and Tjahjono (2014).

4. CHALLENGES AND RISKS OF BIG DATA IN LOGISTICS SYSTEMS

The effective use of Big Data techniques introduces great advantages in economy transformation, but also raises many challenges, including, among others, difficulties in data capture, storage, searching, shearing, analysis and visualization. These challenges need to overcome in order to exploit capabilities of Big Data. Computer architecture is one of the greatest challenges. Central Processing Unit (CPU) performance is doubling each 18 months, according to the Moore's law by Philip Chen and Zhang (2014). Performance of the disk drives is also doubling at the same rate, but rotational speed of the disk has slightly improved. In addition, the amount of information increases exponentially. This has a big impact on limitation of real-time values discovery from Big Data. Another important challenge related to the Big Data analysis includes data inconsistence and incompleteness scalability, timeliness and data security. Hence, data must be appropriately constructed and a number of preprocessing

techniques, such as data cleaning, data integration, data transformation and date reduction need to be applied in order to alleviate noise and correct inconsistencies. Big Data has significantly changed data capturing and storing, including data storage device, data storage architecture, data access mechanism. The knowledge discovery process puts the highest priority on the accessibility of Big Data. In that sense, Big Data should be accessed efficiently and enabled to fully or partially break the constraint of computer architecture. Direct-attached storage (DAS), network-attached storage (NAS), and storage area network (SAN) are often used storage architecture. However, they have severe drawbacks and limitations in large-scale distributed systems. Optimizing data access is common way of improving the performances of data-intensive computing. This includes data replication, migration, distribution and access parallelism. When data volume is enormous, network bandwidth capacity is the bottleneck in cloud and distributed systems. Another issue related to cloud storage is data security. Data curation is aimed at periodically data discovery and retrieval, data quality assurance, value addition, reuse and preservation. This includes authentication, archiving, management, preservation, retrieval and representation.

In logistics systems, a comprehensive analytics framework requires integration of supply chain management, customer management, after-sales support and advertising by Kambatla et al (2014). Enormous amounts of multi-modal data including customer transactions, inventory management, store-based video feeds, advertising and customer relations, customer preferences and sentiments, sales management infrastructure, and financial data among others. Comprehensive deployment of RFIDs to track inventory, links to supplier's databases, integration with customer preferences and integrated financial systems provide improved efficiency. Big Data approach facilitates exploitation of RFID-enabled manufacturing data for supporting production logistics decision-makings by Zhong et al (2015). These applications mostly have relatively well structured and integrated datasets. Since infrastructure and data analysis is being performed in the same security domain, privacy and security issues are easier to handle. The major bottleneck in this domain is the development of analytics capable to scale vast amounts of multimodal data.

With increasing data volume, the probability that the data contain valuable and confidential information raises. Thus, information stored for the purpose of Big Data analytics is vulnerable for cyber criminal by Kshetri (2014). Besides, availability of personal data can be used to create value. Another important issue is determination of relevance within enormous data volume and usage of Big Data analytics for creating value from relevant data. Using such data, different products can be offered to different groups through quality discrimination and differential pricing. Big Data analytics enables determination of variables with a much higher correlation than in non-Big Data techniques. It also designs offerings and set prices based on such variables. Combination of structured and unstructured data for various sources, hidden connections between outwardly unrelated data can be revealed. Security problems also include intellectual property protection, personal privacy protection, commercial secrets and financial information protection by Philip Chen and Zhang (2014). Data protection laws are already established in most developing and developed countries. For Big Data related applications, data security problems are harder to deal with because of extremely large amount of Big Data and much more difficult workload of the security.

5. CONCLUSION

This paper presents overview of benefits, business opportunities of Big Data in logistics systems, but also emphasizes challenges and potential risks in this domain. Big Data analytics is still in the initial phase of development, since existing Big Data tools and techniques are not capable to entirely meet the requirements. More efforts from various fields of expertise need to be involved in order to more efficiently exploit all hidden values in vast datasets. There are numerous

obstacles and challenges to deal with, such as data quality, privacy, technical feasibility, among others, before Big Data can achieve widespread influence in the logistics sector. In the long run, these challenges are likely to be solved, considering venturesome character of Big Data. Big Data have a potential to improve operational efficiency, customer experience and to create new business models. Therefore, it is reasonable to predict that Big Data will be important success driver in logistics sector.

ACKNOWLEDGMENT

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MACHINE-TO-MACHINE COMMUNICATIONS TOWARD SMART LOGISTICS SYSTEMS

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Abstract: *Transport and logistics companies face continuous competitive pressure to maximize capacity and improve efficiencies of their infrastructure as well as to meet the increasing governmental regulation and compliance demands. Deployment of new communications technologies, e.g. cloud computing, Internet of Things (IoT) and Machine-to-Machine (M2M), represents a prospective solution for achieving these objectives. Owing to low power, cost efficiency and low human intervention, M2M communication has become a main driving force for a number of wide variety of real-time applications. The expected huge number of interconnected devices and the significant amount of available data open new opportunities to create services that will bring tangible benefits to the logistics companies, as well as to the end users. This paper represents a comprehensive survey on M2M communications considering some open research issues and challenges toward the realization of smart logistics systems.*

Keywords*: Logistics systems, M2M communications, mobile networks.*

1. INTRODUCTION

Machine-to-machine (M2M) communications have emerged as a paradigm which provides ubiquitous connectivity among devices (objects) without human intervention. The main idea of M2M communications is to enable mechanical and electrical components to be interconnected, networked, and controllable remotely, with low-cost, scalable, and reliable technologies. Current market penetration and recent predictions confirm that M2M system deployments are increasing exponentially (Cisco, 2014). This is driven by the needs of industries to automate their real-time monitoring and control processes as well as the increasing popularity of smart applications to improve the living style.

Achieving better cost efficiency, M2M communications has become a market-changing force for a wide variety of real-time applications, such as smart environments, industrial control, security and emergencies, e-healthcare, transport and logistics, etc. In Vodafone (2014) report, transport and logistics are considered as prospective leaders in the use of M2M communications, taking into account significant benefits of implementation. According comprehensive market research, 12% of all companies in this field already deployed some solutions of M2M communications. Moreover, the fact that great majority of them (67%) achieved significant return of their investments for a very short time, is of great importance. Major benefits of M2M communications deployment in transport and logistics sectors can be identified as cost reduction, better customer service, business agility, improved productivity, consistency of

delivery across markets, etc. Generally, M2M communications can be observed as promising technological tool for optimization of complex industrial processes.

This paper is organized as follows. First, general end-to-end architecture for M2M communications is presented. Then we focus on some specific properties of M2M communications which are of importance for applications of M2M systems in logistics services. Finally, prospective solution for realization of M2M communications over mobile networks is presented.

2. GENERAL NETWORK ARCHITECTURE FOR M2M COMMUNICATIONS

The characteristics of M2M communications are quite different from those of conventional networks (Kim et al., 2014). M2M networks are composed of large numbers of nodes, since the main subject participating in communication is a machine (device). Because most devices are battery operated, energy efficiency is the most important issue. As for the machine senses, itself or its surrounding physical environment, the traffic generated by device is very small. However, data are generated from a large number of objects, and because the data generation period, amount, and format are all different, a large quantity of data is generated. While M2M communication can occur without human intervention, operational stability and sustainability are also required.

In 2009, the European Telecommunications Standards Institute (ETSI) has established the M2M Technical Committee with the purpose to develop an end-to-end architecture for M2M communications. According to ETSI, an M2M system is composed of the five key elements with following functions:

- M2M component, embedded in a smart device, transmits data or replies to requests.
- M2M gateway enables connectivity between the M2M components and the communication networks.
- M2M server works as a middleware layer to pass data through various application services.
- M2M area network provides connectivity between M2M components and M2M gateways.
- M2M communication network provides connection between M2M gateways and M2M servers.

These key elements constitute the general M2M communication architecture in the three interlinked domains, i.e., the M2M device domain, network domain and application domain as shown in Fig. 1.

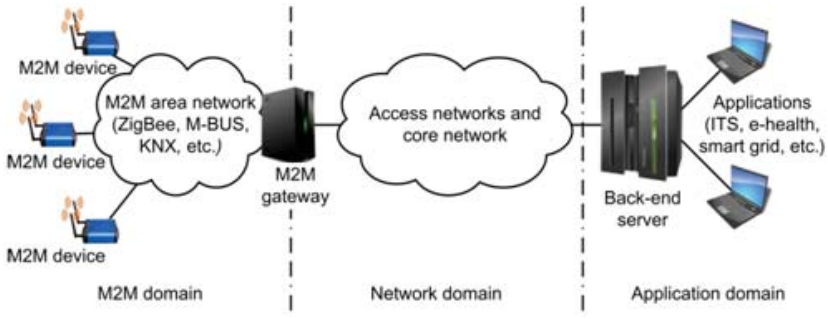


Figure 1. General M2M communication architecture

In the M2M domain, a potentially large number of nodes and M2M gateway (GW) are integrated to enable automated and diverse services. Each embedded node as flexible and smart device

should be equipped with various functions, such as data acquisition, data preprocessing, data storage, distinctive address, communication interface, power supply, etc. They can make intelligent decision and transmit the sensory data to the GW in single-hop or multihop manner. The M2M GW is an integrated device. After collecting the packets from embedded nodes, it is able to intelligently manage the packets and provide efficient paths for forwarding these packets to the remote back-end server via wired/wireless networks.

In the network domain, a large number of heterogeneous points of attachment potentially coexist. Here, convergence of heterogeneous networks in an optimal way provides cost-effective and reliable channels for sensing data packet transmission from M2M to the application domain.

Finally, in the application domain, various real-time services for remote management monitoring are provided and can be classified into several categories, such as traffic, logistics, business, home, etc. Back-end server is the key component for the whole M2M communication system. It forms the integration point for all collected data from M2M device domain.

M2M devices can be either stationary (e.g., smart meters at homes, vending machines, etc.) or mobile (e.g., fleet management devices in vehicles, e-health sensors, etc.). The access networks connect M2M devices to the core network using either wired or wireless links. Although the wired solution can provide higher data rates, reliability, security and low latency, it may not be adequate for the all M2M applications due to it cost ineffectiveness, lack of scalability and mobility support. Wireless access can be either capillary/short range (e.g., ZigBee, Bluetooth, Wireless Fidelity - WiFi, etc.) or cellular (e.g., Long Term Evolution - LTE, Worldwide interoperability for Microwave Access - WiMAX, etc.). Wireless capillary solutions, mainly used for shared short range links, are rather cheap to roll out, and generally scalable. However, small coverage, low data rates, weak security, severe interference, and lack of universal infrastructure pose restriction on their applications to M2M communications. On the other hand, mobile systems offer wide coverage, mobility support, satisfactory security, and ready-to-use infrastructure, making cellular networking a promising solution for M2M communications. Therefore, current and next generation mobile systems (i.e., LTE and LTE-Advanced) are in the main focus of recent researches as stated by Ghavimi and Chen (2015).

3. PROPERTIES OF M2M COMMUNICATIONS AND APPLICATIONS IN LOGISTICS SERVICES

The properties of M2M communications are quite different to traditional human-based communications. While human-to-human (H2H) and human-to-machine (H2M) communications obey a certain session length, data volume and interaction frequency, M2M communications follow some very specific traffic properties. M2M devices generate heterogeneous traffic patterns, including periodic (uniform), event-driven (stochastic), and multimedia streaming (heavy tailed), depending on their applications. These various traffic patterns are generated by the massive number of nodes, which have different patterns, generation periods, and generated intensities. As most of M2M devices are reporting sensor data, such as temperature, pressure, humidity, etc., the transmitted packets consists of the measured data plus the corresponding protocol overhead. In general, this overhead is kept as small as possible, whereas the actual payload differs according to its application. Although the expected intensity of generated traffic per device is relatively low (in order of few kbit/minute) the share of M2M traffic will soon exceed 5% of global Internet traffic, having in mind huge number of devices.

The combination of M2M communications and intelligent objects can largely improve the supervision of logistic processes (Palafox-Albarran et al., 2012). With an increasing number of vehicles on the road, the transportation and logistics services will become big market for M2M communication technology. Vehicles equipped with M2M sensors and actuators, become M2M communication entities. Furthermore, roads and transported goods use M2M sensors and tags (e.g., Radio Frequency Identification - RFID and Near Field Communication - NFC) that can also send valuable information to the M2M control centers and logistics companies to route the

vehicles, monitor the status of the transported goods, seamlessly track the physical locations of fleet vehicles, and deliver updated schedule information to customers.

Today, a large number of container cargo ships are traveling through international waters. These container cargo delivery services may risk theft, physical damage, delivery delays, piracy, and even ship sinking. M2M technology provides solutions that are being used in fleet management to acquire a better control where cargos can be rapidly delivered across different continents. The M2M applications enable the tracking of vehicles and cargo containers to collect the data on locations, fuel consumption, temperature, and humidity, in order to increase fleet safety, reduce the accident rates, and increase the productivity of a logistics company. With more precise information, greater control, better resource management, and higher cost effectiveness, a fleet business can be able to maintain its competitiveness with the help of M2M technology.

Goods supply chain can work in a more efficiency way as M2M communications provide possibility to track the status of goods in real-time. The M2M logistics enables ubiquitous surveillance on the status of products, raw materials, transportation, storage, sale of products, and aftersales services by keeping an eye on temperature, humidity, light, weight, etc. If the status has some problem, the M2M devices can automatically send an alert to the M2M server via the LTE/LTE-A core network. Furthermore, it is also possible to track the inventory in a warehouse so that stockholders and enterprises can respond to the market dynamics and to decide when to refill and when to go on sale. Therefore, this can significantly reduce the size of warehouse, the waiting time of customers, and the number of the employees in order to save the operational costs for business entities.

4. HIERARCHICAL CELLULAR-CENTRIC M2M ARCHITECTURE

As previously stated, cellular networks are considered as a prospective solution for M2M applications, especially for high mobility services such as smart transportation systems and logistics. Current M2M solutions already use second and third generation (2G, 3G) of mobile networks, but with expected exponential increasing of M2M devices density and consequently traffic intensity, their capacity will soon be overcome. Thus, implementation of M2M communications in next generation cellular systems (i.e., LTE/LTE-A) is unavoidable. Moreover, M2M communications are declared by Boccardi et al. (2014) as one of the five disruptive technology directions for the fifth generation (5G) mobile networks. Recently, flagship standardization bodies in this field, Third Generation Partnership Project (3GPP, 2012) and Institute of Electrical and Electronics Engineers (IEEE, 2012) have introduced some enhancements of cellular systems architecture in order to support M2M communications.

Based on ETSI general architecture, complemented with 3GPP LTE-A and IEEE 802.16p enhancements, it is possible to define a cellular-centric architecture proposed by Lo at al. (2013). It can provide useful reference architecture for designing a complete M2M communications system. As shown in Fig. 2, the resulting M2M network architecture is hierarchical, consisting of four tiers. First tier consists of the M2M application (M2M-A) services and server (M2M-S). In second tier, a new functional entity M2M relay (M2M-R) is introduced. M2M-R is an extension of the conventional LTE-A relay functionality and can be used as an M2M data aggregator. In this case, M2M-R aggregates data units from multiple M2M devices (M2M-Ds) into a single large packet for transmission to the same or different M2M-Ss. M2M-R increase system capacity and, more importantly, reduces transmission power of M2M-Ds that have power constraints. At third tier, the M2M gateway (M2M-G) ensure M2M-Ds interworking and interconnection to the M2M network domain. Unlike M2M-R, the M2M-G supports multi-radio access technologies (e.g., RFID, ZigBee, low power Bluetooth, WiFI, etc.) in addition to LTE-A. In principle, the M2M-G can assume the role of M2M-R. However, such a solution might not necessarily lead to optimal performance because the deployment of M2M-G is dictated by the

coverage of the supported wireless technologies. On the other hand, an M2M-R can be strategically deployed to achieve good coverage and signal quality, resulting with better quality of service. Typically, an M2M-R can be positioned to attain line-of-sight with the LTE-A evolved node B (eNB). Thus, legacy (non-3GPP compliant) M2M-Ds are connected to the M2M-G at fourth tier, while low mobility, power and location-sensitive 3GPP M2M-Ds are connected to M2M-R at upper tier. Furthermore, M2M-Ds and M2M-Gs with high mobility requirements are directly connected to the LTE-A eNB at second tier.

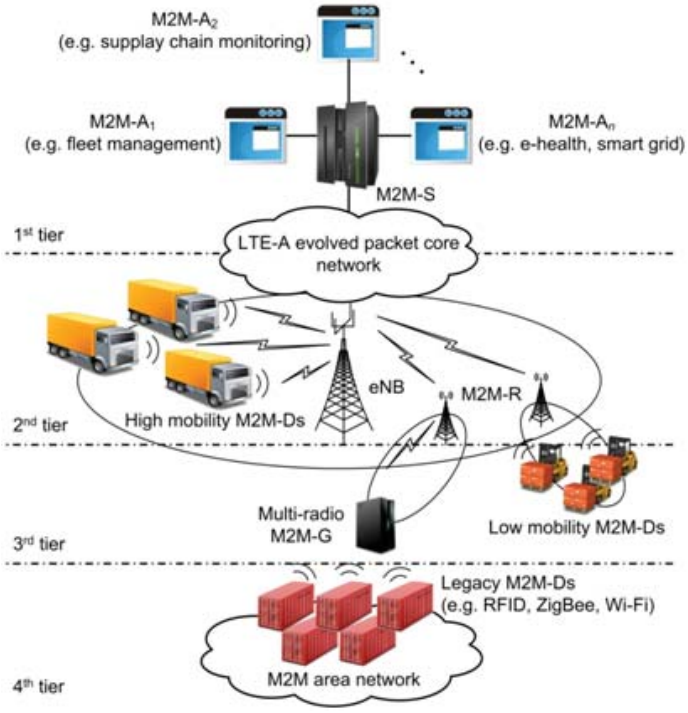


Figure 2. Hierarchical cellular-centric M2M architecture

When an M2M-A data unit is sent from the M2M-D to the M2M-S, every protocol layer on each network entity adds its own header. In addition to the entity headers, IP-in-IP tunneling established between M2M-R and eNB, and between eNB and core network adds three protocol headers (i.e., network, transport, and tunneling). This means a significant portion of the bandwidth is wasted on transmitting overheads, thus reducing spectral efficiency. It is shown by Lo et al. (2013) that in the worst case, the total overhead consumes more bandwidth than the actual M2M-A protocol data unit. Although eNB incurred the highest overheads, the overhead problem is more pronounced on the M2M-R to eNB transmission than on the eNB to core network link due to limited frequency spectrum. Moreover, M2M-Ds share the frequency spectrum with the mobile terminals. However, the overhead problem cannot be neglected when the eNB serves several M2M-Rs, and each of which serves a large number of M2M-Ds.

Rational solutions for solving considered problem are mainly related to the traffic aggregation. In research provided by Lo at al. (2013) a tunnel-based data unit aggregation scheme is proposed. M2M-A data-unit aggregation entity can be introduced at M2M-R, eNB, core network, as well as at M2M-G. Data units are classified into two distinct classes, high and low priority. An outgoing first-in first-out (FIFO) queue is defined for each of them. The high priority queue buffers delay-sensitive data units (e.g. accident events), while delay-tolerant data units

(ordinary reports) are placed in the low priority queue. Obtained results show a significant reduction in protocol overheads using aggregation scheme since LTE-A is optimally designed for H2H communication. Although aggregation causes data-unit delay, it rapidly decreases as the number of M2M devices increases. On the other hand, Ahmad et al. (2014) proposed a methodology for facilitation of logistic processes by exploiting the M2M-R functionality for aggregation and multiplexing of M2M data traffic. By integrating traffic demands from several M2M devices in a single physical resource block, system performance can be considerably improved in terms of lower delay and higher throughput, in comparison to the case of unaggregated M2M traffic. In this approach, traffic classification is not considered, so it seems that increased delay can be expected for stochastic (i.e., event-driven) demands such as emergency and accident events.

5. CONCLUSION AND FUTURE WORK

It is obvious that convergence of M2M communications and logistics services is one of the pillars of the IoT environment. The expected benefits are significant for both, telecommunication operators and logistics companies. In this paper some specific properties of M2M communications which are of importance for applications of M2M systems in logistics services are emphasized. Having in mind these characteristics and fact that mobile systems offer wide coverage, mobility support, satisfactory security, and ready-to-use infrastructure, hierarchical cellular-centric architecture is analyzed as a prospective solution for M2M-driven logistics services. Moreover, challenging issue regarding overhead problem is noted, and some rational solutions based on traffic aggregation are presented. As main direction of future researches, M2M traffic characteristics and comprehensive simulation analysis of their influences on mobile network performances are envisaged.

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RADIO FREQUENCY IDENTIFICATION: TECHNOLOGIES AND APPLICATIONS IN LOGISTICS

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Abstract: *Monitoring and management of complex logistics processes could not be realized without appropriate information and communications systems. A well-structured and technically safe information flow of valid data has come to form an essential element for designing and extending materials-flow systems. Radio frequency identification technology (RFID) plays an important role in supporting logistics and supply chain processes due to their ability to identify, trace and track information throughout the supply chain. The paper focuses on the technical characteristics of RFID systems, their opportunities, challenges, barriers and standards. Furthermore, the paper discusses the results of RFID application in the realization of logistics processes. The main goal of the paper is to stimulate further interest in this area by providing a comprehensive review of RFID application, which will be a good resource for researches interested in the RFID systems.*

Keywords*: logistics, RFID, supply chain management*

1. INTRODUCTION

The realization and management of logistics processes includes a number of technologies, primarily transport, reloading, storage and information technologies. All of them are essential for logistics, and their development in the previous period has caused reoccurring waves of changes in the organization and management of logistics processes. Technical possibilities of the means in transport, storage and reloading in the area of the goods flow have been greatly researched and employed; hence, the directions for further rationalizations in this area are being investigated in the new approaches for the realization of logistics processes and in new strategies of logistics management. The important factor in the creation and realization of new logistics strategies are the contemporary information and communications technologies. Their significance is even greater considering that the companies in the last decade have begun to be more and more oriented towards their key competencies, causing in its turn the trend towards the outsourcing of business processes, and thus enlarging the network for adding new values and increasing the logistics cross-section between partners exchanging goods and information (Nikoličić, 2011).

Manifold transport, reloading and storage processes during the logistics process realization

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demand for a fast goods identification and stock updates. The unambiguous identification of goods and the related data exchange have presented the basis of the efficient processes in logistics process management and control (Guenthner, 2004). Identification systems are only the first step, i.e. the link between goods and computers, directly linked to the supervising computer system for process management. In this paper, the emphasis is on the auto-ID systems that enable wireless option for accepting and transferring data using radio waves, i.e. systems for radio frequency identification (RFID). The paper presents the technical properties of RFID systems, as well as the advantages, drawbacks and examples of the RFID application in the logistics process realization. The main goal of the paper is to stimulate further interest in this area by providing a comprehensive survey of the RFID application.

2. RFID TECHNOLOGY

RFID technology enables automatic and non-contact identification of objects, people and animals using radio signals being emitted at a certain frequency (VDI nachrichten, 2004a). A typical RFID system consists of tags and readers, application software, a computing hardware, and a middleware. Tag (transponder) is the basic component of the RFID system, presenting in the essence the microprocessor chip and containing the electronically memorized data. Generally, when a tag is in the field of a RFID reader, it is activated and it transmits the data stored on its memory chip to the reader. The tag has an identity that can be broadcast to a reader that is operating on the same frequency and under the same tag protocol. The reader then converts the radio waves returned from the tag into digital data and forwards them to a computer system that collects and processes them (Figure 1).

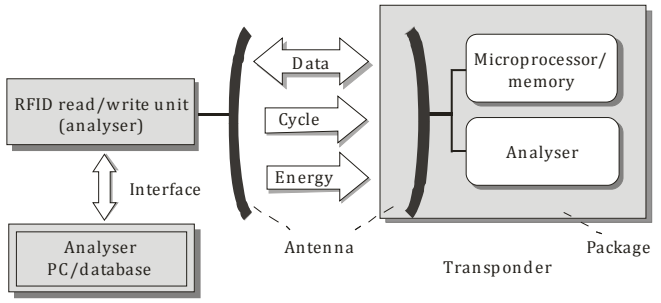


Figure 1. Functioning principle of an RFID system (VDI 4472, 2006)

RFID systems have more determinants for differentiation and for establishing the area of their application. The following can be stated as the basic determinants of an RFID system: working frequency (LF, HF, UHF, MF), tag power source (active, passive, semi-passive tags), data input possibilities (read only, write once read many, read-write), memory capacity (from 32 Byte to 1 kByte), reading range (from 0.15m to 30m), etc. The frequency on which the RFID system operates designates the intensity of the radio waves used to transmit information and is a key factor in determining the performance levels and applications for the system (Tajima 2007). All this demonstrates the wide range of the RFID and the possibilities for their implementation into diverse areas (animal detection, logistics and supply chain management, waste management, museums, retailing, etc.). The general RFID system characteristics may be the following: high reading velocity and relatively large distance between the reader and the object to be identified; possible reading outside the visual range; simultaneous multiple data reading; automated data registration; identification and monitoring of individual products, containers and means of transportation, even in extreme conditions; possibility to memorize great amounts of data and the communication directly on the product level; decentralized data storage in the product itself; ability of writing information on the tag (depending on the type), etc. (VDI nachrichten, 2004a).

In addition to the above advantages of RFID system, there are also some barriers: the price, the share of mistakes, radio interference, removal problems, underdeveloped conscience of users, security and privacy issues. The following are four frequently cited barriers for widespread adoption of RFID: a lack of return on investment (ROI), technical risks, the popularity of bar codes, and privacy concerns (Tajima, 2007).

3. RFID SYSTEMS IN LOGISTICS

Although commercial applications of RFID date back to the 1960s, the use of RFID in supply chain management is relatively new (Tajima, 2007). At the beginning of this century, a significant stimulus for developing and introducing RFID in supply chain management came from the world's leading retailers such as Metro Group, Wal-Mart, Tesco, Carrefour, etc. Since 2002, the reoccurring paper topic in European journals has been related to the diverse aspects of the RFID application in logistics (Behrenbeck, 2004). This section comprises from two parts: the first part provides a short overview of academic publications where diverse aspects of the RFID system application in logistics were researched, while the second part presents the description of the examples of the RFID system applications in practice.

3.1 RFID researches

The research in the application of RFID in logistics and supply chain management are diverse and oriented towards different segments: technical problems related to the implementation, methodological procedure of implementation, as well as the evaluation and determination of the technology usefulness for different participants in the supply chains. The overview and the systematization of academic literature are provided by several authors (Tajima, 2007; Sarac et. al., 2010; Zhu et al., 2012). Very interesting and useful is the general classification of papers according to the most used approaches and the main topics of the publications on the RFID applications in a supply chain (Sarac et. al., 2010), presented in Table 1.

Table 1. Types of publications

Publications	Most used approaches	Main topics
Practical papers	Pilot projects Case studies ROI analyzes	Inventory management Logistics and transportation Assembly and manufacturing Asset tracking and object location Environment sensors
Academic papers	Analytical approach Simulation approach Case studies ROI analyzes Literature review	Inventory inaccuracy Bullwhip effect Replenishment policies

Bottani and Rizzi (2008) quantitatively evaluated the effects of the RFID technology and the EPC system (Electronic Product Code) on the major processes of fast moving consumer goods supply chains. A feasibility study was conducted on the basis of qualitative and quantitative data related to the logistics processes of all participants. As a result, it was concluded that the use of the RFID technology on the level of pallets produced positive effects from the income aspect for all participants in the chain; on the other hand, at the product level, negative economic results were recorded.

Ustundag and Tanyas (2009) used a simulation model for the calculation of the expected benefits of the RFID systems integration into a three-stage chain. It was concluded that the value of products and demand had a significant impact on the expected benefits of the RFID

technology. The increase of the product value increased the total chain cost savings, and the increased demand uncertainty reduced savings in the chain.

In order to improve the inventory management, an experiment was performed for determining the improvement in the inventory record accuracy before and after implementing RFID-enabled adjustments to the inventory management system (Hardgrave et al., 2011). As a result, it was concluded that the effectiveness of the RFID tagging was not homogenous for all products. Reductions in the percentage of stock-outs ranged from 21% to 36%, depending on the category.

The Supply Chain RFID Investment Evaluation Model that is based on the classic economic order quantity (EOQ) model considers the possibilities of the RFID investments to improve order efficiency, JIT efficiency and operational efficiency (Lee and Lee, 2010). For the aforementioned efficiency factors, analytical procedures were developed to determine the optimal level of investment in the RFID.

For the practical usage, the VDI guideline (VDI 4472, 2006) can be very useful, containing, apart from the detailed costs list, a list of individual process effects in the supply chain. The essential prerequisite for the implementation of the RFID technology are the positive economic effects; in that sense, the recommendation is to have a consistent and clear system for evaluation.

Kok at al. (2008) conduct break-even analysis of the RFID technology implementation focusing on the costs resulting from inaccurate inventory data. The break-even analysis also includes the main factors like: technology costs, length of review period, etc. The results are presented with exact analytical expressions for the cost-effective price of RFID, and show that there is a high correlation between the cost of RFID technology and the value of products lost.

Between the participants in the supply chains there are disagreements on the necessary investments and achieved benefits from the RFID technologies (Karkkainen and Holstrom, 2002). Most savings are achieved in the retail, while the suppliers are burdened with the costs of introducing RFID (Smith, 2005).

3.2 RFID in practice

The potentials of the RFID applications in logistics processes are manifold; however, there are still many barriers for the wider application in practice (e.g. necessary investments, popularity of barcodes, and question of privacy). This section of the paper describes the experiences of companies that implemented the RFID for logistics processes monitoring and management.

In 2003, Metro AG began the project named Metro Extra Future Store that implemented and tested the RFID technologies in real surroundings (Behrenbeck et al., 2004). In 2004, the first phase of the implementation of this system was completed, and the test demonstrated that the costs of out-of-stock, ranging from 9% to 14%, could be reduced for 17%; thefts were reduced from 11% to 18%, and the working costs from 8% to 11%. In 2006, another 300 suppliers were included. In 2008, the RFID project was expanded to 200 Metro centres. That process included 1.3 million palettes annually (LOG.m@il Newsletter, 2008).

In Wal-Mart projects, as one of the potential options for the improvement, they investigated the influence of RFID on the out-of-stock reduction (OOS situation) that provided a number of benefits for retail, suppliers and consumers. As a result, it was concluded that the application of RFID reduced the out-of-stock for 26% (Hardgrave et al. 2005). Furthermore, the surplus of stock in the supply chain was minimized (LOG.m@il Newsletter, 2007).

Best Buy tested the RFID usage in the storage level in two distribution centres. During the testing, 70 suppliers used RFID for palettes and packaging, and the data were processed automatically in the software system for business management. Very positive results were obtained, i.e. stock in storage was reduced for 20%, while the participation of the cross-docking process was increased.

Apart from following the goods flow in order to rationalize it, RFID can be applied for security reasons as well. Hutchinson corporation, with the annual turnover of 44 million containers, introduced sensors inside and outside for every container, which could detect, among other, light, humidity, air pressure, certain chemical parameters, etc., being ready in any given moment to send an e-mail alarm to the central unit. In some ports (e.g. Los Angeles and Long Beach), the active RFID system is used for security reasons and for solving problems of the congestion in ports. All trucks entering the ports need to have RFID tags being read in entrance and exit (VDI nachrichten, 2004b).

SSA Marine, one of the leading worldwide cargo companies, introduced the RFID technology for container monitoring in several ports on the Western coast. On the container hoist, there is a reader, while the active tag is on the container, enabling the identification of the appropriate container and loading onto the appropriate truck (Voyles, 2005).

The company Iveco in cooperation with Kuehne + Nagel uses RFID to manage spare parts in the automotive sector. The system in the plant in Torino simplifies orders for parts replacements from suppliers. Kuehne + Nagel receive the parts and add EPC Gen 2 marks coded with the identification number and printed together with the barcode, hence dealers can use them for tracing and monitoring (Wessel, 2010).

DHL integrated RFID into their trucks for delivery in order to achieve faster parcel delivery. This initiative was named SmartTruck and it achieved a number of goals. They accomplished the expected savings in fuel consumption and CO_2 emission, and increased the accuracy in parcel collection and delivery (Neely, 2009).

4. CONCLUSION

RFID systems show a great potential for the improvement of processes and the reduction of costs associated with the supply-chain management. However, some of the basic problems of the RFID system application include the introduction and development costs. Opinions of experts on the implementation of the RFID systems in supply chains are still divided, though, the opinion that the time of the RFID technology is still to come seems to dominate.

The paper demonstrated the basic principles in utilizing the RFID system, together with the potential application in logistics. A short survey of published papers has demonstrated a great interest of scientists for researching diverse effects of RFID in logistics, while the examples from the practice emphasise that the RFID system application is possible in diverse companies and that it is directed towards the increase in the logistics process efficiency. It is only hopeful that this paper will represent a valuable basis for the researchers interested in researching the RFID systems.

ACKNOWLEDGMENT

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Part VI SIMULATION OF LOGISTICS PROCESSES

BULLWHIP EFFECT ANALYSIS BY SIMULATION EXPERIMENTS IN ECHELON UNDER (R, s, S) INVENTORY POLICY

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Abstract: *In order to improve their performance on market, modern companies and supply chains are focused to reduce all excess costs, especially those related to inventories and logistics. However, reducing such costs must be taken into consideration seriously, since there are many difficult-to - predict interdependencies between variables of periodic (R, s, S) review inventory systems. In order to set up the inventory system in most optimal manner or predict its behavior, simulation experiments should be executed.*

Keywords*: Bullwhip effect, Supply chain, Simulation experiment, Inventory management*

1. INTRODUCTION AND PREVIOUS RESEARCHES

Modern companies and supply chains compete globally in a large number of independent variables with non-trivial dependencies. Together with constant fluctuations in inventory levels, structural and logistical characteristics of a supply chain also change. Therefore, influential variables of supply chain inventory management systems need to be monitored continuously; forecasted and optimal business scenarios in response to future events should be calculated. In order to optimize the properties of the supply chain inventory systems it is necessary to thoroughly investigate the interdependence of variables in inventory management system.

Researches from Houlihan [1987], Taylor [1999], and Fransoo and Wouters [2000] describe the bullwhip effect in Make-to-stock supply chains. Works from Baganha and Cohen [1998], Graves [1996], and Cachon [1999] are dealing with the increased deviation of demand information when transferred away from the market, and Chen et al. [2000] and Metters [1997] were trying to analytically quantify the consequences of the bullwhip effect. Forrester in his work [1958] describes tendencies of business systems to amplify, cause delay and distort information about actual market demand as this information moves further away from it. This phenomenon was first recognized by the manufacturers with own inventories of raw materials, semi-finished and finished products intended for sale. Lee et al. [1997a], [1997b] call this phenomenon the Bullwhip effect since small changes or variances in customer's demand often cause a large increase in orders received in companies within the supply chain towards the direction of the manufacturer.

A small variance in actual consumer demand can result in the various companies operating at different stages of a supply chain being subject to the bullwhip effect (Fig. 1). Forrester's work concluded that the bullwhip effect occurs due to unstable business conditions and proposes a methodology of simulation of dynamic models of business systems. The study by Lee et al.

showed that the bullwhip effect is caused by the following effects: (1) Forrester effect, or lead-times and demand signal processing, (2) Burbidge effect, or order batching, (3) Houlihan effect, or rationing and gaming, and (4) promotion effect, or price fluctuations.

Sterman's work [1989a] determined an additional cause of the bullwhip effect which occurs due to the limited human possibilities of perception and management of complex dynamic systems. The above, as well as numerous other studies have shown the negative impact of behavioral causes on the supply chain.

Increase of customer demand gives rise to a number of problems: the accumulation of excess inventories at certain times followed by serious inventory shortages and low customer fill rate, excess or insufficient capacity, unstable and inefficient production leading to higher costs resulting from the corrective actions that have to be taken.

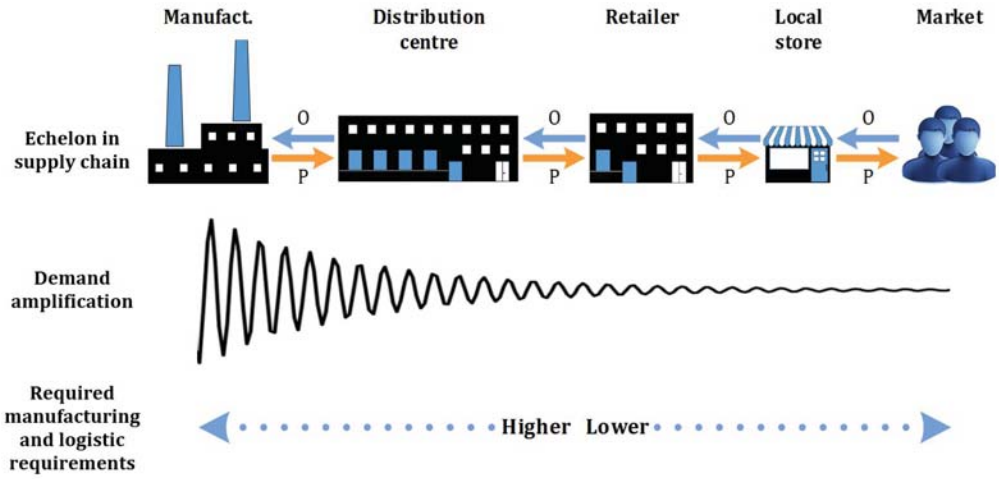


Figure 1. Oscillation demand in the supply chains in the direction of the manufacturer

This type of deviation from the actual market demand causes significant costs and ultimately calls into question the existence of the supply chain for continuously increased costs, overload production, increased logistics requirements, insufficient or excessive inventories and thus insufficient storage and logistics capacities, resulting with a low percentage of meeting market demands. Due to the significant and negative impact of the bullwhip effect in supply, and thus in many other business indicators, the bullwhip effect becomes the research subject of numerous scientists and business experts.

This paper is organized as follows. Section 2 presents the setup of simulation experiments and experimental work with a 300 simulation experiments of periodic (R, s, S) review inventory system. In section 3, the conclusions are provided.

2. EXPERIMENTAL WORK

Demand within the supply chain is often random and unpredictable. Where it is not possible to accurately predict market demand, simulation experiments are used to examine the occurrence and size of the bullwhip effect. The positive results of the application of simulation experiments were confirmed by works of Ouyang and Daganzo [2008] and Baccadoro et al. [2008].

Chen et al. [2000] suggested that the bullwhip effect could be measured by the ratio of σ^2/μ between the input and output flows in each echelon in a supply chain; or between the final

demand and the manufacturer when the whole supply chain is to be evaluated as can be seen in equation (1).

$$Bullwhip = \frac{\sigma_O^2/\mu_O}{\sigma_D^2/\mu_D} \quad (1)$$

where:

- O represents orders; D represents demand
- σ^2 - variance of demand observed in echelon
- μ – mean demand observed in echelon

2.1. Setup of simulation experiments

Experiments will simulate performance of periodic (R, s, S) review inventory system of one echelon in traditional supply chain. Monitoring period is 5000 days (several times longer than similar researches have worked with), mean demand μ = 99,998, variance of demand observed in echelon σ^2 = 1857,532 and distribution of demand is generated as normal, independent and identically distributed. Simulation experiments were created and analyzed by OptimInventory software in cases where fill rate of 99,9%±0,01% is achieved. This tight tolerances are needed in order to reduce the number of results and to get better understanding of (R, s, S) inventory policy. Echelon does not backlog unfulfilled demand.

Variables on the supplier side of echelon are as follows: lead time is 3 days, observed echelon and its supplier work every day in week and minimal order quantity is 100 products.

OptimInventory is a computer application that simulates real world inventory conditions in either individual echelons or whole supply chain. It offers in depth and intelligent analysis of multiple types of inventory systems allowing significant reductions in costs and simultaneously increasing customer satisfaction and fill rate on the market.

2.2. Experimental work

Best simulation experiment (SE) is considered to be the one that has lowest level of inventory but manages to satisfy desired fill rate of 99,9%±0,01%. This simulation experiment will be assigned with ID value 1, after which the software will increase level of inventories and recalculate fill rate.

It is important to know that with inventory level increase (especially order up to level – S); many different factors affect the inventory system. Only those experiments that satisfy fill rate will be analyzed and the software will calculate following variables in each of them: lower inventory level (s), upper inventory level (S), exact fill rate, minimal and maximal stock level, average inventory level, number of shipments, total number of products shipped, bullwhip factor etc.

For this paper, 300 simulation experiments were examined and results are shown on figures 2 to 6.

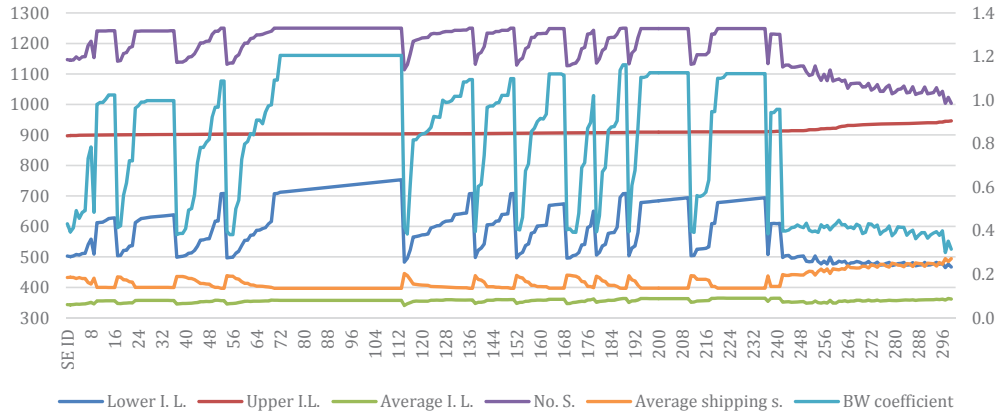


Figure 2. Results of SEs sorted by ascending simulation experiment's ID

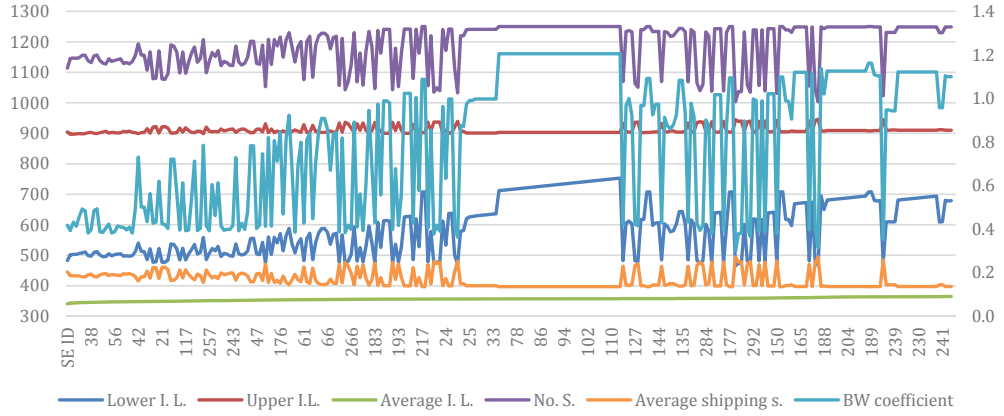


Figure 3. Results of SEs sorted by ascending values of average daily inventory level (average I. L.)

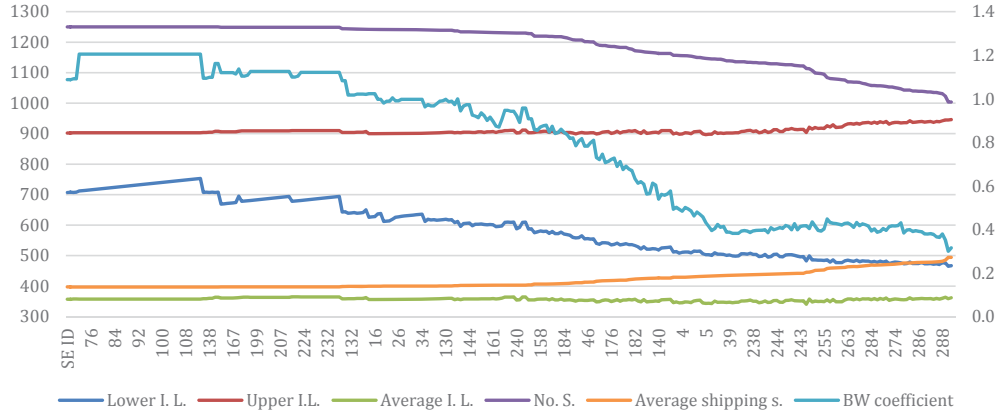


Figure 4. Results of SEs sorted by descending value of required number of shipments (No. S.)

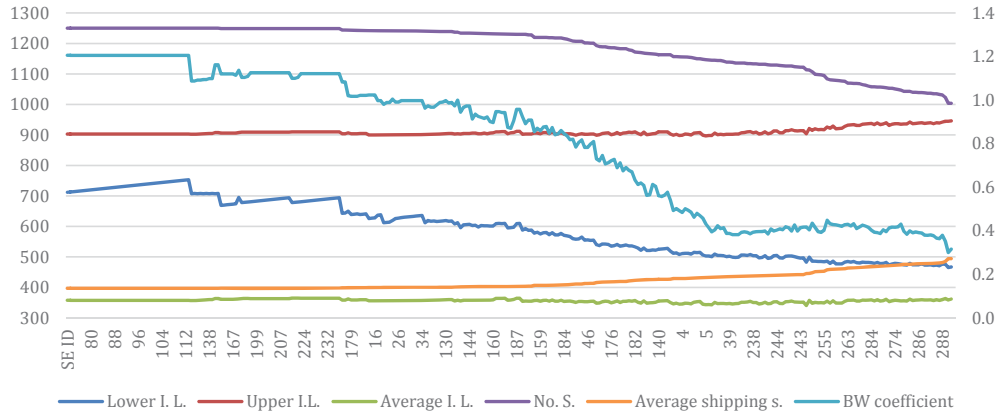


Figure 5. Results of SEs sorted by ascending values of minimal required average shipping size

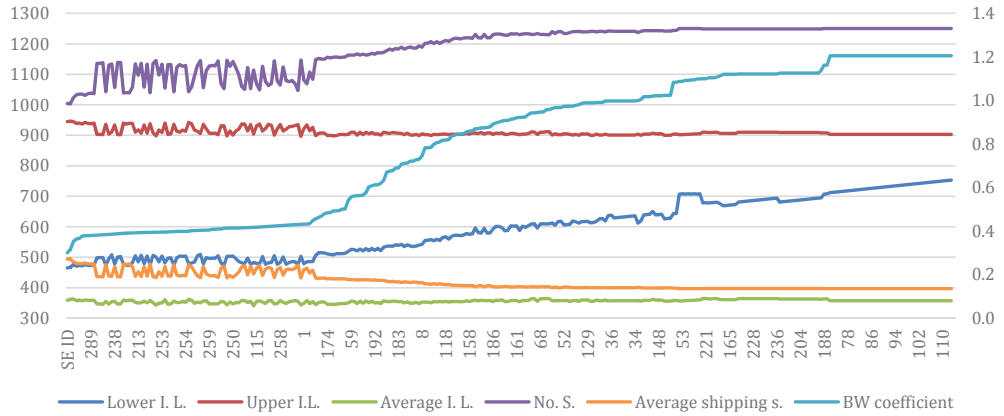


Figure 6. Results of SEs sorted by ascending value of Bullwhip coefficient (secondary Y axis)

3. CONCLUSION

From these 300 simulation experiments it is noticeable that important variables of inventory management system show significant oscillations resulting in more or less negative effects on echelon. This concludes with previous work on SEs used in (R, s, S) inventory systems. It is also important to notice that these simulations analyzed only one product in echelon and if we assume that bigger retailer stores can hold up to 80.000 products it is clear that fine tuning of inventory system is impossible without advanced simulation software such as the one used in this paper.

Another important thing noticeable from figures 2-6 is the fact that with reducing number of required shipments, bullwhip effect significantly reduces in an absolute value and its variance is significantly lowered too. Therefore this research shows that by setting characteristic inventory levels higher than needed and respectively reducing number of deliveries to specific echelon, one can actually reduce the bullwhip effect. If this setup is monitored regularly, negative effects such as increase in average inventory level can be avoided.

This level of analysis is computationally very intensive but offers benefits that, in the long run, offer significant savings and make echelons and supply chains more effective and competitive on

global market. In the future we plan to explore the behavior of periodic (R, s, S) review inventory system with different delivery terms, batching size and backlog performance.

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SIMULATION AS A TOOL FOR EXTRACTING KEY PERFORMANCE PARAMETERS IN POSTAL LOGISTIC CENTERS

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Abstract: *Today, postal operators are becoming more and more market-oriented and customer-driven. As a consequence of that, many of the traditional postal centers expanded their service in area of logistics and transform itself in postal logistics centers (PLC-s). Prior orienting to the providing logistic services management of PLC needs to determine current key performance parameters while performing basic postal activities, driven from defined business objectives of postal service. In order to determine PLC capabilities for additional logistic services, first step is to know how much resources can be redirected to the those new logistic services. This paper deals exactly with this kind of problem, and we propose the simulation of postal processes in PLC, using discrete event simulation (DES), as a methodology approach for extracting and representing the influence of different worker layouts on overall processing time in PLC. Accordingly, simulation model of current operation conditions in PLC was created (AS-IS model).*

Keywords*: postal logistics centers, discrete event simulations, mails, postal processes, logistics performances.*

1. INTRUDUCTION

Postal service plays a significant role in the development of a leading commercial and financial regions, providing communications between individuals, business and government. In recent years, postal operators are facing with the challenges of rapid technological development, market liberalization, segmentation and increasing competition. In such conditions, the industry has evolved to include traditional post (like package and mail delivery), courier services, freight services and e-services (Chan et al., 2006) in logistics fright flows, and leading European postal operators (such as: Deutsche Post DHL, La Poste and Royal Mail) have expanded their operations in the logistics sector. This development of the postal sector is conditioned by the rapid development of e-commerce, which, among other things, includes a strong logistics.

PLC are important link in the delivery of shipments between the sender and the recipient. Their main function is collecting and distribution of large quantities of shipments in the postal network. Postal processes that are carried out in these centers, arising from defined business objectives of postal service and generally include: sorting of postal shipments, organizing the transport and provision of postal and logistics services. Heterogeneity of postal shipments in the PLC causes various postal activities in order to process different mails. Depending on the shipments type, depends which resources will execute the processing and in what manner. Different mails have different lead times, and acquire different resources for processing, which

implies different costs of processing. Bearing in mind the global determinants of postal operators and the structure and characteristics of the business processes in postal service, it is clear that the logistics as an instrument of differentiation and rationalization, should be integral component of the postal operators business strategy (Kujačić et al., 2013). In order to determine the level of efficiency of executed processes in PLC-s, it is necessary to establish procedure to extract the measures of logistic performances of basic postal operations in the PLC. For that purpose we used DES of basic postal processes in PLC, and we focused on determining overall processing time of mails, taking into account engaged number of workers.

2. STRUCTURE OF THE POSTAL NETWORK AND BUSINESS PROCESSES IN THE POSTAL SERVICE

The key characteristics of postal services is reflected in the massive user demand for transfer of postal items, which is realized through postal processes that generate physical moving of mails with aim of their transfer to the recipient. From an organizational point of view, for the implementation of postal services that demands the market (national operators are conditioned to also to provide a universal service) it is necessary to establish a uniform postal network (on national and international level), and use of unique technologies and standardization of equipment. The structure of the postal network and its equipment is conditioned by the economic capabilities of operators, traffic volume, and in the case of a national operator, government investment policies.

From the logistical point of view, a PLC performs the function of intra logistics (Lisec and Rihter, 2007), and as a units of postal network, PLC are located in the traffic hubs in order to achieve the concentration and diffusion of shipments on the geographical area that they cover, and consequently, they have a key role in the concentration, processing, delivery and transshipment of received mails. Recently, Serbian Posts constructed three new regional PLC hubs (Belgrade, Novi Sad and Nish), and performed automatization of mails processing. In the PLCs Novi Sad and Nish automatization is caried out only for the letters with standard sizes (dimensions from 90x140 mm to 120x235 mm), while in PLC Belgrade automatization also included the automatization of parcel deliveries. For more details about organization of postal-logistics processes, especially about organization of postal service in Serbia, refer to (Kujačić et al., 2013).

3. CASE STUDY OF PLC

The case study was carried out on the example of PLC Novi Sad (Republic of Serbia). In a simplified analysis PLC Novi Sad can be considered as post hub with basic function of receiving, sorting, delivery and transshipment of incoming mails. In the observed PLC different mail classes are processed (priority mail express, first class mails, standard mails and international mails). Priority mail express represent service which allows fastest transfer all kind of mails (letters, parcels, advertisements, bills, etc.). This service also provides tracking of shipments during transfer, and service is available only in domestic traffic (i.e. within the boundaries of the Republic of Serbia). First class mails includes valuable parcels and valuable letters. By business practice of Post of Serbia, for valuable parcels medium and large packages are considered. Valuable letters are special kind of postal shipments, which are processed in separate section of PLC, since they are confidential contracts between companies, they can be international shipments and government shipments. By standard mails Post of Serbia consider: advertisements, circulars, newsletters, small parcels, merchandise, bills, etc. Standard postal items are classified on the basis of their dimensions, and in practice of Serbian Posts classification is performed on the ordinary and nonordinary mails. Ordinary mails include letters with standard dimensions which are consisted from recommended letters and priority mails. Recommended letters are similar shipments as post mail express. They also allow tracking of letters and but they are slower than the post mail express shipments. Priority mails are mails

which have priority in delivering to the final consumer, and usually there are consisted from bills for electric energy, TV, and other kind of government taxes. Accordingly, during processing in the PLC different shipments (i.e. mail classes) have different sequence of activities through PLC, and by average 7 000 000 mails are processed in PLC Novi Sad, for one month. Typical flow of mails through PLC Novi Sad is shown in Figure 1.

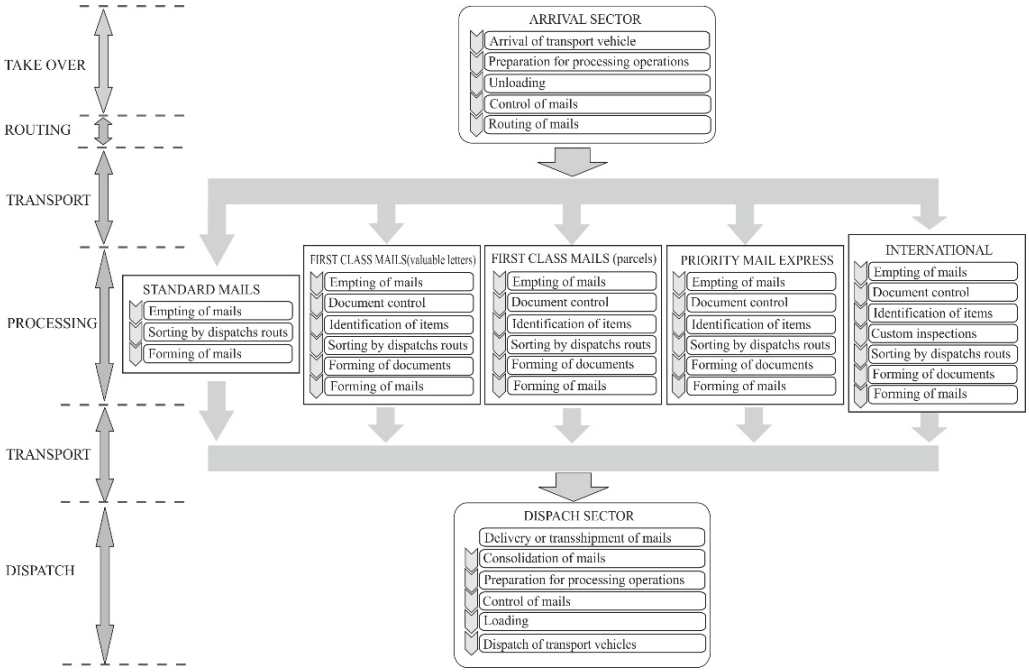


Figure 1. Flow of mails through PLC (adapted from (Kujačić et al., 2013))

3.1 As-Is

Simulation of current operation conditions in the PLC (AS-IS model), is carried out using the several databases and experience gained from vocational training in the PLC. Following the logic of Figure 2, and using data about time duration for each activity from document "Postal statistics" (Đakovački, 2006) and also data related to actual layout of activities (determined from vocational training in PLC), PLC Novi Sad is simulated. As a result AS-IS model is formed, and presented in the Figure 2. For building the simulation scenarios iGrafx software was used. Simulation scenarios include simulation of PLC for a one month (March 2014). As a input in simulation, real shipment quantities of the mail classes and different number of workers are used. Each simulation lasted for approximately half an hour and twelve different simulation were performed. During each simulation 7,048,126 mail shipments were simulated. In AS-IS model, every activity is associated with: particular resource which is executing that activity, and with time needed for execution of observed activity. For creating the AS-IS process map basic elements and reasoning of business process modelling is used, and while performing simulations AS-IS process map was fixed (i.e. the interconnections between the elements and the quantity of postal shipments that flow between them). Only parameter that was changing in each simulation was number of workers and their position in AS-IS process map, according to the Table 1. For more details on business process modelling using iGrafx, refer to (Groznik et al., 2008).

Process map for AS-IS model presents four sectors in which incoming mails are processed according to mails type (i.e. mail class). Each mail class has different specificities and requirements for processing. Green color objects represent the generators of mail classes. Mails are then directed to particular sectors, according to their requirements for further processing. Gray color objects represents the activities where time duration of the activities are determined by measuring at the PLC during the vocational training carried out in PLC Novi Sad. Reason for measuring time of execution of activities is because PLC Novi Sad is newly constructed center and Posts of Serbia didn't yet perform measuring and update the official document "Postal Statistics" (Đakovački, 2006), with time durations for the above mentioned activities. Blue color objects represents the activities related with manual sorting of incoming mails, were accepted standard is that one worker sorts the 1000 mails per hour. Brown color objects represent the activities with their time of execution taken from the "Postal statistics" (Đakovački, 2006).

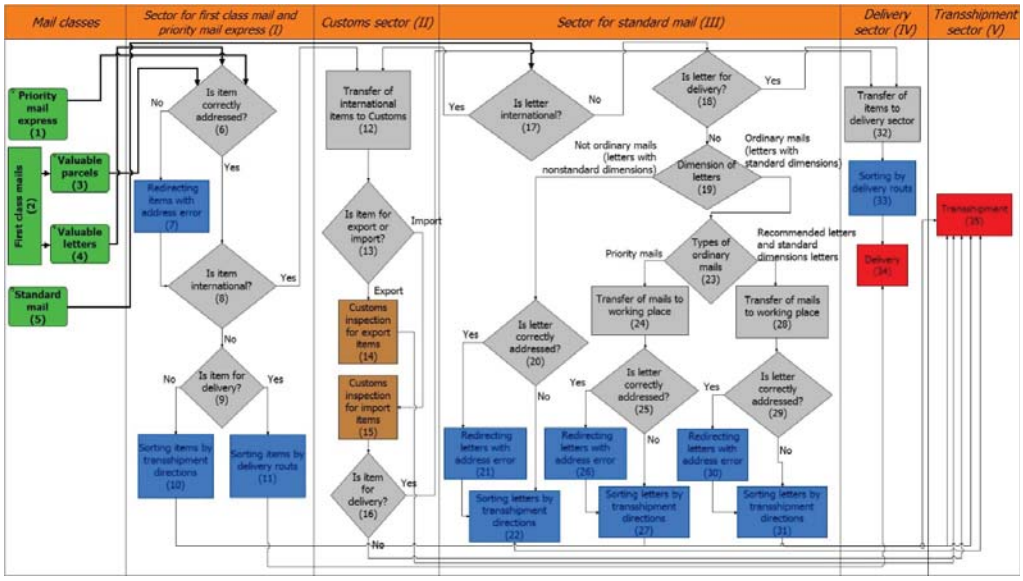


Figure 2. Simulation of current operation conditions in the PLC (AS-IS model)

3.2 Overall mails processing time vs. engaged workers

First step in analyzing the operation capabilities of observed PLC was performing of several simulations with different number of workers in particular sectors in order to determine relationship between engaged workers and processing time of center. Simulations were performed based on several different layouts of workers, and there were twelve different scenarios. Results of simulation, accompanied by different layouts of workers, are presented in Table 1. From Table 1 it is obvious that engaging the different number of workers leads to the different processing time of shipments, bearing in mind the defined workers layout.

Figure 3 presents mentioned relationship, from which we can conclude that processing time is monotonically decreasing with engaging large number of workers. But, from Figure 3 we can conclude that there is a bottom limit, and that drop of processing time with engaging larger number of workers stops at some point. Reason for that is because labor operation capacity has physical limitations, and engaging more and more workers isn't accompanied by significant drop in processing time. Which leads to conclusion that engaging more workers isn't always economically justified, since the decrease in processing time is not big enough, compared with costs related with engagement of additional workers.

Table 1. Simulation results with twelve different layout of workers

Different simulation scenarios	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Support workers	3	3	3	3	3	3	3	3	3	3	3	6
Workers in sector first class and priority mails	8	8	8	8	8	9	9	9	9	12	9	12
Controller	1	1	1	1	1	1	1	1	1	1	1	1
Workers in Customs sector	9	9	9	9	9	10	10	10	10	12	10	15
Workers in sector for delivery	10	10	10	10	11	12	12	13	15	15	18	21
Workers in standard sector	18	20	22	25	26	27	28	30	32	30	36	40
Total number of workers	49	51	53	56	58	62	63	66	70	73	77	95
Average processing time (minutes)	3137	2042	881	232	172	148	70	64	50	57	31	20

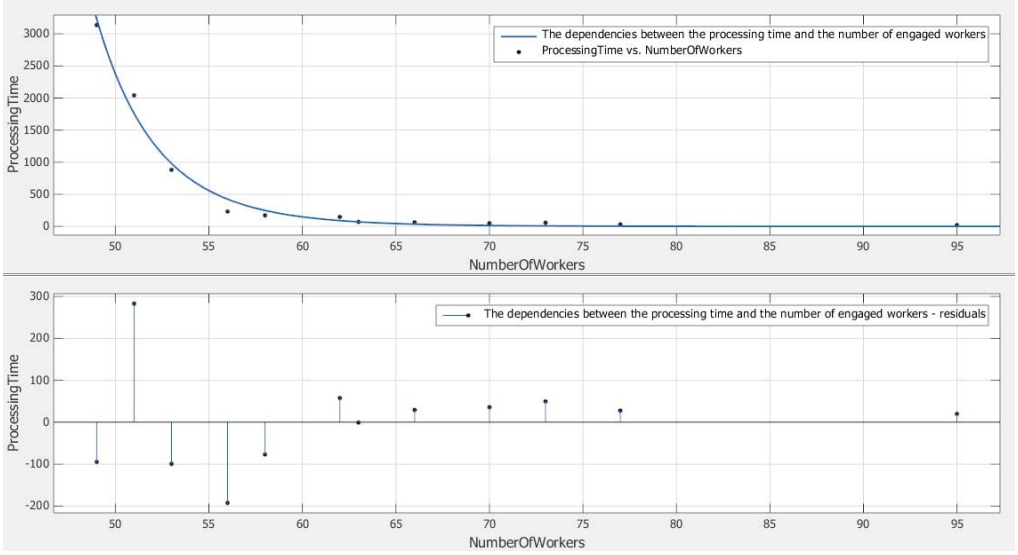


Figure 3. The relationship between the processing time and the number of engaged workers

The dependence of the processing time and the number of workers engaged is numerically estimated by equation (1):

$$f(x) = 1{,}5 \cdot 10^{29} \cdot x^{-15{,}2} \tag{1}$$

Where x is number of engaged workers, and *95%* confidence intervals for coefficients are $(-1{,}3 \cdot 10^{30}; 1{,}6 \cdot 10^{30})$ and (-17,61; -12,8). Equation (1) can be used by managers in order to determine on how big drop in processing time can they expect when they engage different number of workers. This is important, especially in days of peak load, which are days with big increase of incoming mails. PLC have problems in processing this huge amount of incoming mails in small period of time (usually peak load is at the beginning of the month, due to the increase of standard mails shipments). In those days PLC managers need to rearrange workers activities (transfer of workers from other sectors to the sector for standard mails) and engage additional labor force to deal with peak load.

4. CONCLUSION

Efficiency of the executed processes directly affects on overall efficiency of the entire logistics subject. This paper directly deals with this kind of problem. The main research hypothesis in presented paper was to examine the possibility of application of DES on basic postal-logistics processes in PLC. Papers aim was to create framework of PLC in which different simulation scenarios could be performed, in order to test various design solutions on logistic performances of particular PLC. Basically, model can be used for any kind of "what if" analysis, which is from interest for PLC managers. Beside framework, in this paper we also focused on the problem of additional workers engagement and their impact on processing time. As a result we presented the equation (1), derived from simulating the several different workers layouts. Equation (1) can serve to the managers as a guiding tool for deciding how much workers should be included, in which sectors, in order to obtain desired processing time, and in that way fulfill defined level of service.

ACKNOWLEDGMENT

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SIMULATION BASED LIFE-CYCLE ANALYSIS OF A VEHICLE FLEET

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Abstract: *Throughout the years the logistic experts have developed a variety of simulation models for specific applications. This paper addresses a discrete-event simulation model, which estimates the operational availability and maintenance cost of a vehicle fleet throughout complete life cycle, under a certain maintenance scenario. The model gives all necessary parameters to compute the total vehicle life cycle cost, linking reliability, operational tempo and maintenance scenario with vehicle acquisition and maintenance costs. Based on simulation results one can make cost-effective decision relative to buying adequate vehicles and organizing proper fleet maintenance, which gives required operational availability at lowest costs. In this work we have analyzed application of our model on an example – a light tactical vehicle fleet.*

Keywords*: vehicle, availability, maintenance, cost, simulation.*

1. INTRODUCTION

The technical performance of vehicles (such as speed, range, stability, fuel consumption, power generation) has improved significantly over the last several decades. On the other hand, suitability parameters (such as reliability, availability, and maintainability) have not been analyzed and improved. Suitability determinants are generally not addressed early enough during program development and are not prioritized with the same seriousness and discipline as performance parameters. The cost of operating and maintaining a vehicle fleet is a large expense for the owner, and suitability performance is a major factor affecting these costs. The existing off-the-shelf and best-practice methods to select maintenance strategies are mainly based on experience and manufacturers proposals. Improvements are usually done in a trial and error manner without taking into account cost effectiveness. Within the last few years, pressure on costs and delivery on time have dramatically gained importance to optimize maintenance process. Very often logistics and maintenance objectives are separately optimized and optimization results are moderate.

In this work an integration of required availabilityand maintenance optimization is done, based on vehicle life cycle simulation. The simulation model is a very flexible one, and gives the opportunity to change a variety of parameters: fleet size, vehicle reliability, operational tempo, work allocation between maintenance levels, time-to-repair distribution, maintenance cost – vehicle age correlation, preventive maintenance strategy, etc. The simulation results give a detailed insight into fleet life cycle: obtained availability of the fleet and every vehicle, every

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vehicle and fleet daily and total path, maintenance facilities utilization, queues, logistics administrative time, maintenance labor, maintenance cost (minimal, maximal, mean, standard deviation).

2. RELATED WORK

The development of life-cycle models is necessary to identify key factors that affect operational readiness and cost of required readiness. Modeling needs complex and time consuming research to examine many input parameters and possible scenarios, and models usually cover specific system or only a part of a life-cycle. One approach uses optimizations maximizing availability and profitability of the production system by varying both maintenance strategies and logistics factors. The obtained results indicate that a joint optimization of logistics and maintenance strategies provides better results than optimizing those elements independently and highlights the need for a comprehensive sophisticated model (Achermann, 2008). Some works are focused on a particular influencing parameter. The authors stress the problem of influence of the reliability parameters for final system functional measures (required time of delivery). The presented problem is practically essential for defining organization of vehicle maintenance and transport system logistics (Walkowiak and Mazurkiewicz, 2007). To establish a relationship between achieved reliability improvement and reduction in support cost, one model uses the Cost Analysis Strategy Assessment (CASA), combining the two relationships—investment in reliability to reliability improvement and reliability improvement to support cost reduction (Long at al., 2007). Many works are dedicated to transportation systems. One paper suggests analysis based on the modeling and simulating of the system behavior. Monte Carlo simulation is used to encourage reliability and stochastic functional parameters. The simulator is built using Scalable Simulation Framework (SSF) (Walkowiak and Mazurkiewicz, 2008). In some other works the primary goal is to conduct comparison of different support strategies of a system. Smith (2011) analyzes the cost per unit usage and operational availability of the military tactical vehicle. Transportation systems, with different levels of importance, are analyzed via simulation. Naidu at al. (2010) used a discrete event simulation to highlight the difficulties involved in a typical four-wheeler service center.

This work is aimed at developing simulation tool for revealing the mutual impact of acquisition and proving evidence for benefit of a joint optimization of logistics and maintenance, incorporating availability, logistics, and financial aspects. In this paper we suggest a simulation model, based on General Purpose Simulation System (GPSS), which allows integrated analysis of complete vehicle fleet life cycle, from acquisition to retirement.

3. SIMULATION MODEL

The simulation model was built using GPSS in such a way that software not only provides tools for modeling and simulation of a wide variety to maintenance services, manufacturing, but also has possibility to shape input data and carry out output statistics (Schriber, 1974). Simulation model describes a modern two-level maintenance concept, shown in Figure 1.

The first maintenance level includes preventive maintenance and corrective maintenance for minor failures, and all maintenance activities are done via one of M available mobile maintenance stations. The second level is dedicated to serious maintenance actions (repairs caused by serious failures), and maintenance depot with N working places is the available infrastructure of this level. Input and output parameters of the simulation model are as follows:
Input parameters: number of operational vehicles, fleet reserve (number of vehicles intendedto replace faulty vehicles),vehicle serial numbers, operational tempo, vehicle reliability, failuredistribution between minor and serious failures, maximal path between preventive

maintenance actions, first maintenance level capacity (M), second maintenance level capacity (N), time to execute preventive maintenance, time distributions to repair vehicles, labor and spares cost for mobile stations, labor and spares cost for depot maintenance, maintenance cost – vehicle age factor.

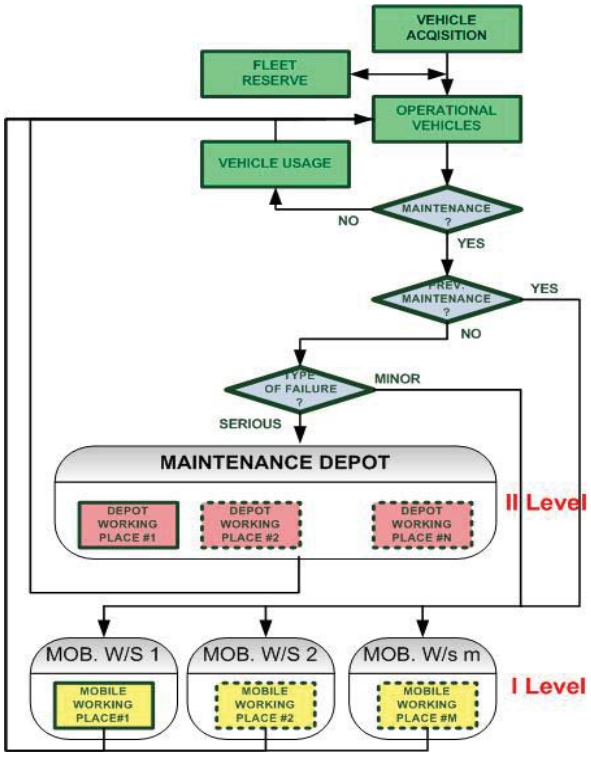


Figure 1. Two-level Maintenance Concept

Output parameters: fleet availability, vehicle availability, vehicle usage histogram, number of preventive maintenance actions, vehicle preventive maintenance histogram, number of first level corrective actions, number of second level corrective actions, mobile maintenance station utilization, mobile stations queue, depot utilization, depot queue, total preventive maintenance working hours, total first level corrective maintenance working hours, total second level corrective maintenance working hours, vehicle failure histogram, vehicle daily path, vehicle total path, vehicle maintenance cost.

Operational availability. Operational Availability is a measure of the percentage of the total inventory of a system operationally capable (ready for tasking) of performing an assigned mission at a given time, based on materiel condition.

$$A_O = \frac{t_{uptime}}{t_{uptime}+t_{downtime}} \quad (1)$$

Operational Availability also indicates the percentage of time that a system is operationally capable of performing an assigned mission and can be expressed as uptime divided by uptime plus downtime, where t_{uptime} is the time when a system is ready for operation, and $t_{downtime}$ is the maintenance down time, which includes repair time, administrative and logistics delay times. In

this model Operational Availability is calculated for every vehicle and complete fleet using equation (1). Fleet t_{uptime} and $t_{downtime}$ are calculated as the sums of each vehicle's t_{uptime} and $t_{downtime}$.

Operational tempo.Operational tempo is a measure of the dynamics of an operation in terms of equipment usage. Operational tempo can be changed by increasing/decreasing daily number of driving hours. The driving speed depends on operational environment. Higher than expected utilization rates and fatigue caused by operating environment are resulting in reduced service life.

Maintenance. Maintenance depicts the entity of all technical, technological, organizational, and economic actions to delay wear out and/or recovery of functional capability, including technical safety, of a technical system. Two-level maintenance strategy, shown in Figure 1, with regular scheduled maintenance actions are restoring the lost capability of subsystem impairments, and these maintenance actions allow the vehicles to meet operational standards and requirements. That means - vehicle failure intensity can be considered constant throughout complete service life. In the case of extreme operational tempo (wartime operations of military vehicles, for example),maintenance done to counter the effects of it, to some degree, but regardless of the maintenance or "reset" completed, it does not bring the vehicle to a true "zero-km" condition (USA DoD, 2008).

Vehicle maintenance cost. The maintenance cost in our model is defined by equation (2), and consists of two components, cost of maintenance activities done by mobile maintenance stations (I maintenance level) and cost of depot level corrective maintenance (II maintenance level).

$$MC_{Total}=MC_{MobSt}+MC_{Depot} \quad (2)$$

$$MC_{MobSt}=WH_{MobSt}xC_{Labor}(1+S_{MobSt})\ xK_{Age} \quad (3)$$

$$MC_{Depot}=WH_{Depot}xC_{Labor}(1+S_{Depot})\ xK_{Age} \quad (4)$$

Calculations of the mobile stations and the depot maintenance level costs are defined by equations (3) and (4). The maintenance cost depends on working hours spent on each maintenance action (WH_{MobSt} and WH_{Depot}), average cost of one hour labor (C_{Labor}), average cost of spares replaced during one working hour ($C_{Labor}xS_{MobSt}$ and $C_{Labor}xS_{Depot}$), and aging maintenance cost correction factor (K_{Age}). Having in mind that older vehicles show greater probabilities of having repair costs, our cost model introduces the aging maintenance cost correction factor K_{Age}, which connects maintenance cost and vehicle age. Values and shape for K_{Age} maintenance cost factor is adopted from research report (Pint at al., 2008).

3. EXAMPLE

Importance of simulation and its use in optimization lies in the fact that many problems are too complex to be described in mathematical formulations. Nonlinearities, combinatorial relationships or uncertainties often give rise to simulation as the only possible approach to solution. Our simulation model is tested through relatively complex example: find the cheapest life cycle solution for a fleet of 220 light tactical vehicles with required availability 0.89.Light tactical vehicles are platforms capable for small-unit combat and tactical operations in complex urban and rural environments, convoy escort, troop transport, explosive ordinance disposal, and ambulance missions. Fleet consists of 200 operational and 20 reserve vehicles.The key reliability parameter is Mean Km Between Failure. This parameter depends on vehicle reliability and operational conditions. For HMMWV (High Mobility Multipurpose Wheeled Vehicle)example vehicle, under supposed operational conditions, simulated Mean Km Between Failure was 1300 km. Maintenance alternatives are generated by varying number of mobile maintenance stations and number of depot working places. Nine alternatives were tested. Level I is the field

maintenance, consisting of preventive maintenance and 70% of corrective maintenance activities. Level II is the depot maintenance, covering 30% of vehicle failures (serious failures). Scheduled preventive maintenance labor was fixed - 2 hours per vehicle. Corrective maintenance working hours follow lognormal distribution, with mean equal 4 hours for minor failures, and 10 hours for serious failures.

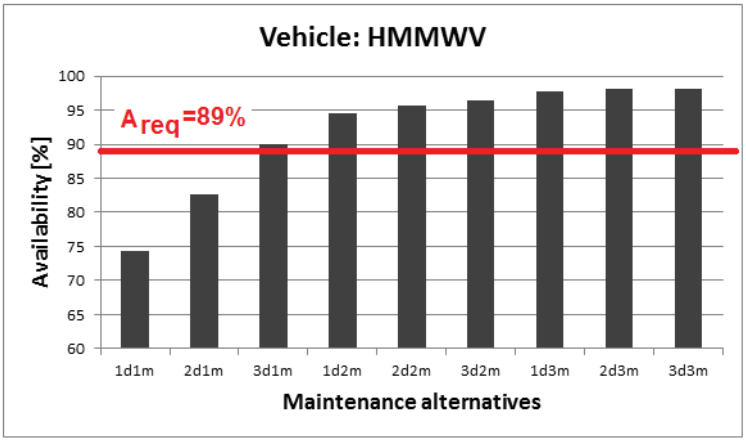


Figure 2. Fleet availability for different vehicle-maintenance alternatives

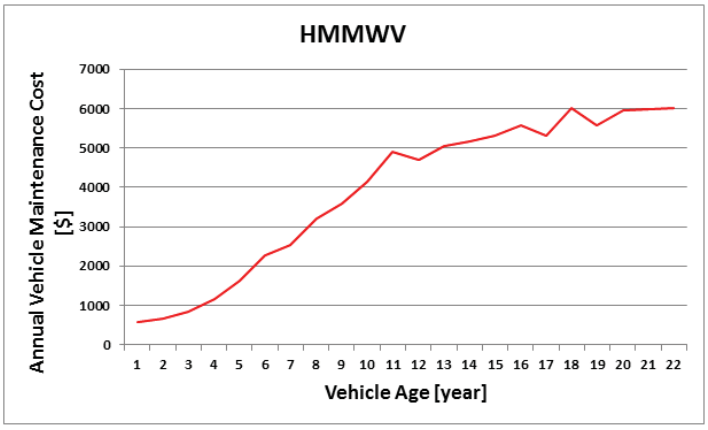


Figure 3. Average annual vehicle maintenance cost

Each maintenance alternative was tested in 20 operational conditions (a total of 180 scenarios). The presented simulation resultsare from one peacetime scenario. The results show, Figure 2, that 6 of 9 maintenance alternatives satisfy required fleet availability, one alternative is marginal (3d1m = 3 depot working places + 1 mobile station) and 2 alternatives do not satisfy requirements. For adopted maintenance alternative (1d2m = 1 depot working place + 2 mobile stations) under supposed operational tempo, during 22 year service life average vehicle availability was 0.8493 with 0.0509 standard deviation. Figure 3 shows a time dependentvehicle maintenance cost (average 6065 $ with 927 $ standard deviation).Results suggest that the effects of fleet aging on annual maintenance cost are significant. It is easy to observe that average annual maintenance cost for a vehicle 5 years old is 30% of the average annual maintenance cost at the end of vehicle life cycle.

4. CONCLUSION

Results of the simulation runs confirmed the assumption that system availability alone is an insufficient objective function for optimizing a maintenance strategy. Availability considerations have to be merged with financial aspects to achieve optimal maintenance strategy that satisfies both, the required availability and lowest possible total life cycle costs. Our simulation model is flexible enough to cover variety of scenarios: different requirements, different fleet size, different vehicles, different operational tempos, different maintenance strategies and infrastructure, etc. In addition to the classic optimization criteria, as minimizing costs and maximizing fleet availability, some other characteristics can be taken as supplementary objective functions. The model functionality was demonstrated through an illustrative example, fleet of 220 light tactical vehicles.

ACKNOWLEDGMENT

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SIMULATION MODEL FOR IRP IN PETROL STATION REPLENISHMENT

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Abstract: *Quality of a two-echelon distribution system, comprised of vendor and a set of clients, is greatly dependent on vehicle routing and inventory management. Simultaneous optimization of these two segments in distribution systems is commonly known as Inventory Routing Problem (IRP), where decision maker must determine delivery quantities and vehicle routes in a planning horizon of several days. For successful implementation of IRP, a Vendor Management Inventory (VMI) concept must exist in which vendor is responsible for inventory management at clients' side. Many models for solving the IRP in different systems are based on deterministic input data, although in real life these systems have some level of uncertainty. In this paper we observe IRP approach in petrol station replenishment, where we present simulation approach for applicability analysis of deterministic solution to systems with stochastic nature.*

Keywords*: simulation, inventory routing problem, heuristics, petrol station replenishment.*

1. INTRODUCTION

Inventory Routing Problem (IRP) is a relatively new field that is gaining an increasing attention in recent years by the international research community. There are many different definitions of IRP in available literature and perhaps the most comprehensive definition is given by Coelho et al. (2014): "*IRP can be described as the combination of vehicle routing and inventory management problems, in which supplier has to deliver products to a number of geographically dispersed customers, subject to side constraints*". IRP comprises of two subsystems with a strong interdependence, the vehicle routing and the inventory management, which are being simultaneously optimized. Andersson et al. (2010), based on the literature survey in various industries, defines three basic benefits that can be achieved with the IPR: economic benefits, flexibility of service, and improved robustness of the system due to better coordination. IRP can be observed as an extension to the vehicle routing problem in a sense of taking into consideration the inventory management segment, usually in the planning horizon of several days. The basic prerequisite for the implementation of IRP is the Vendor Managed Inventory (VMI) concept, which implies the application of modern information and communication technologies. To solve IRP, many authors develop models that use deterministic data input (deterministic consumption) to simplify the problem and enable the solving of the problem instances. In real systems, consumption has stochastic character and this simplification may lead to adverse effects, primarily as shortages or excesses of inventories and unplanned changes in

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the realization of the delivery plan. Applicability analysis of the deterministic solutions to the real system of stochastic nature can be made with the use of simulation.

This paper is one part of the doctoral dissertation (Popović, 2015) where we present heuristic's solutions (which presumes deterministic consumption) applicability analysis to the system with stochastic consumption using simulation. We observe petrol station replenishment problem in which fuel must be distributed from one depot to a set of petrol stations, where each station has stochastic consumption in real life. In the proposed simulation, stochastic consumption can result in the possibility of two negative events which represent two additional performances for evaluating the quality of solutions (in addition to inventory and routing costs): inventory shortages due to unplanned high consumption, and the need for urgent deliveries to minimize the inventory shortages.

The rest of this paper is organized as follows. Section 2 contains brief literature review with main focus on stochastic IRP. Section 3 presents IRP in petrol station replenishment problem formulation with deterministic consumption. In Section 4 we present proposed heuristic and simulation models used for applicability analysis of deterministic solution to systems with stochastic fuel consumption. Test instances and computational results are presented in Section 5. Conclusions and future research directions are given in Section 6.

2. LITERATURE REVIEW

Two most recent IRP review papers (Andersson et al. 2010, Coelho et al. 2014) made similar IRP classification based on the most important problem characteristics, presented in Table 1. IRP related papers usually observe deterministic systems to simplify the problem and to obtain the solution, where consumption is represented with some expected value. One of the first papers that observed IRP with demand uncertainty was by Federgruen and Zipkin (1984) where this uncertainty can lead to inventory stock-out. Golden et al. (1984) also observed IRP with consumption uncertainty where they developed heuristic model based on clients' service emergency. Berman i Larson (2001) analysed somewhat different case of stochastic IRP where drivers don't know exact client's demand quantity before visiting that client.

Table 1. IRP classification (derived from Andersson et al. 2010, Coelho et al. 2014)

CHARACTERISTIC	POSSIBLE OPTION			
Time horizon	Finite	Infinite		
Structure	One-to-many	Many-to-many	Many-to-one	
Routing	Direct	Multiple	Continuous	
Inventory policy	Fixed	Stock-out	Lost sale	Back order
Fleet composition	Homogeneous	Heterogeneous		
Fleet size	Single	Multiple	Unconstrained	
Number of products	Single	Many		

In some papers authors use simulation to analyze applicability of deterministic IRP solution to real-life systems with stochastic nature. One of those papers is Jaillet et al. (2002) where heating oil distribution from one depot to a set of customers was observed. Rolling horizon framework was used to obtain solution for longer time period and Monte Carlo simulation was used to test the solutions. Customers' consumption was randomly generated from a truncated normal distribution. Hemmelmayr et al. (2010) used simulation approach to analyze different distribution concepts in blood delivery to healthcare institutions where blood consumption was randomly generated from a truncated normal and uniform distribution. From stochastic IRP literature, some general conclusions can be made that are applicable to petrol station replenishment and therefore incorporated in the approach presented in this paper: solution from deterministic IRP is obtained by an approximation of stochastic consumption/demand;

simulation can be used to analyze applicability of deterministic IRP to stochastic systems; preventive and corrective measures are necessary to decrease negative effects of uncertainty; rolling horizon framework is used to obtain solution in longer time period.

3. PROBLEM FORMULATION

Two main decisions to be made in IRP petrol station replenishment are: (1) fuel quantities to be delivered per each fuel type to set of petrol stations in predefined planning horizon of several days; (2) according to delivery quantities, route construction for fuel delivery from one depot to set of petrol stations. Objective function, in the process of decision making, tries to minimize total costs which are comprised of routing and inventory costs. Routing cost is defined by total travel distance of all vehicle routes, while inventory costs are defined by average inventory levels of different fuel types at petrol stations. Observed IRP can be described as distribution of several fuel types ($j\epsilon\{1, 2, ..., J\}$) in one-to-many system with homogenous fleet of vehicles in planning horizon of several days ($t\epsilon\{1, 2, ..., T\}$). In each day of the planning horizon one petrol station $i\epsilon\{1, 2, ..., I\}$ can be served with only one vehicle. Each petrol station has constant daily consumption per each fuel type q_{ij} and underground tank of known capacity Q_{ij} (one for each fuel type). It is not allowed that inventory levels in petrol stations for any fuel type fall below predetermined safety stock level. Fuel is transported by a fleet of vehicles F with vehicles that have compartments. Only full compartments can be delivered to petrol stations. Number of compartments in a vehicle for fuel distribution usually varies from 4 to 6 and we test proposed model with three vehicle types. Given the total number of compartments in vehicles and more than one fuel type, in practice one vehicle can serve up to three petrol stations in a single route (Cornillier et al. 2009), and this limitation is applied in our model.

4. HEURISTIC AND SIMULATION MODELS FOR IRP IN PETROL STATION REPLENISHMENT

Observed IRP in petrol station replenishment is a complex combinatorial problem, as is the case with most IRP problems (Anderssson et al., 2010), where optimal solution cannot be obtained in acceptable computational time. Therefore, a heuristic approach is a necessity and we have developed a Variable Neighbourhood Search (VNS) model (Figure 1.a). This VNS model considers fuel consumption as a deterministic value in order to obtain delivery plan for a given planning horizon. Since fuel consumption is uncertain in real life, we developed simulation model to analyze applicability of a VNS solution to the stochastic case (Figure 1.b). Both, heuristic and simulation models were implemented using C++ programming language on PC Intel(R) Core(TM) i3 CPU M380@2.53GHz with 6 GB RAM memory.

4.1 VNS heuristic

The VNS metaheuristic was introduced by Mladenović and Hansen (1997) with the basic idea of systematic change of neighbourhoods in the process of finding improvement of current best solution. Therefore, VNS is based on multiple neighbourhoods in which algorithm attempts to find local best solution. Search of local minimum of multiple neighbourhoods improves chances to find a global minimum. We have developed general VNS heuristic that has the following procedures: initial solution, shaking procedure, local search procedure. Initial solution is created by delivering minimum fuel quantity (one full compartment) at the latest possible moment (day of planning horizon) regarding level of safety stock. Then, vehicle routes (for each day of planning horizon) are created using Sweep algorithm which are improved by Swap and Reallocate/Insertion (VND-route) procedures. Last step of obtaining the initial solution is Compartment transfer procedure which tries to improve the solution by changing the day of a fuel compartment delivery. This initial solution can be additionally improved by two inventory local search (VND-IR) procedures: reallocation of a single fuel compartment delivery between

days of planning horizon; reallocation of all fuel compartments in a petrol station between days of planning horizon. Shaking procedure is used to partially and in gradually intensified manner "destroy" (parameters of destruction are increased) current best solution and then to reconstruct it to obtain some new solution which is located in another segment of solution space (compared to current best solution). From this new solution, VND procedures with randomized order of neighbourhoods (RVND-route and RVND-IR) are used to obtain improvement. Finally, new solution is compared with the current best solution. If the new solution is better than the current best solution, then it becomes current best solution (and shaking procedure parameters are reseted). VNS heuristic algorithm is presented in Figure 1.a.

4.2 Simulation approach

Having a sufficient amount of fuel in petrol stations that can meet the consumption is a basic requirement for solution excellency in petrol station replenishment problem. In the case of stochastic consumption there is a risk of stock-out due to the possibility of excessive consumption. To avoid stock-outs, safety stocks are used (as a preventive measure) which have the role of meeting the extreme fuel consumption deviations. Larger consumption deviations require a higher level of safety stock that causes higher inventory costs. A solution which will be based only on raising safety stock is not cost-effective (high costs related to capital stock). To avoid a high level of safety stocks, with simultaneous satisfaction of stochastic consumption, concept of emergency fuel delivery (as a corrective measure) for those petrol stations which are in danger of stock-out is a necessity. Simulation is being used for the analysis of the applicability of deterministic solutions in terms of routing and inventory costs, as well as additional negative effects of inventory stock-outs and the number of emergency deliveries.

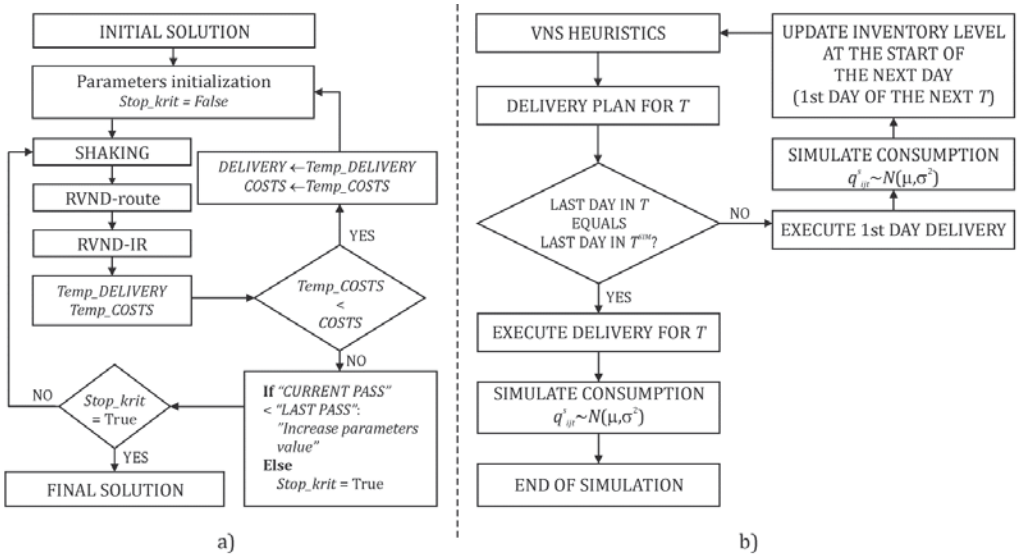


Figure 1. VNS heuristic and simulation algorithms

The basic idea of simulation approach is to obtain solution for a planning horizon using VNS heuristic, and then to simulate daily fuel consumption using appropriate random distribution. To simulate consumption we used Normal distribution $q^s_{ijt} \sim N(\mu, \sigma^2)$ (truncated left from zero to forbid negative consumption), as it was used in some other papers (see Jaillet et al. 2002, Hemmelmayr et al. 2010). After the realization of deliveries and simulated consumptions, model checks the inventory level of al fuel types in all stations. If inventory level falls below safety stock

level, an emergency delivery is activated. Any excessive fuel consumption that cannot be satisfied is registered as stock-out. Length of simulation planning horizon T^{SIM} is limited by computational time, and this was the reason why we introduced a rolling planning horizon in which we used VNS heuristic to solve successive shorter periods $T<T^{SIM}$. In the simulation, from each solution of a shorter period T only first day delivery was executed (expect the shorter period T at the end of T^{SIM}) where this first day takes into account expected costs of entire shorter period T. Simulation algorithm is presented in Figure 1.b.

5. COMPUTATIONAL RESULTS

In the proposed simulation approach we observed following instances' characteristics: 15 petrol stations; 3 fuel types; fleet size is F=4; transportation cost per travelled kilometre is 2 €/km; daily inventory holding cost is 1 €/1000 l; daily fuel consumption per type q_{ij} can randomly take values from intervals [1000-3000 l], [800-2000 l], [500-1500 l]; petrol stations' underground tanks per fuel type can have random values from intervals [30000-50000 l], [20000-40000 l], [20000-30000 l]; petrol station inventory level per fuel type at the start of simulation can randomly take values from $[2*q_{ij}, 8*q_{ij}]$; petrol stations are randomly located in a square [-100, 100] km, while depot is located at [0,0]; simulation planning horizon is T^{SIM}=16 days, while each shorter period is T=4 days. We have randomly generated 100 test instances with 10 simulation runs per each instance. Additionally, we tested the impact of following parameters on solutions' quality:

- different consumption deviation: $\sigma=0.2*\mu$, $\sigma=0.3*\mu$, where $\mu=q_{ij}$;
- different vehicle types [K – number of compartments, Qo – compartment capacity]ϵ{[4, 8800 l], [5, 7000 l], [6, 5800 l]};
- different levels of safety stocks: $V=0.5*q_{ij}$, $V=1.0*q_{ij}$, $V=1.5*q_{ij}$, $V=2.0*q_{ij}$.

Simulation results are presented in Table 2. Results show that increase in safety stock level consequently increases both inventory and routing costs (due to increase in delivery quantities). Depending on the level of consumption deviation different safety stock level is required to reduce stock-outs to practically zero (between $1.0*q_{ij}$ and $1.5*q_{ij}$). Additionally, number of emergency deliveries is higher with higher level of consumption deviation. Vehicles with more compartments have lower total costs but also more emergency deliveries and stock-outs.

Table 2. Simulations results for 100 test instances (average with 10 repetitions)

σ	Vehicle type [K, Qo]	V [q_{ij}]	Routing costs [€]	Inventory costs [€]	Total costs [€]	CPU time [sec]	Emergency deliveries	Stock-outs [l]
$0.3*u$	[4, 8800 l]	0.5	10968.9	5348.5	16317.5	8.6	6.76	292.3
		1.0	11323.6	5875.0	17198.6	8.8	7.33	22.4
		1.5	11720.2	6447.3	18167.5	8.5	7.06	0.8
		2.0	12122.1	6987.7	19109.8	8.7	6.96	0.0
	[5, 7000 l]	0.5	11149.9	4883.2	16033.1	11.3	7.29	323.0
		1.0	11485.3	5393.5	16878.9	11.8	7.94	24.2
		1.5	11947.7	5954.8	17902.5	11.4	7.59	1.1
		2.0	12328.7	6481.9	18810.6	11.7	7.37	0.0
	[6, 5800 l]	0.5	11397.5	4598.3	15995.8	14.1	7.82	379.8
		1.0	11731.2	5090.1	16821.3	14.7	8.42	32.1
		1.5	12178.7	5644.8	17823.5	14.4	8.02	0.1
		2.0	12540.8	6177.9	18718.7	14.8	7.87	0.0
$0.2*u$	[4, 8800 l]	0.5	11059.7	5317.7	16377.4	8.7	4.59	47.2
		1.0	11388.9	5848.0	17236.9	8.9	4.92	0.7
		1.5	11813.1	6416.7	18229.9	8.6	4.77	0.0
		2.0	12189.2	6956.4	19145.6	8.7	4.53	0.0
	[5, 7000 l]	0.5	11231.1	4858.7	16089.9	11.5	4.81	52.1
		1.0	11534.6	5364.6	16899.2	12.0	5.31	0.6
		1.5	11987.0	5914.5	17901.5	11.6	5.22	0.0
		2.0	12356.0	6445.2	18801.2	11.9	5.12	0.0
	[6, 5800 l]	0.5	11424.9	4560.0	15984.9	14.3	5.23	56.9
		1.0	11773.6	5059.8	16833.4	15.0	5.65	2.1
		1.5	12224.2	5607.5	17831.7	14.6	5.33	0.0
		2.0	12547.9	6141.9	18689.8	15.0	5.36	0.0

6. CONCLUSIONS

Simulation can be used to analyze petrol station replenishment problem in different environments and to choose the most suitable distribution variant (e.g. vehicle type, safety stock level). Based on simulation results presented in this paper, general conclusion can be made that the total inventory and routing costs decrease with the increase of the number of vehicles' compartments (smaller capacity of a single compartment). On the other hand, looking at the aspect of service (number of emergency deliveries and stock-outs) vehicles with smaller number of vehicles' compartments (larger capacity of a single compartment) are more suitable. Decision makers must determine the degree of importance between quality of service (possible loss of revenue) and the total inventory and routing costs, and based on that to design distribution structure and policy. Potential research directions are adjustments of the proposed model to different petrol stations replenishment distribution structures as well as modifying the proposed models for use in different business systems with similar characteristics, such as the collection of waste and recyclables, transport of live animals, collection of milk or olive oil, distribution of frozen products that are kept at different temperatures, etc.

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SIMULATION MODEL OF A QUEUING SYSTEM: THE CASE STUDY OF A FAIR TRADE MANIFESTATION IN NOVI SAD

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Abstract: *The main idea of this paper is to evaluate supply processes at a Fair Trade (FT) manifestation in Novi Sad. To successfully organize such a manifestation detailed preparation plan and transparent exhibitors' arrival schedule are required. In our case, exhibitors' arrivals are random, which may result with long queues and bottlenecks. Simulation model is created in MATLAB to evaluate whether the FT manifestation was overload with queuing during supply processes. According to obtained results all vehicles that entered manifestation are serviced without the need for long queuing.*

Keywords*: FT exhibition, simulation model, supply processes, performance evaluation.*

1. INTRODUCTION

This paper analyzes performance evaluation of a Fair Trade (FT) manifestation. According to the World Fair Trade Organization, FT is a trading partnership, based on dialog, transparency and respect, which seeks greater equity in international trade (WFTO, 2015). Observed FT manifestation is located in the second largest city in Serbia – Novi Sad. It spreads on the area of 226.000 m^2 and the indoor exhibition area covers 60.000 m^2. There are 37 halls, among which the most up-to-date is the Master Hall, which spreads on 5.970 m^2 of exhibition area. Tourism FT manifestation was in the main focus of this analysis. It was held in the Master Hall.

The main idea of this paper is to provide an answer should the stochastic schedule of exhibitors' arrivals be reorganized and replaced with deterministic timetable? The main dilemma is whether there is a short time window in which exhibitors' set up their exhibits? If so, the execution of supply processes will be dysfunctional. Simulation model provides calculation of various performance parameters which should give the answer to key question in this analysis. Performance parameters (1) *utilization (U)*, (2) r*ejected exhibitors (R), (3) mean number of vehicles in the queue (Lq), and (4) mean time vehicles have spent in the queue (Wq)* are selected as the main indicators.

The rest of the paper is organized in the following way. Section 2 describes a discrete event simulation and queue modeling in logistics. Section 3 considers the methodology. Section 4 explains simulation model and provides simulation results. Concluding remarks and future work follow in Section 5.

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2. DISCRETE EVENT SIMULATION AND QUEUE MODELING IN LOGISTICS

Discrete-event simulation (DES) is modeling approach widely used as decision support tool in logistics and supply chain management. Specific examples of the issues that these DSS address are supply chain design and reconfiguration, inventory planning and management, production scheduling and supplier selection (Tako and Robinson, 2012). Simulation models are usually built to understand how systems behave over time and to compare their performance under different conditions. DES can be applied at operational and tactical level (Figure 1). Several papers have suggested that DES is not suitable for strategic modeling as it does not normally represent systems at an aggregate level (Baines and Harrison, 1999). For strategic modeling, system dynamics (SD) is more adequate modeling approach. In some cases the use of hybrid simulation approaches combining DES and SD gives the best results (Rabelo et al., 2005).

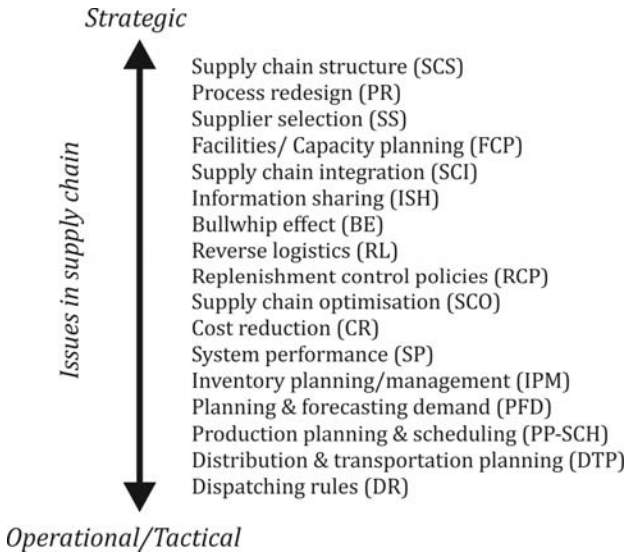


Figure 1. Ordering of logistics issues into strategic and operational/tactical (Tako and Robinson, 2012)

DES models systems as a network of queues and activities where state changes occur at discrete points of time. In DES entities (e.g. objects, people) are represented individually. Specific attributes are assigned to each entity, which determine what happens to them throughout the simulation. Statistical calculations are usually performed to describe entities' attributes.

Queuing models are widely used in service facilities, production, material-handling systems, and in situations where congestion or competition of scarce resources can occur. Generally, a queuing system is described by defining its population, the nature of arrival, the service time and mechanism, queuing behavior, and the queuing discipline (Jahn et al., 2010). The purpose of queuing models is to provide information about important performance parameters such as queue lengths, response times, waiting times, utilization, probability that any delay will occur, probability that some customers will be rejected, probability that all service facilities will be idle, etc. (Bhaskar and Lallement, 2010).

In our approach, *U, R, Lq,* and *Wq* are targeted performance parameters in the simulation model. Performance parameter - *U* - should reveal how high the percentage of the system usage is? The higher value of utilization is shown, the higher value of system usage is implied. Performance parameter - *U* - measures what percentage of daily supply activities has been operational. The key parameter was time on the basis of which simulation results are calculated and proposed.

Performance parameter - *R* - should show whether there were rejected exhibitors from servicing. Exhibitors are rejected in case of excessive queuing. Those situations are unacceptable in practice. Considering that exhibitors arrive randomly, organizers of the FT manifestation need to make available sufficient number of places for vehicles that are waiting in a queue. Performance parameter - *Lq* - should indicate what is the average number of vehicles during queuing. Correspondingly, performance parameter - *Wq* - should show what is the average time that vehicles have spent in the queue.

3. METHODOLOGY

The most efficient method for data collection was quantitative research. The total number of monitored vehicles at the Tourism FT was 56 at two servicing channels. Servicing channels are places in front of entrances into exhibition halls. They can be compared with regular parking places, but each servicing channel can serve only one vehicle at once. The size of entrances into exhibition halls and vehicles' dimensions restrict that only one exhibitor can set up its exhibits simultaneously. Observed FT manifestation is medium sized exhibitions. It lasted for three days. A sampling frame was identified through Novi Sad exhibition web site and organizational scheduling program. Table 1 shows the framework of this research.

Table 1. Basic information about the research

Observed FT manifestation	Tourism Fair Trade
Type of research	Quantitative research
The aim of research	To identify main characteristics of arrival rates (λ) and service rates (μ) during supply processes
Target groups	vans, cars
Obtained results	56 vehicles recorded
Research period	October 2013.

With the FT management support, the lead author and three research helpers were able to approach exhibition on-site and conduct the research at servicing channels. After arriving at exhibition area, the helpers were assigned to different entrances to Master Hall to ensure systematic coverage of supply processes. The illustration of the FT manifestation is presented to visualize similarity with the queuing system (Figure 2).

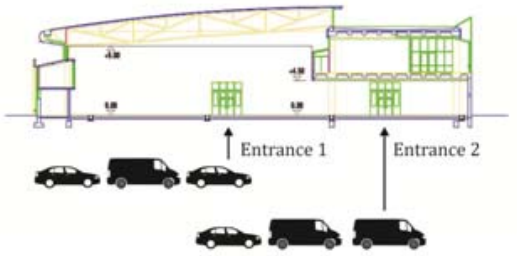


Figure 2. Master Hall at the FT exhibition in Novi Sad

It can be noticed that there are two entrances into Master Hall in front of which exhibitors unload their exhibits. Both entrances are observed in the context of one queuing system, not separately. If more than one vehicle arrives at the same time queuing will occur. Organizers of FT manifestation need to provide sufficient space for vehicles when queuing occurs. Exhibitors'

arrivals are random. All supply processes are organized one day before the FT manifestation becomes opened for visitors.

4. SIMULATION MODEL AND RESULTS

Collected data from the quantitative research are merged into one dataset. The first step was to perform statistical analysis and define the input parameters for the simulation model. To determine probability distributions of collected data software MINITAB has been used. The main criterion during statistical analysis was that the p-value from obtained statistic results be, at least, at the 5% of the significance level. The p-value indicates the probability that tested data are in correlation with selected distribution. Obtained results from statistical analysis imply that arrival rates are in correlation with Normal distribution (p-value = 0.743) and service rates are in correlation with Weibull distribution (p-value = 0.187).

Software MATLAB and its graphical programming tool Simulink are used to create simulation model. MATLAB provides a relatively easy-to-use, versatile, and powerful simulation environment for investigating the basic, as well as advanced, aspects of dynamics systems (Hung, 1998). Simulink is simulation software developed for simulating and analyzing dynamic and discrete systems, which is widely used within industry for representing process behavior and control systems (Asbjörnsson et al., 2013). The simulation model is created using Simulink's SimEvents section with different blocks. The graphical drag-and-drop interface in Simulink was environment in which a discrete-event simulation model was build (Figure 3). The key features include (1) Libraries of predefined blocks, such as queues (first-in-first-out (FIFO) queue), servers (N-server), generators (Time-based entity generators) and sinks (Entity sink) for modeling system architecture, (2) Built-in statistics such as number of entities timed-out and utilization, and (3) M-function for calculating the main results (Inyiama, 2012). Event-Based Random Number block generates random numbers from specified distribution, parameter and initial seed. Depending on the type of determined distribution input parameters for arrivals and servicing are statistically determined. Time-Based Entity Generator block generates entities using integration times that satisfy specified criteria. The integration time is the time interval between two successive generation events. Start Timer block associates a named timer to each arriving entity independently and start the timer. Read Timer block reads the value of a timer that the Start Timer block was previously associated with. FIFO Queue block stores entities in sequence first-in, first-out for undetermined length of time. N-Server block stores up to N entities, serving each one independently for a period of time and then attempting to output the entity through the OUT port. Entity Sink block accepts all blocks entities and provides a way to terminate an entity path.

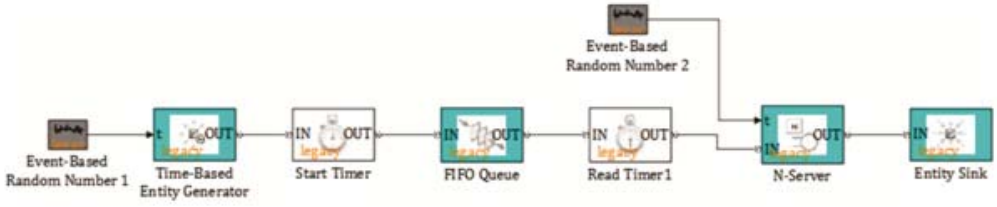


Figure 3. Basic blocks in the simulation model

Arrival rates and service rates are measured during 12 hours period, as long as supply processes lasted. In some cases, supply processes may last longer depending of the exhibitors' dynamics of arrivals and exhibition size, in general. The main criterion for determination of the upper limit of prediction period was average duration of supply processes of medium-sized FT manifestations. According to FT managers' expertise and experience the upper limits is five additional hours.

Therefore, the simulation and prediction results of parameters *U, R, Lq,* and *Wq* are calculated correspondingly (Table 2).

Table 2. Simulation and prediction results from the simulation model

	Time intervals					
Key performance parameters	12h	13h	14h	15h	16h	17h
R	0	0	0	0	0	0
U	67.7%	68.2%	68.8%	69.1%	69.5%	69.8%
Lq	3.41	3.62	3.84	3.91	4.02	4.13
Wq	10.43 min	10.64 min	10.73 min	10.85 min	11.06 min	11.22 min

Table 2 shows that performance parameter - *R* - has value 0 for simulation period of 12 hours, as well as for all prediction periods. Performance parameter - *U* - shows that system hasn't been used up to its limits, considering that obtained values from the simulation model are smaller than 100%. Performance parameter - *Lq* - shows average value of 3.41 vehicles in the queue during simulation period. Prediction results for - *Lq* - indicate that there is no large increase in obtained values considering that the greatest value is 4.13. Correspondingly, performance parameter - *Wq* - shows average value of 10.43 minutes for each vehicle during queuing. Similarly, prediction results for - *Wq* - do not show a significant difference compared to simulation result.

5. CONCLUDING REMARKS AND FUTURE WORK

The aim of this analysis was to provide an answer should the stochastic schedule of exhibitors' arrivals at the FT manifestation be reorganized and replaced with deterministic timetable? According to obtained results from the simulation model all vehicles that entered manifestation are serviced without the need for long queuing. Performance parameter - *R* - has value 0 for all simulation periods, which implies that there are no rejected exhibitors from servicing. Performance parameter - *U* - suggests that manifestation has not been overload with queuing during supply processes. Prediction results imply that at the current operating regime Tourism FT manifestation can efficiently function for 17 hours considering that 30% of time during daily supply activities system hasn't been used. Performance parameter - *Lq* - also supports effectiveness of FT manifestation because FT's managers easily can organize up to 10 waiting places in front of each entrance into Master Hall. Performance parameter - *Wq* - implies that exhibitors need to wait to unload their exhibits around 10 minutes. Unloading of exhibits at Tourism FT manifestation is relatively fast, because the exhibits are mostly composed of promotional tourism material. Simulation results of performance parameters imply that at a present operating regime stochastic schedule of exhibitors' arrivals at Tourism FT manifestation is quite efficient supply strategy.

Future research can be focused towards more comprehensive analysis with larger number of performance parameters, such as mean number of vehicles on servicing, mean number of vehicles in the system, mean time vehicles have spent on servicing and mean time vehicles have spent in the system. Also, different sized manifestations may be analyzed and compared. Additional data are required in that case. Proposed simulation model is universal for each manifestation held at the FT in Novi Sad. Additional blocks can be added in cases when larger-sized manifestations are being analyzed.

ACKNOWLEDGMENT

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Part VII QUALITY MANAGEMENT AND PERFORMANCE MEASURES IN LOGISTICS

CITY LOGISTICS PERFORMANCE

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Abstract: *Problem identification, modeling, planning and management of the city logistics solutions requires knowledge about the parameters of logistic flows and systems, generators and logistics demands of the urban environment, i.e. the environment in which requirements are being realized. By combining the parameters, city logistics performances are being obtained. A set of performances and the way of their identification are not standardized, while the permanent monitoring of some part of the parameters is in fact an exception present in certain cities. Performances are analyzed and defined at the different levels of research, while being in line with the basic objectives and scope of the research. In this paper, the most commonly quantified parameters and performances of city logistics are presented. The necessary parameters are collected and processed in different ways so their reliability and comparability are questionable.*

Keywords*: city logistics, performance, research, reliability.*

1. INTRODUCTION

Problem identification, modeling, planning and management of the city logistics (CL) requires a large number of parameters that describe the logistical flows and systems which enable their implementation, as well as the parameters of the logistics demands generators and the urban environment, i.e. the environment in which the requirements are being realized. By combining the parameters, CL performances are being obtained (Tadić, 2014). Considering that logistical flows depend on the parameters of the urban environment (infrastructure conditions, economic structure, etc.), and that their implementation affects the parameters of the urban areas (traffic congestion, accessibility, air pollution, etc.), in addition to their establishment, continuous monitoring and updating of parameters of the surrounding and performances of the city logistics is necessary. However, a set of the CL parameters and performances that need to be monitored, as well as the way of their determination, are not standardized. Performances are being defined according to the specific research objectives, after which the necessary parameters are being collected, processed, analyzed and quantified. A comprehensive study of the logistics, in terms of space, activities, types of goods flows, activities and processes and participants, is a concept that has not been implemented in any study of a certain city in the world. The main reasons are the extremely high complexity and the lack of understanding of the problem, but also the different goals and interests of direct and indirect participants of the CL. The paper presents a set of the most commonly used city logistics performances, as well as the methods for their determination.

2. IMPORTANCE OF THE CITY LOGISTICS PERFORMANCE

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Identifying CL problems requires knowledge on the characteristics of logistics, goods and traffic flows, as well as the systems which enable their realization. The volume of flows is directly related to the size of the city. However, in addition to the consumer goods, it is also necessary to examine the flows of the intermediate raw materials, construction materials and different types of cargo. On the other hand, the volume of flows largely depend on the geographic and physical characteristics, spatial organization of the urban functions, logistics infrastructure and the role of the observed zone in the realization of cargo flows on a higher level (Tadić et al., 2015).

Due to the lack of research and constant monitoring of the CL performances, urban authorities and planners do not have a clear and complete picture of the logistics activities and processes. On the other hand, without the knowledge of the current situation, and without the identification and quantification of the CL performances and problems, it is not possible to search for the effective solutions (Figure 1).

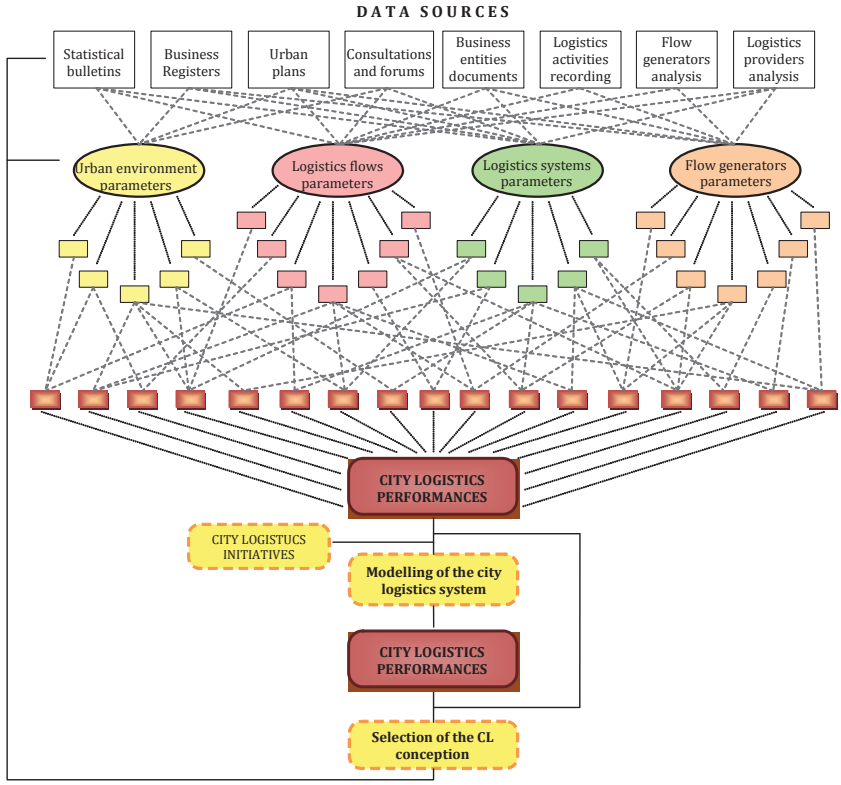


Figure 1. Determination of the city logistics performances and their importance (Tadić, 2014)

The parameters are being obtained using the different data sources, such as local and national statistical bulletins, transport statistics, business registries, urban plans, vehicle diaries and waybills, discussion forums, consultations with local governments and lawmakers. However, most of the information is being obtained by a dedicated research of the logistics activities (recording of the loading/unloading zones, GPS vehicle tracking, etc.) and participants of the CL (generators and logistics providers). By combining the parameters, the performances that describe the state of the CL are being obtained. Performances may be used for identifying the problems and modeling of the flows and CL system. On the other hand, the success of the initiatives, measures and concepts of the CL is determined by comparing the performance efficiency and the sustainability of the system before and after its implementation. Application of

the certain CL initiatives and concepts requires the change of the urban plans, infrastructure systems, legal regulations, price policy, traffic organization and other elements that represent data sources; it changes the parameters of the urban environment, attributes of the flow generators and parameters of the logistics flows and systems, i.e. CL performances (Figure 1). The lack of monitoring of the CL performances is more or less present in all the cities. The exceptions are the statistical data on freight traffic in the cities, but they are also relatively useless. Statistics only keep the records on the trips of the registered carriers, and only for the vehicles with the gross capacity of over 3.5 tones, while light commercial vehicles (less of 3.5 t) have the most significant growth in the number of vehicle-km in the city (Browne et al., 2007) and make up the largest part of the cargo vehicles, usually over 80% (DfT, 2012). In addition, the research does not include shopping trips, which in the large European cities make up between 45 and 55% of the urban goods movement (Gonzalez-Feliu et al., 2012) and can participate with 15-20% of the total vehicle-km (Dablanc, 2009) .

2.1 The parameters of the urban environment

The parameters of the urban environment include spatial, demographic and economic characteristics of the city and they are generally publicly available. The main sources are the publication of the public bodies at the local and national levels (statistical bulletins, urban plans, commercial registers, etc.). For the analysis of the CL performances the most important parameters are: size, population, family size, age structure, economic structure, number of employees, service price, taxes and the number of jobs. These parameters are determined for the whole city and the urban zones and have a great importance for the assessment and modeling of the CL flows and systems (Tadić, 2014). Logistics activities in the city largely depend on the characteristics of the traffic network: categories of roads, dedicated lanes, organization and regulation of the movement, taxi stands, location, organization and parking capacity, etc. These parameters affect the structure of the vehicle in the realization of the commodity flows, the intensity of commercial vehicles and traffic burdening, delivery vehicles' route planning, duration of the loading-unloading operations, operating costs of the carriers, service providers and others.

2.2 The parameters of the logistics system

Most of the flows that start or end in the city are realized through the various logistics systems. In order to determine the performances and conceptual modeling solutions of the CL, one needs to know their number and structure, purpose (type of goods), ownership, size, location, capacity, transshipment volume, the available modes of transport, but also the technologies of the logistics subsystems for storage, transshipment and transport of the incoming and outgoing goods flows (Tadić, 2014). Parameters of the logistics systems, especially those that are the part of the public infrastructure, are generally available and could be found in the planning documents, reports and publications of the city administration. However, determining the parameters of the private systems requires research and consultation with the owner.

2.3 The parameters of the logistics demands generators

The generator, i.e. the facility that requires the delivery and/or the collection of goods, may be seen as an entity with the attributes (parameters) which describe it. The parameters differ according to the economic sector, but also within the same industry. The most commonly used parameters of the generators are (Zečević & Tadić, 2006): business activity, size, ownership and location, the structure of the goods in the incoming and outgoing flows, used systems of ordering and supplying, the size of the storage area in the facility, the time of receiving and dispatching the goods, size and frequency of deliveries and shipments, the stopping places for the vehicles performing the operations of loading/unloading of goods, types of vehicles performing delivery

etc. In most cities, only some of these parameters are being recorded (e.g. location, ownership, business category, total surface area), while the largest number of the attributes are being obtained in the one-off researches, mostly through the interviews with the employees and by recording the loading/unloading operations (Tadić, 2014).

2.4 The parameters of the logistics flows

At the national level, the basic parameters of the commodity and transport flows are being monitored (volume and structure of the goods and transport flows, transport work). In certain countries, some other parameters, such as (Browne & Allen, 2006): transport intensity, traffic intensity, energy consumption; average transport distance; loading factor; number of empty runs etc. are being determined. However, none of these parameters is being determined exclusively for the urban freight transport, and the cases in which some of them are being studied apart from the national researches are rare. This is likely the result of the weak understanding of the CL importance at all administration levels. The most important parameters of the logistic flows are: type of vehicle, number of trips, time of realization, tour duration, number of requests per tour, trip duration, dwell time in front of the object, the length of the route, the distance traveled by the vehicle, the vehicles' operation system, type of goods, fuel consumption etc. (Tadić, 2014). Parameters are being determined for all flow categories (supply, recycling materials and service activities) and require extensive research (recording of the logistics operations, driving logs and waybills analysis, survey of the participants of the cargo flows - logistics providers, carriers and drivers, etc.). Due to the lack of continuous monitoring of goods and traffic flows in the city, the models that enable the obtaining of the part of the logistics flows parameters on the basis of the one-off researches are developed.

3. BASIC CITY LOGISTICS PERFORMANCE

CL performances describe the logistics activities and processes and enable the identification of the problems and the quantification of the specific measures and initiatives application effects, and they are being defined in accordance with the objectives of the specific researches. Their analysis, while defining the spatial, urban and development plans, can improve the sustainability of logistics and the urban environment. Generators structure and the number of vehicle launch requirements are the parameters that directly affect the number, capacity and location of the infrastructure systems for loading/unloading of the commercial vehicles. It is often wrongly assumed that the large retail chains are the largest generators of the freight traffic. However, they generally use a centralized system of supplying, bigger freight vehicles and have a predefined dynamics and delivery times. On the other hand, small shops and specialized stores may be responsible for a significant part of the activities of freight vehicles, mainly vans. In order to plan the logistics activities and the CL concepts, but also to define the urban plans (spatial, traffic), it is necessary to know various CL performances, some of which are:

The delivery frequency differs from city to city, between the economic sectors, but also within the same industry. At the city level, it depends on the economic structure, economic development, market conditions, share of the informal sector, share of the large retail chains, presence of the logistics providers, users' behavior, time of the year, policies and regulations of the local government etc.

The delivery time is an important parameter for the planning activities of the shipper and receiver of goods, as well as for the logistics providers, i.e. the carriers. It depends on regulations that define the access for the delivery vehicles (intervals of the restricted movement of the certain categories of vehicles, restrictions related to the stopping and loading/unloading of the vehicles, etc.); deliveries of the time-sensitive goods which loses its value after a certain time (daily newspapers, fresh dairy and bakery products, etc.), as well as the time intervals in which the facility can receive goods (during the working hours and off-hours). Suppliers (shippers) and

carriers (logistics providers) have the greatest influence on the delivery time, while a substantial part of the recipients has no effect on the time of receiving the goods (Cherrett et al., 2012).

The structure of the delivery vehicles depends on the business category, the supplying system, requirements for goods, delivery frequency, infrastructural constraints, regulations that define conditions of access etc. In the centralized supply system, the deliveries are mainly realized by the different vehicle categories, while in the decentralized they are mainly realized by vans. Passenger cars dominate in supplying the facilities of the informal sector.

The return loading of the delivery vehicles shows the frequency of the recollection of the goods from the facility (reusable packaging, defected goods or the date expiring goods, goods for the resupply in some other facilities) to the distribution center, suppliers' depot or some other facility in the route. Using the delivery vehicles for realization of the reverse flows, transport efficiency is increasing, the number of vehicles and vehicle-km is reducing,, as well as the negative impacts on the environment. However, a small part of the delivery vehicles regularly realize the reverse flows, while almost half of the generators do not use the services of reverse logistics by the provider that realizes the deliveries (Cherrett et al., 2012).

The dwell time of the delivery vehicles affects the deliveries coordination, vehicle routing, planning and better use of loading/unloading zones or street parking places. Researches show that the average time spent at the place of unloading the vehicle depends on the vehicle category (longer for larger vehicles) and service provider (longer in insourcing strategy). Researches show that there is not a strong correlation between the average dwell time of the delivery vehicle and the size of the facility, i.e. the supply system (Cherrett et al., 2012).

The place of unloading activities depends on the urban area. In areas with large shopping centers (mainly peripheral zones) delivery vehicles mainly stop on the reserved off-street parking spaces, while in the central, shopping streets, they stop on the street. Place and time of the vehicle stopping, for the loading and unloading operations at the facility, are affected by the type and form of the goods. Some goods require the use of special vehicles or special reloading equipment, so the vehicles are stopping as close as possible to the facility.

The number of deliveries per tour depends on the logistics provider, carrier, delivery sizes, the required delivery time, supply system etc. By applying the system of handling the multiple facilities in a single tour, the vehicles are traveling longer distances because they do not use the shortest routes to each facility, but on the other hand the number of trips is significantly smaller than in the system of the direct delivery. In practice, the number of vehicle-km is usually minimized by the use of the direct delivery and smaller vehicles. However, the direct delivery is often not acceptable for several reasons: a small amount of goods, long distances, etc.

The frequency of service visits to the facility depends on the business category and type of the service. Service flows can have a significant impact on the total number of commercial trips. On average, the frequency of the service visits to the facilities is 7.6 on a weekly basis (Cherrett et al., 2012). The highest frequencies have mail deliveries and waste collections, while others are not that often (maintenance of computer equipment, copier devices, elevators and escalators, etc.).

Vehicle types used for service visits and dwell times indicate that these activities may be responsible for a significant consumption of parking spaces and pavements in the urban areas. About 70% of the service visits are realized by the motor vehicles, half of which are vans. The vehicles' dwell time depends on the type of service, and the UK researches show that the mean dwell time for all services is 35 min (Cherrett et al., 2012).

A wide set of performances can be obtained by combining the basic CL performances with the parameters of the urban environment and logistics systems. The number and type of the obtained CL performances depends on the research objectives, but each of them helps understanding the situation of logistics and identification of critical elements with respect to the

business, time interval, logistics organization (insourcing and outsourcing), performers of the delivery, vehicle type, etc. For the assessment of efficiency and sustainability of the initiatives, measure and conceptual solutions of the CL, the most commonly quantified performances are (Zečević & Tadić, 2006; Tadić, 2014): the number of trips, i.e. the number of vehicles launched for the distribution of goods; the number of vehicle-km; the required number of delivery vehicles; driving time; delivery size; loading factor; delivery reliability; time and frequency of loading/unloading operations; the required capacity of the storage systems; fuel consumption; emissions; distance traveled per unit of delivery; operating costs; etc.

4. CONCLUSION

Researches of the CL significantly differ by the number and quality of the quantified parameters. The information concerning the collection and processing of data are mainly scarce, therefore their reliability and comparability are questionable. Even in the countries with a significant base of the CL parameters, most of the inputs are obtained by the disaggregation of the data collected for a wider geographical area. On the other hand, the parameters are being collected by the different public sector organizations, as parts of the short-term (one-off) studies and projects, but also by the private sector organizations, including industrial, retail, utilities and transport companies, trade associations and companies involved in the market research. However, their studies are not coordinated and there is a large number of the data sources that vary in quality and methodology of the assessment. This makes the comparison or combination of the parameters very difficult or impossible. Even in the cities where the large number of parameters is collected, it is still impossible to get a clear picture of the CL system when the data unites.

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FORECASTING DEMAND IN THE LOGISTICS MARKET: A CASE STUDY OF LOGISTICS CENTER VRŠAC

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Abstract: *This paper proposes a new methodological approach for estimation of demands and flows in the logistics market. Proposed approach is developed in a comprehensive way to better understand and evaluate perspective trends of logistics flows and demands for logistics services in conditions of great uncertainty, variability and unpredictability of geopolitical, economic, commercial, transport and traffic factors and opportunities in the logistics market. The procedure is applied in the concrete example for the forecasting of demands for logistics services and subsystems of future logistics center Vršac. In the case when there is a large variability in demand and when there are no obvious trends that can be applied in the future, the authors have decided to carry out the prediction of three possible scenarios for economic and social development. The goal was to develop approach that will use the larger field of possible future events on the logistics market.*

Keywords*: logistics market, logistics flows, demands, forecasting, logistics center*

1. INTRODUCTION

The logistics market is defined as the place where flows of material and service products are created, realized and finished. The subjects of trade in these markets are material goods and logistics services related to the efficient flow of goods. The elements of commodity and transport flows are: generators of commodity flows - users (industry, trade, catering and craft enterprises, residents, economic and non-economic institutions and organizations, etc.); demand and market requirements for a particular structure and volume of material and service products (raw materials, intermediate goods, consumer goods, finished products, transport and logistics services, etc.); offer of the certain structure and volume of material goods, transport and logistics services for product delivery to the final consumers; carriers of the transport and logistics services, which are able to offer and provide specific services in the realization of cargo flows (transport companies, freight terminals and freight villages, shipping companies, logistics operators, service providers and others); places in which they carry out commodity flows and provide transport and logistics services (area, location, relations); time of the occurrence and realization of commodity flows, transportation and logistics demands associated with the flow and delivery of goods. (Kilibarda, 2011).

Logistics flows and requirements are extremely variable categories and sizes in terms of all parameters that characterize them. Markets, customers, place of origin and the end of the logistics flow are variable. Structure, volume and appearance of logistics demands are also

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variable, as well as technology and carriers of logistics providers. Variability and instability of commodity flows is the result of a number of factors that directly affect the appearance and the flow dynamics and intensity. In situation of variability and unpredictability of geopolitical, economic, commercial, transport and traffic factors and opportunities in the logistics market it is very difficult to give a reliable assessment of the perspective trends of the logistics flows.

In contrast to all of these difficulties the successful development of logistics systems and the companies is not possible without forecasting and thinking about what will happen in the future (Leeuw et al. 1998). Logistics systems must analyze the future demands for services in more detail, and predict the relevant market, economic and logistics trends. However, because of the extreme specificity and complexity of relationships in the market, in the logistics literature and practice, there are no universal forecasting models and methods (Mcgivern, 2003; Mcneil, 2005). Also, standard methods and techniques often can not be directly applied. It is necessary to develop specific research and forecasting methodologies of logistics flows and demand which will include all relevant factors and possible scenarios of the development in accordance with the characteristics of specific markets and logistics systems. In this paper mentioned methodology is proposed, which was developed in order to assess the perspective trend of the logistics flows and demands for services and subsystems of logistics center.

2. METHODOLOGICAL APPROACH FOR LOGISTICS DEMAND FORECASTING

Bearing in mind all the problems, limitations, aggravating factors, as well as the importance of this problem, the authors have decided to develop and implement a complex methodological approach for forecasting. The process involves a series of interrelated and coordinated steps (figure 1): commodity flows market definition, the analysis of commodity flows characteristics, definition of development scenarios and factors, estimation of commodity flow perspective trend, commodity flow redistribution, logistics center and intermodal terminal Vršac demands determination.

In the catchment area of logistics center and intermodal terminal in Vršac, it is possible to extract the four typical types of markets: M1 - Vršac market which includes users of logistics services and commodity flow generators which are located in the municipality of Vršac. Economic entities are primarily located in the technology park and in the industrial zone, but also in the wide area of Vršac; M2 – Narrow catchment area include users who are spatially distributed in the South Banat and middle Banat District, and gravitate towards the logistics center and intermodal terminal Vršac; M3 – Wider catchment area includes all users of logistics services in the area of Vojvodina, Belgrade and Serbia, for which it is reasonably expected to be realized through the border crossing Vatin, and municipality of Vršac. Mainly it is import and export flows between certain areas of Serbia, on the one side, and Romania, Russia and eastern markets, on the other side; M4 – International market, which refers to customers who are on the territory of Romania and neighboring countries, with flows can reasonably be expected to serve logistics center and intermodal terminal Vršac subsystems. For defined markets economic and market potentials are perceived, characteristics of commodity flows, particularly in terms of realization over the logistics center. A detailed analysis of strategies and potential of economic development was made. Plans and business trends of economic development in are discussed. Relation between the development potential on the perspective trend of trade flows for different development scenarios are investigated.

For the described market, a detailed identification and quantification of import, export and transit commodity and transport flows is done. Trade flows were investigated and analyzed according to all relevant properties, such as: structure and intensity of flow, type and quantity of goods, direction and relations, etc. Commodity flows are investigated and analyzed for the period of 2005 - 2012. Commodity flows, current trends and future development plans, as well as the available logistical resources of the relevant business subjects in the catchment area are

identified and quantified through the survey and interviews. Specific requirements of the companies for logistics centre subsystems are determined.

Several factors which reflect market, business, economic, logistic and transport environment have strong influence on the appearance and realization of commodity flows in the region (Mentzer and Schroeter, 1997). In volatile and uncertain conditions that a longer period is characterized by commercial, economic, geopolitical and social trends in the region, it is difficult to reliably predict the effect of certain factors on the commodity flow trend. Due to the global economic crisis, the restructuring process, it is not possible identify clear trends that could be continued in the future. For these reasons, the research team decided to estimate certain trends in relation to the various scenarios of possible social and economic development.

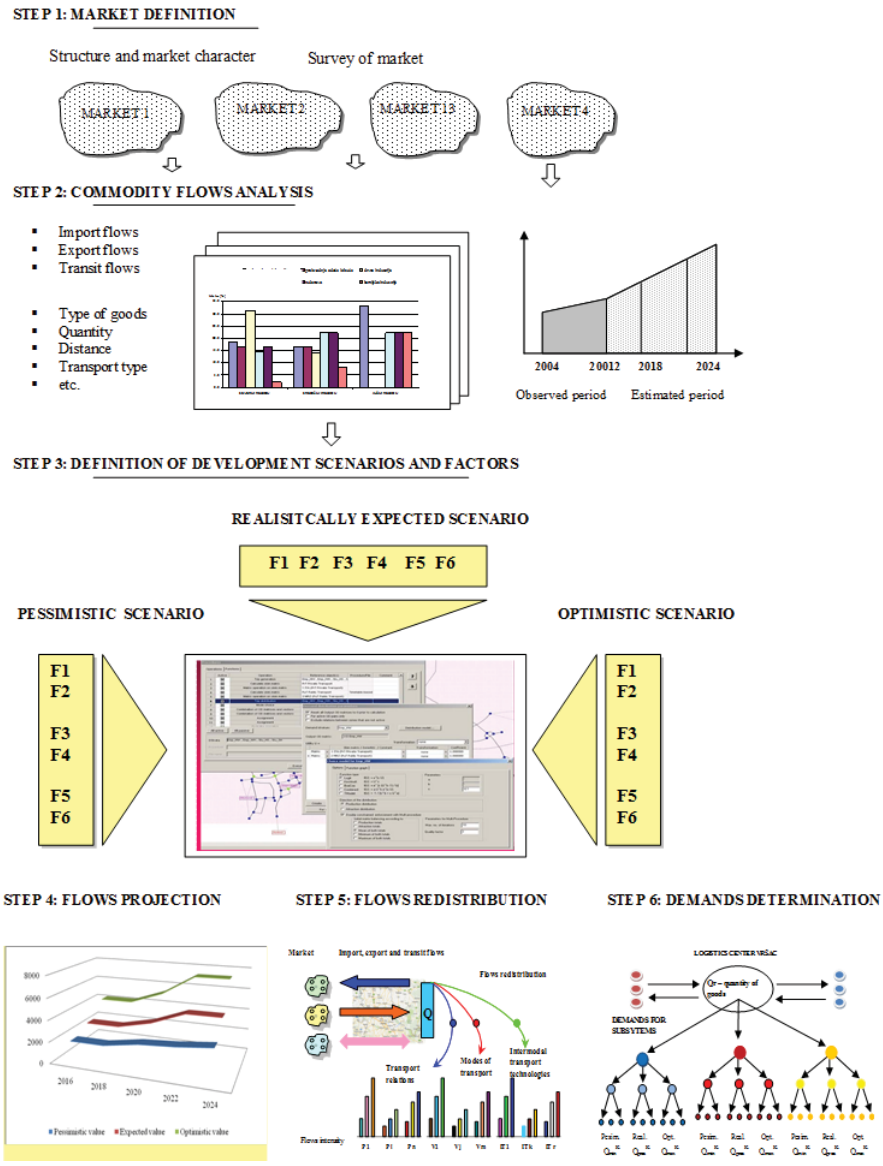


Figure 1. Procedure of estimation commodity and transport flow perspective trends

In order to cover as much of the possible future events, the three development scenarios are defined: basic (realistically expected), pessimistic and optimistic scenario. Five groups of factors are identified: F1 - structure and character of the market (from limited to expansive growth market), F2 – corporate and economic development (from slow to intense), F3 - political, market and economic integration (lack of market linkages to accelerated European integration), F4 - development of transport infrastructure (from underdeveloped and unrelated to the fully developed and associated transport and logistics network) and F5 - development of a logistics center with intermodal terminal (from slow to rapid construction and development). These factors have direct impact on the certain scenarios (table 1).

Table 1. Scenario and economic factor development

FACTORS	DEVELOPMENT SCENARIOS		
	Pessimistic	Basic (Real)	Optimistic
F1- structure and character of the market	Limited market	Medium expansion of the market	Expansive market growth
F2 – Economic development	Slow economic development	Rapid economic development	Intensive economic development
F3 – Market integration	Lack of market and economic integration	Regional market integration and connection with countries in region	Accelerated European integration
F4 – Transport infrastructure development	Low level of development of road transport infrastructure	Revitalization of road and rail infrastructure	Rapid construction and connection with European and Pan European transport network
F5 – Development of logistics center and intermodal terminal	Slow construction of logistics center and intermodal terminal and weakly attracting of commodity flows	Moderate development of the logistics center and intermodal terminal Vršac	Fast construction and development of the logistics center and intermodal terminal and strong attraction of commodity flows

Estimation of commodity flow perspective trend is realized in accordance with different flows categories, types of goods and different markets. In the logistics centre and intermodal terminal Vršac catchment area there are two types of commodity flows: flows with stable characteristics, which in the long run continuously appear with greater or smaller oscillations and flows with extremely variable characteristics, which in one period of time appear in a significant shape and intensity while in the next period almost did not appear.

In accordance with the above, expert estimations of commodity flow for period of next ten years are determined. Each estimation has a confidence interval in which can be found total commodity flow. For each assessment number of different options and corresponding probability of possible states are defined. The final assessment of the size of transport Q is a random variable, and it is defined for three defined scenarios. In this way, for commodity flow is obtained pessimistic, realistic and optimistic expected value. Perspective trends are estimated for all goods categories and all regions. Forecasted values for chemical products are shown in Figure 2, while forecasting values for South Banat region are presented in Figure 3.

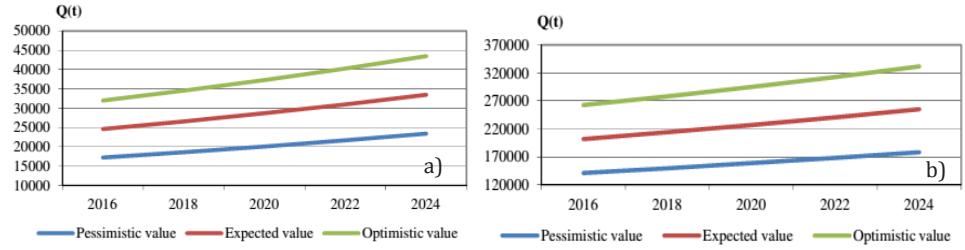


Figure 2. Perspective trends of commodity flows in narrow catchment area (a-import; b-export) – example of chemical products

It is realistic to expect that import flows of chemical products in narrow catchment in the beginning of the time horizon Serbia import 25000 t, while at the end of time horizon Serbia import 35000 t through narrow catchment area. In observed time horizon export flows will from 15000 t to 20000 t. Optimistic perspective trends for import and export flows in wider catchment area are 50000 t to 65000t for import and from 20000 t to 27000 t for export flows. Mention flows are very important for logistics center terminal operating.

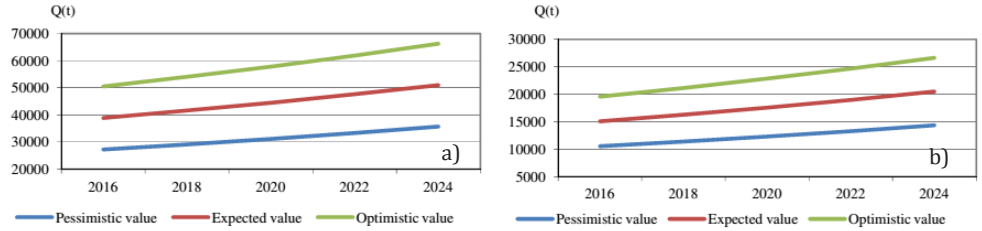


Figure 3. Perspective trends of commodity flows in wider catchment area (a-import; b-export) – example of South Banat region

After estimation commodity flow prospective trend redistribution of commodity flows on transport routes, modes of transport and intermodal transport technologies is done (figure 4). Redistribution is based on next factors: type and quantity of goods, transport distance, the advantages and shortcomings of certain types of transport, transportation resources and facilities, development of transport infrastructure, etc. Several criteria like transport time, transport costs, resources utilization, service quality and environmental criteria are used. In this paper two main redistribution categories are presented: according transport distances and according markets.

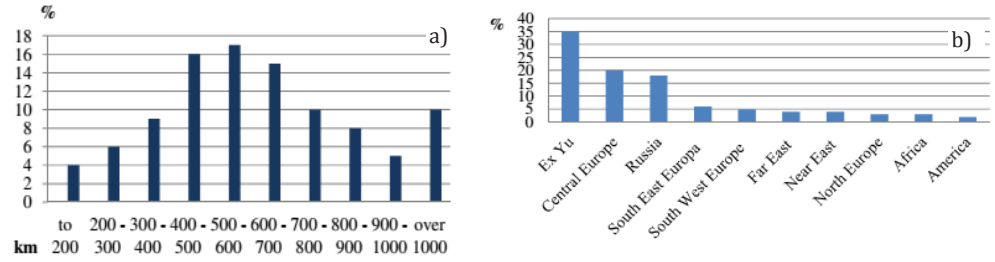


Figure 4: Commodity flow redistribution (a- according different transport distances; b-according markets)

For each flow from the previous step assessment of possible affiliation to logistics center is done. Affiliation was made on the basis of: categories and volume of commodity flow, goods types, the origin and the end of commodity flow, direction and distance, the location of the generator and connections of transport infrastructure with logistics center and intermodal terminal. As shown in table 2 four markets with different zones are analyzed: a zone of very high affiliation (the market of municipality of Vršac), zone of high affiliation (narrow catchment area), zone of medium affiliation (wider catchment area) and the zone of lower affiliation (international market).

The estimation took into account the position of the logistics center and intermodal terminal Vršac to competing centers and terminals in catchment area, such as Pančevo and Timisoara. For basic subsystems logistics center of Vršac estimation of demands volume with different probabilities that can be expected from the four types of market. The assessment was performed according to the possible development scenarios (pessimistic, expected, and optimistic). In this

paper warehouse and customs terminal are analyzed in more details. According table 2 it is easy to see that the most of the demands for customs and warehouse terminal are coming from Vršac market (M1) and narrow gravity area (M2).

Table 2. Estimation of demands for subsystems of logistics center (example of customs and warehouse terminal)

Markets (Pallets/year)	**Customs terminal**			**Warehouse terminal**		
	Pessimistic scenario	*Basic scenario*	*Optimistic scenario*	*Pessimistic scenario*	*Basic scenario*	*Optimistic scenario*
M1 - Vršac market	11960-17680	14040-9760	20800-26400	11900-15500	15300-18600	19100-23300
M2 - Narrow catchment area	11960-15600	14040-9760	16700-23200	12400-15500	13500-16700	15000-18100
M3 - Wider catchment area	6240-8320	10400-4040	12200-16500	3800-5600	5700-9200	14300-18000
M4 - International market	2600-3640	3640-4680	4300-5500	2500-4600	4100-6400	9200-11900
TOTAL	32760-45240	42120-8240	54000-71600	30600-41200	38600-50900	57600-71300

3. CONCLUSION

A new methodological approach for forecasting of demands and flows on the transport market is proposed in this paper. The main advantage of the proposed approach lies in the fact that approach includes all relevant factors of the marketing environment for the logistics market. Obtained results show great practical applicability of the model. Results also show that model has universal applicability for forecasting demands for services and subsystems of planned and projected logistics centers. The above-mentioned results represent a basis for further research towards the identification and quantification of requirements for the subsystems and structural elements of the logistics center, the determination of the corresponding values for dimensioning subsystem and determining expected revenues and evaluation of financial and economic feasibility of the project.

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LOGISTICS FAILURES IN DISTRIBUTION PROCESS

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Abstract: *The importance of failures identification, monitoring and elimination in logistics is recognized in literature and practice. Failures elimination directly affects the increase of logistics services quality. This further has impact on costs reduction, increasing customer satisfaction, loyalty and finally revenue increasing. In this paper logistics failures in product distribution are identified. Methodological approach for identification and correction of failures in distribution process is proposed in this paper. Failures in warehouse, transport, inventory and other processes are described in more details. Also the main causes are identified. In this paper the failures are analyzed in 13 distribution centers of one trading company that operates in Serbia. The model for distribution centers ranking based on Principal Component Analysis (PCA) is tested. The results show great applicability of the proposed approach.*

Keywords*: failures, distribution, logistics, Principal Component Analysis*

1. INTRODUCTION

In order to survive on the market and achieve profitability, the companies need to meet customer requirements and perform their activities in an efficient way. Quality and efficiency indicators are very important for companies' operations analysis. According Christopher (2002) logistics process becomes more and more complex and with much higher levels of demands, especially when related to achieving a competitive advantage. In that manner, companies need to follow up on services offered to customers. Very important aspect is failure management. The failures are present in each system. Even more the most efficient distribution systems have failures. These failures directly affect complaints. Service recovery may be understood as a set of activities that a company performs to resolve complaints and to change the attitude of unsatisfied customers trying to keep them as loyal customers. Fleury et al. (2000), studying wholesale suppliers and retailers in the Brazilian Industry, found that failure recovery is considered by customers, the fifth most important customer service feature. Thus, it is very important to plan, follow up and evaluate the failure recovery process (key customer services attribute) throughout the supply chain and not only in the final chain stage when there is a contact with the end consumer (Flores and Primo, 2008). Only if systematic effort is made to monitor, mitigate and eliminate failures that effect complaints in distribution process companies can keep customers. There are numerous quality and efficiency indicators in logistics. The ultimate goal of each company is customer satisfaction. Satisfied and loyal customers mean a secure income for the company. On the other side unsatisfied customers and customer's complaints create additional costs. Quality indicators are rarely used for ranking distribution systems (Andrejić et al. 2013). In this paper, more attention is paid on logistics failures in

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distribution process. The next section describes the methodological approach for failures identification and correction. The third section is devoted to the failure analysis of distribution centers of trading company. In the same section model for ranking distribution centers is proposed. Concluding remarks and future directions are described in the last section.

2. METHODOLOGICAL APPROACH FOR FAILURES IDENTIFICATION AND CORRECTION

Failures in the transport, warehouse and other subsystems represent quality indicators which may be the cause of dissatisfaction and complaints of the customer. In distribution processes and logistics in general there are different types of failures. They are characterized by different parameters: time and place of origin, caused consequences, size, etc. It is very important to identify failures as soon as possible, before they pass on and increase the consequences. It is necessary to correct observed error in the shortest period. This paper proposes new methodological approach for failures identification and correction. The basic steps are:

- **Step 1:** Distribution process decomposition
- **Step 2:** Identification of potential places (systems) of failures appearances
- **Step 3:** Failures identification (according defined systems)
- **Step 4:** Identification of responsibility
- **Step 5:** Failures causes detection
- **Step 6:** Assessment of the consequences
- **Step 7:** Definition of preventive and corrective measures

Distribution process decomposition is shown on figure 1. The first process is product ordering with two basic aspects. The first aspect of product ordering is ordering from suppliers, while the second is customer ordering. All activities in this process relate to information flow. The next process is warehousing. Activities in this process may be divided in two segments. In the first segment are activities of goods receiving, putting away and storage while in the second are activities of order processing and preparing for delivery. Warehousing largely depends on speed of information exchange. Order picking process is the crucial process in warehouses. The following is the process of packaging. This process is realized through merging goods from different segments, forming transport units, goods inspection, as well as the loading goods in vehicles. Packaging is in direct relation with the order processing and distribution (transport). The transport is key processes in the product distribution. This process largely affects customer satisfaction. The process that is related to all mentioned processes is inventory management. The last process is unloading goods in the retail stores. According to the point of origin failures ***potential places of failures appearance*** can be divided into: failures in logistics systems (failures in DC, factory failure, supplier failure, etc.); failures in logistics subsystems (failures in warehouse, failure in transport, failure in inventories, freight forwarding, reverse logistics, IT, etc); failures in logistics process (order processing failure, order picking failure, shipping failure, etc.); failures in logistics activity (labeling mistake, picking failure, transport failure, forklift driver failure, truck driver failure, etc). The next step is ***failures identification***. Warehouses and distribution centers are integral components of supply chains. Processes in warehouses are very labor and cost intensive. In that manner there are different and numerous failures in warehouses. Wang (2002) found five causes of complaints in warehouse: wrong label (18%), later or wrong delivery (45%), damaged cargo (18%), input error (12%) and system error respectively (7%). Transport failures greatly affect delivery process and customer complaints. There are different aspects of transport failures in literature. According Wang (2002) there are five main transport failures. Research shows that wrong calculation (10%), wrong or missed process (7%), input error (7%), delayed shipping (20%) and document error (56%) are responsible for the complaints in freight transport sector. Inventory management has a strong influence on the failures in warehouses and distribution in general.

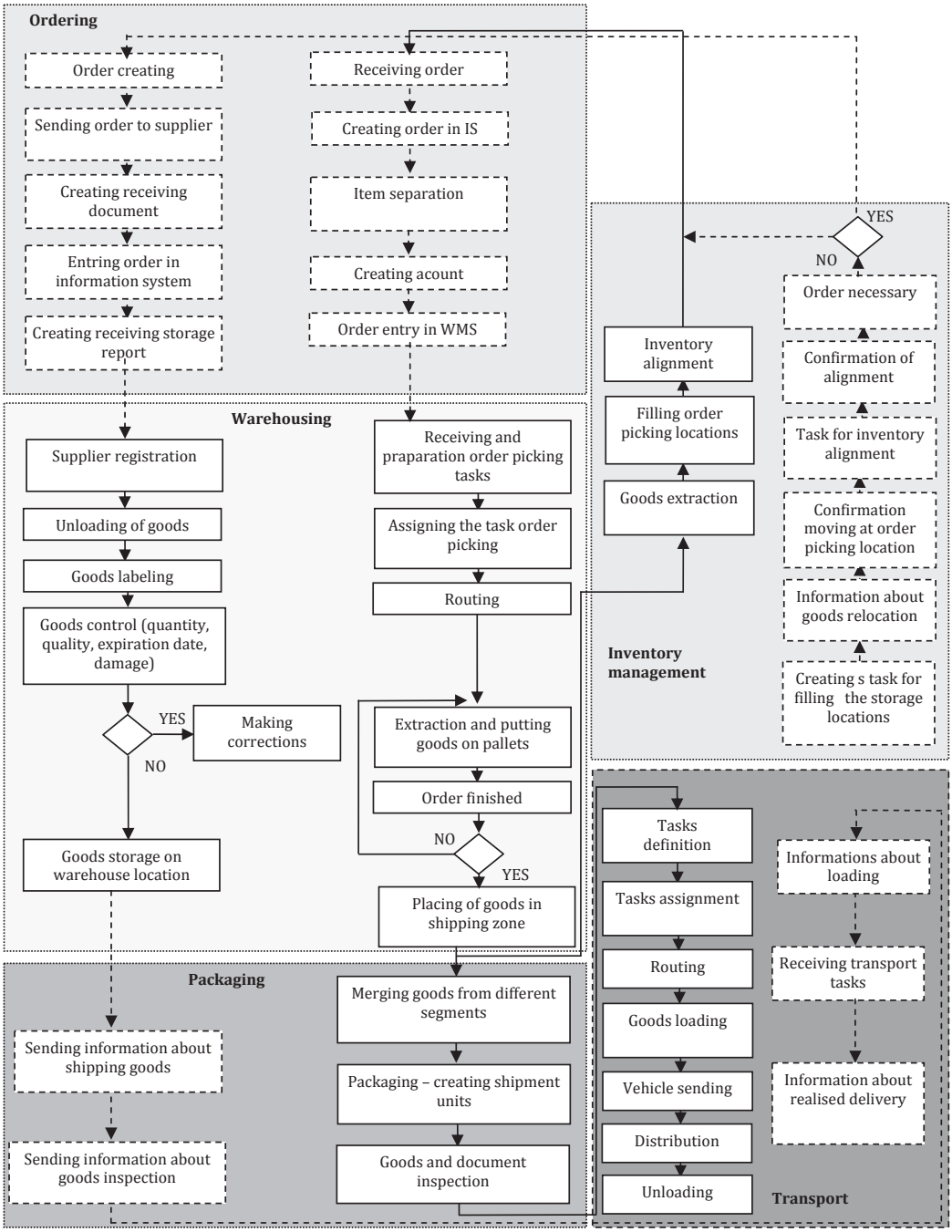


Figure 1. Distribution process decomposition

In that sense there are different causes of complaints in warehouses that relate to inventory maintenance and control: product identification, stock-outs, contaminated products, obsolete merchandise, wrong customer's goods, back orders, percent of demand filled, omission rate, number of incomplete orders, minimum order size, minimum frequency allowed, inventory

backup during promotions, new product, introductions and competitive tests. There are different criteria for identification of failures in order – picking process. According place of identification there are internal (in house) and external (outside) failures. External failures in the most cases cause customer complaints. In the literature there are four basic categories of failures: typing failures (addition, confusion, etc.), failures in amount (shortage, excess, etc.), omission failures and condition failures (damage, lack of packaging, labeling). The failure rate depends of type of order picking system: pick-by-voice (0.08%), voucher (0.35%), labels (0.37%), pick-by-light (0.40%), mobile terminals (0.46%), mob. terminals + labels (0.94%) (Lolling 2002). ***Identification of responsibility and cause*** is the next step in the proposed methodology. Warehouses are responsible for 55% of the total failures in distribution process, while 35% of the failures relates to transport. Together they stand for around 90% of the total failures in distribution logistics. According causes there are four main distribution failures: method caused failures, management caused failures, process caused failures and man caused failures. It is very important to identify the responsibilities of employees for each failure. ***Assessment of the consequences*** is very important step**.** The major causes of customer complaints are failures in logistics subsystems and processes. If failures are detected on time, they will not cause customer complaints. Each failure makes its costs but the failures that cause complaints are more expensive. In the distribution process, not all failures have equal importance. For example, the most damages in warehouse cannot cause customer complaints, because they are detected before delivery. On the other side bad inventory management can cause short expiration date which may results in customer complaints. There are also failures in order picking process like shortage/excess or articles mix-up that cannot be detected in warehouse. They can cause customer complaints. Definition of ***preventive and corrective actions*** is the last step in the proposed methodology. There are problems in the warehousing process when supplier supplies the goods of low quality and short expiration date. One of the basic steps is to define the level of quality and dimensions (specific check lists) of each unit of goods for each supplier. A relative small number of employers in this process limit the level of control. Putting away is very important activity in warehouse. A large number of mistakes are generated in this process. In real systems, order pickers realized this activity. Frequently relocation of order pickers from picking to putting away process greatly affects the occurrence of failures and reducing the level of customer service. They realize this process with insufficient attention. Assignment of smaller number of workers that will realize only putting away process should reduce failures to minimum. Inappropriate organization of space may affects failures. Managers in warehouse often have the goal of minimizing the space for order picking. One of the main aim is to reduce the effort in the order picking process. However, a large number of similar items at very short distances can cause failures. Order picking process is work and labor intensive process. Failures may be reduced if the order pickers strictly follow information system, and do not make decisions alone. Like in the process of order picking process the same situation is in the order processing, packaging and loading. It is very important to assign workers for particular processes. Reducing failures in transport refers to the reduction of losses in money, time, and users that are caused by theft, damage to goods, delays in delivery. Warehouse failures often are transferred in transport process. Failures in transport can be decreased with good organization and process planning. Delivery delays can be overcome by better motivation of drivers and control of the movement of vehicles, as well as good planning routes and predictions of traffic congestion. Theft can be prevented with modern systems for protection of the cargo space. Systems of driver reward and punishment can additionally reduce the number of failures. Failures in inventory management directly affect the write-off of expired goods, which creates significant losses in the observed companies. A failure in the inventory is also the lack of goods required by the user. Failures can be overcome on different ways: inventory monitoring with advances information systems, definition of delivery priority according expiration date, more precise estimation of the expected deliveries of suppliers and expected demands of customers. Video monitoring is one of the basic systems of protection against theft, etc.

3. BENCHMARKING LOGISTICS FAILURES IN DISTRIBUTION PROCESS OF TRADING COMPANY

As mentioned before in this part o f the paper failures in 13 distribution centers (DCs) of the one trading company are analyzed. As shown in Table 1 observed company monitors nine indicators that relate to quality: total losses, failures in warehouse, failures in transport, write off expired goods, total value of complaints, number of complaints, complaint articles, approved complaints and not approved complaints. Managers also monitor other indicators like number of employees, number of vehicles, pallet places, demands and turnover. Complaints caused by logistics failures represent multiple losses logistics services providers. The first are costs of failure correction. After that are time losses, and sometimes the material losses if the goods are permanently damaged or lost. Additionally, losses caused by customer's dissatisfaction can appear. The value of complaints in total turnover in average counts about 0.2%, which at first glance does not represent a significant percentage. However, complaints are significant losses for companies. Received complaints are analyzed, checked the causes, time of occurrence, executors, value, etc. Based on all this, a decision on whether the complaint will be approved or not. According values in Table 1 in analyzed distribution centers 60% of complaints are approved. The analysis of the observed sample shows that the number of complaints depends on the type of customers. The distribution centers that supply external customers approved about 77% of total complaints. On the other hand, the distribution centers that supply retail outlets that are owned by the same retail chain only 42% of complaints are approved. This can be explained by the fact that the company focus is on the external clients (easier approve complaints), but also the fact that retailers, as well as members of the same retail chain, frequently (easier) complain. As can be seen monitored DCs have different combinations of input and output variables. The aim of this paper is the ranking of DCs according fourteen variables with special emphasis on failures. There are different approaches for ranking decision making units in the literature. Considering relatively large number of indicators and the relatively small number of decision units in this paper PCA approach for ranking DCs is proposed. PCA approach for ranking DCs has several steps (Petron and Barglia, 2000): *Step 1*: Data normalization and reorientation (failures - negative outputs); *Step 2*: Definition of independent output/input ratio (d_i); *Step 3*: Extracting Principal Components (PCs) for all d_i ; *Step 4*: For each d_i determination of corresponding weight coefficient $w_{i,}$;*Step 5*: Multiplying each coefficient by the value of the corresponding variable d_i for each DC to get the final score; *Step 6*: Final ranking based on the obtained scores. Ranking results of observed set of DCs are shown in Table 2.

Table 1. Descriptive statistics of 13 DCs

Indicator	***Average***	***St. Dev.***
Inputs		
Employees (number)	53,54	31,04
Number of vehicles (number)	8,77	7,06
Pallet places (number)	2974,49	1552,43
Demands (number)	3486,46	2142,25
Outputs		
Turnover (10^6 m.u.)	182,78	107,49
Total losses (10^3 m.u.)	589,63	436,92
Failures in warehouse (10^3 m.u.)	129,16	107,06
Failures in transport (10^3 m.u.)	222,97	197,63
Write off expired goods (10^3 m.u.)	169,57	142,55
Total value of complaints (10^3 m.u.)	360,21	343,04
Number of complaints (number)	169,00	137,30
Comlaint articles (number)	350,38	441,70
Approved complaints (10^3 m.u.)	214,97	205,28
Not approved complaints (10^3 m.u.)	145,26	258,97

Table 2. Ranking scores of 13 DCs

DC	***PCA SCORE***	***Rank***
DC 11	302,01	1
DC 10	180,80	2
DC 5	114,09	3
DC 12	83,31	4
DC 1	16,56	5
DC 3	15,63	6
DC 9	11,51	7
DC 13	10,47	8
DC 6	8,77	9
DC 4	7,04	10
DC 8	4,91	11
DC 2	2,88	12
DC 7	0,95	13

Based on the results it can be concluded that the DC 11 has the best combination of input and output variables. This means that this center with a relatively small number of resources implemented relatively large turnover with a minimum level of failures. In contrast to DC 11, DC 7 has the smallest ranking score, which can be explain with relatively small turnover and large level of failures.

4. CONCLUSION

This paper identified the basic steps for identification and correction of failures in the distribution process. The importance of failure elimination and increasing logistics service quality is equally important for customers and providers. PCA approach for DCs ranking is used in this paper. The analysis of the results confirmed the convenience of its application. There are papers in literature that deals with efficiency in logistics. On the other side, there are also approaches that investigate failures in logistics and supply chains. However, to the best of author knowledge, there is a lack of papers in literature that investigate relationship between efficiency and failures in logistics. In the future research it is necessary to develop new models for measuring and improving quality efficiency. The future models must include new quality indicators, with the special emphasize of failures.

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PERFORMANCE INDICATORS FOR PROFESSIONAL DRIVERS' EVALUATION IN SUPPLY CHAIN

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Abstract: *Contemporary road vehicles are equipped with state-of-the-art devices and on-board computers that record parameters mainly from vehicle condition diagnostics and their operation. Along with the growing use of business information systems and with the implementation of telematics systems on vehicles, large amount of driver activity data becomes available to the fleet and transport manager, which enables and even facilitates the insight into drivers' activities and their evaluation. Naturally, besides the above mentioned electronic data, the company still maintains some paper- or computer-based registers and documents allowing further insight into driver behaviour. Such complete overview of driver activity from the aspect of driving behaviour, vehicle treatment and other business and transport related performances, as well as the possibility of these parameters' evaluation, ultimately leads to a better human resource management, lowering transport activity and vehicle maintenance costs, increasing traffic safety and lowering vehicle and driver negative environmental impact.*

Keywords*: drivers' performance, on-board devices, driving skills*

1. INTRODUCTION

Professional drivers of road motor vehicles represent one of the most important factors regarding vehicle operation costs, transportation and delivery service quality and in the long run the company image.

Automotive industry is involved in increasing vehicle fuel economy by introducing modern technology to lower harmful gas emissions and decrease fuel costs, as well as on-board devices allowing vehicle and driver operations monitoring and analysis. In general, the latest implemented technology in vehicles is not supported by adequate drivers training, on the one hand compulsory driving licensing and on the other continuous and periodic knowledge upgrade. This is especially true for commercial vehicles involved in the supply chain, where the related driver influence is more important having in mind their higher vehicle value, annual mileage and fuel consumption.

The objective of this paper is to present differences between professional drivers through an overview and systematization of overall driver performance indicators (PIs), based on literature, today's practices and specify those indicators that could be identified and measured by using modern vehicle and telematics technologies applied in the supply chain. This certainly represents the first and the most important step in models' building which would be later used

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for driver selection while employing, their ranking concerning rewarding / penalizing or even noticing individual weaknesses that could be corrected by a custom-made personalized training program.

The rest of the paper begins with a review of driver performances recognised as relevant in literature, as well as their measurement options, potential effects and limitations. Next section deals with PIs obtained from dataset collected as a result of drivers monitoring over certain period in Serbian logistics company using an on-board device. Finally concluding remarks are presented along with directions for future research.

2. LITERATURE REVIEW ON PROFESSIONAL DRIVERS PERFORMANCES EVALUATION

Supply chain are complex systems where drivers are required to possess different knowledge and skills except from driving. Those requirements depend on their interaction with other supply chain actors. Thereof originates the fact that driver's performance used to measure the quality of work is by nature multidisciplinary and roughly could be divided into technical (driving skills and other professional service skills) and nontechnical (social and other soft skills).

Technical driver performance, which will be considered in this paper, regarding:

- Driving skills, involve relations between: Driver and vehicle (vehicle technology comprehension, vehicle care and maintenance, ability to solve some unexpected problems, etc.), and Driver and vehicle in traffic (driving style, knowledge of traffic regulations, avoiding incidents and critical situations, etc.);
- Other professional service skills, involve interactions between: Driver and client (client request resolution, timely appearance, client feedback, etc.), Driver and vehicle on terminal / in warehouse (loading, unloading, goods handover, paperwork, administration, etc.), and Driver and company (task realization, obeying procedures, etc.).

Many papers are dedicated to other drivers' professional service skills, whose evaluation is mostly based on individual perception of their quality and importance. Meanwhile, this paper focuses on driving skills based purely on measured data with an attempt to obtain as exact and objective performances as possible.

Certain authors in their papers and studies highlight the importance of driving performance, presenting its measuring methodology and/or determine the acceptance thresholds, which could be as well perceived as drivers' PIs. Those indicators are mostly focused on quantifying road safety and fuel consumption and/or harmful or greenhouse gas emissions.

Kim and Choi (2013) stated the fact that the speed is a main factor to estimate macro amount of fuel consumption and emission of vehicles. However they have focused on acceleration and determination of critical values of aggressive acceleration influencing fuel consumption and emission significantly by testing vehicle speeds range from 10 km/h to 80 km/h considering different driving patterns in urban areas. Hari et al. (2012) developed and tested retro-fittable driver behaviour improvement device in real world conditions (15 vans on over 39,000 km). That device provided real-time audio and visual feedback to the drivers to improve their driving style. Analysis showed that fuel savings of an average 7.6% were obtained as a result of reduction in harsh accelerations and early gear shifting into higher gears. El-Shawarby et al. (2005) evaluated the impact of vehicle cruise speed and acceleration levels on vehicle fuel consumption and emission rates using field data gathered under real-world driving conditions. An on-board emission-measurement device was used to collect emissions of nitrogen oxides, hydrocarbons, carbon monoxide, and carbon dioxide using a light-duty test vehicle. The analysis demonstrated that fuel consumption and emission rates per-unit distance are optimum in the

range of 60–90 km/h, with considerable increase outside this optimum range. The study demonstrated that over a sufficiently long fixed distance, fuel consumption and mobile-source emission rates per-unit distance increase as the level of acceleration increases. Rolim et al. (2014) assessed the impacts of eco driving training and on-board devices that provide real-time feedback on 600 bus drivers' behaviour regarding hard stops and starts, extreme accelerations and brakes, time spent idling and speeding. This analysis considered drivers characteristics (age and time working at company) and vehicle characteristics (bus age and type). Zarkadoula et al. (2007) showed the effects of eco-driving training for three drivers leading to a decrease of fuel consumption by up to 17.8% while the average decrease in fuel consumption for all bus drivers was 10.2%.

Barr et al. (2011) in their study assessed the impact of driver fatigue on driving performance using the naturalistic data of 42 local/short-haul truck drivers from two companies that participated in the field study that lasted for approximately two weeks per driver. The trucks were instrumented with cameras and data collection equipment consisting of sensors to monitor vehicle parameters: speed, lateral and longitudinal acceleration, steering position, and brake pedal activation. Predictive models were developed to determine the driver characteristics (e.g. age, years of commercial driving experience, sleep quality/quantity) and external or environmental factors (e.g. time of day, weather, traffic) that influence the likelihood of driver fatigue occurring on the job. Two measures of driver performance - lane-keeping and speed management - were evaluated in an effort to correlate driver fatigue and performance.

However, in tasks performed by drivers within supply chain, the sole fuel consumption indicator, that is often recurred to by fleet managers, is not sufficiently good indicator since it is influenced by other factors that could not be easily determined (such as landscape, traffic congestion, idling) and could even lead to inaccurate perception of different driver quality, even in similar activities and environments (since not all parameters match). Often the driver's impact on vehicle maintenance costs and lowering vehicle and its components lifecycle period and costs is disregarded or neglected. In (TIAX, LLC, 2009) are set fundamental driving segments that U.S. medium- and heavy-duty vehicle drivers should pay attention to, in order to lower fuel consumption: speed fluctuation, engine braking, shift optimization and gear selection, idling, tire condition and inflation, speed, cruise control, clutch control, trip planning, block shifting/skipping gears, aerodynamics, overfilling the fuel tank, and maintenance.

Morte et al. (2013) deals with multi-criteria ranking of drivers based on two quantitative and nine qualitative criteria obtained as decision-makers' impressions on the quality of each driver (out of the total of 31 drivers) using narrow or wide scales. They selected the following set of criteria: technical knowledge, labour legislation knowledge, accidents, fuel consumption, ability to solve unexpected problems, timely delivery, internal rules compliance, customer's standards compliance, information, conflict resolution, expectation fit, responsibility, and availability. This paper's main shortcoming is a great number of expert-based qualitative criteria values, without a clear determination approach, leading to subjectivity in driver evaluation and final ranking.

From the presented review it is obvious that there is a gap of a comprehensive model for driver performance evaluation and ranking. Since in previous evaluation models there is an issue of indicators' determination objectivity, the authors opted for data collected directly from vehicle sensors and processed in order to determine and evaluate driver PIs, which is significantly facilitated by todays' vehicles in conjunction with state-of-the-art on-board devices and telematics systems.

3. ON-BOARD DEVICES IN EVALUATING DRIVER PERFORMANCES

In order to use vehicle data for driver performance evaluation, authors have chosen a fleet of diesel-powered vans of one express courier delivery company from Serbia. Three identical vans (by make, model, and age) were equipped with an on-board diagnostic device, OBD MATRIX

(TEXA), which in this setting (compression-ignition engine) was limited to the following set of data: engine speed, vehicle speed, engine load and engine temperature. Data were recorded for a period of 5 days at every quarter of a second (at the largest possible frequency of 4Hz) while vehicle ignition was on, which resulted in large amount of data to be processed.

From measured data the authors have tried to determine a set of relevant and impartial PIs to evaluate drivers in view of basic fleet managers' objectives: fuel consumption, road safety and vehicle maintenance. For that purpose engine speed and vehicle speed, relevant by themselves, were used as raw data. Acceleration and deceleration were derived from instantaneous vehicle speed. Each of these values are rated based on a developed scale, shown in Table 1. For each PI, driver quality decreases with rating increase. Rating scales for acceleration and deceleration were set according to Beusen et al. (2009) and Kim and Choi (2013) researches, along with recommendations of fleet managers from the considered company and field experts. Engine speed range for the rating scale was set consistent with van manufacturer's specifications regarding maximum power and torque to engine speed diagram. The vehicle speed limit values are set in accordance with traffic speed limits in vehicle operating area. As considered company vans operate outside motorways, the authors have set the initial speed limit at 80 km/h (with 10 km/h increment).

Table 1 – Driver rating scale for different parameter values

Acceleration (a)		Deceleration (b)		Engine speed (n)		Vehicle speed (v)	
Range (m/s^2)	Rating	Range (m/s^2)	Rating	Range (rpm)	Rating	Range (km/h)	Rating
$0 < a \leq 1.7$	0	$-2.3 \leq b < 0$	0	$0 \leq n \leq 2600$	0	$0 \leq v \leq 80$	0
$1.7 < a \leq 2.3$	0.2	$-3.4 \leq b < -2.3$	0.5	$2600 < n \leq 2800$	0.2	$80 < v \leq 90$	0.2
$2.3 < a \leq 3.4$	0.5	$-4.5 \leq b < -3.4$	2	$2800 < n \leq 2850$	0.4	$90 < v \leq 100$	0.5
$3.4 < a \leq 4.5$	2	$-5.6 \leq b < -4.5$	4	$2850 < n \leq 3100$	0.6	$100 < v \leq 110$	2
$4.5 < a \leq 5.6$	4	$-6.7 \leq b < -5.6$	10	$3100 < n \leq 3350$	0.8	$110 < v \leq 120$	4
$a > 5.6$	10	$b < -6.7$	20	$n > 3600$	1	$v > 120$	10

Based on previous parameters and their rating scales, eight PIs were defined and calculated for each driver:

I. **Start-up acceleration** – Average acceleration rating per start-up (start-up consists of initial ten seconds of driving from standstill).
II. **Start-up engine speed** – Average engine speed rating per start-up.
III. **Halt deceleration** – Average deceleration rating per halt (halt consists of last ten second of driving until vehicle stop).
IV. **Acceleration in continuous driving conditions** – Average acceleration rating per acceleration time of all continuous driving periods (continuous driving consists of the period between initial and final 10 seconds of driving, i.e. after start-up period until halt period).
V. **Deceleration in continuous driving conditions** – Average deceleration rating per deceleration time of all continuous driving periods.
VI. **Engine speed in continuous driving conditions** – Average engine speed rating per duration of all continuous driving periods.
VII. **Idling** – ratio between idling time, determined as engine running time (engine speed ≠0) with simultaneous vehicle standstill (vehicle speed =0), and total engine running time.
VIII. **Speeding** – Average speed rating per driving time.

Authors have recognized three characteristic driving periods: start-up, continuous driving and halt. Start-up and halt events, as separate time sequences, allow for the drivers to be objectively compared on the basis of their skills to operate vehicle during start-up and halt. Besides, observing drivers' behaviour during continuous driving condition allows to identify those who accelerate or decelerate aggressively or operate the vehicle at high engine speeds beyond the start-stop regime where such inadequate driver actions occur most commonly. Average ratings

were used for different characteristic driving periods in order to minimize the impact of route configuration and traffic conditions (mileage, travel time, unloading points, etc.) on driver performance rating.

Start-up acceleration and start-up engine speed are related to fuel consumption and vehicle maintenance by influencing engine, drivetrain and tire wear. Halt deceleration directly influences vehicle maintenance by brake wear and indirectly fuel consumption as indicator of insufficient driver anticipation leading to unnecessary stop-and-go situations. Extreme accelerations and decelerations in continuous driving conditions denote aggressive driver behaviour leading to road safety issues, increased fuel consumption and eventually higher maintenance costs. High engine speeds in continuous driving conditions influence fuel consumption, showing lack of adequate knowledge and skills regarding gear shifting techniques, which could be resolved by appropriate driver training. It could also imply that the driver is aggressive or negligent, tending to maintain vehicle acceleration capacity. Idling impacts only fuel consumption suggesting driver's negligent behaviour. It includes idling times longer than 120 seconds, in order to avoid accounting for congestion delays and waiting times at traffic lights. Speeding (driving over the speed limit) primarily influences road safety, as well as fuel consumption and reflects driver awareness and complying with rules and traffic regulations. The speeding indicator would be much more accurate if available speed data would be matched to speed limits on the network by using GPS data.

In order to examine vehicle data utility to obtain reliable PIs for driver comparison and evaluation, the authors decided to monitor, record and process vehicle operation data for three drivers. Based on fleet managers' opinion two moderate and one aggressive driver were selected to be further examined. Driver 1 was characterised as moderate and attentive driver. Driver 2 had a reputation of an aggressive driver, often exceeding speed limits. Driver 3 had a reputation of a moderate driver, confident in his own driving skills. After determination of driver PIs, for easier comparison, their normalization was made (Table 2).

Table 2 – Normalized priority of drivers' performance indicators

Drivers	Start-up acceleration	Acceleration in continuous driving conditions	Halt deceleration	Deceleration in continuous driving conditions	Idling	Start-up engine speed	Engine speed in continuous driving conditions	Speeding
1	0.3101	0.3519	0.3705	0.5208	0.1865	0.1365	0.4054	0.0058
2	0.2294	0.2375	0.1834	0.1258	0.1375	0.2308	0.0354	0.0004
3	0.4605	0.4106	0.4461	0.3534	0.6760	0.6327	0.5592	0.9938

From Table , it is obvious that there is a clear distinction of examined drivers in all PIs. Obtained results give detailed and measurable illustration of differences between their driving skills and behaviour. Very high difference in speeding indicator between the third driver and the others is result of differences between their operation areas. The third driver only operates in central urban area with speed limit at 50 km/h, opposed to others operating in suburban areas where the speed limit of 80 km/h is attainable, but still restricted.

4. CONCLUSION

Today, in supply chain fleets too much attention is given to driver evaluation upon easily available parameters, as fuel consumption, which in authors' opinion is not a parameter, but an objective. Fuel consumption does not represent a reliable comparison parameter, as besides driving skills, it also depends on other conditions resulting from transport task, loading/unloading technology, operating conditions, payload utilisation and a number of other, often unidentifiable indicators.

In this paper the driver evaluation is attempted by more objective indicators offered by modern vehicle technologies. Based on a simple on-board device and a small number of recorded parameters a larger set of PIs was derived that are not correlated among each other and therefore justify their application allowing high-quality and comprehensive perception of driving skills. For data processing and results analyses MS Excel was used, which caused important time delays with available dataset implicating the need for a more adapted database software for larger datasets. Aside from described PIs it is possible to generate other indicators obtained from used or more complex on-board devices. Likewise, for driver evaluation it is essential to involve other quantitative indicators accessible to fleet managers, such as: driver safety and accident costs records, different test results, vehicle maintenance costs as consequence of driver's behaviour, but also some qualitative PIs related to other professional service skills. It was earlier explained that PIs for driver evaluation are related to multiple logistics company objectives, hence next research step is creation of drivers' evaluation and ranking model including all mentioned PIs and objectives, their relations and importance.

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THE ROLE OF ALLOCATION AND ORGANIZATION OF CUSTOMER SERVICE DIVISIONS AS AN ELEMENT OF MARKET COMPETITIVENESS OF TELECOMUNICATION OPERATORS

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***Abstract**: This paper deals with the impact of customer service divisions allocation and organization to the services and telecommunication operators positioning at competitive market conditions. The estimation in this paper is based on an analysis of users movement level in correlation with concrete allocation and customer service division organization as a market player strategy to respond to different customer demands and expectations so as to make the market position of operators stronger and more competitive.*

***Keywords**: Allocation, organization, services, customer, market.*

1. INTRODUCTION

For many organizations, contact center management system and CRM (customer relationship management) represents the first line of contact with customers. As such, they provide a unique opportunity to increase customer satisfaction level and develop long-term relationships between customers and the operator in order to meet the rising user expectations. For this purpose, organizations must develop a unified view of the user that is often harder than it looks like.

Contact center is a unit of organization focused on raising the quality of services and customer satisfaction level. The employees in contact center as a first line of service providing are representatives of the company. Two very important parameters – retention and churn are in direct correlation with the quality of their work.

Philip Kotler points out that each organization needs to control and improve the level of customer satisfaction. There are several reasons why it is more difficult to acquire new customer than to keep the existing one:

- The price of acquiring a new customer is five to ten times higher than the price of keeping the existing one,
- The average annual churn in companies ranges from 10% to 30% .
- Churn reducing in level of 5% reflects to profit increasing in level between 25% to 85% according to the specific type of industry.
- The rate of profit per customer is in proportion to the time of his retention.

Contact center is a central place of implementation of external communication and business strategy of the company. The fact is that majority of customers rather call the contact center

then get to the shop. The correlation between a shop and a contact center is such that all that can be done in the shop can be realized by calling the contact center. Allocated shops cover a significant part of the territory, but contact center provides services through the whole territory irrespective of a user location. Previously, contact centers were organised as allocated units on a geographical basis serving customers on a particular location. Development of technology brought new possibilities for completely different work organization of contact centers. The main advantage of a new model organization is reflected in the implementaton of a principle in which free agent is available for a user regardless of the allocation of both subjects – contact center and a customer. The further estimation will be done through a case study including Telekom Serbia contact center.

2. RESEARCH METHODS

The sample size in this study case are 240 call center agents in 8 allocated call centers. In order to review the entire process of communication between contact center agent and the users, the following methods have been used:

2.1 The method of content analysis

The method of content analysis involves analysis of documents, internal documents and relevant reports related to the communication with users. Present subjects are related to statistical reports of quantitative and qualitative parameters of operator's contact center work on a monthly and quarterly basis, and these are:

- Quantitative criterion for call duration – if the call duration exceeds 11 % of the adopted value indicator then the effect is below expetations. If the call duration doesn't exceed 10% of the adopted value indicator the effect is within the expected limits. The pecentage of avarage call duration which is below 99% of the adopted value indicator shows the effect which is above expetations.
- Quantitative criterion for the average number of the answered calls – if the pecentage of the answered calls is less than 89% of the adopted value indicator then the effect is below the expetations. The percentage between 90% and 110% related to the value indicator shows the effect at the level of expetations and all that exceeds 111% is above the expectations.
- Qualitative criterion for evaluating the flow of conversation – refers to the art of interviewing and professionalism in communication, and they are measured by the call response speed as well as by the successful implementation of user requirements.

2.2 The comparative method

The comparative method involves comparing the specific parameters of contact center in the situation before and after the introduction of a new technology i.e. new contact center organization of work in an observed period of three months before and three months after the introduction of changes.

2.3 The method of case study

The method of case study deals with the research of communication between Telekom Serbia contact center and customers.

2.4 Statistical method

Statistical method involves data processing and their presentation in tables and graphs.

3. HIPOTHESIS

In accordance with the defined object exploration was appointed hypothetical framework which consists of the main hypotheses and individual that will be partially or fully confirmed.

3.1 Main hypothesis:

As the organization of contact center is on a higher level the need for allocated shops is lesser.

3.2 Specific hypotheses:

- As the possibility to perform calls overflow to the first available agent, regardless of physical location, is bigger, the user satisfaction level is higher.
- As the user satisfaction with services provided is higher, the users will be more willing to accept new services.
- As the time of resolving the customer complaint is shorter, the level of user satisfaction is higher.
- As the user satisfaction is on a higher level, the market position of operator is stronger.

4. THE OBSERVED PARAMETERS

In order to perceive the level and type of the impact of new implementation of work organization on the quality of service, in analysis have been used measurable parameters which identify the quality of the services provided. The used parameters are as follows:

4.1 Percentage of answered calls

Percentage of answered calls represents the number of answered calls in relation to total number of calls to the contact center. The results shown in Figure 1. indicate that the percentage of answered calls is 36% higher in observed period after implementation of unified contact center than in observed period when contact center was allocated.

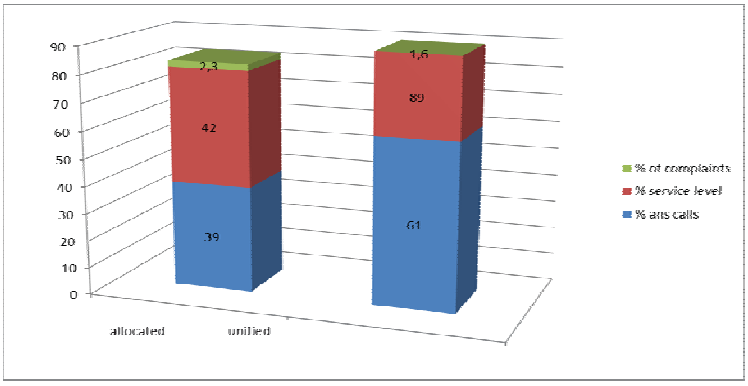


Figure 1. Parameters before and after unified call centers

4.2 Service level

Service level is the percentage of answered calls within 20 seconds. The results of this analyzed parameter are shown in Figure 1. It can be seen that the service level is 53% higher in the

observed period after the implementation of a unified contact center than in the observed period when contact center was allocated.

4.3 Waiting time

Waiting time represents the time that a user spends waiting for the first available agent to answer the call. The results in Figure 2. indicate that the waiting time is 50% shorter in the observed period after the implementation of unified contact center than in observed period when contact center was allocated.

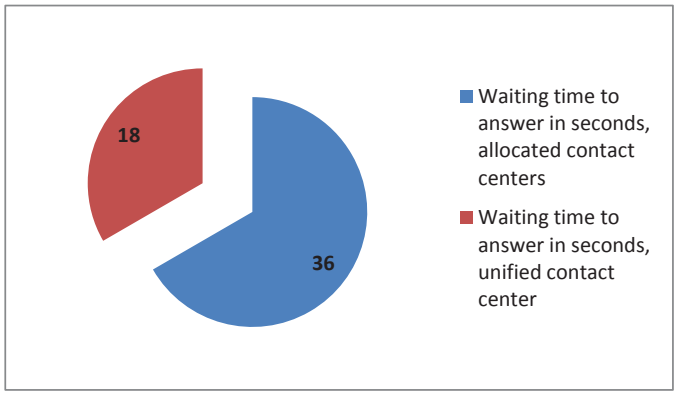


Figure 2. Waiting time

4.4 Percentage of complaints on the quality of services

It represents the number of complaints on the quality of services in relation to the total number of the answered calls. The results of analysed parameters are shown in Figure 1. The percentage of users' complaints is 0,7% smaller in the observed period after the implementation of unified contact center than in the observed period when contact center was allocated.

4.5 Complaints resolving time

Complaints resolving time is the time needed for resolving of complaints. The results of this parameter are shown in Table 1 where it can be seen that the needed time for resolving of complaints is 22% shorter in the observed period after the implementation of unified contact center than in the observed period when contact center was allocated.

4.6 Talk time

Talk time is duration of conversation between an agent and a user. The results of analysis of this parameter indicate that this parameter remained the same in both models of contact center organization.

4.7 Percentage of retention

Percentage of retention in the observed period represents the percentage of users who continued to use the service after the application for suspension of it in relation to the total number of users who have applied.

4.8 Percentage of churn

Percentage of churn is correlation between the number of users who canceled service and the total number of users who have applied for suspension of service.

5. RESEARCH RESULTS

Research results are shown in the Table 1.

Table 1. Parameters and results

Parameters	allocated	unified
The percentage of answered calls	39%	61%
Service level	42%	89%
Waiting time to answer in seconds	36	18
Percentage of complaints	2,3%	1,6%
Time resolution of complaints in days	3,2	2,5
Duration of the conversation, in seconds	245	236
Percentage of retention during 3 months	35%	56%
The percentage of customers who canceled service	65%	44%

Having in mind that first individual hypothesis relates to the correlation between the speed of the response call and customer satisfaction, the values shown in the table which refer to the parameters of the services provided supports the set hypothesis.

Second individual hypothesis set in this research relates to the level of customer satisfaction with the services provided and his willingness to accept new services. Having in mind the results of the parameters from the table which relate to customer retention and customers who cancelled the services, it is evident that the aforementioned hypothesis is largely confirmed. It is expected that the retained customers will be potential users of new services.

Third set hypothesis that relates to the correlation between the time of complaints resolving and a level of customer satisfaction is totaly confirmed by the results given which can be seen in the value of parameters of complaints resolving and in the value related to retention and churn.

Forth set hypothesis that represents correlation between a level of customer satisfaction and operator's market position is confirmed through all parameters which relate to the quality of services provided as well as through the values of parameters related to churn and retention. As the parameters of the quality of services provided are better, the churn is lesser, and the retention of the customers is bigger which directly reflects to the operator's market position.

Having in mind that all individual hypothesis are confirmed, thus the main hypothesis is confirmed and it is evident from the information in the Table 1.

All of the parameters above speak in favour of unified contact center. The results of analysis represent that the percentage of retention is higher and that the percentage of churn is lesser in concept of unified contact center. Those are very important indicators of operator's market position and competitiveness.

6. CONCLUSION

There is no doubt that there is a strong correlation between the quality of staff comunication and service users and a level of user satisfaction with services provided. For this reason its

permanent improvement is necessary primarily through the selection of appropriate organizational models.

The aim of this paper was to indicate the importance of selecting an appropriate model of contact center organization for implementation of external communication and business strategy of the company.

Comparing the results of analyzed parameters during the time of allocated contact center with observed work period of unified contact center the conclusion is that the implementation of new model of organization gives much better results. The direct effect of new model organization reflects in the fact that the users who are far from shops have the opportunity to realize their needs in the same time period and at the same level of quality as the users located near the shop.

The second important effect is reflected in the efficiency of trouble ticketing and consequently in their resolving. The observed case study leads to the conclusion that in case of efficient organization of unified contact center there is no need for allocation of units on geographical basis. Appropriate organization of contact center including ongoing staff training and market trends monitoring are of great importance for retention of existing and acquisition of new users as well as for preserving and increasing of user basis as the real market power of operator which determines his market position.

In addition to considering of concrete case, the objective of this study was to identify and publish additional scientific understanding about interdependence of business communication and satisfaction of a user with the services provided through description of all phenomena and processes related to the process of communication between an organization and service users, classification of concepts, phenomena and processes related to the process of communication, as well as through description of mutual influences, connections and relationships in the process of communication between an organization and service user.

Having in mind that in this paper the research is oriented to the overview of parameters which maintain the impact of communication on the achievement of business policy, the impact of communication on customer satisfaction and finally the impact of a user satisfaction on the company image, present research may have even wider social contribution because it could serve as a basis for further research and application in other organizations that want to improve business communication and operations of their organizations, and thereby strengthen its market position.

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Part VIII SUPPLY CHAIN MANAGEMENT AND REVERSE LOGISTICS

A MODELING APPROACH OF DESIGNING AND MANAGING SUPPLY NETWORKS

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Abstract: *Supply chain management is more and more affected by network and dynamic business environment. The fundamental decisions to be made during the design phase are the location of facilities and the capacity allocated to these facilities. An approach to designing sustainable supply networks is to develop and solve a mathematical programming model. The sustainability of supply networks can be measured by multiple objectives, such as economic, environmental, social, and others. Traditional concepts of optimality focus on valuation of already given systems. New concept of designing optimal systems is applied. Searching for a better portfolio of resources leads to a continuous reconfiguration and reshaping of systems boundaries. To respond to rapidly changing market conditions, firms must be able to dynamically form and dissolve business interactions. Using double combinatorial auctions can solve the problem. The proposed combined approach is promising for designing and managing supply networks.*

Keywords*: Supply network, De Novo optimization, multiple criteria, combinatorial auctions*

1. INTRODUCTION

Supply chain management has generated a substantial amount of interest both by managers and researchers and is more and more affected by network and dynamic business environment. The Supply network is defined as a system of suppliers, manufacturers, distributors, retailers and customers where material, financial and information flows connect participants in both directions (see for example Fiala, 2005). There are many concepts and strategies applied in designing and managing supply networks. The sustainability of supply networks can be measured by multiple objectives, such as economic, environmental, social, technological, and others.

Traditional concepts of optimality focus on valuation of already given systems. Multi-objective linear programming (MOLP) is a model of optimizing a given system by multiple objectives. New concept of designing optimal systems was proposed (Zeleny, 1990). As a methodology of optimal system design can be employed Multi-objective De Novo linear programming (MODNLP) problem for reshaping feasible sets in linear systems. The approach is based on reformulation of MOLP problem by given prices of resources and the given budget and searching for a better portfolio of resources. The paper presents approaches for solving the MODNLP problem for design of sustainable supply networks.

How to coordinate the decentralized supply network to be efficient as the centralized one? There are many concepts and strategies applied in managing supply networks. Auctions are

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important market mechanisms for the allocation of goods and services. An auction provides a mechanism for negotiation between buyers and sellers. Combinatorial auctions are those auctions in which bidders can place bids on combinations of items (see Cramton et al., 2006). In forward auctions a single seller sells resources to multiple buyers. In a reverse auctions, a single buyer attempts to source resources from multiple suppliers, as is common in procurement. Auctions with multiple buyers and sellers are called double auctions. Auctions with multiple buyers and sellers are becoming increasing popular in electronic commerce. We propose to use a model of double combinatorial auctions as trading model between layers of supply network.

2. SUSTAINABLE SUPPLY NETWORKS

In the next part a sustainable supply network design problem is formulated. The fundamental decisions to be made during the design phase are the location of facilities and the capacity allocated to these facilities. An approach to designing a sustainable supply network is to develop and solve a mathematical programming model. The mathematical program determines the ideal locations for each facility and allocates the activity at each facility such that the multiple objectives are considered and the constraints of meeting the customer demand and the facility capacity are satisfied. A general form of the model for the sustainable supply network design is Multi-objective linear programming (MOLP) model. A specific model is presented below.

The model of a supply network consists of 4 layers with m suppliers, S_1, S_2, ... S_m, n potential producers, P_1, P_2, ... P_n, p potential distributors, D_1, D_2, ... D_p, and r customers, C_1, C_2, ... C_r. The following notation is used:

- ai = annual supply capacity of supplier i, bj = annual potential capacity of producer j,
- wk = annual potential capacity of distributor k, dl = annual demand - customer l,
- f_j^P = fixed cost of potential producer j, f_k^D = fixed cost of potential distributor k,
- c_{ij}^S = unit transportation cost from Si to Pj, c_{jk}^P = unit transportation cost from Pj to Dk,
- c_{kl}^D = unit transportation cost from Dk to Cl, e_{ij}^S = unit environmental pollution from Si to Pj,
- e_{jk}^P = unit environmental pollution from Pj to Dk, e_{kl}^D = unit environmental pollution from Dk to Cl,
- x_{ij}^S = number of units transported from Si to Pj, x_{jk}^P = number of units transported from Pj to Dk,
- x_{kl}^D = number of units transported from Dk to Cl,
- y_j^P = binary variable for build-up of fixed capacity of producer j,
- y_k^D = binary variable for build-up of fixed capacity of distributor k.
- Using the above notations the problem can be formulated as follows:

The model has two objectives. The first one expresses minimizing of total costs. The second one expresses minimizing of total environmental pollution.

$$\text{Min } z_1 = \sum_{j=1}^{n} f_j^P y_j^P + \sum_{k=1}^{p} f_k^D y_k^D + \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}^S x_{ij}^S + \sum_{j=1}^{n}\sum_{k=1}^{p} c_{jk}^P x_{jk}^P + \sum_{k=1}^{p}\sum_{l=1}^{r} c_{kl}^D x_{kl}^D$$

$$\text{Min } z_2 = \sum_{i=1}^{m}\sum_{j=1}^{n} e_{ij}^S x_{ij}^S + \sum_{j=1}^{n}\sum_{k=1}^{p} e_{jk}^P x_{jk}^P + \sum_{k=1}^{p}\sum_{l=1}^{r} e_{kl}^D x_{kl}^D$$

Subject to the following constraints:

- the amount sent from the supplier to producers cannot exceed the supplier capacity

$$\sum_{j=1}^{n} x_{ij} \le a_i, \quad i = 1, 2, \ldots, m,$$

- the amount produced by the producer cannot exceed the producer capacity
  $\sum_{k=1}^{p} x_{jk} \le b_j y_j, \ j = 1, 2, \ldots, n,$
- the amount shipped from the distributor should not exceed the distributor capacity
  $\sum_{l=1}^{r} x_{kl} \le w_k y_k, \ k = 1, 2, \ldots, p,$
- the amount shipped to the customer must equal the customer demand
  $\sum_{k=1}^{p} x_{kl} = d_l, \ l = 1, 2, \ldots, r,$
- the amount shipped out of producers cannot exceed units received from suppliers
  $\sum_{i=1}^{m} x_{ij} - \sum_{k=1}^{p} x_{jk} \ge 0, \ j = 1, 2, \ldots, n,$
- the amount shipped out of distributors cannot exceed quantity received from producers
  $\sum_{j=1}^{n} x_{jk} - \sum_{l=1}^{r} x_{kl} \ge 0, \ k = 1, 2, \ldots, p,$
- binary and non-negativity constraints
  $y_j, y_k \in \{0,1\}, x_{ij}, x_{jk}, x_{kl} \ge 0, \ i = 1, 2, \ldots, m, \ j = 1, 2, \ldots, n, \ k = 1, 2, \ldots, p, \ l = 1, 2, \ldots, r.$

The formulated model is a multi-objective linear programming problem (MOLP).

3. FROM OPTIMIZING GIVEN SYSTEMS TO DESIGNING OPTIMAL SYSTEMS

Multi-objective linear programming (MOLP) is a model of optimizing a given system by multiple objectives. In MOLP problems it is usually impossible to optimize all objectives together in a given system. Trade-off means that one cannot increase the level of satisfaction for an objective without decreasing this for another objective. Trade-offs are properties of an inadequately designed system and thus can be eliminated through designing better one. The purpose is not to measure and evaluate tradeoffs, but to minimize or even eliminate them. An optimal system should be tradeoff-free. Multi-objective De Novo linear programming (MODNLP) is a problem for designing an optimal system by reshaping the feasible set (Zeleny, 2010).

3.1 Optimizing given systems

Multi-objective linear programming (MOLP) problem can be described as follows.

$$\text{“Max”} \quad z = Cx$$
$$\text{s.t.} \quad Ax \le b, \ x \ge 0. \tag{1}$$

where C is a (k, n) – matrix of objective coefficients, A is a (m, n) – matrix of structural coefficients, b is an m-vector of known resource restrictions, x is an n-vector of decision variables. In MOLP problems it is usually impossible to optimize all objectives in a given system. For multi-objective programming problems the concept of non-dominated solutions is used (see for example Steuer, 1986). A compromise solution is selected from the set of non-dominated solutions. There are proposed many methods. Most of the methods are based on trade-offs.

3.2 Designing optimal systems

By given prices of resources and the given budget the MOLP problem (1) is reformulated in the MODNLP problem (2)

$$\text{“Max”} \quad z = Cx$$
$$\text{s.t.} \quad Ax - b \le 0, \ pb \le B, \ x \ge 0. \tag{2}$$

where b is an m-vector of unknown resource restrictions, p is an m-vector of resource prices, and B is the given total available budget. From (2) follows $pAx \le pb \le B$.

Defining an n-vector of unit costs $v = pA$ we can rewrite the problem (2) as

$$\begin{aligned} &\text{“Max”} \quad z = Cx \\ &\text{s.t.} \quad vx \le B\ ,\ x \ge 0. \end{aligned} \tag{3}$$

Solving single objective problems

$$\begin{aligned} &\text{Max } z^i = c^i x \quad i = 1,2,...,k \\ &\text{s.t. } vx \le B, x \ge 0 \end{aligned} \tag{4}$$

z^* is a k – vector of objective values for the ideal system with respect to B. The problems (4) are continuous “knapsack” problems, the solutions are

$$x_j^i = \begin{cases} 0, j \ne j_i \\ B/v_{j_i}, j = j_i \end{cases}, \quad \text{where } j_i \in \left\{ j \in (1,...,n) \middle| \max_j (c_j^i / v_j) \right\}.$$

The meta-optimum problem can be formulated as follows

$$\begin{aligned} &\text{Min} \quad f = vx \\ &\text{s.t.} \quad Cx \ge z^*, x \ge 0. \end{aligned} \tag{5}$$

Solving the problem (5) provides solution: x^*, $B^* = vx^*$, $b^* = Ax^*$. The value B^* identifies the minimum budget to achieve z^* through solutions x^* and b^*. The given budget level $B \le B^*$. The optimum–path ratio for achieving the best performance for a given budget B is defined as $r_1 = \frac{B}{B^*}$.

The optimum-path ratio provides an effective and fast tool for the efficient optimal redesign of large-scale linear systems. Optimal system design for the budget B: $x = r_1 x^*$, $b = r_1 b^*$, $z = r_1 z^*$.

3.3 De Novo approach for sustainable supply networks

The De Novo approach can be useful in the design of the sustainable supply network. Only a partial relaxation of constraints is adopted. Producer and distributor capacities are relaxed. Unit costs for capacity build-up are computed:

- $p_j^P = \frac{f_j^P}{b_j}$ = cost of unit capacity of potential producer j,
- $p_k^D = \frac{f_k^D}{w_k}$ = cost of unit capacity of potential distributor k.

Variables for build-up capacities are introduced: u_j^P = variable for flexible capacity of producer j, u_k^D = variable for flexible capacity of distributor k.

The constraints for non-exceeding producer and distributor fixed capacities are replaced by the flexible capacity constraints and the budget constraint:

$$\sum_{k=1}^{p} x_{jk} - u_j^P \le 0,\ j = 1, 2, ..., n,\ \sum_{l=1}^{r} x_{kl} - u_k^D \le 0,\ k = 1, 2, ..., p,\ \sum_{j=1}^{n} p_j^P u_j^P + \sum_{k=1}^{p} p_k^D u_k^D \le B.$$

4. MANAGING SUPPLY NETWORKS BY DOUBLE COMBINATORIAL AUCTIONS

We propose to use a model of double combinatorial auctions as trading model between layers of supply network.

4.1 Double auctions

Auctions with multiple buyers and multiple sellers are becoming increasing popular in electronic commerce. Double auctions are not so often studied in the literature as single-sided auctions (see Xia et al., 2005). For double auctions, the auctioneer is faced with the task of matching up a subset of the buyers with a subset of the sellers. The profit of the auctioneer is the difference between the prices paid by the buyers and the prices paid to the sellers. The objective is to maximize the profit of the auctioneer given the bids made by sellers and buyers.

We present a double auction problem of indivisible items with multiple sellers and multiple buyers. Let us suppose that m potential sellers $S_1, S_2, ..., S_m$ offer a set R of r items, $j = 1, 2, ..., r$, to n potential buyers $B_1, B_2, ..., B_n$. A bid made by seller S_h, $h = 1, 2, ..., m$, is defined as $b_h = \{C, c_h(C)\}$, a bid made by buyer B_i, $i = 1, 2, ..., n$, is defined as $b_i = \{C, p_i(C)\}$, where

$C \subseteq R$, is a combination of items,
$c_h(C)$, is the offered price by seller S_h for the combination of items C,
$p_i(C)$, is the offered price by buyer B_i for the combination of items C.

Binary variables are introduced for model formulation: $x_i(C)$ is a binary variable specifying if the combination C is assigned to buyer B_i ($x_i(C) = 1$), $y_h(C)$ is a binary variable specifying if the combination C is bought from seller S_h ($y_h(C) = 1$).

$$\sum_{i=1}^{n} \sum_{C \subseteq R} p_i(C)\, x_i(C) - \sum_{h=1}^{m} \sum_{C \subseteq R} c_h(C)\, y_h(C) \rightarrow \max$$

$$\text{s.t.} \quad \sum_{i=1}^{n} \sum_{C \subseteq R} x_i(C) \leqq \sum_{h=1}^{m} \sum_{C \subseteq R} y_h(C), \quad \forall j \in R, \tag{6}$$

$$x_i(C) \in \{0,1\}, \ \forall C \subseteq R, \forall i, \ i = 1, 2, ..., n, y_h(C) \in \{0,1\}, \ \forall C \subseteq R, \ \forall h, \ h = 1, 2, ..., m.$$

The objective function expresses the profit of the auctioneer. The constraints ensures for buyers to purchase a required item and that the item must be offered by sellers.

4.2 Solving of double auctions

The formulated combinatorial double auction can be transformed to a combinatorial single-sided auction. Substituting $y_h(C)$, $h = 1, 2, ..., m$, with $1 - x_i(C)$, $i = n+1, n+2, ..., n+m$, and substituting $c_h(C)$, $h = 1, 2, ..., m$, with $p_i(C)$, $i = n+1, n+2, ..., n+m$, we get a model of a combinatorial single-sided auction.

$$\sum_{i=1}^{n+m} \sum_{C \subseteq R} p_i(C)\, x_i(C) - \sum_{i=n+1}^{n+m} \sum_{C \subseteq R} p_i(C) \rightarrow \max$$

$$\text{s.t.} \quad \sum_{i=1}^{n+m} \sum_{C \subseteq R} x_i(C) \leqq m, \quad \forall j \in R, \tag{7}$$

$$x_i(C) \in \{0,1\}, \ \forall C \subseteq R, \ \forall i, \ i = 1, 2, ..., n+m.$$

The model (7) can be solved by methods for single-sided combinatorial auctions. Complexity is a fundamental question in combinatorial auction design. The algorithms proposed for solving combinatorial auctions are exact algorithms and approximate ones. Many researchers consider iterative auctions as an alternative.

One way of reducing some of the computational burden in solving the problem is to set up a fictitious market that will determine an allocation and prices in a decentralized way. In the iterative approach, there are multiple rounds of bidding and allocation and the problem is solved in an iterative and incremental way. Iterative combinatorial auctions are attractive to bidders because they learn about their rivals' valuations through the bidding process, which could help them to adjust their own bids (see Parkes, 2001). The key challenge in the iterative

combinatorial auctions design is to provide information feedback to the bidders (see Pikovsky and Bichler, 2005). We propose to use an iterative approach for combinatorial auctions. The primal-dual approach is used for solving. For the problem (7) we will formulate the LP relaxation and its dual. The scheme can be outlined as follows:

1. Choose initial prices for sellers and buyers.
2. Announce current prices and collect bids.
3. Compute the current dual solution by interpreting the prices as dual variables. Try to find a feasible allocation, an integer primal solution that satisfies the stopping rule. If such solution is found, stop and use it as the final allocation. Otherwise update prices and go back to 2.

5. CONCLUSION

De Novo approach was applied for sustainable supply network design problem and provides better solution than traditional approaches applied on fixed constraints. The design problem was formulated as MOLP problem. The economic and environmental objectives were used in the model but multiple objectives can be used in general. De Novo programming (DNP) approach is open for further extensions as fuzzy DNP, interval DNP, complex types of objective functions and continuous innovations. The numerous applications in electronic commerce have led to a great deal of interest in double auctions. The paper presents a model of combinatorial double auctions for managing supply networks. The formulated model can be transformed to a combinatorial single-sided auction and solved by methods for single-sided combinatorial auctions. We propose to use an iterative approach to solving combinatorial double auctions. The primal-dual algorithm can be taken as a decentralized and dynamic method to determine equilibrium.

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LOCATION ROUTING MODEL FOR DESIGNING PLASTICS RECYCLING NETWORK

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Abstract: *This paper proposes location-routing model for designing recycling network with profit. Proposed model simultaneously determine collection points' locations with distance-dependent returns, location of intermediate consolidation points (transfer centers) and the route of the collection vehicle so as to maximize its profit from the collection of recyclables. Routing part of the model was formulated as a multiple matching problem.*

Keywords*: location-routing problem, recycling network, MILP*

1. INTRODUCTION

The location-routing problems (LRP) merges facility location and vehicle routing into a single problem where strategic location and tactical/operational routing decisions are taken simultaneously. This integrated approach has found to be useful in several real-life applications (Nagy and Salhi, 2007). In this paper we consider a LRP in plastics recycling. Namely, it is estimated that 66.5 million tons of plastic will be placed on the European Union (EU) market in 2020 and global plastic production could triple by 2050 (Green Paper, 2013). Once in the environment, plastic waste can persist for hundreds of years (Green Paper, 2013). In order to deal with the problem of plastic waste, EU introduced legislation like the Packaging Directive 94/62/EC and Framework Directive on waste 2008/98/EC. The Packaging Directive has a specific recycling target for plastic packaging, while the Framework Directive on waste sets a general recycling target for household waste which covers plastic waste (Green Paper, 2013). For achieving imposed recycling targets, it is necessary to establish appropriate logistics network structures. This logistics networks must be convenient for end users (González-Torre and Adenso-Díaz, 2005), since the participation of end users is crucial for a successful achieving any recovery target set by legislation, because they are responsible for separation of these products at their residence and carrying them to designated collection points (CPs). Although, efficient source segregation collection can contribute significantly to maximizing material recycling, but can represent up to 70% of the entire cost of waste management (Dogan and Duleyman, 2003).

From here, the main intention of this paper is to propose a model for designing recycling logistics network (RN) with profit. The LR model for designing RN with profit proposed here, has the following specificities. Location part of the model includes decisions of the positioning both CPs as a lower level of the network and transfer stations (TSs) at the higher level of the network. The revenue obtained from quantity of recyclables for specific CP is related with the

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proximity of the CP to the end users. So, we introduced distance dependent quantity of recyclables dropped off to CPs introducing collection rate as a function of distance. Particularly, we consider a problem where end users are located in city blocks. Most of the today modern cities have so called block structures, characterized with buildings in which residents live, and internal streets network within. In order to collect recyclables in such environment, CPs must be located along these internal streets. Therefore, routing part of the model gives opportunity for considering whole blocks as a network nodes to be visited by collection vehicles. Internal street network in city blocks is usually simple, so it is possible to determine optimal route through blocks in advance. Another specificity of the proposed approach is that while performing one collection route, due to its limited capacity, vehicle can visit only small number of city blocks. This facts gives opportunity to formulate and solve routing part of the problem as multiple matching problem.

The remainder of the paper is organized as follows. Section 2 presents the problem description, and mathematical formulation of the described problem. Section 3 gives numerical example. Finally, section 4 concludes the study.

2. MATHEMATICAL FORMULATION

Most of the today modern cities have so called block structures. These blocks can be in a variety of sizes and shapes, and they are characterized with buildings in which residents live and road network within. In this paper, term end user refers to a building inside the specific city block (we aggregated residents to its residential building considering them as a single end user). Each end user is characterized by the volume of waste produced per day which corresponds to the total quantity generated in all households residing in a building. Potential locations of CP are characterized by its capacity and distances to all end users in each city block. In order to model the influence of distance between end users and CPs on the collecting of recyclables, we assume that recyclables collection rate $f_d \in [0,1]$ is a known function of distance. This function models the influence of distance between end users and CPs, in way that collection rate is inversely proportional to distance (Berman et al., 2003). We define two characteristic distances *l* and *u* (l < u), between the end user and CP where *l* represents the lower and *u* upper bound of walking distance to CP for each end user. When the distance *d* from the end user to the closest CP is $0 \le d \le l$ then *f(d)=1*, while in case when $d \ge u$, *f(d)=0*. If the distance between the end user and CP is $l \le d \le u$, we assumed that the collection rate corresponds to $f(d) = \frac{u-d}{u-l}$. In the routing part of the problem, there is a capacitated vehicle that has to visit CPs located in city blocks, originating from TS. Transfer station represents a facility in which recyclables are inspected and consolidated for further processing. We have a set of potential locations for TSs, characterized by costs of opening TSs. The length of inner streets in city blocks may differ depending of the city block shape and size, but once the vehicle enters the city block it could only be traverse through these inner streets, along which CPs are located. The length of the route through city block is always the same, regardless of the number of stops per CP. This fact enables us to route distance only from TS to city blocks, while route part when vehicle traverse city block is predetermined and included in routing costs. More importantly this fact, gives us opportunity to formulate vehicle routing part of the LR problem as a multiple matching problem instead of classical VRP formulations. Also, we include idling time at each CP in costs calculation. Assumptions of the proposed LR model are:

- TS is assumed to be uncapacitated
- The route in city block can be predefined as the CPs are placed along the internal streets within the city block, whose network is short and simple, and the optimal internal route within the block can easily be determined by solving arc routing problem. The internal

route has constant length which is passed always when block is visited and does not depends on the number of CPs opened

- Quantities of recyclables that are generated during the observation period in city block do not allow the vehicle to serve more than four blocks in one route
- In order to propose a MILP model for the problem the following notation is introduced.

Sets:

$I = \{1,..i..|I|\}$ set of end users

$B = \{1,..b..|B|\}$ set of city blocks

$K = \{1,...k...|K|\}$ set of potential sites for CPs

$J = \{1,... j...|J|\}$ set of potential sites for transfer points

Parameters:

R revenue from selling collected quantity of recyclables

d_{ikb} walking distance between end user i to k-th CP in a city block b

Z_{ikb} collection rate for the distance d_{ikb}, $Z_{ikb} = \begin{cases} 1, & when\ 0 \le d_{ikb} \le l \\ f(d_{ikb}), & when\ l < d_{ikb} \le u \\ 0, & when\ d_{ikb} > u \end{cases}$

F_k costs of opening CPs $k \in K$

F_j costs of opening transfer points $j \in J$

α_{kb} idling time costs at CP $k \in K$ in city block $b \in B$

Q_r capacity of vehicle (or route)

Q_j capacity of transfer station $j \in J$

Q_{kb} capacity of CP $k \in K$ in city block $b \in B$

Q_{ib} available quantity of recyclables at end user $i \in I$ in city block $b \in B$

C_{jpqwe}, C_{jpqw}, C_{jpq}, C_{jp} costs of visiting CPs in blocks $p, q, w, e \in B$ in a single route (including costs from/to transfer station $j \in J$ and costs inside city blocks), respectively for routes visiting four, three, two, and one city block $b \in B$. Cost of routes through city blocks are added to these cost.

Big M number (sufficiently large number)

Decision variables:

$$Y_{kb} = \begin{cases} 1, if\ collection\ point\ k \in K\ is\ opened\ in\ city\ block\ b \in B \\ 0, otherwis\ e \end{cases}$$

$$Y_j = \begin{cases} 1, if\ transfer\ station\ j \in J\ is\ opened \\ 0, otherwis\ e \end{cases}$$

$$Y_{jpqwe} = \begin{cases} 1, if\ nodes\ p,q,w,e \in B\ are\ merged\ in\ the\ same\ route\ from\ transfer\ point\ j \in J \\ 0, otherwis\ e \end{cases}$$

$$Y_{jpqw} = \begin{cases} 1, if\ nodes\ p,q,w \in B\ are\ merged\ in\ the\ same\ route\ from\ transfer\ point\ j \in J \\ 0, otherwis\ e \end{cases}$$

$$Y_{jpq} = \begin{cases} 1, if\ nodes\ p,q, \in B\ are\ merged\ in\ the\ same\ route\ from\ transfer\ point\ j \in J \\ 0, otherwis\ e \end{cases}$$

$$Y_{jp} = \begin{cases} 1, if\ \ node\ \ p, \in B\ are\ served\ \ in\ the\ direct\ \ route\ \ from\ transfer\ \ point\ \ j \in J \\ 0, otherwis\ e \end{cases}$$

$X_{ikb} \leq 1$ defines fraction of recyclables brought from end user to $i \in I$ collection site $k \in K$ in city block $b \in B$.

The mathematical formulation of the proposed MILP model is given below:

$$Max \quad \sum_b \sum_k \sum_i RQ_{ib} X_{ikb} - \sum_b \sum_k (F_{kb} + \alpha_{kb}) Y_{kb} - \sum_j F_j Y_j - \sum_j \sum_{p \in B} \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\})} \sum_{e \in B/(\{p\} \cup \{q\} \cup \{w\})} C_{jpqwe} Y_{jpqwe} - \sum_j \sum_{p \in B} \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\})} C_{jpqw} Y_{jpqw} - \sum_j \sum_{p \in B} \sum_{q \in B/\{p\}} C_{jpq} Y_{jpq} - \sum_j \sum_{p \in B} C_{jp} Y_{jp} \tag{1}$$

s.t.

$$Q_{ib} X_{ikb} \leq Z_{ikb}, \quad \forall\ i, k, b \tag{2}$$

$$\sum_k X_{ikb} \leq 1 \quad \forall, i, b \tag{3}$$

$$\sum_i Q_{ib} X_{ikb} \leq Y_{kb} Q_{kb} \quad \forall k, b \tag{4}$$

$$X_{ikb} \leq Y_{kb} \quad \forall k, b \tag{5}$$

$$\sum_j \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\})} \sum_{e \in B/(\{p\} \cup \{q\} \cup \{w\})} Y_{jpqwe} + \sum_j \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\})} \sum_{e \in B/(\{p\} \cup \{q\} \cup \{w\})} Y_{jqpwe} + \sum_j \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\})} \sum_{e \in B/(\{p\} \cup \{q\} \cup \{w\})} Y_{jqwpe} + \sum_j \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\} \cup \{w\})} Y_{jqwep} + \sum_j \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\})} Y_{jpqw} + \sum_j \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\})} Y_{jqpw} + \sum_j \sum_{q \in B/\{p\}} \sum_{w \in B/(\{p\} \cup \{q\})} Y_{jqwp} + \sum_j \sum_{q \in B/\{p\}} Y_{jpq} + \sum_j \sum_{q \in B/\{p\}} Y_{jqp} + Y_{jp} = 1, \quad \forall p \tag{6}$$

$$Y_{jpqwe} \leq Y_j, \forall j \in J, \forall p \in B, \forall q \in B/\{p\}, \forall w \in B/(\{p\} \cup \{q\}), e \in B/(\{p\} \cup \{q\} \cup \{w\}) \tag{7}$$

$$Y_{jpqw} \leq Y_j, \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\}, \quad \forall w \in B/(\{p\} \cup \{q\}) \tag{8}$$

$$Y_{jpq} \leq Y_j, \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\} \tag{9}$$

$$Y_{jp} \leq Y_j, \forall j \in J, \quad \forall p \in B \tag{10}$$

$$\sum_i \sum_k Q_{ip} X_{ikp} + \sum_i \sum_k Q_{iq} X_{ikq} + \sum_i \sum_k Q_{iw} X_{ikw} + \sum_i \sum_k Q_{ie} X_{ike} - M(1 - Y_{jpqwe}) \leq Q_r Y_{jpqwe}, \forall j \in J; \quad \forall p \in B; \quad \forall q \in B/\{p\}; \quad \forall w \in B/(\{p\} \cup \{q\}); \quad e \in B/(\{p\} \cup \{q\} \cup \{w\}) \tag{11}$$

$$\sum_i \sum_k Q_{ip} X_{ikp} + \sum_i \sum_k Q_{iq} X_{ikq} + \sum_i \sum_k Q_{iw} X_{ikw} - M(1 - Y_{jpqw}) \leq Q_r Y_{jpqw}, \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\}, \quad \forall w \in B/(\{p\} \cup \{q\}) \tag{12}$$

$$\sum_i \sum_k Q_{ip} X_{ikp} + \sum_i \sum_k Q_{iq} X_{ikq} - M(1 - Y_{jpq}) \leq Q_r Y_{jpq}, \quad \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\} \tag{13}$$

$$\sum_i \sum_k Q_{ip} X_{ikp} - M(1 - Y_{jp}) \leq Q_r Y_{jp}, \quad \forall j \in J, \quad \forall p \in B \tag{14}$$

$$\sum_k Y_{kp} \geq Y_{jpqwe}, \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\}, \quad \forall w \in B/(\{p\} \cup \{q\}), \quad e \in B/(\{p\} \cup \{q\} \cup \{w\}) \tag{15}$$

$$\sum_k Y_{kq} \geq Y_{jpqwe}, \quad \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\}, \quad \forall w \in B/(\{p\} \cup \{q\}), \quad e \in B/(\{p\} \cup \{q\} \cup \{w\}) \tag{16}$$

$$\sum_k Y_{kw} \geq Y_{jpqwe}, \quad \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\}, \quad \forall w \in B/(\{p\} \cup \{q\}), \quad e \in B/(\{p\} \cup \{q\} \cup \{w\}) \tag{17}$$

$$\sum_k Y_{ke} \geq Y_{jpqwe}, \quad \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\}, \quad \forall w \in B/(\{p\} \cup \{q\}), \quad e \in B/(\{p\} \cup \{q\} \cup \{w\}) \tag{18}$$

$$\sum_k Y_{kp} \geq Y_{jpqw}, \quad \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\}, \quad \forall w \in B/(\{p\} \cup \{q\}) \tag{19}$$

$$\sum_k Y_{kq} \geq Y_{jpqw}, \quad \forall j \in J \quad \forall p \in B \quad \forall q \in B/\{p\} \quad \forall w \in B/(\{p\} \cup \{q\}) \tag{20}$$

$$\sum_k Y_{kw} \geq Y_{jpqw}, \quad \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\}, \quad \forall w \in B/(\{p\} \cup \{q\}) \tag{21}$$

$$\sum_k Y_{kp} \geq Y_{jpq}, \quad \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\} \tag{22}$$

$$\sum_k Y_{kq} \geq Y_{jpq}, \quad \forall j \in J, \quad \forall p \in B, \quad \forall q \in B/\{p\} \tag{23}$$

$$\sum_k Y_{kp} \geq Y_{jp}, \quad \forall j \in J, \quad \forall p \in B \tag{24}$$

$$Y_{kb} \in \{0,1\}, Y_j \in \{0,1\}, Y_{jpqwe} \in \{0,1\}, Y_{jqpwe} \in \{0,1\}, Y_{jqwpe} \in \{0,1\}, Y_{jpqw} \in \{0,1\}, Y_{jqpw} \in \{0,1\}, Y_{jqwp} \in \{0,1\},$$
$$Y_{jpq} \in \{0,1\}, Y_{jpq} \in \{0,1\}, Y_{jp} \in \{0,1\}, X_{ikb} \leq 1, X_{ikb} \geq 0 \tag{26}$$

The objective function maximizes the profit which is composed of obtained revenue from the collected recyclables (term 1 in objective function), minus the fixed cost of opening CPs and idling time costs in each city block (term 2), costs of locating transfer points (term 3), an routing costs (terms 4, 5, 6 and 7). First constraint set (2) represents the quantity of recyclables to be collected under ''coverage decay function''. Constraints (3) ensures that fraction of recyclables assigned to CP *k* is less or equal to quantity generated at end user *i*. Quantity of recyclables assigned to CP cannot exceed the capacity of CP (4), while constraints (5) ensures that recyclables are assigned to only opened CPs. Constraints (6) prohibit multiple visits of the same node (city block b), and provide that each city block must be visited exactly once. Constraint sets (7)-(10) ensures that vehicles starts tour only from transfer point which is opened. Constraint sets (11)-(14) ensures that vehicle capacity isn't exceeded. Constraint sets (15)-(24) ensures that only city blocks in which CPs are opened are visited in the route, Finally, constraint sets (26) define nature of the variables.

3. NUMERICAL EXAMPLE

To test proposed MILP model for designing RN with profit, we generated three different problem instance sets: small (S), medium (M) and large (L) instances. The main difference between instances is in number of end users and spatial distribution in city blocks. For all set of problems we generated 240 instances (Table 1). The execution of the instances (CPU time) has been limited to 7200 seconds. Models have been solved with the usage of Cplex 12.6, and instances were run on an Intel(R) Core(TM) i5-4200U (2.30 GHz, RAM 8Gb).

Table 1. Input parameters of the model

Input parameters	S	M	L
F_k(€/day)	0.5		
F_j(€/day)	0		
Costs per stop (€/per stop)	0.002		
revenue(€/kg)	0.12264		
Q_k(kg)	20		
Q_r(kg)	200	300	800
l(m)	50		
u(m)	400		
Time horizon	2.5 day		
No. of city blocks	{4,5,6,8,10,12,15,20}		
No. of potential location for transfer points	2		
Number of residents in each city block	Beta (2,5) distribution in the range[48,200]		
Generated quantity of recyclables in (Q_{ib})	Uniform distribution (0.8;0.1)* P (P-% of plastics in municipal waste)		
Number of potential CPs	(Q_{ib}/Q_k)+1		
Distances between city blocks (m)	Randomly generated in the range [100,700]		
Distances between transfer points and city blocks (m)	Randomly generated in the range [1000,10000]		
Distances inside city blocks (m)	Randomly generated in range[400,1200]		
Distances between end users and potential locations for CPs	Beta (2,5) distribution in the range[15,400]		
Cost per km traveled (€/km)	0.0006 (inside the block x3)		
Number of end users in each city block (Randomly generated in the shown range :)	[4,7]	[5,25]	[10,70]

Due to the complexity of proposed LR model, the instances that can be solved to optimality are typically of small size. When solving large and medium instances in preliminary tests, computational difficulties were faced due to the hard combinatorial problem characteristics. For

medium instances, instances up to 8 city block (not all of it) could be solved to optimality. In case of large instances, even the smallest number of city blocks caused difficulties, while the biggest number of city blocks could not be loaded into computer memory (Table 2). Although this results present the beginning of the research in this area, it is clear that proposed MILP model needs development of appropriate heuristics or application of metaheuristics for solving models of larger size.

Table 2. Results of the proposed LR model

No. of city blocks	***S instances***			***M instances***			***L instances***		
	*#opt***	*Fopt**	*CPU-opt(s)**	*#opt***	*Fopt**	*CPU-opt(s)**	*#opt***	*Fopt**	*CPU-opt(s)**
4	10/10	2.04	12.59	9/10	24.32	313.81	1/10	134.37	11.80
5	10/10	-0.26	12.16	9/10	40.37	104.20	0/10	/	/
6	10/10	-0.05	0.83	3/10	47.85	20.67	0/10	/	/
8	9/10	5.95	55.98	1/10	53.3	98.83	0/10	/	/
10	10/10	3.40	25.33	0/10	/	/	0/10	/	/
12	10/10	7.244803	67.42	0/10	/	/	0/10	/	/
15	10/10	9.268272	632.88	0/10	/	/	0/10	/	/
20	10/10	15.56321	537.26	0/10	/	/	a*	a*	a*

*average value; ** time limit 7200s;a* couldn't be loaded into the memory

3. CONCLUSION

This paper presents a possible approach to define the optimal network for recycling plastic waste, by presenting LR formulation for this problem. Preliminary testing of the proposed approaches is promising, but numerous aspects of the problem and application of approach proposed need future research. Future research direction may include examining the system behavior with different system parameters (different vehicle capacity, different capacity of the containers, etc). But most importantly, development of appropriate heuristics for solving models of larger size.

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DYNAMIC ANALYSIS FOR END-OF-LIFE VEHICLES MANAGEMENT SYSTEMS: AN INEXACT MULTI-STAGE PROGRAMMING APPROACH

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Abstract: *Nowadays, export of used vehicles represents the most significant barrier to the more efficient vehicle recycling in the EU, because millions of vehicles which are expected to go to domestic vehicle recycling factories are exported. As a result, how to allocate limited and frequently insufficient quantities of collected end-of-life vehicles (ELVs) to satisfy vast demands of vehicle recycling factories becomes a significant concern of many waste management systems that control the ELV collection and treatment networks across the EU. In this paper, a multi-stage interval-stochastic programming (MSISP) model is developed for supporting the management of ELV allocation under uncertainty. The MSISP is a hybrid of inexact optimization and multi-stage stochastic programming. The formulated MSISP model can directly handle uncertainties expressed as either probability density functions or discrete intervals. In addition, it can handle uncertainties through constructing a set of scenarios and reflect dynamic features of the system conditions.*

Keywords*: End-of-life vehicle; Decision making; Multi-stage stochastic programming; Interval programming.*

1. INTRODUCTION

The amount of material passing through the end-of-life (ELV) recycling networks all over the EU has been reduced due to an increased export of used vehicles for reuse as second-hand vehicles or as sources of used parts and materials. Nowadays, export of used vehicles represents the most significant barrier to the more efficient vehicle recycling in the EU, because millions of vehicles, which are supposed to go to domestic vehicle recycling factories, are exported. Illegal treatment facilities represent another problem for the EU vehicle recycling industry sector, especially in some new EU member states (Tavoularis et al., 2009). Illegal operators can pay more to the last owners for an ELV, because they have no intention of incurring the cost of either depolluting the vehicle or attempting to reach the eco-efficiency targets promulgated by the EU ELV Directive (EU, 2000). Abandoned vehicles represent another major problem and the introduction of the EU ELV Directive initially increased their number. Consequently, how to allocate limited and often insufficient quantities of collected, decontaminated and flattened ELVs to satisfy vast demands of vehicle recycling factories becomes a significant concern of many waste management systems that control the ELV collection and treatment networks all over the EU.

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Owing to the complexity of the vehicle recycling subject, a very small number of research articles have been published. Reuter at al. (2006) formulated a nonlinear model to optimise the performances of the ELV recycling system. Qi and Hongcheng (2008) proposed a mixed integer linear programming model for designing ELV recovery network. Cruz-Rivera and Ertel (2009) constructed an uncapacitated facility location model in order to design a collection network for ELVs in Mexico. Vidovic et al. (2011) presented modelling approach that could be used to locate collection facilities for ELVs. Stoyanov (2012) formulated a multi-source capacitated facility location model in order to design a network of dismantling centers for ELVs in Bulgaria. Gołębiewski et al. (2013) proposed a simulation approach that could be used to determine locations for ELV dismantlers. Simic and Dimitrijevic (2013) developed a risk explicit interval linear programming model for optimal long-term planning in the EU vehicle recycling factories. Mora et al. (2014) proposed a mixed integer linear programming model for ELV closed-loop network design.

From the review of previous literature, it is evident that a number of systems analysis methods were developed for solving various ELV management problems. However, the above methods can hardly solve problems where multi-stage decisions need to be made, particularly when random variables exist in the vehicle recycling system while decisions have to be made before the random event occurs. In fact, no previous study was reported on the application of the multi-stage stochastic programming technique to ELV management problems. Therefore, in view of the limitations in previous works, the multi-stage interval-stochastic programming (MSISP) model is formulated and presented in this paper.

The remaining part of the paper is organized as follows: Section 2 describes the considered problem and presents the multi-stage interval-stochastic programming model for supporting the management of ELV allocation under uncertainty. Section 3 presents conclusions of the work.

2. METHODOLOGY

Consider a waste management system where a recycling manager is responsible for allocating ELVs from multiple regions to multiple vehicle recycling factories within a multi-period planning horizon. The available quantities of ELVs in each region are random variables with known probabilities. Decisions about ELV allocation targets must be made at an earlier stage when varying probability levels exist, because managers of all vehicle recycling factories need to know in advance which quantity of ELVs they can expect in order to create adequate production plans. Therefore, guaranteed quantities of ELVs from each region to each vehicle recycling factory are promulgated in advance. On the other hand, if the guaranteed quantities of ELVs cannot be distributed to vehicle recycling factories due to insufficient number of collected ELVs, vehicle recycling factories will have to import ELVs at a higher price and/or work at reduced capacity. To all vehicle recycling factories which have not fully been provided with preliminary ELV allocation targets penalties must be reimbursed, as specific compensation for acquiring ELVs from more expensive sources or because of smaller profit due to reduced working capacities.

The quantities of collected, depolluted and flattened ELVs during every planning period are random variables, and the appropriate ELV allocation plan would be of dynamic feature. As a result, ELV allocation decisions need to be made periodically. Thus, the problem of ELV allocation needs to be solved using a multi-stage stochastic programming approach, because it provides the possibility to represent various uncertainties in a form of multilayer scenario tree.

Uncertainties exist also in economic parameters, ELV allocation targets and demand from vehicle recycling factories. Observing aforementioned modelling parameters as interval values is purely natural. In order to reflect such uncertainties, interval-parameter programming needs to be introduced into the modelling formulation.

Thus, the described problem can be formulated as a multi-stage interval-stochastic programming model for planning end-of-life vehicles allocation as follows:

$$Max \quad f^{\pm} = \sum_{t=1}^{T} \sum_{r\in \mathrm{R}} \sum_{v\in \mathrm{V}} (D_{vrt}^{\pm}(Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt}) - \sum_{s\in \mathrm{S}_t} p_{rst} K_{vt}^{\pm} M_{vrst}^{\pm}) \tag{1a}$$

subject to:

$$\sum_{v\in \mathrm{V}} (Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt} - M_{vrst}^{\pm}) \le Q_{rst}^{\pm} + H_{rs't-1}^{\pm}, \forall r \in \mathrm{R}; \forall s \in \mathrm{S}_t; \forall s' \in \Gamma_s^{-1}; \forall t \in \{1,...,T\} \tag{1b}$$

$$H_{r10}^{\pm} = \Pi_r^{\pm}, \ \forall r \in \mathrm{R} \tag{1c}$$

$$H_{rst}^{\pm} = Q_{rst}^{\pm} - \sum_{v\in \mathrm{V}} (Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt} - M_{vrst}^{\pm}) + H_{rs't-1}^{\pm}, \quad \forall r \in \mathrm{R}; \forall s \in \mathrm{S}_t; \forall s' \in \Gamma_s^{-1}; \forall t \in \{1,...,T\} \tag{1d}$$

$$\sum_{r\in \mathrm{R}} (Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt} - M_{vrst}^{\pm}) \ge I_{vt\,min}^{\pm}, \ \forall v \in \mathrm{V}; \forall s \in \mathrm{S}_t; \forall t \in \{1,...,T\} \tag{1e}$$

$$Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt} \ge M_{vrst}^{\pm} \ge 0, \ \forall v \in \mathrm{V}; \forall r \in \mathrm{R}; \forall s \in \mathrm{S}_t; \forall t \in \{1,...,T\} \tag{1f}$$

$$H_{rst}^{\pm} \ge 0, \ \forall r \in \mathrm{R}; \forall s \in \mathrm{S}_t; \forall t \in \{0,1,...,T\} \tag{1g}$$

$$0 \le \gamma_{vrt} \le 1, \ \forall v \in \mathrm{V}; \forall r \in \mathrm{R}; \forall t \in \{1,...,T\} \tag{1h}$$

where: t is index of time period, $t \in \{1,\ldots,T\}$; R is set of considered regions; V is set of considered vehicle recycling factories; S_t is set of scenarios in period t; $\mathrm{S} = \bigcup_{t=1}^{T} \mathrm{S}_t$ is set of scenarios in planning horizon; $\mathrm{A} \subseteq \{(s',s) | s' \in \mathrm{S}, s \in \mathrm{S}\}$ is set of conse-cutive scenarios, which is determined in line with the structure of the scenario tree; $\Gamma_s^{-1} = \{s' | (s',s) \in \mathrm{A}\}, s' \in \mathrm{S}$ is set of scenarios that precede scenario s; T is number of analyzed time periods; $f^{\pm}$ is interval value of the expected profit to ELV management system over the planning horizon; $\Pi_r^{\pm}, \forall r \in \mathrm{R}$ is interval value of initial inventory weight of ELVs collected, depolluted, flattened and piled in region r; $I_{vt\,min}^{\pm}, v \in \mathrm{V}$ is interval value of safety inventory level of vehicle recycling factory v in period t; $D_{vrt}^{\pm}, v \in \mathrm{V}, r \in \mathrm{R}$ is interval value of revenue to ELV management system per weight unit of ELVs allocated from region r to vehicle recycling factory v in period t; $K_{vt}^{\pm}, v \in \mathrm{V}$ ($K_{vt}^{\pm} > D_{vrt}^{\pm}, \ \forall v,r,t$) is interval value of loss (i.e. penalty) to ELV management system per weight unit of ELVs not delivered to vehicle recycling factory v in period t; $p_{rst}, r \in \mathrm{R}, s \in \mathrm{S}_t$ is the probability of occurrence for scenario s in region r and period t; $Q_{rst}^{\pm}, r \in \mathrm{R}, s \in \mathrm{S}_t$ is interval value of quantity of ELVs collected, depolluted and flattened by authorized treatment facilities from region r in scenario s and period t; $Z_{vrt}^{\pm}, v \in \mathrm{V}, r \in \mathrm{R}$ is interval value of fixed ELV

allocation target from region r to vehicle recycling factory v in period t; $\gamma_{vrt}, v \in \mathrm{V}, r \in \mathrm{R}$ is decision variable that is used for identifying an optimized set of ELV allocation targets $Z_{vrt}^{\pm} = Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt}$, where $\Delta Z_{vrt} = Z_{vrt}^{+} - Z_{vrt}^{-}$ and $\gamma_{vrt} \in [0,1]$; $M_{vrst}^{\pm}, v \in \mathrm{V}, r \in \mathrm{R}, s \in \mathrm{S}_t$ is interval value of quantity by which ELV allocation target prescribed between region r and vehicle recycling factory v is not met in scenario s and period t; $H_{rst}^{\pm}, r \in \mathrm{R}, s \in \mathrm{S}_t$ is interval value of weight of ELVs piled in region r and scenario s at the end of period t.

In Model (1), the objective function (1a) seeks to maximize the expected profit of the ELV management system through allocating ELVs from multiple regions to multiple vehicle recycling factories over a multi-stage context. In the objective function, the first term calculates revenue to ELV management system from allocating ELVs to vehicle recycling factories. The second term represents the loss (i.e. penalty) to ELV management system for violating the promulgated ELVs allocation targets. Constraints (1b) enforce that under all possible scenarios the quantity of ELVs allocated from some region to vehicle recycling factories handled by the ELV management system cannot be larger than the sum of quantity of piled ELVs across that region and the quantity of ELVs collected, depolluted and flattened by authorized treatment facilities located in that region. Constraints (1c) initialize inventories in regions which covers the considered ELV management system. Constraints (1d) enforce the inventory balances. Constraints (1e) ensure the safety inventory levels in vehicle recycling factories handled by the considered ELV management system in order to protect their shredders from starvation. Finally, constraints (2f)–(2h) define the value domains of decision variables used in the proposed model.

Model (1) can be decomposed into two deterministic sub-models corresponding to the lower and upper bounds of the desired objective value, and solved using an interactive algorithm. The sub-model corresponding to f^{+} can be firstly formulated as follows:

$$Max \quad f^{+} = \sum_{t=1}^{T} \sum_{r \in \mathrm{R}} \sum_{v \in \mathrm{V}} (D_{vrt}^{+}(Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt}) - \sum_{s \in \mathrm{S}_t} p_{rst} K_{vt}^{-} M_{vrst}^{-}) \tag{2a}$$

subject to:

$$\sum_{v \in \mathrm{V}} \left(Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt} - M_{vrst}^{-} \right) \le Q_{rst}^{+} + H_{rs't-1}^{+}, \forall r \in \mathrm{R}; \forall s \in \mathrm{S}_t; \forall s' \in \Gamma_s^{-1}; \forall t \in \{1,...,T\} \tag{2b}$$

$$H_{r10}^{+} = \Pi_r^{+}, \forall r \in \mathrm{R} \tag{2c}$$

$$H_{rst}^{+} = Q_{rst}^{+} - \sum_{v \in \mathrm{V}} (Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt} - M_{vrst}^{-}) + H_{rs't-1}^{+}, \quad \forall r \in \mathrm{R}; \forall s \in \mathrm{S}_t; \forall s' \in \Gamma_s^{-1}; \forall t \in \{1,...,T\} \tag{2d}$$

$$\sum_{r \in \mathrm{R}} \left(Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt} - M_{vrst}^{-} \right) \ge I_{vt\,min}^{-}, \ \forall v \in \mathrm{V}; \forall s \in \mathrm{S}_t; \forall t \in \{1,...,T\} \tag{2e}$$

$$Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt} \ge M_{vrst}^{-} \ge 0, \ \forall v \in \mathrm{V}; \forall r \in \mathrm{R}; \forall s \in \mathrm{S}_t; \forall t \in \{1,...,T\} \tag{2f}$$

$$H_{rst}^{+} \ge 0, \ \forall r \in \mathrm{R}; \forall s \in \mathrm{S}_t; \forall t \in \{0,1,...,T\} \tag{2g}$$

$$0 \le \gamma_{vrt} \le 1, \ \forall v \in \mathrm{V}; \forall r \in \mathrm{R}; \forall t \in \{1,...,T\} \tag{2h}$$

where M_{vrst}^{-}, H_{rst}^{+} and γ_{vrt} are decision variables. Let f_{opt}^{+}, $M_{vrst\,opt}^{-}$, $H_{rst\,opt}^{+}$ and $\gamma_{vrt\,opt}$ be the solutions of sub-model (2). Then, the second sub-model corresponding to f^{-} can be formulated as follows:

$$Max \quad f^{-} = \sum_{t=1}^{T} \sum_{r\in \mathrm{R}} \sum_{v\in \mathrm{V}} (D_{vrt}^{-}(Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt\,opt}) - \sum_{s\in \mathrm{S}_t} p_{rst}K_{vt}^{+}M_{vrst}^{+}) \tag{3a}$$

subject to:

$$\sum_{v\in \mathrm{V}} (Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt\,opt} - M_{vrst}^{+}) \le Q_{rst}^{-} + H_{rs't-1}^{-},\ \forall r \in \mathrm{R};\ \forall s \in \mathrm{S}_t;\ \forall s' \in \Gamma_s^{-1};\ \forall t \in \{1,...,T\} \tag{3b}$$

$$H_{r10}^{-} = II_r^{-},\ \forall r \in \mathrm{R} \tag{3c}$$

$$H_{rst}^{-} = Q_{rst}^{-} - \sum_{v\in \mathrm{V}} (Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt\,opt} - M_{vrst}^{+}) + H_{rs't-1}^{-},\quad \forall r \in \mathrm{R};\ \forall s \in \mathrm{S}_t;\ \forall s' \in \Gamma_s^{-1};\ \forall t \in \{1,...,T\} \tag{3d}$$

$$\sum_{r\in \mathrm{R}} \left(Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt\,opt} - M_{vrst}^{+}\right) \ge I_{vt\,min}^{+},\ \ \forall v \in \mathrm{V};\ \forall s \in \mathrm{S}_t;\ \forall t \in \{1,...,T\} \tag{3e}$$

$$Z_{vrt}^{-} + \Delta Z_{vrt}\gamma_{vrt\,opt} \ge M_{vrst}^{+} \ge M_{vrst\,opt}^{-},\ \ \forall v \in \mathrm{V};\ \forall r \in \mathrm{R};\ \forall s \in \mathrm{S}_t;\ \forall t \in \{1,...,T\} \tag{3f}$$

$$0 \le H_{rst}^{-} \le H_{rst}^{+},\ \ \forall r \in \mathrm{R};\ \forall s \in \mathrm{S}_t;\ \forall t \in \{0,1,...,T\} \tag{3g}$$

where M_{vrst}^{+} and H_{rst}^{-} are decision variables. Let f_{opt}^{-}, $M_{vrst\,opt}^{+}$ and $H_{rst\,opt}^{-}$ be solutions of sub-model (3). Thus, the primal solutions for Model (1) are:

$$f_{opt}^{\pm} = \left[\, f_{opt}^{-},\, f_{opt}^{+} \right], \tag{4a}$$

$$M_{vrst\,opt}^{\pm} = \left[M_{vrst\,opt}^{-}, M_{vrst\,opt}^{+} \right],\ \ \forall v \in \mathrm{V};\ \forall r \in \mathrm{R};\ \forall s \in \mathrm{S}_t;\ \forall t \in \{1,...,T\} \tag{4b}$$

$$H_{rst\,opt}^{\pm} = \left[H_{rst\,opt}^{-}, H_{rst\,opt}^{+} \right],\ \ \forall r \in \mathrm{R};\ \forall s \in \mathrm{S}_t;\ \forall t \in \{1,...,T\} \tag{4c}$$

The optimal ELV allocation scheme over the planning horizon is:

$$A_{vrst\,opt}^{\pm} = Z_{vrt}^{\pm} - M_{vrst\,opt}^{\pm},\ \ \forall v \in \mathrm{V};\ \forall r \in \mathrm{R};\ \forall s \in \mathrm{S}_t;\ \forall t \in \{1,...,T\} \tag{4d}$$

where $A_{vrst\,opt}^{\pm}$ is calculated quantity of ELVs allocated between region *r* and vehicle recycling factory *v* in scenario *s* and period *t*.

3. CONCLUSIONS

This paper introduces the multi-stage interval-stochastic programming model for planning end-of-life vehicles allocation which is applicable across vehicle recycling industry that processes dozens of millions of ELVs every year. The formulated model is based on multi-stage stochastic

programming and interval linear programming approaches. Thus, it can directly handle parameter uncertainties expressed as both probability density functions and discrete intervals.

The presented model is capable of incorporating multiple policies within the optimization framework. It permits comprehensive analyses of various policy situations that are associated with different levels of economic penalties and system failure risks when the promulgated ELV allocation targets are disregarded. Compared with the conventional multi-stage stochastic programming approach, the presented multi-stage interval-stochastic programming model for planning end-of-life vehicles allocation can incorporate much more uncertain information. Finally, it can be outlined that the proposed model is more than effective in tackling hard, uncertainty existing waste management problems. Future research will focus on extensive testing of the formulated model.

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OPTIMIZATION OF INTERNAL LOGISTICS IN A WASTE MANAGEMENT COMPANY WITH QUEUING THEORY

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Abstract: *The number of companies for collection, processing and disposal of waste is increasing, as is the amount of waste we produce. Bigger companies have their own vehicle fleet, their own collection centers and they often cover large geographical areas. For such network of supply of services, a quality logistic organization is needed. The paper focuses on a case study of a Slovenian waste management company, which has a well-organized external logistics system on one hand, but a lacking organization of internal logistics on the other. The paper will focus on potential for optimizing the process of vehicle weighing and fuel filling, since this process represents a bottleneck of the internal logistics. Congestions appear often due to excessive vicinity of the weighing device and the gas pump. During the refueling of a bigger truck the weighing device becomes useless as the truck trailer is still standing on the balance. The paper will present different improvement scenarios for internal logistics, which will be calculated using stochastic processes and queuing theory.*

Keywords*: waste management, internal logistics, queuing theory, case study*

1. INTRODUCTION

Logistics functions can be divided into external and internal, and this paper will focus on the latter. Internal or in-house logistics is comprised of transport in a company, all internal processes and all internal flows of materials and people. Many costs can be avoided with optimal planning of these processes. In the past it has been shown that in the short term, many optimization changes are not sensible, but in the long run may mean a significant move in the direction of optimal logistics. This is the case also in the researched company for the collection, treatment and disposal of waste. Because of the bottleneck in the process of weighing trucks on returning to the collection center and refueling with gas, losses are caused by waiting. Hourly rate of the driver, vehicle depreciation, opportunity costs, longer operating costs and much more are costs, which the company is not aware of and so far have not been measured. The focal company has been increasingly faced with spatial problems in recent years due to the increased volume of work, which in turn affects poor organization of internal transport at the collection center. The aim of the research is to examine the processes of internal transport at the collection center of the company and thus show the current situation. Processes will be examined by a thorough analysis of the data, mostly focusing on the bottleneck situations. The final goal is to demonstrate how using queuing theory can affect a company's performance and improve processes which in turn means reduced optimized internal logistics to save on the cost of the organization, labor costs, cost of resources and time.

2. METHODOLOGY

The case company is located in Slovenia and covers a large portion of its vicinity in terms of general waste management services. Additionally, they perform services of specialized waste management for known customers, such as medical or metal waste disposal and recycling.

Research for this paper is performed in three segments. First, it is necessary to analyze the current situation with the use of longitudinal data, topological layout analysis and internal transport processes. With this, the actual losses of time in different situations will be possible to calculate. Based on this, a queuing model will be assembled in order to further assess processes of internal transport. Finally, possible scenarios for improvements will be presented.

The processes of internal logistics in the case company can be described as queues and therefore have the potential to be analyzed and optimized using queuing theory. Queuing systems include one or more servers, queuing nodes - customers requiring service, and the process of serving. Where it is not possible to serve all customers at the same time, customers must wait to be served in a queue (Hudoklin-Božič, 1999, p. 136). In the presented case, the customers of the queue are the drivers of cargo vehicles, which carry the waste and other material into the collection center. Servers are the scale where vehicles are weighed and the fuelling tank. If the number of vehicles weighing in and refueling is more than one, this results in queues. The arrivals of vehicles to the collection center are not at regular intervals, therefore the succession of arrivals of vehicles to the center forms a Poisson process.

According to Hudoklin-Božič (1999, p. 139), the M / M / 1 queuing system is subject to an input stream of customers described as a Poisson process, serving times are exponentially distributed, the number of servers is 1. Such queuing systems ca appear in practice also in a slightly modified or more complicated version – when the queue is in fact a network, consisting of two stations in a tandem with a finite intermediate buffer (see Tsiotras, Badr & Beltrami, 1987).

Applied to the situation in the case company, such a system can be used to determine the operating capacity of the weighing scale and fuel pump as two independent units, which are also co-dependent because of their placement in the topology of the collection center. These are the basic arguments and assumptions that are based on an assessment of internal logistics processes at the collection center of the company. Due to this topography, the queuing system in the company is a two-stage tandem queuing system with two stations and a finite buffer between both stations, where the scale is the first station and the weighing unit is the second station, interdependent on the scales.

3. ANALYSIS OF INTERNAL LOGISTICS IN THE CASE COMPANY

Basic and also the main activity of the company is collecting, processing and disposal of waste. Location of their collection center is less than 5 km off the main highway, which does not cause logistical problems. The biggest logistical problem is represented by internal layout of buildings and lack of maneuverability areas for large vehicles.

In Figure 1, internal flow of transport is shown. Vehicles that enter the collection center are obliged to weigh in, except if they are empty. In this case, they turn left, past the scale. Upon completion of the weighing process, certain vehicles refuel, other continue to the destination in the center. The vehicles which are owned by the company must always refuel only at the collection center and not on any other external fuel stations.

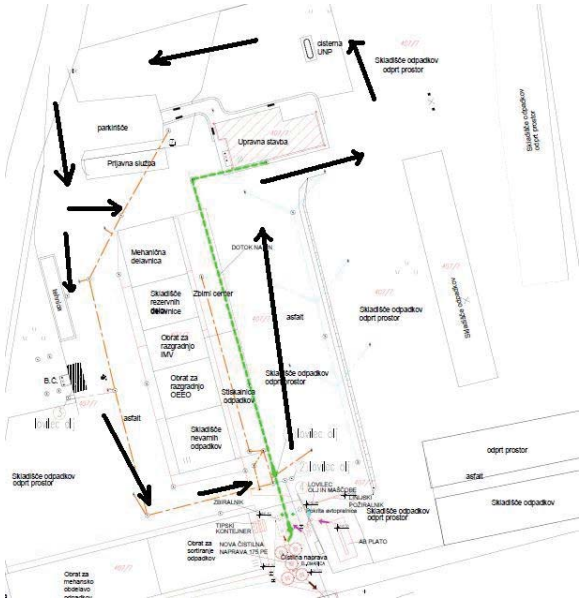


Figure 1. Layout of the collection center and internal transport flows (Source: Internal data from the case company, 2013)

2.1 Refueling and weighing

During the company's daily operations, on average 83 vehicles are weighed, while 13 vehicles averagely refuel. Towards the end of the month, that number rises for as much as 50%. Bottlenecks and losses are generated mostly in the process of weighing and refueling the vehicle. Every vehicle in the center brings waste, must necessarily be weighed first. Because of this, drivers must wait up to 30 minutes to be able to weigh the vehicle and must not complete any other operation prior to that. Weighing vehicles takes on average not more than two minutes, meaning that the average waiting period should not be more than 6 minutes. The flow of vehicles is stopped if any vehicle is refueling. Due to lack of space in the area of the scale and refueling unit, vehicles cannot leave the scale if a vehicle is refueling and cannot even pass by.

The first step was to analyze longitudinal data concerning weighing and refueling. Table 1 shows the recorded data on the number of refuels during the months of January 2013 through October 2013 with a total sample of 272 working days. The average flow of the fuel tank is 70 l / min, with an average of vehicles pumping 155,4 liters of fuel at a time. The analysis of refueling times in relation to the entire sample shows that most refueling occurs in two peaks. Most refuels occur in the morning between 6 and 7 am, when the vehicles are leaving the center, and another peak is in the hours between 14 and 17 pm after the vehicles return. A graphical representation is shown in Figure 2. Additionally, in-depth observations of internal logistics on the company location was performed in the period between 30. September 2013 and 6. October 2013. Analysis of observed data shows that the highest average of arrivals for refueling per hour is 3 vehicles, which is in the period between 14 and 15 pm. Average serving time for refueling was 5,25 minutes.

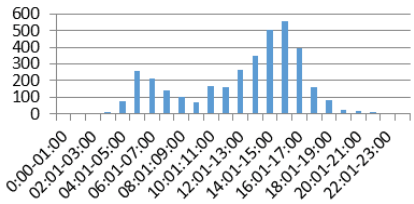


Figure 2. Distribution of refueling occurrences by hours of the day

The same analysis was prepared for the arrival of vehicles to the weighing scale. This distribution by hours of the day is shown in Figure 3. The data shows the entire period of 2013, i.e. 365 days. On the graph of the number of weighings by hours it can be observed that the density distribution is a little different than the distribution of arrival for refueling. Most of the weighings occur between 13 to 14 hours, a little less in the hours before and after this time. The average time for weighing is 2 minutes.

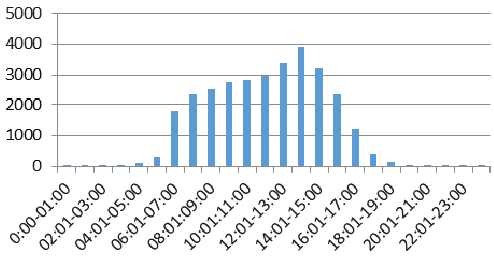


Figure 3. Distribution of weighing occurrences by hours of the day

If the two distributions are compared, it is evident that the greatest potential for congestion in front of the scales is between 13 and 15 pm.

2.1 Queue model

For each server, namely the weighing scale and fuel tank, stochastic processes can be used to analyze and optimize the serving processes. M / M / 1 model of queuing is the basic model with stochastic processes, based on an infinite population of customers and serving discipline "first come, first served". This is the case in the weighing and refueling processes in the case company. The vehicle which first moves onto the scale will be weighed first, and the vehicle which first moves to the fuel pump will be the first to refuel. Since each server is treated separately, it is sufficient to calculate the basic M / M / 1 model.

For the calculation of the queuing model, the following calculations are needed (Cloud & Rainey, 1998, p. 66):

- utilization of servers; $\rho = \frac{\lambda \cdot E(W_S)}{c}$ (1)
- probability that the servers are busy; $C\ (c, \rho) = \frac{\frac{(c\cdot\rho)^c}{c!}\cdot\frac{1}{1-\rho}}{\sum_{n=0}^{c-1}\frac{(c\cdot\rho)^n}{n!}+\frac{(c\cdot\rho)^c}{c!}\cdot\frac{1}{1-\rho}}$ (2)
- average number of waiting vehicles $L_q = E(N_q) = \frac{\rho \cdot C(c,\rho)}{1-\rho}$ (3)
- average waiting time in the queue $E(W_q) = \frac{E(W_S)}{c\cdot(1-\rho)}$ (4)

Strength of arrivals is obtained from a simple calculation of the average value of the number of arrivals, which was measured only during peak frequencies from 6 pm to 17 pm, in the days from Monday to Friday. In the observed time period, 279 vehicles per week were weighed. In the same time period, 88 vehicles per week refueled. Therefore, the intensity of the input current – arrivals to the weighing scales is 0,1, the intensity of arrivals to refueling is 0,05. Using this data, the inputs and outputs of the queue model were calculated using equations above and are shown in Table 1.

Table 1. Results of the M/M/1 model for the weighing scale and refueling station

	weighing scale	refueling station
c = number of servers	1	1
X = arrivals (vehicles/min)	0,1	0,05
Ws = average serving time (min/vehicle)	2	5,25
Ro = utilization of servers (portion)	0,2	0,2625
C = probability, that the server is occupied (portion)	0,2	0,2625
Lq = average number of vehicles waiting to be served	0,5	0,0934
Eq = average time of vehicles waiting to be served (minutes)	2,5	7,1186

The weighting location, which is treated as server 1, has a 20% occupancy rate. The computation shows that the scale could be even more burdened is the layout of the center would allow passage past the scales. Since the occupancy of the server is less than 1 (or 100%), the likelihood that the server is busy is the same as the occupancy rate. In the case of an occupied server, the average waiting time is 2,5 minutes, the average number of waiting vehicles is 0,5.

For the server 2, the fuel tank, the situation is very similar. A distinction is made in relation to the arrivals of vehicles and occupancy of the server. The occupancy of the refueling server is 26%. Also here the probability that the server is occupied is 26% as the occupancy is less than 100%. Average number of vehicles waiting in the queue is less than 0,1. From the data it is seen that despite the smaller number of vehicles arriving to server 1, server utilization is slightly higher due to the longer serving time. All of these times are offering a reserve for optimization: if the vehicle must wait in line for refueling, the average waiting time is 7,1 minutes.

With these calculations it was proved that both servers allows for the smooth functioning of the internal logistics processes in relation to the current flow. The data gained by observations in the company show an opposite story. Drivers are losing too much time waiting for one of the servers, the weighing scale or the fuel tank, to be free. From this it can be concluded that the main reason for delays in the collection center is the incorrect placement of both servers, i.e. one directly after the other.

The collection center additionally has more circumstances which prevent the smooth unwinding of internal transport. Failure to comply with traffic regulations in the center is a major problem due to lack of space for manipulation of vehicles. Since vehicles are driving in the opposite direction on designated one-way areas, there is significant congestion and certain vehicles must recede backwards, which is not easy due to space restrictions and interruptions to other

business operations. Another problem is the parking of vehicles and other means of transport in places where this is expressly forbidden.

4. CONCLUSION

More and more households and production facilities are generating and more waste, which has to be removed and managed by specialized companies. An example of such a company was discussed in this paper. The case company has a problem with internal logistics at their collection center. At present there is a lot of overcrowding, since the amount of gathered waste material is relatively large given the amount of available space. The biggest bottleneck of the collection center of the company constitutes the system of weighing and refueling the vehicles.

Currently the process of internal transport takes place so that the vehicle arriving to the center has to be weighed. The weighing scale is not necessarily free, as it can be occupied by a vehicle waiting for another vehicle to refuel due to the topology of the center where the fuel pump is located immediately behind the scale. During this time there is a possibility that a queue of vehicles forms that should be weighed or refueled.

The main problem of the paper was to identify whether there is a possibility of reducing these queues with the given parameters. The company is aware that the forming queues bring unnecessary costs, but did not know how to evaluate them. The research showed that in the case of a change of topology, the queues would more or less cease to be problematic, since the server capacities are sufficient to support the company's needs.

Moreover, some other optimization solutions exist. The first proposal is to consider outsourcing the refueling service to an external provider on remote fueling stations outside of the company. Taking into account all investment factors, fixed costs and the potential sale of the fuel pump, this solution could bring a reduction of expenses (excluding the fuel itself) of as much as 75% within five years. The following proposed solution is to update the system for weighing and data entry. In this case, the use of automatic weighing system with RFID terminal is proposed. By calculating the savings, it can be assessed that it is possible to achieve 50% cost reduction compared with the existing system within five years. Both these solutions would additionally contribute to the reduction of queuing problems at both servers and even their diminishment.

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EXPLOITATION INDICATORS OF RETREADED TIRES DEPENDING ON THE NUMBER OF RETREADINGS

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Abstract: *The usage of retreaded tires is becoming more common due to the effects that are achieved by this method. In practice, the distance travelled by a retreaded tire is a key parameter that shows the effects of retreading itself. This parameter is not independent of the number of previous retreading, and, as a rule, it is a random variable. This paper presents a set of output results obtained by the statistical analysis of the database of travelled distance depending on the number of previous retreading but also on the previous exploitation history of the tire. In practice, these analyses may be of importance in making decisions about further exploitation – retreading of tires.*

Keywords*: retreaded tires, number of retreading, number of retreading of tires, statistical analysis.*

1. INTRODUCTION

Tires belong to the category of wearing products/parts which appear during the exploitation of a vehicle. Once the working life of a tire has expired, it is usually classified into a category of waste, which means that it gets its index number (19 12 04) determined according to the Waste Catalogue (Belgrade, 2010). When it is disposed on the ground as waste, that is, at a landfill, its decomposition lasts for more than 150 years and as such it represents a threat to the environment (Hammond at al. (2009)). One of the treatment modes of these parts of the vehicle, allowing to use them again – restoring their function after their tread has been worn out, is called retreading – a procedure consisting of application of a new tread on a prepared/treated tire (Hammond at al. (2009) and Dabić-Ostojić (2014)).

The use of retreaded tires for commercial road vehicles has been growing, both worldwide and in our country. The reason lies in a number of positive effects reached by this procedure. Retreaded tires are cheaper than the new ones with equivalent standard and almost identical quality; retreading of tires leads to important savings in money ranging to about 45% (cost of a retreaded tire compared to the cost of a new one). This procedure has also a positive effect on the environment – about 5 l of fuel is used for the process of tire retreading instead of 35 l for the manufacture of a new one (Dabić-Ostojić (2014) and Dabić at al. (2013)).

A special group of problems concerns the exploitation of retreaded tires. Regarding this aspect, one of the most important parameters are the number of retreadings (NRT) and the distance travelled by a tire (TD) (of a new tire and after each retreading). It can be deduced that there are

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few papers dealing exclusively with the decision making during the exploitation of retreaded tires. This is the reason why the authors of this paper have decided to devote themselves to these issues. In practice, the question is often if retreading is useful and how many times it can be done and what decision shall be made? It is especially important to bear in mind that the costs of tires are among the highest exploitation costs related to commercial vehicles (Gavrić at al. (2009) and Boustani at al. (2010)).

In order to decide whether a tire shall be retreaded or not and if yes how many times, it is necessary to carry out appropriate statistical analyses and obtain appropriate results related to its exploitation (Dabić-Ostojić at al. (2013)). The aim of this paper is to identify certain causal connections concerning the relationship between TD and NRT on the basis of a sample of tires belonging to a subset of the vehicle park of the largest company for public city and suburban passenger transport in Belgrade.

Having this in mind, the paper includes different parts. After the introduction, the second part of the paper presents statistically processed data, mathematical expectations (μ) and standard deviations (σ) for the subset of the above mentioned sample of tires with the highest participation of tires according to the number of retreadings (up to 3) and TD classes (from 20 to 40.000 km, from 40 to 60.000 km and 60 to 80.000 km). There has been observed the mutual dependence between NRT and TD and there has been discovered that there are some deviations regarding this relationship which require more detailed statistical analyses. They have been carried out within this part of the paper divided into two units. Within the first unit, we have observed the change of parameters μ and σ after the I, II and III retreading for the above mentioned TD classes. The second unit of this part of the paper includes only the analysis of the parameter μ according to the different TD classes after the I and then after the II and III retreading individually. The fourth part of the paper includes a conclusion based on the realized analysis which has also indicated potential directions of the future research.

2. STATISTICAL PROCESSING RELATED TO A SUBSET OF TIRES

When the tread of a tire is obsolete or damaged, the decision related to its next retreading or dismiss should be made. Beukering and Janssen (2001) assume that TDs of retreaded tires are the same as the new ones. Ferrer (1996) presumes that the TD of a retreated tire is reduced after every retreading process and that total NRT also depends considerably on the manufacturer – it is not unlimited. In that case, there are two important issues, the first one related to the NRT by that moment and the second one concerning the TD during the exploitation. It can be assumed that these two parameters are random values, since they depend on a number of factors (manufacturer, driving conditions, road quality, type/load of vehicle, mode of driving…). It is clear that these parameters have been observed for homogenous groups of tires and conditions of their exploitation. As illustration, the Table 1 presents the results of statistical processing of TD of a tire depending on the NRT for the analysed sample.

Table 1. Average TD of a tire as a new one and depending on the NRT

NRT	*average TD (km) depending on NRT*
0 (as a new one)	70256
1	35237
2	32830
3	36971
4	30738

The Table 1 generally shows that the increase of NRT causes the decrease of TD of a tire. This correlation can be described by the exponential trend with the correlation coefficient, R^2=0.7586.

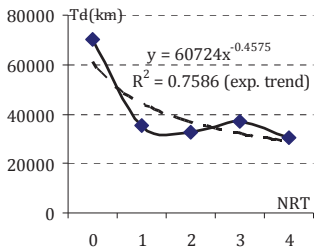


Figure 1. Dependence of (TD) by tire on NRT – exponential trend

The diagram of the Fig. 1. shows that TD decreases by the second retreading, then increases slightly after the third one and then decreases again. These oscillations have initiated a more detailed analysis of the above mentioned dependence in order to obtain a basis for a better decision making regarding retreading and it will be carried out further down in this paper.

3. DATA ANALYSIS FOR THE SUBSET OF A RETREADED TIRE SAMPLE

In order to search for the specificities of the relationship between TD and NRT, in this part of the paper we have carried out some additional analyses regarding the change of TD after a characteristic NRT. The first analysis included the application of statistical parameters of the number of tires (μ and σ) especially after the I, II and III retreading, according to TD classes. The second analysis included a change of the parameter related to the number of tires (μ) but only for characteristic TD classes.

3.1 Analysis of statistical indicator after each retreading

Within this unit of the paper, the analysis has shown the frequencies of the number of tires according to the TD classes depending on NRT. As input values, there have been used the frequencies of the number of tires (obtained from the data base), given in Table 2 (Dabić-Ostojić (2014)).

Table 2. Frequency of the number of tires depending on the TD after the I, II and III retreading

	TD after I retreading (000 km)		
TD of new tire (000 km)	*20-40*	*40-60*	*60-80*
20-40	**25**	**36**	**10**
40-60	**43**	**55**	**13**
60-80	**14**	**10**	**1**
	TD after II retreading (000 km)		
TD after I retreading (000 km)	*20-40*	*40-60*	*60-80*
20-40	**22**	**17**	**2**
40-60	**22**	**20**	**3**
60-80	**7**	**4**	**0**
	TD after III retreading (000 km)		
TD after II retreading (000 km)	*20-40*	*40-60*	*60-80*
20-40	**9**	**6**	**2**
40-60	**4**	**6**	**0**
60-80	**0**	**2**	**0**

Statistical processing of data from Table 2 has provided the parameters (μ and σ of the number of tires) given in tables 3, 4, 5 for the different TD classes after the I, II and III retreading. These values are presented by a diagram on the Fig. 2.

Table 3. Parameters related to I retreading

TD after I retreading (000 km)	**μ** (tires)	**σ** (tires)
from 20 to 40	**34.69**	**37.32**
from 40 to 60	**36.96**	**39.74**
from 60 to 80	**38.46**	**41.77**

Table 4. Parameters related to II retreading

TD after II retreading (000 km)	**μ** (tires)	**σ** (tires)
from 20 to 40	**31.77**	**35.39**
from 40 to 60	**32.03**	**35.45**
from 60 to 80	**27.86**	**29.62**

Table 5. Parameters related to III retreading

TD after III retreading (000 km)	**μ** (tires)	**σ** (tires)
from 20 to 40	**20.60**	**25.47**
from 40 to 60	**20.98**	**26.60**
from 60 to 80	**18.53**	**21.44**

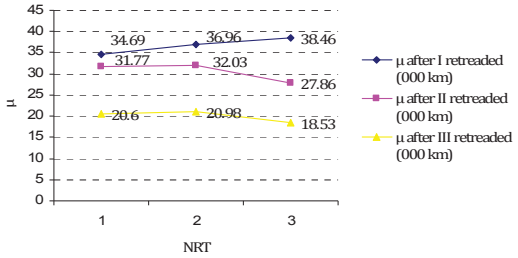


Figure 2. μ of NRT depending on TD

In order to obtain additional basis for decision making regarding retreading, it has been necessary to analyse the statistical indicator μ, that is, its values, but for the above mentioned TD classes. This has been done in the following unit of this part of the paper.

3.2 Analysis of the parameter μ after each retreading for the characteristic TD classes

Based on the analysis carried out after each retreading, but separately for each of the TD classes, the table 6 presents the change of the parameter μ. It can be concluded that μ of the number of retreaded tires decreases with the increase of the NRT, namely within each of the TD classes, which is shown by the diagrams of the figures 3, 4 and 5.

Table 6. μ of tires (for TD classes) for I, II and III retreading

TD (000 km)	**μ** (tires) after **I** retreading	**μ** (tires) after **II** retreading	**μ** (tires) after **III** retreading
from 20 to 40	**34.69**	**31.77**	**20.60**
from 40 to 60	**36.96**	**32.03**	**20.98**
from 60 to 80	**38.46**	**27.86**	**18.53**

In order to test the change of the parameter μ there has been done a dependence analysis describing this relationship. There has been observed that for TD in the class from 20 to 40.000 km (Fig. 3.) this correlation (with R^2=1) is best described by the polynomial trend of the 2nd

degree. The same trend describes the correlation of μ and NRT when TD is in the class ranging from 40 to 60.000 km (Fig 4.), as well as when TD is in the class from 60 to 80.000 km (Fig. 5.).

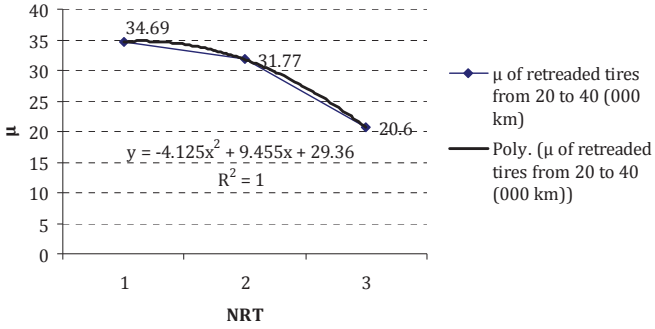


Figure 3. μ of retreated tires (TD from 20 - 40.000 km)

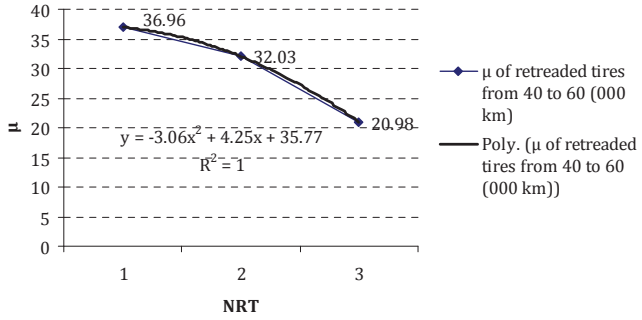


Figure 4. μ of retreaded tires (TD from 40 - 60.000 km)

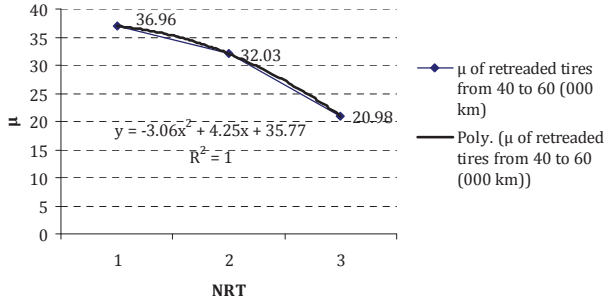


Figure 5. μ of retreaded tires (TD from 60 - 80.000 km)

4. CONCLUSION

Decision making of a transport company deciding whether to by new tires or retread the used ones is especially important for the use of retreaded tires that have reached the wear limit of the tread. Therefore, it is necessary to know the exploitation parameters of tires, while the accent shall be on the specificity of the change and relationship between NRT and TD. The results obtained in this paper have indicated important stochastic character of these parameters, but

also a high level of correlation between these values although the concerned sample of tires has homogenous exploitation conditions.

According to the realized analyses, there has been observed that there are certain correlations related to the decrease of the TD of tires depending on the NRT, which puts in question the hypothesis of Beukering and Janssen (2001) saying that these values are independent from each other (Dabić Ostojić (2014)), as well as the hypothesis of Ferer (1996) that the NRT is unlimited.

Based on the results obtained by sample processing, it is concluded that in real working conditions of a transport company it is necessary to carry out continuous and detailed statistical analyses in this field. Such a data base and its processing would indicate the behaviour of the relevant parameters.

For other combinations of the above mentioned exploitation conditions (non-homogenous vehicle park, characteristics of a road…) the necessary analyses could be done in an appropriate manner. This would ensure an appropriate base for decision making on retreading for each tire separately which is of extreme importance for rational business of a transport company.

ACKNOWLEDGMENT

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Part IX STUDENTS' PAPERS

CITY LOGISTICS OF BELGRADE WATERFRONT

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Abstract: *The importance of city logistics is increasing with urban areas' sprawling and development. Considering that logistics activities have a great influence on the system competitiveness and sustainability, it is necessary to pay special attention to their planning. The beginning of „Belgrade Waterfront" project realization requires defining the plan of logistics processes and activities. This paper shows the problems and gives some potential logistics solutions in both construction and planned facilities functioning phases.*

Keywords*: city logistics, construction logistics, supply logistics*

1. INTRODUCTION

Being a city situated on two rivers, the potential of Belgrade is underused. The bottomland value is priceless, but it is not properly exploited. In the past, the various projects were planned on this area and they were aimed at the development of more profitable business activities, modernization and attractiveness growth of the city. The „Belgrade Waterfront" is current and adopted reconstruction project of a part of Sava's bottomland. On the location of outdated industry, where some of the national minorities found his harbourage, in the very heart of the city, Master plan envisages the construction of attractive residential and commercial facilities (http://www.rapp.gov.rs). Considering that Belgrade is a city with a rich history and beautiful architectural heritage, the certain number of buildings will be renewed within „Belgrade Waterfront" project and will retain their original appearance.

The construction of the planned complex is a great challenge for the city logistics. The large construction site, with numerous contractors and subcontractors, will generate the intensive goods and material flows for a longer period. The lack of planning, management and control of supply flows and returnable and waste material extraction from this area could have serious consequences for the functioning of the whole city, especially of central and urban area of Belgrade. On the other hand, the construction by phases of planned residential-commercial facilities allows their settlement by phases. The activating of various urban functions (residential, trading, catering etc.) will increase the logistics demand heterogeneity and the problems of people and goods flow realization. By moving the people into buildings, the demand for their supplying, i.e. the various goods, material and freight delivery, will emerged. The dominant role of road transport in these flows' realization and their adverse environmental effects, especially in terms of noise, air pollution and traffic safety, will cause the decline of urban system efficiency and quality of life. In order to avoid this scenario, it is necessary to define the city logistics conceptions which will allow the undisturbed construction work and efficient

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functioning of newly constructed systems, provide the attractiveness of these part of the city and improve the quality of life in it. The conceptions should be defined in accordance with the interests of all participants, city logistics stakeholders (Zečević & Tadić, 2006; Tadić & Zečević, 2009; Tadić et al., 2014).

This paper aims to perceive the problems and goals, i.e. the importance of logistics in urban area construction and functioning. The problems related to „Belgrade Waterfront" construction logistics and the supplying of planned facilities, as well as the possible solutions of them, are presented.

2. BELGRADE WATERFRONT PROJECT

According to the project, "Belgrade Waterfront" (Figure 1) covers an area of 1.85 millions of squared meters and includes the space on right Sava's riverside, from Railroad Bridge to Branko's bridge. The project construction is planned to be implemented in four phases (http://www.rapp.gov.rs).

The first phase includes the construction of the space situated among Old Sava Bridge, river Sava and future Sava Boulevard. Two 170 m tall buildings and a shopping mall, as well as the other residential and business facilities, are planned to be constructed on this area.

The second phase includes the space between Branko's bridge and Old Sava Bridge, as well as the space between Gazela Bridge and the Fair. At this site it is being constructed the facilities of cultural and historic importance, as well as the cycling bridge which also may have a role in supplying the city with easier shipments.

The third and fourth phases envisage the construction of space situated among Old Sava Bridge, Gazela Bridge, Sava Street and future Sava Boulevard. In this phase, the various purpose buildings are constructed, but the number of floors is significantly smaller compared to that in previous phases.



Figure 1. "Belgrade Waterfront" project (http://www.beobuild.rs)

This project will engage numerous Serbian construction companies, improve the economic development and the city and region attractiveness, and its realization requires a serious concept of city logistics.

3. CONSTRUCTION AND SUPPLY LOGISTICS OF BELGRADE WATERFRONT

The all kinds of goods, freight and material flows are present in the city. Depending on the type of generator running the flow, the quantities and forms of appearance vary and the flows are present permanently, once or several time during a day or occasionally. During the realization, the flows are passing through the various systems and require various services (Zečević & Tadić, 2006).

Due to the high concentration of urban functions, the central urban areas generate the significant part of logistics activities, primarily the freight transport. In the current situation, the generators from the central area of Belgrade initiate the running of several thousands of road freight vehicles of various types, on a daily basis (Tadić et al., 2014). Their presence induces a series of effects on both business performance of participants and environment and quality of life. In the attractive part of Sava's bottomland, the "Belgrade Waterfront" project envisages the development of various residential and business-commercial facilities with architecturally and visually modern buildings. The project realization and the new plan require new logistics solutions. On the one hand, the demand for providing the sites with construction materials is emerging, and along with this, the supplying the facilities that will be activated by phases.

3.1 Construction logistics of "Belgrade Waterfront"

The construction logistics includes planning, organization, coordination and control of flows and logistics activities that are related to construction project realization (Duiyong et al., 2014). The scope of envisaged works and the site of "Belgrade Waterfront" project indicate the additional complexity and problems of logistics in both narrow and broader areas of the construction site.

In the current situation, the high traffic density in this urban area causes huge problems from the aspects of both congestion and road safety and ecology etc. The street network is not adjusted for the efficient freight vehicle management. This problem is particularly present in the morning hours when the transport flows overlaps the people flows, thus resulting in their mutual disturbance. The requests for construction material delivery will significantly worsen the situation by running the additional heavy duty vehicles. A special problem is JIT (Just in Time) deliveries, which are dominant in the construction industry. In addition, it will emerge the problems of the material disposal, i.e. of its storage at the site. Due to the high traffic congestion and with aim to deliver the goods timely, the vehicle comes earlier to the delivery point and wait for unloading, thus worsening the congestion and disturbing other road users. The efficient distribution of the construction material requires the supply chain management and the cooperation between construction companies and suppliers and their adaptability to various changes that may occur (Ahmetasevic & Samuelsson, 2014). The lack of the planning, cooperation and coordination of the logistics flows and activities generated by future construction site may have serious consequences for the functioning of Belgrade's urban area and for the project realization efficiency.

In order to reduce the number of vehicle runs and traffic jams generated by freight vehicles during a construction material delivery to the construction site and to improve living and working conditions, it is proposed to introduce the city logistics terminal for the consolidation of smaller material deliveries. The participation of numerous contractors and subcontractors in project realization involves the numerous daily deliveries of various materials at different locations within a construction site. The city terminal has to be able to accept all small deliveries, to consolidate them and delivery to a specific location according to the work schedule, as well as to provide the temporary storage of the construction material. In order to avoid traffic jams, the supplier or construction manager has to announce the vehicle arrival and the delivery which is not taking place through the city terminal. Based on the delivery plan, each supplier is provided with a time interval within which the delivery should be realized (Zečević & Tadić, 2006).

This system allows the coordinated delivery flows management and timely supply of construction sites, without the additional congestion within and near the construction site.

There are numerous examples of city terminals supplying a construction site, e.g. in London (Transport for London, 2008) and Stockholm (Ottosson, 2005). The stated advantages of the consolidation centre involve (Transport for London, 2008):

- Reduction in goods and vehicle movements at the construction site
- Reduction in deliveries realized by smaller vehicles; the higher-capacity vehicles are used
- Absorption of CO_2, noise and vibrations
- Increase of the supply network capacity
- Delivery reliability improvement
- Savings for drivers; they deliver the goods to the consolidation centre rather than to the construction site
- Savings for contractors waiting for the delivery
- Reduction in the waste material
- Waste material and packaging are collected in the centre
- Centre provides the opportunity for repairs and recycling services etc.

However, the successful implementation of the consolidation centre concept requires (Transport for London, 2008):

- Trained and informed labour force; tendency to the error elimination
- Control of delivered goods from the consolidation centre to the construction site
- Insurance of goods if it is profitable
- Temporary warehouse construction

By studying the disadvantages, the clearer picture of the opportunity to implement a consolidation centre concept for the construction logistics realization is obtained. These disadvantages are manifested by the lack of knowledge in people that will be the work leaders at the construction site. Considering that aspect, it should emphasise how it is necessary to involve the logistics thinking (Transport for London, 2008).

3.2 Supply logistics of "Belgrade Waterfront"

As a capital city, Belgrade is an administrative and economic centre which makes it the largest generator of goods flow. Although, the problems of logistics activities and goods flows are solving partially and individually, without considering the entire city logistics system and plan. The increase in the number of generators in the urban area of the city and the construction of "Belgrade Waterfront" will result in significant worsening of the logistics problems and adverse effects on the environment and quality of life.

Supply and extraction logistics is essential for the urban area prosperity, but simultaneously it is a source of problems from the aspect of the environmental protection, traffic safety and availability. Increasing requirements in terms of the speed, flexibility, reliability and diversity of logistics services and the lack of planning activities and long-term logistics plans influence the increase of commercial vehicle volume and the loss of urban vitality. Without appropriate city logistics solutions, the supplying of new "Belgrade Waterfront" facilities will worsen the current situation. On the other hand, the modern urban concept of the urban riverside area development requires the modern logistics concept. Herein defined conceptions are compatible with the development plan of this attractive urban area and involve the implementation of new, old solutions for the logistics chains realization in the city. In order to meet the new demand, i.e. planned business-commercial facilities in the attractive part of central urban areas, but also the solutions of the current problems, two logistics conceptions are defined:

Conception 1: Construction of a city logistics terminal for consolidated supply of generators in the gravitation area. The goods delivery from logistics centres, situated at other locations, to the city logistics terminal would be realized by implementation of cargo tramway, while distribution to the generators in the gravitation area would be realized by electric vehicles. The main advantages of this conception involve (Tadić & Zečević, 2009): delivery consolidation and minimum of vehicle movements; cargo tramway implementation for reducing the urban street network congestion, thus having a positive impact on traffic safety, air pollution and road maintenance costs; the use of electro vehicles significantly reduce the adverse environmental effects. Besides these significant advantages, this conception has some disadvantages. First, a part of goods (perishable groceries, daily newspaper etc.) has to be delivered in the conventional manner, by conventional road delivery vehicles without transhipment and consolidation (Tadić & Zečević, 2009). In addition, the cargo tramway implementation impairs the flexibility of a "Just In Time" delivery due to the use of existing fixed infrastructure (Robinson & Mortimer, 2004).

Conception 2: Construction of underground logistics system for supplying "Belgrade Waterfront". The goods would be delivered to the logistics centre at the edge of this urban area according to the city logistics conception of the whole city. The logistics centre is a link with the environment and offers the storage, sorting and commissioning services as well as the preparation of units for the underground system and delivery to the generators. The system would have several stations for accepting/shipping the goods. The flows between the station and generator would be realized by non-motorized transport modes (by walking, cycling or by handcarts). The environmental advantages of undergrounding freight transport are numerous: street network clearing, reduction in traffic congestion, energy consumption, hazardous gases emissions, noise, traffic safety improvement and more rational use of the existing space. In addition, there are significant advantages for the logistics: faster delivery, less damage to the goods, weather conditions not undermining flow realization. Besides all the advantages, this system implementation requires a long construction time and large investments, so it is necessary to determine its justifiability.

Considering that both conceptions have some advantages and disadvantages, the final choice requires more detailed analysis and estimation from the aspect of numerous criteria. The criteria should be defined in accordance with economic, environmental and social sustainability indicators.

4. CONCLUSIONS

A city is a concentration point of various functions and social-economic systems. The succesful functionning requires planning of logistics systems and activities and defining city logistics plans. The city logistics should provide an efficient and environment-friendly realization of the goods flows. "Belgrade Waterfront" generate new logistics demand in both construction and planned facilities' activation phases and requires solving numerous logistics problems. Inadequate logistics organization will lead to the serious disturbances in the functioning of this area and the whole city.

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CONSTRUCTION LOGISTICS OF BELGRADE WATERFRONT

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Abstract: *"Belgrade Waterfront" is the one of the most important projects of the city of Belgrade and currently the largest investment project in this part of Europe. The undisturbed project realization requires serious planning and management of the complex and intensive flows of goods, freight, material, people and information, as well as the flows of vehicles and mechanization, so it is the major challenge for the city logistics and construction logistics. This paper describes the construction logistics problems of "Belgrade Waterfront" and possible solutions. The location of temporary logistics centres, the problems of supplying the construction sites with materials, the supply chain management and the role of the reverse logistic during the project realization are considered.*

Keywords*: construction logistics, delivery flows, reverse logistics, logistics consolidation centre*

1. INTRODUCTION

The construction logistics involves all technologies, rules, methods, knowledge and solutions related to the movement of material and other types of resources in construction flows (Duiyong et al., 2014). From the aspect of the project realization scheduling, it could be divided into three segments (Duiyong et al., 2014). The first segment is related to the logistics before starting the construction and involves supplying a construction site with necessary goods, labour force and mechanization to start the work. This construction logistics' segment is very important and allows undisturbed construction starting. The basic project is following by the logistics during the construction, where the good communication among all construction site sectors is of particular importance for efficient logistics flows realization and undisturbed construction. The third construction logistics' segment is related to the period after the completion of construction works and involves the activities related to the removal of various types of waste for their proper disposal at landfills, recycling and other renewal options. This paper presents the general project overview, construction logistics problems, possible solutions and the logistics concept of "Belgrade Waterfront" project.

2. "BELGRADE WATERFRONT" PROJECT

According to the project, "Belgrade Waterfront" covers an area of 1.85 millions of squared meters and envisages the construction of about 200 facilities for various purposes and functions on the right riverside of Sava, between Railroad Bridge and Branko's Bridge, up to Karadjordjeva and Savska Street. The project implementation was conceived to be realized in four phases

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(Figure 1). The biggest part of the area, about 60%, is planned for the construction of residential units, 17% for commercial properties, 8% for hotels and a shopping mall, separately, 5% for shops and about 1% of planned areas for cultural and leisure activities. The buildings standing out are "Belgrade Tower", 170 m tall, and the shopping centre which will cover more than 148,000 of square meters. When it comes to the street network, it was planned to keep the existing street matrix which will be linked by newly constructed boulevards. The project appreciates the cultural and historic heritage of the city of Belgrade, thus some buildings will not be razed during the works (http://www.rapp.gov.rs).



Figure 2. Phases of "Belgrade Waterfront" project realization

3. CONSTRUCTION LOGISTICS

The construction logistics involves planning, organization, coordination and costs of flows and logistics activities that are related to the construction project realization (Duiyong et al., 2014). The large construction project realization requires precise and clear organization of all operations at the construction site, implying developed supply chain. The supply chain includes all logistics activities, production operations and process coordination management and activities related to marketing, sale, product development, finance and information technologies, but their relationships too, as well as the coordination and collaboration among partners being in the same chain (Miljuš M., 2015). The supply chain may have a different impact on the construction site depending on the point of view (Vrijhoef R. & Koskela L., 2000). It is possible to consider the inherent relationship between the supply chain and construction site, the supply chain as an independent unit, activity shifting from the construction site to the supply chain and the construction sites (Vrijhoef R. & Koskela L., 2000). The experts in this field have attempted to define the main problems with construction work realization (Rogers P., 2005.): underused loading space of vehicles, waiting at the transshipment front, qualified staff engaged for unqualified tasks such as unloading, material are often transferred from one to another place within the construction site, poorly planned work time schedule for professional tasks, the large amount of material and waste and very poor training of logisticians for the work in the construction industry. Figure 2 shows the problems in the construction process.

Poor logistics implementation may cause a series of consequences such as: unnecessary costs, poor image of the construction industry, poor construction quality, prolonged designing time, additional health and security risks etc. (Rogers P., 2005). On the other hand, by implementation of good logistics the many positive effects could be achieved, such as: reduction in movement volume, reduction in credit-linked capital, reduction in waste amount, rapid construction time, improved quality, lower health and security risk of the workers, more efficient use of labour force results in construction cost decreasing and, generally, in the improvement of industry's image (Rogers P., 2005). The good logistics can reduce the unnecessary material movements, shorten the production process and increase the productivity up to. It is possible to monitor system performances (both quantitative and qualitative) in two ways: 1) observation and monitoring of systems and its functioning; (2) comparison of implemented solutions, i.e.

monitoring how much the applied solutions are appropriate and to what degree they improve the system (Wegelius-Lehtonen T., 2001).

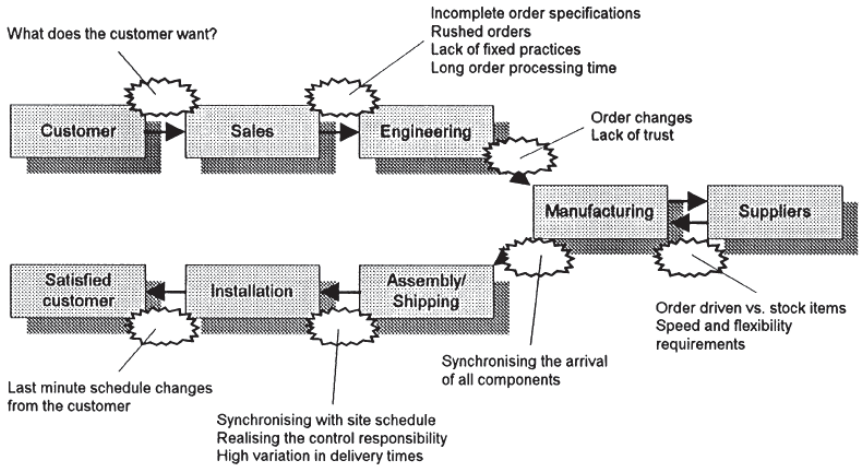


Figure 3. Problems in the construction process (Vrijhoef R. & Koskela L., 2000)

When designing, it is possible to use "Last Planner" method. The reasoning is to meet all prerequisites that are necessary for performing various construction tasks before these tasks are assigned to a working group. By this method, all the tasks related to the project could be classified into four categories (Ala-Risku T. & Karkkainen M., 2006):

- SHOULD – tasks that need to be performed in the near future according to the overall project plan.
- CAN – tasks that have all their prerequisites ready: e.g. previous project steps are completed, necessary materials are at hand, and work force is available.
- WILL – the tasks that are commenced before the next planning round.
- DID – the tasks that are completed.

4. CONSTRUCTION LOGISTICS OF "BELGRADE WATERFRONT"

The construction of "Belgrade Waterfront" involves the processes of transport, storage, loading, unloading, packaging and stock management related to numerous of various types of materials and equipment. It is necessary to provide that all activities are taking place in a simple, quick, continual and controlled manner. In order to provide material availability in the moment of the request occurrence at the construction site, it is necessary to develop both long- and short-term plans for the material delivery which could be adjusted and upgraded during the project realization. During this period, each construction sector is obliged to submit a list of required materials for the next period (day, week and month) to the logistic centre. In order to make this system function, it is necessary to have a well-developed supply chain.

4.1 Supply chain

The implementation of the supply chain into the project has many advantages: shorter time of the request realization, precise amount of material for the production, decreasing in stock and trapped capital level, quick realization of the logistics processes, electronic data processing and exchange, quality of service improvement, reduction in total costs etc. Considering that this is a

long-term project, it is necessary to make contracts among all participants in "Belgrade Waterfront" construction process and define their rights and obligations in order to secure the undisturbed supply chain functioning. To make supply chain function, it is primarily necessary to make a special IT platform in order to provide a high-level communication and data exchange and processing. The material and information flows have different movement directions within a system. To consolidate smaller deliveries and provide the timely material delivery to different locations within a construction site, it is proposed to implement the construction material consolidation centre. Its implementation is temporary and it is determined by project duration.

4.2 The location of temporary logistics centre

After detailed analysis of the project and schedule of "Belgrade Waterfront" realization, the authors identified some possible location of the logistics consolidation centre. Based on the estimation by several criteria (the available surface area, time distance from all construction phases, transport infrastructure development, connection to main roads etc.), the location of future "Belgrade Park" is proposed. However, the location of the centre may vary in different phases of the project construction if it is economically justified. The chosen location covers 40,000 m^2 of space, occupies the central position on the project map, being situated near the riverside and connected to other construction phases by main roads. Within the centre, there will be the entry/exit check point, administration building and warehouse for construction material, parking facility for freight and construction vehicles, fuel tanks, maintenance system, the space for waste and unused material disposal. The planned area for the logistics centre installation is also convenient from the aspect of the arrangement after the completion of work. Nevertheless, the choice of a logistics centre location requires quantitative and qualitative analysis of potential locations from the aspect of a larger number of criteria and the application of operational research methods.

4.3 Types and amounts of material

With the aim of flow volume estimation and for the purpose of this paper, only basic material categories are considered in the facility construction process. Besides the steel poles, which presents the frame and gives shape to the facility, this paper involves steel floor coverings, through which the concrete is poured for the purpose of the fire protection, armature, bricks for room separation, sheet material (marble, ceramic tiles, parquet) and windows that provide a futuristic look to the buildings. The material amounts are estimated by phases (Table 1), based on the scope of work, i.e. the planned area in m^2.

Table 1. Estimated material amounts for "Belgrade Waterfront" construction

Type of material	Estimated scope					
	Phase 1 555.000 m^2	Phase 2 832.000 m^2	Phase 3 278.000 m^2	Phase 4 185.000 m^2	Total 1.85 mil.m^2	With 5% of reserve
Steel poles (t)	120.000	39.000	14.500	21.000	194.500	204.225
Floor coverings (t)	30.000	3.500	1.300	2.300	37.100	38.955
Concrete (m^3)	2.175.000	330.000	66.000	135.000	2.706.000	2.841.300
Armature (t)	110.000	16.500	3.500	6.700	136.700	143.535
Brick (t)	640.000	80.000	30.000	53.000	803.000	843.150
Sheet material (m^2)	2.100.000	245.000	91.000	164.000	2.600.000	2.730.000
Windows (m^2)	95.000	24.000	8.900	16.000	143.900	151.095

Among estimated amounts, the dominant material is the concrete, which will be used for the purpose of building stability, paneling of steel poles, forming of floor concrete slabs and public roads too. The large amounts of concrete and armature will be used in the construction of central support pillar of Belgrade Tower, on which the steel frame will be relied.

Besides timely material delivery, the successful project realization requires the delivery of the construction mechanization such as: earthmoving machines (bulldozers, excavators, loaders, levelers, vibratory rammers, rollers and pavers), lifting (cranes and elevators) and transport machines (trucks, tippers, dumpers) and mixers (towing mixer and truck mixer).

4.4 Problems, possible solutions, directions and methods of material delivery

It is well-known that the city of Belgrade has difficulties with traffic jams on the bridges and the street matrices in the old part of the city are mainly narrow and unidirectional, with the prohibition of large transport means' movements. Night delivery is not feasible for all flows, so the construction site supply will be a large traffic problem. Since "Belgrade Waterfront" is spatially relied on right riverside of Sava, one of the possible solutions to the problem is the use of the river transport. By choosing this delivery method, it is possible to enable the unloading of street networks, without vehicle accumulation and congestion occurrence, as well as the timely delivery of large amounts of the material by reduced number of transport means (one push barge-barge system replaces dozens of road vehicles). In addition, the transport cost will decrease and the environmental pollution will be significantly reduced.

The use of river transport was also justified by analysing the potential directions of material delivery: Smederevo Ironworks (steel materials), factories from Pančevo producing concrete and glass, brick production plant from Novi Sad and sheet material manufacturer from Šabac. For the delivery of the concrete, it is also possible to use river transport by choosing the vessels for transport of the whole road vehicles (mixers and truck mixers).

It is possible to establish the connection between the riverside and consolidation centre by installation of an adequate type of belt conveyor. For the heavy-weight and irregular-shape materials, it is possible to use cranes for reloading into road transport means for bulky loads. Nevertheless, the choice and use of transport and transshipment systems, as well as the opportunities for vessel docking, require a detail analysis.

4.5 Reverse logistics

The reverse logistics has a very important role in the construction project realization. Large construction sites generate a large amount of waste which could cause many problems (Nunes et al., 2009). The waste material could be classified into three main groups: the inert construction waste, which is disposed at landfills, the recycling waste (glass, steel, iron etc.) and the waste which is the overage in some facility construction, but it could be temporary reused in some other facility construction (marble slabs, windows, parquet, rod materials etc.). Waste collection from the active construction sites could be realized periodically, by special vehicles. The waste would be disposed at temporary landfill near the consolidation centre. With the aim of the vehicle movement optimization when delivering material from the consolidation centre and collecting the waste, it is possible to apply the travelling salesman method in order to minimize the distance and, consequently, the collection time and transport costs, and to maximize the capacity utilization of vehicles. After collecting a priori determined amount of waste, it is performed its ad-hoc removal, i.e. dial a removal. This method of waste removal from the logistics centre is good because the transport capacity of vehicles used for delivery is maximally exploited. Since there are various groups of material at the construction site, it is necessary to sort them, in terms of separating inert and recycling materials. It is probably better to sort materials at the construction site by placing containers for different types of waste, in order to reduce time interval until the later further sorting. The material which could be used for the

construction of other facility is stored in the consolidation centre until the moment of requesting its re-delivery to the embedding site. Besides the reverse logistics of the materials, the return logistics of the construction mechanization must not be forgotten after the completion of work.

5. CONCLUSIONS

The construction logistics faces numerous technical and organizational problems, as well as environmental problems, which influence the costs and construction time and quality. In larger construction projects, such as "Belgrade Waterfront", which includes a broad scope of work, numerous contractors and extensive and complex material flows, an inadequate logistics concept and a lack of coordination result in serious disturbances. The logistics centralization and supply chain introduction implies the reduction in total costs of project, quality improvement and shorter time for completion of the construction. Numerous studies have showed that the most of the problems in the supply chain occur in the previous phases of the chain. The information exchange among the participants is often very poor, resulting in poor synchronization of construction project's processes and activities. The solution to these problems lies in cooperation among all participants in the construction project and in coordination of all activities and processes in its realization. One of the main strategies would be the integration of basic logistics function in the supply chain with marketing, production and finance.

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HOSPITAL LOGISTICS

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Abstract: *Hospital decision makers are facing various difficulties arising from unpredictability of patients and their arrival time mix. The complexity of flows - specific only for this industry branch – also contributes that. More efficient business with lower stocks and costs, as well as with quality services could be achieved through organized and developed logistics, which could be managed from separate sector. Properly management of this system could be achieved only if all flows and activities are analyzed together. This paper covers some of the hospital logistics difficulties and measures to overcome them, with special emphasis on the situation and problems in Clinical Center of Serbia.*

Keywords*: Clinical Center of Serbia, logistics, hospital flows*

1. INTRODUCTION

The basic function of a hospital, as one of the more important systems in every country, is providing health care to the citizens. Taking into account all available resources and aiming to more efficient basic function realization, every hospital needs logistics. The numerous kinds of flows are present in a hospital every day, but unlike manufacturing industry, here it is not possible to predict the patient mix or the demand for particular material, implying very complex logistics. The complexity of activities, flows and participants in hospital instituions' logistics requires extensive research for service improving and cost reduction. The literature contains different hospital logistics definitions and explanations by which either the traditional logistics definition is just mapped on hospital systems or the different forms of hospital logistics are seen as separate management values and areas.

While reviewing a literature, the different definitions of hospital logistics are observed. Thus, Aptel and Pourjalali (2001) suggest that logistics activities in hospitals include purchase, receiving, stock management, information system management, food service, transport and home care.

Logistics is a vital part of a hospital that is in charge of purchase, receiving, stock management, information system management, telemedicine, food-related services, transport and home care services (Kriegel et al., 2013).

In its comprehensive meaning, hospital logistics includes purchase management and all planning-related tasks, implementation and administration of agreements and methods leading to goal-oriented flows of objects, values and information concerning goods and services required within a hospital (Pieper and Michael, 2008).

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This paper covers hospital system characteristics, its inherent flows and factors that are important for its functioning. Certain fields, which are commonly considered in research conducted in several countries, are extracted. The separate chapter is dedicated to the state of logistics within Clinical Center of Serbia (CCS), distribution organization, stock management, as well as to the significance of certain systems within this complex, for whose elaboration the information were collected by conducting interviews with Central Pharmacy and Orthopedic Institute employees.

2. HOSPITAL LOGISTICS – FLOWS AND PROBLEMS

Hospital logistics is characterized by high-level division of labour, non-standard processes and a lack of relevant information. Due to these problems decision makers in hospital management are facing the challenge of ensuring resource availability every day, at any treatment place, and of constant improving of hospital services considering the capital, efficiency, costs and health care quality. One of the main sectors for ensuring resource availability is the hospital supply sector. Three factors are crucial for service redesigning and improving: costs, customer needs and the quality of service provided. Considering that hospitals should be focused on their basic activity, the secondary and tertiary services should be outsourced and this is the trend in other industries too.

Hospital complex flows are characterized by extreme complexity and they could be classified into goods flows and people flows (Fig. 1). Besides the patients, people flows include employee flows and visitor flows. Within this group it is possible to single out the operating room logistics, emergency logistics, logistics of patient admission and discharge and health care logistics. Goods flows include flows of medical (pharmaceutical products, medical material, instruments and devices, blood and organs for transplantation, laboratory samples) and non-medical material (food, hygiene items, clothing and laundry, beds and furniture, administrative materials, various waste categories). The patient flows are the main flows, which are the drivers of all other flows and activities. The arrival variability determines maximum and minimum points of demand for hospital resources, medicines, operating supplies etc., creating queues, delays, as well as the stress to hospital staff (Noon et al., 2003; Haraden and Resar, 2004).

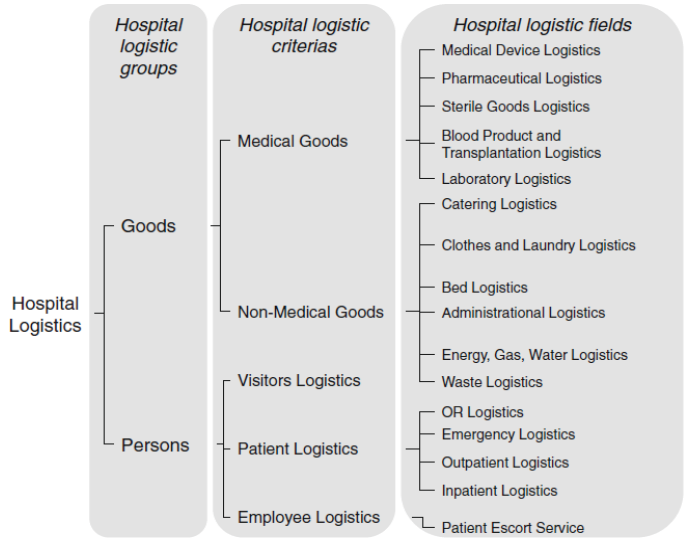


Figure 4. Division of logistics by fields (Kriegel, 2012)

Patient flow logistics deal with their movement through the different parts of a hospital (such as operating rooms, emergency, dispensary or ambulance) from the moment of the admission into the hospital to their discharge. Vissers (1998) suggested that following four problems are the main causes of failure in patient flow management: (1) a lack of coordination of different departments within hospital, (2) variability, (3) a lack of, and (4) inadequately allocated capacities. In addition, Butler (1995) and Haraden and Resar (2004) considered queues, delays and referring patients to inappropriate place, while Villa et al. (2013) considered the bottlenecks along the whole chain within a hospital, which interfere with the patient flow and the elective and emergency case overlapping.

3. REVIEWING THE RESERACH ON HOSPITAL LOGISTICS

Besides the patient flow analysis, the research on stock, material management and their distribution, partnerships and strategic alliances of hospital and suppliers also could be found in the literature. The various authors' opinions on these subjects will be presented in the following.

Pan and Pokharel (2007) were dealing with stock management problems. They identified three methods for stock management: ordering method, periodic filling method and periodic review and filling method. Two main approaches are defined for logistics activities planning in hospitals in Singapore, one stock-oriented and other schedule-oriented. The stock-oriented approach implies that hospitals or medical departments send their orders to their suppliers in the moment when their stocks reach the re-ordering level. The second approach is focused on making goods delivery schedule, which defines the times and quantities for every delivery. In the stock-oriented approach, Lapierre and Ruiz (2005) added that the supplying of a department is performed through the central warehouse (CW).

Aptel and Pourjalali (2001) provided three basic models: a delivery to medical departments through the central warehouse, a semidirect delivery through daily filling of small departmental warehouse. The first model represents the system with large stock quantity where the hospital bears the costs of storage. The stocks of commonly used medicines are stored in a departmental pharmacy, while those being unavailable are requested from central pharmacies. The second model suggests supplier's direct delivery of necessary quantities to the medical departments, without involving central pharmacies. Their application leads to stock reduction and, in addition, the time needed to delivery medicines to the departments is reducing. The third model, being the most similar to JIT (Just In Time), is characterised by very close relations of a hospital and suppliers who take hospital stock management upon themselves. Pan and Pokharel (2007) upgraded the previous authors' models, i.e. the first model is divided on two models: (1) direct delivery to central warehouse and then delivery to medical department for further using, and (2) direct delivery to central warehouse and then delivery to departmental warehouse.

Kim and Schniederjans (1993) identified three types of material management systems in hospitals: conventional, JIT and stockless. Heinbuch (1995) and Jarrett (2006) noted in their papers that effective material management and JIT deliveries could reduce the health care costs. Lapierre and Ruiz (2005) found two approaches upon which most hospitals organize their supply activities and these are two- or three-echelon stock systems. In addition to the questions whether to use two- or three-echelon system, there are also questions of what goods to order and when, how much stocks to store etc. Fig. 2 shows a two-echelon supply system. It could be seen that the key decision is whether to classify a product into the stocks or delivery it directly. If the product is stored in CW, the frequency of ordering from a supplier is reducing, the stocks in care units (CU) are reducing too, but CW's stocks are increasing. Avoiding CW will reduce the handling time and the need for space in CW, but this requires better coordination of receiving and delivery to CU.

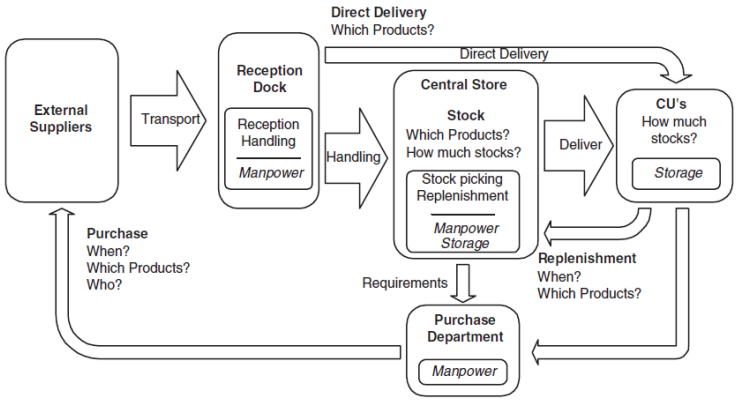


Figure 5. Key decisions in a supply system (Lapierre and Ruiz, 2005)

Aptel and Pourjalali (2001) and Kriegel et al. (2013) highlighted the importance and the advantages of the partnership with other hospitals and material/service suppliers. They considered that it is also possible to reduce the stocks in more complex industries such as medicine, as shown in the hospitals that were the subjects of their research. Improved cooperation among supply chain participants has a positive impact on total costs and service performance improving. Pan and Pokharel (2007) indicated that hospitals in Singapore don't see the associating with suppliers as a strategic option, so they rather decide to outsource logistics services and add that their goods mainly come from local distributors.

4. THE SITUATION IN BELGRADE – CLINICAL CENTER OF SERBIA

CCS complex, located on 34 hectares area, has 41 organizational units in total: 23 clinics, nine centers, polyclinic and nine offices for service activities. Annually, in CCS dispensary units 90,000 patients are treated, 50,000 operations are performed, more than 7,000 childbirths are made and more than 950,000 hospital days of treatment are realized. Annually, 25,000 patients are treated and more than 5,000 operations are performed in day hospitals. Emergency Center has 298 beds at disposal, where 167 of them are in intensive care unit. This number is not sufficient regarding that their average occupancy is 99%.

For every category of goods CCS announce a tender based on annual plans, which are made by each clinic manager on the basis of the consumption in the previous periods. The contract is signed with each supplier and after that the goods are ordered according to demand of each clinic. CCS might request a greater quantity than contracted one only if the suppliers are able to meet this request. The goods are shipped to the central pharmacy warehouse (CP), from where the distribution is performed by CP fleet to the departmental pharmacies (DPs), located on every clinic, and then they are forwarded to the departments for further use. This supply system generates the stocks in three levels: in CP, in DPs and in departments. Within CP is the central server which provides information on a stock status (for every type of goods and for every clinic, at any moment), that are necessary for determining quantities and moments of sending orders to the suppliers. CCS tends to reduce the stocks in clinics, i.e. in DPs and in departments. For some types of goods it is necessary to store greater quantities at any moment, especially when it comes to the functioning of Emergency Center. The stock level of these goods must not drop to the zero, because the costs of out of stock (loss of life) are much greater than costs of additional stock storage. However, due to a priori contracted quantities, there is a decrease in stocks as the year comes to the end and in some cases this could cause the lack of required goods. In these situations the problems are solving by the cooperation of clinics within a complex, by the cooperation of CCS with other hospital systems (Military Medical Academy) or by the use of the

goods considered adequate substitute and being available in a sufficient quantity (e.g. a gauze can be replaced by a compress).

4.1 Central pharmacy

CP building is situated on the edge of CCS complex and consists of two levels (ground and first floor). It consists of four departments: finished drugs (antibiotics, analgesics, etc.), operating supplies (cotton, gauzes, syringes etc.), solutions (sterilization) and oficina (e.g. production of eye drops). The departments are spatially disorganized, consist of several areas that could be on different levels (e.g. operating supplies are stored on both ground and first floor, while solutions only on first floor but at many locations). The space for expensive operating supplies storage (surgical suture) and medicines requiring a special temperature mode is also located on the first floor. The main problem of multi-floor warehouse organization is the vertical transport while the main problem of the admission and dispatch of goods is the only one loading ramp, wherefore the dispatch time (7-9 a.m.) and delivery time (after 9 a.m.) are defined.

4.2 Blood, food and waste flows

Institute for Blood Transfusion is located within Emergency Center (EC), from where all the clinics within CCS complex are supplied. Due to its specificity, EC should have it at any moment. The blood is delivered to the clinics only in cases of scheduled operations, but if there is a lack of it, it comes to their cancellation. Since its lack is a big problem during summer months, the voluntary donor flows are arising as an additional problem.

The specialized company, which cooperates with CCS technical service, is responsible for food supply. The kitchen is situated next to CP, from where the distribution to the clinics is starting. The special smaller elevators are used for vertical transport. The technical service workers delivery the food three times a day and then distributed it within every clinic and to all patients by using handcarts.

The communal service removes non-hazardous waste generated by CCS and ecology and technical service remove hazardous waste. The departments use differently coloured bags for every types of waste (black one for communal waste, yellow one for infective waste, brown one for pathoanatomic waste etc.). Waste disposal is performed up to several times a day in containers with capacity of 220 l in departmental warehouses of clinics, which then the technical service takes over, transport and store it in a hazardous waste warehouse, situated next to CP. After accumulation the waste is being dispatched on further treatment.

5. CONCLUSIONS

Although there are many models of distribution, stock management, material management, flow management etc, it is not possible to map their application from one to another hospital system, but it is necessary to conduct a comprehensive research in order to adjust the model to specific case. However, this is a major challenge for logistics sector, considering all participants, flow diversity and problems that could arise and that are partially covered by this paper. Reconfiguration of such a complex system, like a hospital, requires major infrastructure, financial and staff training investments. These changes of entire or a part of the system are similar to those in other industries, accompanied by participants' repulsive attitude. Several studies showed that hospital systems with more developed and organized logistics, as well as with separate sector for managing these activities, have more efficient business with less stocks, lower costs and better quality of service provided to patients.

CCS complex is characterised by a bad spatial layout, which in some situation leads to the incompatible flows crossing. The cause of this is that goods flows and supply system are not

considering when planning and the consequences involve difficulty and inefficiency in flow realization within the complex, congestion occurrence and disruption of patient flows and basic activity. The current functions of some facilities being inappropriate for their primary purpose are also aggravating circumstances. This observation is confirmed in CP facility where the large-turnover goods are stored at not so suitable places, causing unnecessary manipulations, cost increasing and storage in/off time increasing. In addition, the lack of cooperation of various sectors responsible for different flows' optimization results in inefficient functioning of the entire system.

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UNDERGROUND SYSTEMS IN SERVICE OF CITY LOGISTICS

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Abstract: *The topic of this paper concerns the models of underground logistic systems in order to solve the logistics problems of urban areas. These systems contribute to the protection of environment and quality of life in the city, displacing logistic activities, primarily transportation, underground. However, the investment risk is large, profits uncertain and can be expected only in the long term. It seems that these projects will be realized only as a last option, when the possibility of expansion of the existing road system is depleted.*

Keywords: *underground logistics, urban freight transport, the advantages, disadvantages*

1. INTRODUCTION

Urban freight transport experiences a continuous growth, and expectations are that this trend will be continued in the future. The main causes of this are the trends in production and distribution which are based on the low level of supplies and precisely defined deliveries (Just In Time) as well as the growing trend of e-commerce and home delivery (Zečević & Tadić, 2006). In order to solve the problem and secure more efficient implementation of logistic processes and activities, various initiatives and conceptual solutions of city logistics have been defined and tested. Underground logistic systems belong to the group of the most radical and most demanding financial initiatives. In addition, the abovementioned group seems very innovative and takes into account the system of underground networks, the amount of investments and high level of automation (Tadić, 2014). Underground systems have been intensively analyzed since the end of the 20th century, even though the underground transport system has a 200 years long history. The first system for underground transport of telegrams and postal mail from the center to the branch office in London started its work in 1853. Few years later it was introduced in other European cities as well: Berlin (1865), Paris (1867), Vienna, Munich, Rome, Naples, Marseille etc. These systems can be very effective for solving the problems of urban freight transport. They can also reduce negative impacts on the environment and improve the quality of life in the city. This paper gives various models of underground logistic systems and describes main characteristics, advantages and disadvantages of some of the designed solutions.

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2. CHARACTERISTICS OF UNDERGROUND LOGISTIC SYSTEMS

All underground logistic systems are characterized by some of the following factors (Chenglin et al, 2014):

1) Municipal structures and the aspects of land use – reducing the use of land for road freight stations, parking lots and other facilities.
2) Freight efficiency – reducing urban freight costs and improving transport services, avoiding congestion on the highways during storms, rain, snow and other weather conditions as well as providing a higher level of service that is more reliable, safer and more accurate than existing transport based on the urban freight system.
3) The safety of road transport – reducing traffic accidents caused by trucks.
4) The city's social environment – reducing energy consumption, emissions of harmful gases, traffic noise and vibrations caused by trucks.

Underground logistic systems appear in (Visser & van Binsbergen, 2000):

1) Urban areas in order to deliver mail, merchandise, catering, stationery. The unit of the cargo is the size of a pallet. Testing of the system was carried out in the German cities of Utrecht, Leiden and Tilburg, then in Japan and London.
2) Within and between the industrial complexes, logistic centers and multimodal terminals such as airports and port complexes. Units of the cargo are pallets, shipping containers and aircraft pallets. OLS Schiphol in the Netherlands is an example of such a project.
3) Long-range transport of agricultural products, ore and solid waste. For this purpose, capsule-type piping systems have been developed and implemented in Japan, USA and Russia.
4) Transport of maritime containers to inland ports. The research has been conducted in the United States.

By analyzing the projects and studies on the underground logistic systems, Chenglin et al (2014) have distinguished three development models: the metro model, the model of pipeline cabins and the vehicle model.

2.1 Model of underground logistic system based on metro

This logistic system is based on the use of passenger subway system. The final part of the transport of goods to the customer and the generator flow is realized in the usual way. Pielage and Rijsenbri (2002), Liu et al (2008) investigated the possibility of using the passenger subway system for the transport of goods in the city and analyzed its cargo capacity. Zhang et al (2005) analyzed the experience of underground logistics systems in different countries and suggested construction of the metro for "dual-use". The functioning of this system is affected by the requirements of passengers and cargo flows.

2.2 Model of underground logistic systems based on pipeline capsules

This form of underground logistics is based on pipeline technology that involves the use of round or square capsules, cabins for transportation. The transport capsule has a function of cargo transfer only, whereas orientation, the control function or any other are excluded. Its control function is a passive one and it is executed over the rails and the wall of the tube. The rate of wear of facilities and equipment is very large, and the construction of the pipeline is very demanding. Qian and Guo (2007) suggested that this model of the underground logistic system should be divided into three categories: pneumatic, hydraulic and electromagnetic. Pneumatic and hydraulic pipeline capsules systems are used to transport mail, package, fruits, vegetables

and other time-sensitive goods and materials. Hydraulic systems are also used for the transport of ground, sand, ore and other materials that can endure a long transportation (Chenglin et al., 2014).

2.3 Model of underground logistic systems based on vehicles

This concept uses special vehicles that use mainly batteries as their source of energy for underground transport realization, e.g. AGV (automatic guided vehicles) in the Netherlands and DMT in Japan (Chenglin et al., 2014).

3. EXAMPLES OF UNDERGROUND LOGISTIC SYSTEMS

All around the world, different systems for underground transportation of goods have been proposed and designed. This chapter gives basic characteristics, advantages and disadvantages of some of the designed and tested solutions of the underground logistics.

In the Japanese city of Sapporo, attempted solution for the problems of distribution of goods, such as: traffic congestion, negative impacts on the environment, delays of delivery, especially during the winter when the snow makes transportation difficult, consisted of a system of logistic integration of public service station in order to transport goods from the suburbs to the city center efficiently. Sapporo (1.9 million inhabitants) in northern Japan suffers serious logistical problems in winter when snow drastically reduces transport efficiency on the dirt-roads. The possibility of integrating the city's subway system with a conventional truck transport has been tested in order to facilitate the distribution of goods between the suburbs and the city center (Kikuta et al., 2012).

Carts (sized 500x900x700mm, with a gross weight of 60kg) that are descended to the platform of the metro station and transported by the urban metro system in combination with passengers were used for the transportation of goods. On the station closest to the recipient, i.e. the final destination of goods, the trolley is raised above the ground and, if necessary, further transported by usual road delivery vehicle to the recipient. The pilot project has demonstrated numerous benefits for residents, senders, recipients and carriers, logistics providers, out of which the following can be singled out: (Kikuta et al., 2012)

1) Those who are delivering can avoid traffic jams and reduce the delay by changing the means of transport from truck to the subway
2) The traffic density is mitigated and the urban environment has a lower CO2 emission because the number of operating trucks and unloading of vehicles decreases
3) Traders in the central underground complex can overcome shortages of goods through fast and frequent delivery
4) The office of public transport can increase revenue by providing cargo services outside the city rush-hour

The main disadvantage of the project is the fact that passengers and cargo are not spatially separated.

Planned underground logistic system in Tokyo involves application of hybrid vehicles that have the ability to move on the regular road infrastructure, as well as a separate rail infrastructure within the underground system. Research on the impact of building a system in central Tokyo with a 300 km long tunnel with 150 depots has shown that this system could attract about 30% of the existing road freight traffic, which would reduce NO_2 and CO_2 emissions by 10% and 18% respectively, and power consumption by 18%, while the average speed of traffic in the city would be increased by about 24% (Ooishi & Taniguchi, 1999). Although the use of the system significantly reduces the number of environmental and social problems caused by logistic

activities, analysis of the economic feasibility of its implementation resulted in the inert rate of return which amounted to 10% in the case that the infrastructure is constructed by the public sector. The results confirm that the system is not self-sustainable and can be considered reasonable only if we take into account all the social and environmental benefits for the entire exploitation period.

Underground logistic systems have been the subject of researches in some European cities as well. Germany tested a prototype system based on capsules that move underground tunnels or tubes and that can carry two pallets (Beckmann, 2007). A similar concept has been developed in Italy. A prototype designed in 2006 involved a capsule transport capacity of one euro pallet. Since then, numerous researches and feasibility studies of this system have been conducted (Cotana et al., 2008). Underground logistic systems have been considered in several cities in the Netherlands. The pipeline transportation system (capsules system) for supplying market chains of books and nutritional products has been considered in Groningen. Also, feasibility study for the use of underground supply systems through the implementation of AGVs (automatic guided vehicles) was conducted for Utrecht, Leiden and Tilburg (Tadić, 2014). The concept of automatic guided vehicles moving through the underground tunnels at a speed of 20-40 km/h has been tested for the transport of flowers between airports in Amsterdam, the world's largest flower auction in Aalsmeer and the railway terminal Hoofddorp (van der Heijden et al., 2002).

The first ideas of development of the underground system OLS (Ondergronds Logistiek Systeeem) appeared in the Netherlands in the early 1990s. Deteriorating accessibility, due to traffic congestion, started to threaten the position of Schiphol airport in Amsterdam and Aalsmeer Flower Aution. In order to solve this problem and ensure sufficient transport capacity, with minimal impact on the environment, the concept of the underground transport system has been discussed. Shortly after, it became clear that the third connection was needed too, and that it implied linking international railway terminal near Hoofddorp. By using high-speed freight trains and connecting the airport, auctions and international railway with the help of an underground freight transport system, a trusted connection was created not only between the auction and the airport but also with the rest of the Europe. In 1995, private companies started to work on a feasibility study of the underground transport system of flowers, expensive goods, computer parts and newspapers between Schiphol airport and Aalsmeer flower stock exchange with a new rail terminal in Hoofddorp (Wiegmans et al., 2010). These areas represent the initial and final point of cargo flows and they consist of several terminals: Schipol airport – two to five terminals, Aalsmeer flower auction – one to three terminals, Rail terminal Hoofddorp – a single terminal.

Consumers deliver and pick up goods through terminals, and the OLS vehicles perform transport. The terminals have the role of a buffer for temporary storage of goods and they are connected with tunnels, 5 meters in diameter, which are positioned at a depth of 0-20m underground and they can be unidirectional or bidirectional. Terminals are placed at the level of ground's surface in order to reduce construction costs and facilitate interaction with regional clients. The system is fully automated and uses AGVs for transporting goods between the terminal and fully automated transfer station. Around 400 AGVs, sized from twenty to twenty-six feet and weighing about 10 tons circulate the system. The usage of AGV has certain advantages: less vehicles leads to lower transport costs; there is less chance for human error which improves system reliability. A complex system with several hundred independent AGVs which movement needs to be guided and managed is very complicated to organize. There is a possibility of delays and a high speed and reliability of the system are required (Wiegmans et al., 2010).

This concept combines the social benefits of placing traffic underground and the use of electric drive with the economic advantages of the unobstructed automated transport through infrastructure that is separated from the passenger transport. Economic benefits are demonstrated in almost direct delivery, 24-hour service, low operating costs and short feedback

time. Social benefits take into account legal limits, which results in a reduction of noise, pollution, emissions, reduction of the energy consumption, reduction of CO_2 emissions, better use of available space and increased traffic safety.

The main disadvantages of this project are a big investment, the private sector and the authorities not showing the interest in its development and implementation, as well as the fact that several different technologies have been used in its automation, even though the system itself was easy to understand. After several years of development and testing of various concepts, the project was paused in 2002 due to economic reasons (Wiegmans et al., 2010).

4. CONCLUSION

In this paper, an initiative for underground logistic systems has been demonstrated as a solution to the problems of urban environments logistics. The concept combines social benefits by displacing traffic underground and the application of electric propulsion with the advantages of the unobstructed automatic transport through dedicated infrastructure which is separated from the passenger traffic. The idea was to, through various forms of underground transport, present basic characteristics, advantages and disadvantages as well as the results of their application.

The economic advantages of this system include almost direct delivery, 24-hour service, low operating costs and short feedback time. Social benefits include reduction of noise, visual pollution, physical interferences, gas emissions, reducing congestion and traffic jams, more intensive use of available space, relieving the street network and the increase of overall traffic safety. Investment costs are high and technology which is used is new, which leads to lack of experience in automated mass transport systems. The application of these systems requires building the entire infrastructure which means that its realization requires a long period of time.

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URBAN LOGISTICS SYSTEMS AND NIGHT GOODS DELIVERY

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Abstract: *This paper presents the reasons for relocating logistics systems into peripheral area of a city and the possibilities of their return into urban areas. The implementation of efficient and architecturally modern city terminals and their connection to logistics systems in the fringe areas by more ecological transport modes are crucial for successful return of logistics into central urban areas. Also, this paper states the main advantages, disadvantages and types of night delivery. Considering recently set aim to reduce freight transport during peak hours, there is a tendency to perform logistics activities at night. The purpose is to reduce traffic congestion and environmental effect.*

Keywords*: logistics system, city terminal, night delivery.*

1. INTRODUCTION

The evolution of urban areas caused changes of both forms and physical components of goods procurement, storage and distribution. By spatial city spreading, transport infrastructure development and urban land price increase, the macro distribution flow ending is moving towards peripheral areas, in cargo terminals and warehouses dislocated to the urban fringe. Logistics service providers and customers do not wait for precise planning documents, but they solve location-related and logistics system construction problems by themselves in accordance with their abilities and requests. These systems are being dislocated in a quite disorganized manner, without possibility for concentration and consolidation of the flows they are running (Tadić, 2014; Tadić et al., 2014a). Distancing logistics from urban areas has reinforced the adverse effects of logistics flow realization within a city. The number of commercial vehicles serving urban areas is increasing, but there is also an increase in freight vehicle-kilometres and in all adverse impacts on the environment and the quality of life in a city. In order to stop these trends and increase the efficiency of logistics activities, the different initiatives and conceptions of city logistics are defined and analysed. This paper presents the causes and possibilities to return logistics into urban areas. Furthermore, it also presents the advantages, disadvantages and modalities of night delivery as one of the initiative for solving urban distribution problem.

2. REASONS FOR MOVING THE LOGISTICS OUT FROM URBAN CENTERS

Logistics is very important for city development and residents' life and it also presents the significant source of workplaces (Christopherson & Belzer, 2009; Diziain et al., 2012). Large logistics systems supplying national and international market have become a key element of

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urban economics (Christopherson & Belzer, 2009) and tend to be concentrated in large urban areas (Cidell, 2010). High land price is one of the reasons to distance logistics from urban areas. Moreover, road freight vehicles and vans pollute the air, make a noise and visually impair the environment, so there is even less space for logistics in city hearts, resulting in its dislocating to other locations (Deblanc & Rakotonarivo, 2010). This relocation is called unplanned logistics expansion and it represents the global phenomenon (Cidell, 2010; Woudsma et al., 2008).

The logistics expansion has serious consequences for the environment. Dislocating logistics to peripheral urban areas increases the distances that need to be overcome by using road transport modes, the number of kilometers made by freight vehicles, implying additional harmful gases emissions, increasing highway congestion and additional cost for a community. As the road congestion is increasing, logistics providers and carriers show more interest in locations distanced from the city core (Diziain et al., 2012). When it comes to the goods delivery within a city, it is obvious that road transport doesn't have a competitive alternative compared to the other transport modes because of its price, flexibility and very dense network. Limiting road transport volume increase by public authorities could mitigate its environmental effect, but this requires defining of rail or fluvial transport solution.

The thing which should be emphasised is the reduction of road transport use for "last mile" delivery and logistics expansion suppression. In order to achieve that, it is necessary to develop multimodal technologies, both on periphery and within a city (Diziain et al., 2012). The goal is to enable the good connection of urban distribution centres, city terminals and logistics centres at urban fringe by dense transport network. Ideally, they should be connected by waterways or railway. Without these connections, the logistics would be able to return to the cities only in forms of smaller facilities which could be incorporated into small spaces (Diziain et al., 2012). Cargo tramway implementation, as a link between a city terminal and logistics centre at another location within a city, is a concept tested in many European cities (Tadić, 2014; Tadić et al., 2014a). The goods distribution from the city terminal to the generator in the gravitational area could be performed by alternative electric vehicles in order to mitigate the adverse environmental effect (Munuzuri et al., 2005; Russo & Comi, 2012; Tadić, 2014; Tadić et al., 2014a; Tadić et al., 2014b).

Due to their low status and bad image, the logistics companies cannot afford an expensive land, compared to ones who buy it with the residential or commercial purpose. However, various authors (e.g., Diziain et al., 2012; Zečević, 2006) have investigated the justification of building modern and efficient city terminals - multi-storey facilities ("logistics hotels") – representing very attractive solutions and occupying significantly less space. The systems increase the construction costs to a large extent because of technical elements such as strengthened walls or floors, which must withstand high loads. In addition, it must pay attention to architectural and technical construction requirements defined by local authorities. Designing of such a hotel requires facing with noise and other disturbances incurred by logistics activities' realization, but it also requires the architectural effort such as this in office or residential facility construction. Another aspect that cannot be ignored is careful introduction of logistics activities into urban environments, where besides good building design it is necessary to ensure a minimum of interruptions when transporting the goods, especially in road transport (Diziain et al., 2012).

3. NIGHT DELIVERY

The night delivery concept is one of the city logistics initiatives. In order to reduce freight transport in peak hours during a day, the concept suggests the goods delivery during night hours, most commonly in period 10:00 p.m. - 7:00 a.m. This means shifting logistics activities from peak to night hours, when most city activities are reduced to the minimum, thus avoiding traffic jams and reducing congestion on the streets caused by freight transport during a day.

The idea of freight transport realization during off-peak hours emerged long before the night delivery concept implementation. The first data on the night delivery implementation were recorded in the time of Julius Cesar, who prohibited deliveries during a day (Dessau, 1892). Nowadays the solution is implemented in cities around the world (Holguín-Veras, 2008; Niches, 2009).

3.1 Night delivery advantages

The night delivery concept implementation could provide a numerous advantages for all participants in logistics activities and for the city itself. These advantages could also be perceived on global level, in terms of environmental effect and sustainable development. Since the goods delivery is performed at night, when the roads are empty, the higher transport speed could be achieved, thus decreasing the total delivery time and eliminating delivery delays. This contributes to the quality of service improvement; therefore the service providers achieve higher market competitiveness. Also, shifting transport activities into off-peak hours leads to traffic congestion reduction during a day, allowing better quality of life in the city. Another advantage is reflected in the fact that, instead of greater number of vehicles during a day, the smaller number of vehicles during a night is used for facility supply, i.e. there is a reduction in harmful gases emissions and energy consumption. All these improve the logistic systems efficiency and allow the implementation of more efficient strategies and conceptions, especially in the domain of vehicle routing and labour force scheduling, but also in the case of shipment consolidation and grouping. Road safety is improved by congestion and overall transport reduction (Holguín-Veras et al., 2014; Niches, 2009).

From the point of logistics flow generators, the advantages of night delivery include lower distribution costs (although the initial investments in lower-noise equipment are emerging) and higher reliability of a delivery. Higher reliability and quality of service contribute to greater confidence in suppliers and better cooperation of facility and its customers as well, because there is no customer disturbance due to daily goods delivery while desired products are available in early morning hours. The citizens could benefit from more efficient traffic flows, lower traffic congestion in the city centre and lower harmful gases emissions. From the point of the city, it could lead to economic and business development due to the lower delivery costs (Niches, 2009). The studies show that night delivery conceptions could be more efficient from the aspect of environmental externalities from the policy based on fleet renewal (Filippi et al., 2010) or restrictive local government' measures (Comi et al., 2011).

3.2 Night delivery disadvantages

Besides the numerous advantages, the night delivery implies some disadvantages. Although it is reasonably to consider that night delivery results in the reduction of harmful gases emissions, thus reducing the adverse environmental effect, the exploration of this concept found the opposite. Namely, if we take into account freight vehicle speed and climate conditions, it could be concluded that off-peak traffic, regardless the reduction of total harmful gases emission, could have an adverse environmental effect depending on two mentioned factors. The negative effect is more prominent in central than in peripheral urban area because of greater temperature variations, leading to greater shares of pollutants in the air. This disadvantage could be avoided if the freight transport is realized in specific time periods during a night, thus reducing the adverse effects of harmful gases. Also, the effects are more prominent at higher freight vehicle speeds (Sathaye et al., 2010).

In night delivery concept there is a greater variety of participants having different roles and each of them tends to achieve a greater benefits and profit by solution implementation. On the one hand, it can be observed the logistics service providers, which could experience the night delivery advantages on the fastest way due to the reduction of total delivery costs, faster activity

performing, parking costs elimination etc. Naturally, all this directly influence both a consignee and his/her costs. Nevertheless, the consignees are less willing to accept night deliveries and the reasons involve increased risks and criminal exposure of both staff and goods. Furthermore, by transition to night deliveries the consignees expect the increase in operating costs, equipment costs and salaries (Holguín-Veras, 2008). They have a task to provide either staff that will receive the delivery or some facilities for goods storage that go along with a protective system. While providers have savings in business, the consignees might face the increased operating costs arising from additional auxiliary facility costs, overtime costs of employees and higher price of night work. This situation, where one part has more benefits compared to other one, is popularly called BoS (*Battle of Sexes*). Therefore, it is necessary to balance between service bearer and customer and adjust the concept in some way to the consignees, which in this case still have higher expenses than earnings (Holguín-Veras et al., 2012; Niches, 2009).

From the point of population, the problem of the night delivery is the disturbance caused by noise and delivery vehicle lights, thus decreasing the quality of life in the city. This problem could be influenced by using special vehicles and equipment. The emphasis is put on the use of low-noise or electric vehicles, infrastructure improvement and other technical solutions aiming to reduce the noise. Although these solutions have double positive effect – reduce the urban noise and are more ecological solutions – they require large investments which might be a problem (Holguín-Veras et al., 2012; Niches, 2009). In addition, the night delivery concept is less acceptable solution in cities with higher crime rate.

3.3 The types of night delivery

According to the mode of the acceptance of goods, two main types of night delivery could be distinguished: SOHD (*Staffed Off-Hours Delivery*), implying additional staff engagement for the shipment acceptance, and UOHD (*Unassisted Off-Hours Delivery*), with no staff for assistance when accepting the goods. The first principle requires additional cost of labour and night work, but it is a safe option, while second principle may be less safe. The operating costs and risks ratio (Fig. 1) represents the main difference of these two concepts (Holguín-Veras et al., 2012).

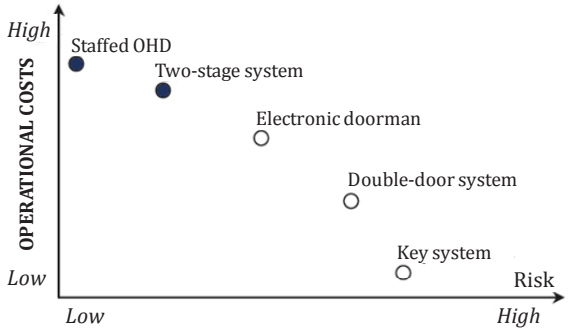


Figure 6. Comparison of UOHD night delivery concept alternatives (Holguín-Veras et al., 2012)

SOHD concept could be found in two variants (Holguín-Veras et al., 2012):

1. Conventional OHD system – one of more members of the staff are present at the site when night delivery is performed;
2. Two-stage system – it is used for supplying large generators and involves two stage, the first one with appropriate delivery room for shipment acceptance and sending, and in the second stage the goods are sent to actual consignees as a part of regular daily transport.

UOHD concept implies more alternatives for acceptance of goods (Holguín-Veras et al., 2012):

1. Double-door system – the driver performing delivery is provided with a key to an outside door that leads to a small storage area, separated from the rest of the business area, so the driver doesn't have a full access to the facility;
2. Key system – the driver is provided with a key which enables him to deposit the goods at a specific location;
3. Electronic key system – the driver is provided a password or security code, defined by facility owner, to access the facility or the storage box;
4. System with manual/electronic key and security cameras – the principle is the same as in previous case, except the installation of monitoring cameras;
5. Electronic doorman system – a remote operator, assisted by security cameras and radio/phone, grants access to the facility and requires identification checks.

4. CONCLUSIONS

Severe road congestion and land price are the main reasons for dislocating logistics systems in peripheral areas of the city. From the other hand, the return of logistics system into the cities requires facing the noise and other disturbances arising from logistics operations. The main problem is the road transport which attracts a special attention due to its dominant role in traffic flows and negative effects that implies. This problem has initiated the development and the use of other transport modes, especially intermodal transport solution of city logistics.

In order to solve the problem of goods distribution in urban areas, the night delivery concepts are analysed. The deliveries during peak hours are ineffective, unpredictable and imply increased fuel consumption (Vilain & Wolfrom, 2001). From the other hand, the night deliveries are faster, more reliable and do not require the change of vehicles, thus reducing delays and improving the efficiency. By analysing the problem of night delivery concept implementation it can be concluded that the efficient transport-distribution system cannot be achieved without a joint action of all participants. It is necessary that all city logistics participants cooperate closely to make the system function efficiently (Tadić, 2014).

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INTERNATIONAL COMMERCIAL TERMS - INCOTERMS 2010

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Abstract: *The Incoterms are a set of International rules that provide an interpretation for the most used commercial terms in foreign trade operations. The aim of Incoterms is standardization and interpretation of contractual trade terms. In this paper Incoterms are presented in more detail and explained through theory and practical application in certain situations. We shall review the changes made in the new compilation of terms, Incoterms 2010, and their impact in both local and international trade.*

Keywords*: Incoterms, trade, rules*

1. INTRODUCTION

With the ever rising global trade, there are more and more issues regarding the international commerce. Both sellers and buyers may be unaware of the existing dissimilarities in trade practices in different countries, leading to misunderstandings, disputes and litigations. In order to avoid negative consequences of poorly composed contracts of sale, there was a need to standardize the rules. In 1936 in Paris, The International Chamber of Commerce defined and published Incoterms, a set of rules to define trade terms. Amendments were added respectively in 1953, 1967, 1980, 1990, 2000 and finally 2010. As of 1st January 2011, the 2010 version is in effect.

Incoterms is a set of international rules regarding shipment when trading internationally. The aim of Incoterms is to create a standardized, unified interpretation of trade terms in contracts and agreements, and conditions of delivery by all who take part in international trade. Incoterms provide definitions of key elements of purchase agreements, indicating to all contractual parties their obligations.

The main difference between the 2000 and 2010 version of Incoterms® is that the number of Incoterms has been reduced from thirteen to eleven. The 2010 edition has introduced two new clauses, DAT and DAP, while four have been removed, namely DAF, DES, DEQ, and DDU. Furthermore, the 2000 edition is divided into 4 groups according the starting letter (E, C, F, and D), while the 2010 edition is divided into 2 groups (all types of transport as opposed to marine transport). In this paper we shall further define all of the Incoterms, as they are divided into the abovementioned groups. The table 1. shows all eleven Terms of Delivery with their breaking points that will be explained in next chapter.

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Table 1.Tearms of Delivery

Incoterms and Services	EXW	FCA	FAS	FOB	CFR	CIF	CPT	CIP	DAP	DAT	DDP
	Named place	Named place	Named port of dest.	Named port of dest.	Named port of dest.	Named port of dest.	Named port of dest.	Named port of dest.	Named place	Named teminal	Named place
Warehouse at point of origin	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Warehouse labor charge at origin	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Export packing	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Loading at point of origin	BUYER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Inland freight	BUYER	BUYER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Port receiving charges	BUYER	BUYER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Forwarding fees	BUYER	BUYER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Loading on ocean carrier	BUYER	BUYER	BUYER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Ocean freight	BUYER	BUYER	BUYER	BUYER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER	SELLER
Charges in foreign port	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	SELLER	SELLER	SELLER	SELLER	SELLER
Delivery charges to final destination	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	SELLER	SELLER	SELLER
Customs duties and taxes abroad	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	BUYER	SELLER

2. INCOTERMS FOR ALL MODES OF TRANSPORT

EXW (Ex Works) Term of Delivery requires that the seller has fulfilled their obligation once they have made the goods available to the buyer at their premises or another designated place (e.g. a workshop, factory, warehouse etc), duty-free and not loaded on any means of transportation. EXW places the maximum obligation on the buyer because they have to organize the entire shipment. It also gives opportunity to the buyer to demonstrate their creativity and business acumen. Although the buyer is free to manage the shipment to their liking, it might not be as beneficial to them since they bear all costs of shipment and incur full risk if the goods are damaged during transport to the final destination, with the seller not liable from the moment of handing the goods over to the buyer's carrier. EXW is not recommended when exporting, due to the fact that the goods may be stolen before leaving the country, or resold in another country. Furthermore, if the submitted invoice has no VAT (Value add tax) included, there may be no evidence that the goods have been exported. When using this particular Incoterm, various issues have been known to occur in different countries. For example, the US market requires an American citizen to be the legal entity when taxing the goods during export and import, all of which makes complications for the buyer. Regardless of the legal issues, this Incoterm remains the reference of choice when importing to the USA (in 95% of cases).

FCA (Free Carrier) involves the obligation of the seller to deliver the goods at the place nominated by the buyer. FCA is equally beneficial to both seller and the buyer, because their obligations are derived from the nominated place of delivery and mode of transport of goods. If the nominated place of delivery is at the seller's premises, the seller is obligated to load the goods on to the carrier chosen by the buyer, whereupon the delivery is considered concluded. In another case, it is required that the goods be delivered to the buyer at the nominated place of destination, not unloaded on the seller's carrier. Here, the place of takeover of goods is to be

clearly stated, since this is crucial when determining who is responsible if the goods are lost. For example, if a seller from Company A sold a buyer in Company B 20 tons of wheat flour using FCA, the seller would be obligated to pay the cost of export fees and loading of goods on to the buyer's carrier. During the customs taxing and loading, the seller is responsible for the loss of or damage to the goods. Upon the loading, all further obligations and risks pertain to the buyer.

According to CPT (Carriage Paid To), the seller is obligated to deliver the goods to the carrier nominated by themselves. This means that the buyer is responsible for the risk and all other costs after the goods have been delivered to the carrier. CPT demands that the seller pay for the export fees. If the delivery includes more than one successive carriers, the risk is transferred when the goods is delivered to the first carrier. CPT is more beneficial to the seller, since they may offer their logistics, thus increasing the profit, on top of selling the goods.

CIP (Carriage And Insurance Paid To) means that the seller fulfills their obligation of delivery to their own carrier, but they also have to pay the additional cost of transport in order to dispatch the goods at the designated destination. This Incoterm demands that the seller provide insurance at the minimum cover rate. If the buyer wishes a better insurance with higher coverage, they need to explicitly agree on it with the seller, or to obtain their own additional insurance.

DAT (Delivered At Terminal) is a new Term of Delivery which replaced the old 2000 DEQ. DAT indicates that the seller has delivered the goods once, upon being unloaded, they are available to the buyer at the nominated terminal, a nominated port, or the nominated destination. The seller covers all the costs and risks that may occur until the delivery to the terminal, including the unloading at the terminal or the nominated port or destination. The seller is obligated to pay the cost of export, but not import, fees.

DAP (Delivered At Place) is also a new Term of Delivery replacing the 2000 DAF, DES and DDU. Delivered at place means that the seller has completed the delivery once the goods have been made available to the buyer on the arrived carrier ready for unloading (not unloaded at the named place of destination). The seller is responsible for all the costs and risks during the delivery to the nominated place. DAP demands that the seller pays the export fees, where required, but not the import fees.

DDP (Delivered Duty Paid) requires the seller to deliver the goods to the buyer by paying the import fees as well, but not the cost of unloading, at the nominated destination. The seller is responsible for costs and risks during the delivery, including duties for import at the destination country. DDP places the maximum obligation on the seller, as opposed to EXW, which places the maximum obligation on the buyer. DDP cannot be used in European Union due to the EU value added tax, VAT, directive which regulates which country's VAT should be charged on the transaction.

Figure 1. shows Terms of Delivery used in all modes of transport and breaking points between sellers and buyers. The red line shows sellers obligations in cost and the blue line shows to what point goes sellers risk over the goods. Insurance that seller has to provide is presented with gray line and it can only be seen in CIP.

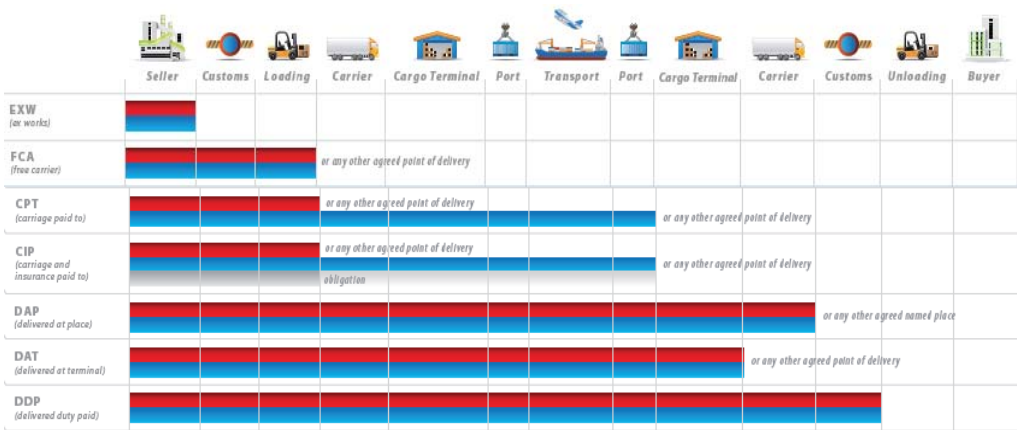


Figure 1. Terms of Delivery for all modes of transport

3. SEA AND INLAND WATERWAY TRANSPORT

FAS (Free Alongside Ship) means that the seller is obligated to deliver the goods by placing it alongside the buyer's vessel at the nominated port. This means that, from that moment, the buyer has to bear all costs and risks of loss of or damage to the goods. FAS requires that the seller pay the export fees. It is more beneficial for the buyer since he determines the place of loading and nominates the vessel. FAS is used only for sea and inland waterway transport, but may also be used if the transport is multimodal, where the initial or the final mode of transport is via sea or inland waterway. It is rarely used, mostly when delivering oil or bulk goods.

FOB (Free On Board) requires the seller to deliver the goods on to a vessel. From that point, the buyer bears all the costs and risk of loss of or damage to the goods. The seller is obligated to pay the export fees. This Incoterm is suitable for the seller, especially the one who cannot impose a more beneficial arrangement for them, or is inapt in transport and risk management when it comes to long distance operations. Since FOB is used in marine transport, there are additional clauses relating to the loading obligations:

- FIO (the deliverer and the recipient both accept the obligation to load and unload the goods from or on to the vessel)
- FIOS (the deliverer is the one bearing the cost of laying out the goods, while the recipient bears the cost of the goods takeover, handling and unloading)
- FIOT (is used in the same way as FIOS, but refers to the bulk goods)

It should be noted that FOB is mainly used in China, when exporting. When transferring the risk from the seller to the buyer, there is a dilemma as to who is responsible if something happens to the goods while loading on to a vessel. When loading with a crane, the goods are elevated above the vessel's railing. If the cargo unhooks and drops outside the vessel, the cost is borne by the seller. If it drops on to the vessel the cost is borne by the buyer.

CFR (Cost and FReight) stipulates that the seller delivers the goods over the ship's railing at the designated loading port, as well as to pay the cost of transport and delivery to the nominated port of destination. But the risk of loss or damage, being additional expenses that may occur from the moment of delivery onwards, is transferred to the buyer (the railing has been passed over). This means that the moment of transfer of risk coincides with the moment and place of transfer of costs from the seller to the buyer. CFR is more beneficial to the seller because the

seller not only sells the goods, but also the services arising from the seller's obligations, e.g.: carrier services, export duty, transport from the port to the designated place etc. At times, the seller may sell these services for a higher profit than that obtained from selling of the goods themselves.

CIF (Cost Insurance and Freight) stipulates that the seller must deliver the goods when they are located on board the ship at the loading port. The seller has to pay the costs and freight at the nominated port of destination, but the risk of loss and damage, as well as any additional costs are transferred from the seller to the buyer once the goods have passed the ship's railing at the loading port. The seller takes care of the insurance, covering the basic insurance.

In order of better understanding the Terms of Delivery used in sea and river transport figure 2. shows graphical sellers and buyers obligations. The red line shows sellers obligations in cost, the blue line shows to what point goes sellers risk over the goods. Insurance is shown with gray line that can be seen only in CIF, like it is mentioned before.

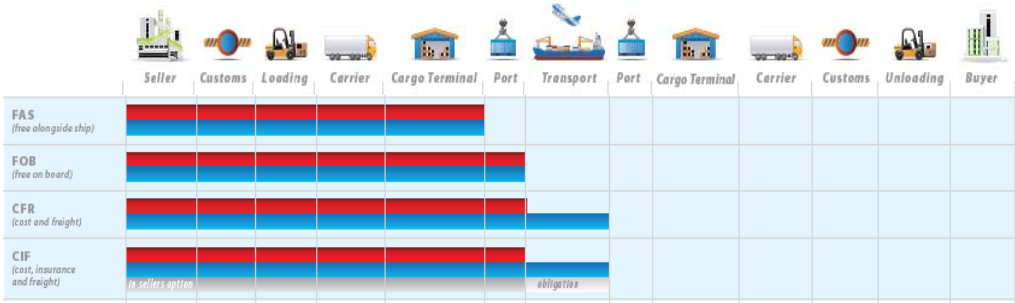


Figure 2.Terms of Delivery for sea and inland waterway transport

3. THE ROLE OF FREIGHT FORWARDER IN 2010 INCOTERMS IMPLEMENTATION

In international trade, alongside sellers and buyers, freight forwarders are also a common sight, taking the role of counselors. When implementing Incoterms, the freight forwarders have a major role, since they possess information and knowhow about all processes occurring in any given supply chain. An international freight forwarder should always be consulted for advice when negotiating the most beneficial Incoterm. To give an example, when exporting the goods, the seller should seek to negotiate the Incoterms CIF, CFR, CPT, CIP, DAT, or DAP, whereas the importing buyer will always prefer one of the following: EXW, FOB, FAS, or FCA. Also smaller companies should trade with DAP or DAT because it doesn't require great amount of work for both sides. Further, freight forwarder may warn their clients that taking on CIP or CIF includes insurance cost, but with minimum coverage. Thus both the seller and the buyer should insure the goods additionally from the possible risks.

The Term Of Delivery provides the seller and the buyer with different obligations and responsibilities, but Term Of Delivery can also create possibilities for the part that has insight into the matter. It decides who controls the external flow of goods. If the seller for instance, wants to achieve this possibility of control, he would come to an agreement with the buyer that gives him that possibility. The more extensive a Term Of Delivery is for the seller, the more control he has over the flow. Also the seller or the buyer can hire a freight forwarder to represent them in this contract, so they can be assured that the flow of goods is in control.

4. CONCLUSION

The ever present conflicts of interests in the backdrop of contemporary globalized production and trade afflict all who take part in international trade. In order to overcome these disagreements, we need to simplify the process of international trade of goods. These issues have been surmounted by defining the Incoterms used in international contracts of sale when goods flow across national borders. Bearing in mind the presented problems, Incoterms gives a unique insight for standardizing the terms and eliminating ambiguities arising from local interpretations. In general, one Term of Delivery is not better than the other, the choice depends on various factors. A good Term of Delivery is the one that is decided after negotiations between aware and initiated buyers and sellers. The chosen Term of Delivery should give reasonable advantages for both parties involved and contribute to achieve the best solution at a given delivery situation.

ACKNOWLEDGMENT

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STANDARDS IN LOGISTIC – IFS LOGISTICS: DELHAIZE CASE STUDY

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Abstract: *Goods and people are rolling over roads and rails, cross the sea or to penetrate beneath the city. Transportation causes the occurrence of traffic. Transportation is the basis of the mobile world and Transport knows no boundaries. International standards set out the guidelines for the transportation service activity, telematic monitoring systems and freight traffic. This paper investigates the standards that are of increasing importance in recent years.*

Keywords*: Standards, IFS Logistics, ISO 28000, Tapa*

1.INTRODUCTION

Standards regulate the flow of data and harmonize complex technical systems, all in order to meet clients. Standards provide cross-border, comparable services and facilitate import and export. Standards are of great importance, and the topic of this work will be to describe one of the most important.The first one that has been reviwed is ISO 28000, which is specially developed for logistics companies and organizations that are handling the transportation. Then TAPA safety requirements in freight transport that determine the minimum threshold of eligibility standards for security in the supply chain that make trucks and similar activities. End of operation will be explained in detail the history of the development of the group IFS standards and the application of the IFS Logistic Company Share.

2. STANDARDIZATION

According to the Law on Standardization, standardization "activity on establishing provisions for common and repeated use, in relation to actual or potential problems, in order to achieve the optimal level of regulation in the present context," which includes the process of formulating, issuing and application of standards and on national , European and international level. The result of standardization of the standards as official documents, with the requirements relating to a product, a process in which the product is formed as a business or enterprise system established to perform a business activity that creates value (product or service) to the market (customers and end customers) and for owners.

Standardization may have one or more objectives which enable products, processes and services to match up with their initial purpose.The general objectives of standardization may be the

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achievement of readiness for purpose, compatibility, interchangeability, reducing the number of variants, safety, environmental protection and product protection. Other goals may be and health, mutual understanding, improving economic performance, removing barriers to trade and more.

3. STANDARS IN LOGISTICS

The standard is a document established by consensus and adopted by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results in order to achieve the optimal level of regulation in specific areas. Standards are documented agreements whose contents are the technical specifications of other precise criteria to be used as rules, guidelines or definitions of characteristics with the aim of ensuring that materials, products, processes and services to fully meet its purpose.

3.1 ISO 28000 – security of supply chains

ISO 28000 was developed specifically for logistics companies and organizations that manage operations in the supply chain, ranging from producers, suppliers, distributors over logistics companies that provide freight forwarding, transport and storage to wholesale and retail. ISO 28000 requires organizations to consider the environment in which it works with the security aspect that bothers whether they are implemented adequate security measures and to identify the relevant legal requirements to which must be matched. The benefits of the introduction of this standard as internal (larger control over operations in the supply chain; larger efficiency; preparedness for emergencies; reduction of theft, breakage, criminal acts; prevention and reduction of economic losses) and external (increase competitiveness; possibility of participating in tenders; possibility of obtaining AEO status; increased confidence in clients and partners)

3.2 TAPA standard

Cargo crime is one of the biggest supply chain challenges for manufacturers of high value, high risk products and their logistics service providers. The threat is no longer just from opportunist criminals. Today, organized crime rings are operating globally and using increasingly violent attacks on vehicles, premises and personnel to achieve their aims. The Transported Asset Protection Association (TAPA) represents businesses fighting back against cargo crime that want to use real-time intelligence and the latest preventive measures to protect goods in the supply chain. TAPA is a unique forum that unites global manufacturers, logistics providers, freight carriers, law enforcement agencies, and other stakeholders with the common aim of reducing losses from international supply chains. Today, globally, TAPA's 700+ members include many of the world's leading consumer product brands as well as their logistics and transport providers with combined annual sales of over US$900 billion, law enforcement agencies (LEA), insurers and other trade associations. The Association's Mission is to help protect our members' assets. TAPA's mission is to minimize cargo losses from the supply chain. TAPA achieves this through the development and application of global security standards, recognized industry practices, technology, education, benchmarking, regulatory collaboration, and the proactive identification of crime trends and supply chain security threats. TAPA Security Standards (FSR/TSR/TACSS) have been established to ensure the safe and secure transportation, storage handling of any TAPA member's (Buyer's) assets throughout the world. The Trucking Security Requirements (TSR) represents minimum standards, specifically for transporting products via road within a supply chain. TAPA TSR certification is discussed further in this document. The successful implementation of the TAPA Security Standards is dependent upon LSPs, Authorized Auditors and Buyers working in concert. However, the safe and secure transportation, storage and handling of the Buyer's assets is the responsibility of the LSP, its agents and subcontractors,

throughout the collection, transit, storage and delivery to the recipient, as specified in a release or contract. Where the TSR is referenced or included in the contract between the LSP and Buyer, the TSR is part of the contracted security requirements between Buyer and LSP, and shall be referenced in the LSP's security programme. Further, where the TSR is part of the contracted security requirements any alleged failure by the LSP to implement any part of the TSR shall be resolved in line with managing disputes under the terms of the contract negotiated between Buyer and LSP.

3.3.IFS standards (International Featured Standard)

Supplier audits have been a permanent feature of retailer's systems and procedures for many years. Until 2003 they were performed by the quality assurance departments of the individual retailers, wholesalers and food services. The ever-rising demands of consumers, the increasing liabilities of retailers, wholesalers and food services, the increasing of legal requirements and the globalization of product supply, all made it essential to develop a uniform process/service compliance, quality assurance and food safety Standard. Also, a solution had to be found to reduce the time associated with a multitude of audits for involved stakeholders. The associated members of the German retail federation – Handelsverband Deutschland (HDE) – and of its French counterpart – Fédération des Entreprises du Commerce et de la Distribution (FCD) – drew up a quality and food safety standard for retailer branded food products named IFS Food, which is intended to allow the assessment of suppliers' products/processes quality and safety in accordance with a uniform approach.This Standard is now managed by IFS Management GmbH, a company owned by FCD and HDE, and applies to all the post-farm gate stages of food processing. IFS Food Standard has been benchmarked with GFSI Guidance Document and is recognized by GFSI (Global Food Safety Initiative).

The first Standard of the IFS Standard family was IFS Food, which was launched at first in Germany in 2003. An updated version was published in January 2004, which was developed by French and German retailers. Within 2005/2006, the Italian federation joined the IFS Working Groups and the development of IFS Food Version 5 was a collaboration of retail federations from France, Germany, Italy as well as retailers from Switzerland and Austria. For the current IFS Food version 6, the International Technical Committee and the national Working Groups from France, Germany (for the whole German speaking area), Italy, Spain and North America have been actively involved, in addition to retailers, stakeholders and representatives of industry, food services and certification bodies from all over the world. Currently, IFS Food has been developed and supported by food industry from Austria, France, Germany, Italy, Netherland, Spain, Switzerland, USA as well as experts from other European countries, Asia and South America. It is the aim of most retailers and producers to have transparency over their whole international supply chain, including the logistical activities. Buyers and quality managers in retail and industry require more and more transparency about the way their products are treated in the logistics chain and they were looking for a solution. In order to prevent logistics companies from being overwhelmed by different requirements, the German and French retailers, supported by other international retailers, developed the IFS Logistics Version 1 in 2006. Version 2 was a collaboration of three retail federations from France, Germany and Italy and the IFS North America working group. The Standard is applicable for all types of transport: truck, train, ship, plane or any other types of transportation, temperature controlled or ambient stable. The IFS Logistics Standard applies to food and non-food products. The IFS Logistics includes all logistical activities like loading, transportation, off-loading, storage, handling and further distribution. Some of the companies that implement IFS are: Delhaize, EDEKA, ALDI, LIDL, Auchan, Metro Group, the US Food, REWE GROUP.

3.4 Implementation of IFS in logistics

Delhaize Group was founded near Charleoi, Belgium in 1867 by Jules Delhaize and his brothers Auguste, Edouard and Adolphe. He was helped in this endeavor by his future brother-in-law, Jules Vieujant. For their new company, they chose the lion, the symbol of strength, as their logo. They also chose a motto: unity is strength. As of 31 December 2014, Delhaize Group had a sales network (which includes directly operated, franchised, and affiliated stores) of 3,402 stores and employed approximately 150,000 people (excluding the stores and related associates of divested and discontinued operations). Store formats are primarily supermarkets, which represent 85% of Delhaize Group's sales network. Delhaize Group's sales network also includes other store formats such as neighborhood stores, convenience stores, and specialty stores. The company is actively engaged with the U.S. Environmental Protection Agency's Energy Star program to manage energy efficiency across its U.S. facilities-Delhaize is currently in the process of implementing the latest version of the IFS Logistics. By the end of the year this process should be completed. Below, we introduce the basic items of the IFS, and more will be handled those related to logistics.

Item 1 – Responsibility of senior management

Corporate policy / Corporate principles

Senior management is required to develop and implement corporate policy. Product safety, customer focus, environmental responsibility, sustainability and employees corporate should be taken into account.

The customer in focus-Documented procedures must be such as to establish and identify basic needs and expectations of the customer. Records of this process are evaluated and taken into account to determine the quality and safety of products.

Management Review-The company will identify infrastructure (at least annually) required to achieve compliance with the requirements for the product (eg, internal audit or control on the spot).

This review includes: wages, warehouses and storage, machinery and equipment, means of transportation, transportation unit and transport containers. Results of the review should be taken into consideration (taking into account risk) for investment planning.

Item 2 - Management system of product safety and quality

The basis of the company's control system security products will be fully implemented, systematic and comprehensive risk management and / or HACCP system. For food to be used and the HACCP system will be based on the principles of Codex Alimentarius. Risk management or HACCP system covering all product groups, as well as all processes from goods receipt to dispatch and delivery. Risk management / HACCP system will describe the difference between the logistic handling unpacked and packed products and between controlled temperature and ambient stable products. The company will have a team of risk management or HACCP team, which is multidisciplinary. The team will have strong support from senior management and members of the team will know in detail the activities in the entire building.

Item 3 – Resource management

The organization will implement a documented training and / or teaching programs. Records of the training program shall include: content of training; the frequency of training (in terms of food safety / hygiene least once a year, for non-food once every two years is sufficient),the tasks employee, a list of participant, languages, qualified trainer / teacher - an evaluation methodology (measuring the effectiveness of training and training programs). Basic training for security products must be carried out before starting work.

Documentary requirements related to the personal hygiene, and where there is need, infection control. These include as a minimum:

- Method of cleaning and disinfecting hands
- Eating and drinking
- Smoking
- Measures to be taken in case of cuts and skin damage. (Not a problem when it comes to packaged products

Item 4 – Realization of services

General requirements for storage and transport:

- Review of contracts and communication: All requirements defined by the contract between the parties must be established and agreed upon prior to the conclusion of the supply contract. All data changes in the company Delhaize deals with the operational department.
- Suppliers and service providers: There are procedures for monitoring and evaluation of suppliers and service providers. Process monitoring includes the assessment of risk based on several criteria. Results from the evaluation of suppliers must be regularly inspected at least once a year.
- Particular requirements for materials handling: IFS special attention to what of goods allowed and what should not be stored together and transported. Traceability is one of the most important system that has been established. Responsible persons in the Company at any time know that the quantity of goods delivered / supplied, and from which supplier / pc retail store. Thanks to the RF technology at any time have all the information on the goods placed in the warehouse, so they shipped the first products with the shortest shelf life.
- The distribution center products are appropriately labeled (For example. products containing allergens must be stored and transported separately from products that do not contain allergens, in order to avoid contamination. The packaging of each product in bold are the names of allergens, in order to avoid confusion)
- The receipt of goods in the warehouse
    - The process defined work instructions.
    - Sectors the company responsible for the effective implementation of these operations are the logistics sector and category management.
    - All Processes that are implemented (eg. Fresh meat) defines a flow chart. It is implemented hazard analysis, critical points are mapped to and for each of them determine the corrective action.
    - The form of the receipt of the control truck in the warehouse. This document states that the conditions a truck carrying fresh meat must fulfill controller.
    - Conditions in the vehicle must be checked before loading and documented in order to ensure compliance with specific conditions. If any of these conditions is not respected technologist returned goods.
    - When loading vehicle, fill out the form on the records of hygiene and temperature conditions of the vehicle at the loading.

- Enter data: on carrier, registration number of the truck, whether the truck clean, if installed termomouse etc.
- Termomouse - a device that reads and records the temperature data during distribution. What is particularly significant-temperature during transport and storage must be the same, in order to maintain the cold chain.

IFS seeks to list a specific critical points. When it comes to the storage of goods, then this is the temperature. If you do not comply with certain conditions to be completed Record for the return of the fresh meat. The temperature in the warehouse is read every 2 hours. For example, raw meat must be stored at a temperature of 0 to 4 degrees C.

When the fresh meat is being delivered, there is a quality control prior to the acceptance. What is characteristic for the company Delhaize is to check the goods carried out in two places, upon receipt of the goods in the warehouse and in the retail store. At least 20% of acceptance volumes must be sent for verification. Sampling is conducted randomly with pallets, to prevent the possibility of abuse

Item 5 – Measurement, analysis and improvement

Internal audits are conducted according to the relevant application. IFS points out that there must be a complaint handling. There are procedures for managing non-compliances and nonconforming products as well as for withdrawal.

Item 6 – Protecting Food and external inspections

The person responsible for the preservation of food is part of the key personnel or has access to a team of top management.

Oblates frequency of these checks is determined on the basis of risk analysis and assessment of associated risks. Risks will be evaluated by competent personnel. On the basis of risk assessment and legal requirements to identify the areas that are critical to safety.

4. CONCLUSIONS

Today, standards are a prerequisite for successful business of any company. They enable them to achieve better contact with customers to distinguish themselves from the competition, to secure a better position in the market. Also, standards show that their goods are safe, that they meet conditions related to the transportation and warehousing. The standards are to take special consideration by the companies, because all the tenders need to meet those standards. Therefore, every company's goal is to meet those standards and organize their workload according to those standards. Considered to be among the IFS standards, which is increasingly applied. They are used by companies primarily in Europe, but they are more and more present on the markets of America and Asia.

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SIMULATION ANALYSIS OF ORDER PICKERS WORKING SHIFTS: THE CASE STUDY OF MILŠPED

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Abstract: *The trend of increasing frequency and decreasing the quantity of goods in each delivery, as well as shorter deadlines for these deliveries, sets a difficult task in front of logistics providers, whose primary field of work is providing these services. Shifts scheduling and determining optimal number of the order pickers can significantly contribute to an adequate response to these requests. There are many different methods and tools that could be used in this purpose, and one of them is simulation. The advantage of simulation is reflected in the fact that the right model can represent a real system, with a possibility of changing different model parameters in order to obtain the best possible solution to the given problem. This paper covers the creation of order picking subsystem model in Milsped company. Before model creation, preparation of input data obtained by processing the received orders in the company, on an annual basis, is needed. By changing certain parameters, such as the number of workers in shifts, their efficiency and shift intervals themselves, and after processing the output data, decision can be made on which solution is the best from a set of simulated scenarios. By correcting model and taking into account all the factors while creating it, can contribute to a better projection of a real system functioning through simulation.*

Keywords*: Milšped, order picking, shifts scheduling, simulation model*

1. INTRODUCTION

The purpose of a simulation is to determine the information on real-world system using a model with the aim of their optimal planning and utilization. The computational modelling is the most economic mode of complex system simulation for this purpose. A simulation is a very powerful tool providing high-quality of logistics system analysis, quantification and dimensioning.

The elaboration of these models is significantly facilitated by the development of simulation software packages and one of them is FlexSim, which was used for simulation analysis of order pickers' working shifts in Milšped company. FlexSim belongs to software group being used for modelling systems whose states are changing in discrete time moments as a consequence of some events' realization. Some of the specific problems that could be solved by it are: improvement of efficient utilization of existing resources, reduction of queues and time spent in them, alternative investment project analysis etc. (Banks et al.., 2005).

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2. PROBLEM DESCRIPTION

Milšped company, whose order picking system is a subject of this case study, receives about 1000 orders daily, on which up to 124 order line (OL) could be found. The purchaser' requests underline orders to be processed, i.e. the goods have to be ready for loading in less than 24h. This impose a very complex task to the order picking system, especially in cases where the time passed from the order entry into system to the requested dispatch time is dramatically shorter, in some cases shorter than 10h. For the realization of these tasks the company engages 22 order pickers, scheduled in three shifts in following manner: three order pickers in first shift, seven in second shift and twelve in third shift (five most efficient ones are among them). Each shift lasts 8h, where first one starts at 6 a.m. This paper presents potential improvement of the system operational performances through the shift scheduling and number of workers determination, where the simulation analysis is used as a tool. One of the most important performances, which is monitoring through the simulation model and needs to be improved, is the percent of orders being processed on time.

3. INPUT DATA ANALYSIS

Milšped company has provided two data groups that were necessary for model elaboration: one related to the order picker work and other related to the orders. When it comes to the order pickers, these data refer to the number of workers per shift and their performances expressed in the number of OL that one order picker is able to process during one shift. Regarding the orders, the data are related to the number of orders arriving into the system, the number of OL being on each order and requested time for the termination of processing. These data are provided for each hour during a day, for the period of one year.

Given that the form of these data was not suitable for the entry into the model, it was necessary to perform their preparation. The order picker performance is expressed in time needed for processing one OL per order picker (h/OL/order picker). It was necessary to present the order data for each hour by following probability distribution: the number of orders distribution, the number of OL per order distribution and the distribution of requested time for each order processing termination. The test of empirical data fitting to theoretical distribution is performed by using χ^2 test, λ-Kolmogorov test and by applying Minitab software. Table 1 shows the parameters of above mentioned distribution that are used in model.

Table 1. The parameters of input data distribution for each hour

Period of order entry [h]	Number of orders			Number of OL			Ready for loading		
	Distribution	Parameter		Distribution	Parameter		Distribution	Parameter	
		μ / λ	σ		μ / λ / α	σ / β		μ / λ	σ
7 - 8	EXPON	0,440	/	NORMAL	15,980	11,980	NORMAL	3,15	1,15
8 - 9	EXPON	0,061	/	EXPON	0,081	/	EMPIRICAL DISTRIBUTION (2)		
9 - 10	NORMAL	28,620	19,040	LOGNORMAL	2,155	0,712			
10 - 11	NORMAL	87,660	39,424	LOGNORMAL	2,033	0,569	EMPIRICAL DISTRIBUTION (1)		
11 - 12	NORMAL	99,960	45,060	LOGNORMAL	2,027	0,538			
12 - 13	NORMAL	116,696	49,750	LOGNORMAL	2,025	0,515			
13 - 14	NORMAL	115,660	45,810	LOGNORMAL	2,038	0,521			
14 - 15	NORMAL	122,078	53,752	LOGNORMAL	2,028	0,526			
15 - 16	NORMAL	120,510	49,460	LOGNORMAL	2,023	0,531			
16 - 17	NORMAL	116,387	50,710	LOGNORMAL	1,948	0,527			
17 - 18	NORMAL	74,120	39,630	LOGNORMAL	1,987	0,523			
18 - 19	EXPON	0,86	/	GAMA	1,707	8,329	NORMAL	2,71	1,47

4. SIMULATION MODEL

Model used in order picker work shift simulation is elaborated in Flexsim simulation software and its layout is presented on Figure 1. This chapter explains the idea upon which the model function, without the description of code upon which each object performs its activities.

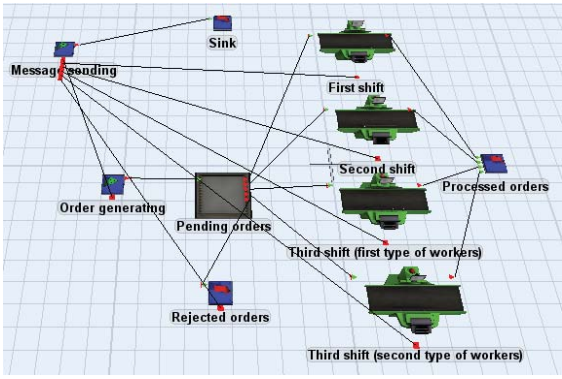


Figure 1. Simulation model

Source-type object, named "Message sending", mostly coordinates the operation of all other objects of this model. Each hour it generates one Flow item which immediately leaves the model through the Sink object. This procedure is necessary in order to Source "Message sending", when activating Trigger "On Exit", sends messages to the object that are connected with it by central connections. It sends messages to the Source-type object, named "Order generating", with information about the moment of order generating, as well as their number. The number of orders is generating upon the probability distribution which varies depending on period during a day. For example, the number of orders' distribution is not the same at 2 p.m., when the most of orders entry into the system, and in 7 a.m., when this number is relatively small. When order leaves the object "Order generating", it is assigned with information on number of OL being in that order and the information on hour when that order should be ready for dispatch. The information on number of OL and desired leaving hour is also generated upon the distribution which is not the same for each time of day. After assignment of all necessary information, the order enters the queue, which is simulated by Queue-type object, named "Pending orders". There are two possibilities for order to leave a queue: first one is that some free order picker from currently active shift takes the order and the other one is to leave a model through the Sink-type object, named "Rejected orders" if the order is not processed until the end of workday. At the end of the day the Source "Message sending" sends the command to the Sink "Rejected orders" to open its input port and remove from the model the all order not being processed until this moment. It should be noted that, in a real system, rejected orders in the model present orders being transferred into the next day in order to be processed.

Source "Message sending" forwards the information on first work beginning of the shifts to the Processor-type objects, by which the work shifts with certain number of workers are simulated. After receiving the messages on work beginning, the processors continue to operate automatically, i.e. they send messages to themselves to stop to work after eight hours and to start again after twenty four hours. The order retention in processors, i.e. their processing, depends of order picker operation efficiency and the number of OL being on the order. It is possible to adjust the number of workers and their efficiency in the processors.

5. OUTPUT RESULTS

Model described in previous chapter allow data monitoring such as: the number of orders processed on time, the number of unprocessed orders, the delay of these orders as well as the number of rejected orders at the end of the day. It is possible to monitor a large number of data, however, the previously mentioned ones were relevant for this case study. It is possible to simulate various system behaviours by changing the number of workers per shifts, their efficiency and by introducing the inter-shifts. Output data analysis leads to different system operation characteristics, which will be explained in the following text in more detail. At the beginning it is necessary to simulate current functioning of order picking system in Milšped company in order to be able to compare all other simulated variants with current state.

5.1 Variants with current resources

It is performed a simulation of great number of variants with current resources, from which only three will be presented and these are the variant that gave the best system operational performances based on the output data processing. These variants include: the introduction of an inter-shift from 4 p.m. to 12 p.m., an inter-shift from 12 a.m. to 20 p.m. and new worker distribution per current shifts. As it has already been mentioned in second chapter, 22 order pickers work in the company and they are scheduled per shifts in the following manner: three order pickers in the first shift (6 a.m. – 2 p.m.), seven in the second shift (2 p.m. – 10 p.m.) and twelve in the third shift (five most efficient ones are among them) with working time from 10 p.m. till 6 a.m. the following day. Figure 2 shows the graphs presenting the comparison of these variants' model operational performances with the current state.

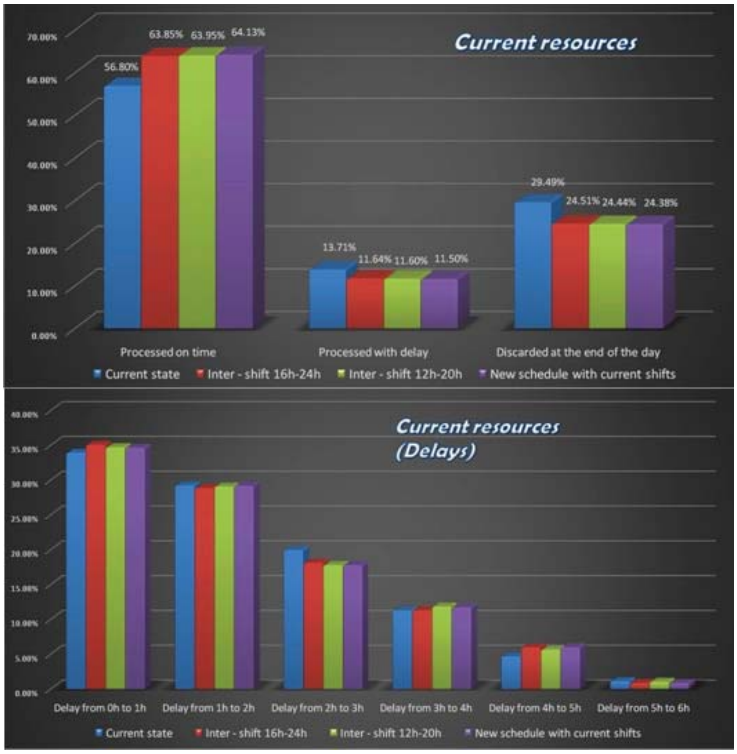


Figure 2. Model operational performances with current resources

The inter-shift from 4 p.m. to 12 p.m. is the variant where the current number of workers is changing in the following manner: one by one worker is transferred from the first and second shifts into the inter-shift, as well as two less-efficient workers from third shift. ***The inter-shift from 12 p.m. to 20 p.m.*** is the same combination of workers per shift as in the previous variant – the only one difference is in the start time of the inter-shift. ***New schedule of workers per current shifts*** implies the variant without inter-shift introduction, so the order pickers are scheduled per current shifts in the following manner: one order picker from the first shift and two less-efficient order pickers from third shift are transferred to the second shift. Therefore, by such a rotation, two order pickers will work in the first shift and ten in second and third shifts separately.

The previous graph shows the best performances are achieved by third variant, where the number of orders being processed on time is increased by nearly 8%, the number of processed, but on time processed orders is reduced by about 2% and the number of orders rejected at the end of the day is reduced by about 5%. Other variants have similar results, where performance values are different by 0.5% compared to previously described variant. The lower graph shows the performance values of delays related to the orders that are not processed on time. In the most cases the order processing delays is up to one hour, while the number of order being not processed on time linearly decreases as the time delays increases.

5.2 Variants with one additional order picker

As it was the case with current resources, here is also possible to simulate a large number of variants with one additional order picker. It will be presented only those variants from the set of simulated ones that had the best system operational performances. These variants include: ***the assignment of an order picker to the second shift***, implying simple increase in the number of order pickers in the second shift by one; ***the assignment of an order picker to the third shift***, ***the assignment of an order picker with a new schedule***, where an additional order picker is assigned to the second shift and the others are assigned to shifts as in the third variant of the previous section. Hence, it implies that two order pickers will work in the first shift, eleven in the second shift and ten in the third shift. Figure 3 shows the graphs presenting the comparison of model operational performances with the current state.

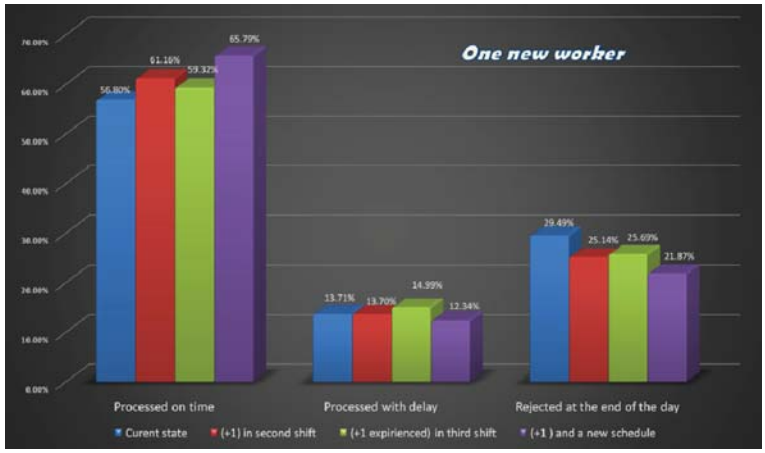


Figure 3. Model operational performances with one additional order picker

The third variant achieved again the best system operational performances, where the number of order being processed on time is increased by 9% compared to the current state, while the number of orders rejected at the end of the day is reduced by almost 8%. The performance

values of delays related to the processing of the orders not terminated on time are very similar to those from previous section. Furthermore, to determine the number of order pickers needed for bringing down the percent of orders rejected on the end of the day to the value lower the 1% of total number of orders entering into system, it is necessary to increase them gradually until this performance value is achieved. Figure 4 shows the decreasing trend of the percent of rejected orders with the increasing number of order pickers.



Figure 4. Decreasing trend of rejected orders

6. POSSIBLE MODEL UPGRADES

As it is already mentioned, this model does not completely describe the real order picking system in Milšped company for several reasons. One of the most important is the fact that the orders in the model being not processed until the end of the day are rejected from the model, instead to be transferred into the next day where they will be first ones processed by the order pickers. In order to model better describes the real-world system functioning, some recommendation for its improvement are given in the following text.

The order transferring is already noted as one of the possible improvement and, in addition, the model could function on the way that each order is assigned with priority information. Prioritized orders would have a priority when processing, where the priority is determined on the basis of the time when the order should be processed. Since there are some days during a year with extremely high number of orders, which are relatively known (e.g. days before holidays), it would be necessary to define the special distribution for them and to perform the special shift organization and to improve model in this manner. There is still a lot of factors that could be included in the model, such as operational performance monitoring for each order picker, the assignment of relevant information to each OL (mass, volume, packaging etc.), which could be the subject of future research.

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STUDY OF INVENTORY MANAGEMENT SIMULATION ANALYSIS: THE CASE STUDY OF MILŠPED

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Abstract: *The aim of inventory management is to provide sufficient quantities of goods in the warehouse so that user requirements can be filled at any moment. Considering the stochastic nature of demands, it is increasingly difficult to manage inventories. Depending on the time of delivery, ordering costs, cost of holding and lack of inventories this objective can be achieved by applying some of the inventory management strategies. By processing and analyzing the data of 57 items held in the warehouse of 3PL provider Milšped for a period of one year we determine requirements applying some of the strategies of inventory management.*

Keywords: *Inventory management, simulation, 3PL*

1. INTRODUCTION

Before the company make a decision whether or not to manage inventories, it is necessary to consider the advantages and disadvantages of keeping them in stock. The main reason that justifies keeping inventories is an increase of the level of customer service, despite the high costs that emerges when inventories are kept. Keeping inventories in the warehouse represents bound capital, especially when there is a surplus in the warehouse inventories.

Inventory management involves finding the optimal balance between product availability and total cost of inventories. The goal of optimal inventory management is to achieve a minimum total cost of holding inventories. Also, a time during the orders' replenishment, levels of demand, costs of keeping stocks and consequences of lack of stock must be respected. One of the most important factors in selecting inventory management model is the nature of demand. According to the factor based on the demand of a product, it is possible to affect the order of product, purchase of raw materials and production schedules (Ballou, 2004).

2. STRATEGY OF INVENTORY MANAGEMENT

The strategy of inventory management is one of the techno - economic characteristics of the stocks. In practice, there are different strategies of inventory management, and only few, basic ones, will be shown. A very important part of the strategy of inventory management is a choice of parameters that defines it.

The first strategy is the (Q, R) strategy. In this strategy, inventory is managed by two parameters: quantity Q and the level Rn. Q is a replenishment quantity which will be supplied

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and Rn is the level on which a user makes an order. This strategy implies that lead time is known in advance and it is very suitable for inventory management in terms of stochastic consumption because the quantity of an item is ordered when it reaches a protective level of stock (Rn). In this strategy two extreme cases might happen and they are shown in the figure 1 (Vukićević, 1995).

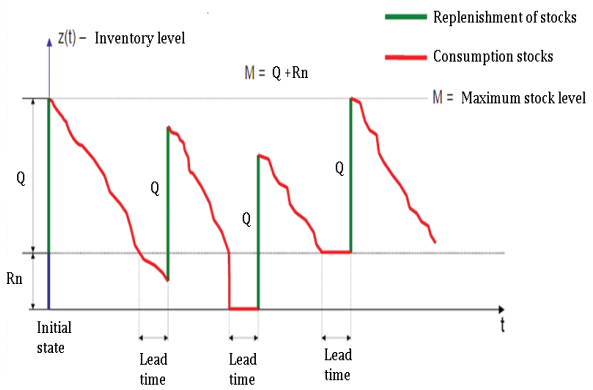


Figure 1. Strategy (Q,Rn)

Another strategy is (Q, W). In this strategy, inventories are managed by two parameters: Q and W. Q is a quantity of product to be replenished and W is interval between two deliveries. This strategy (Figure 2) is suitable only in cases with deterministic consumption (Vukićević, 1995).

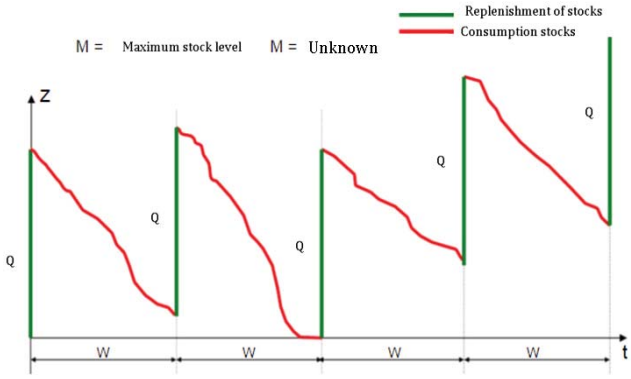


Figure 2. Strategy (Q, W)

The third basic strategy (Figure 3) is (M, Rn) strategy. This strategy implies that inventories are managed through a maximum permitted stack of inventory M and inventory ordering level Rn. In this strategy lead time between placing an order and the arrival of the order, as well as and storage capacity are known in advance. It is important that the warehouse can always be filled by the quantity that arrives. The disadvantage of this strategy is that the buyer knows the quantity of goods they can accept only when the lead time pass, respectively when the goods are delivered (Vukićević, 1995).

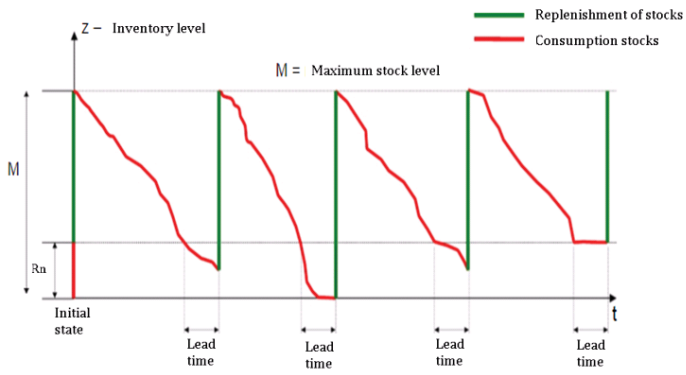


Figure 3. Strategy (M, Rn)

Finally, the last basic strategy is (M, W) strategy. In this strategy inventories are managed by maximum permitted quantity of inventories at hand (M) and time interval between two replenishments (W). This strategy (figure 4) is common in situations when one wants to ensure, respectively timetable of transport processes, whereby external transport unit executes a larger number of orders on the route of movement. In this strategy, in the case of intensive consumption the buyer may remain one period without the necessary stock, and, on the other hand, it may happen that the seller sells an extremely small amount of goods when consumption was extremely low in previous replenishment period (Vukićević, 1995).

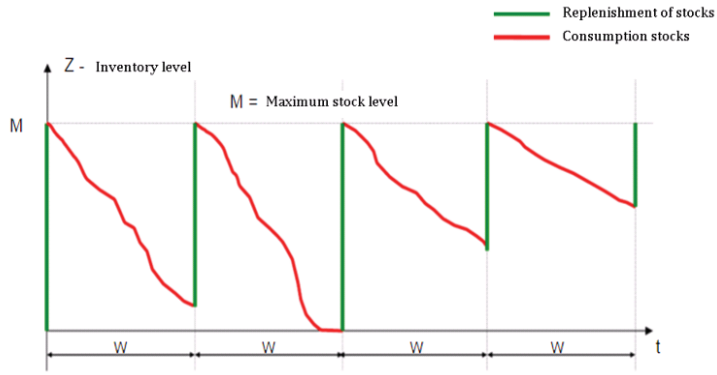


Figure 4. Strategy (M, W)

3. PROGRAM LOGWARE

The decision of which theoretical model to implement may be based on results of output data (in terms of overall costs) of Logware's module for inventories management. It should be noted that Logware provides data for only the first two basic inventory management models from previous section, i.e. (Q, Rn) and (Q,W). To get output results of the program, it is necessary to enter data based on average demand, the cost of a stock per unit, transportation costs per unit and cost of keeping stock per unit. Program requires information about delivery period, costs and ordering costs per unit of product. Since the company Milšped doesn't order products and doesn't manage inventories for clients, lead time is assumed to be 2 days. Also, costs of ordering and costs of transport by units of product are assumed to be 1 dollar. According to the results of the

program the lower costs are achieved when (Q,Rn) strategy is aplied. In this strategy, the level of the average stock is small and therefore total costs are lower. However, each of these strategies has advantages and disadvantages. Benefits of strategy (Q, Rn) are given if the products are ordered individually. In this strategy the average level of stock is low, but on the other hand it is required continuous monitoring of stocks for each product individually. Strategy (Q, W) is used especially when company has batch ordering of products. This strategy requires smaller cost savings of ordering, transportation and unit sales price. However, the average level of stock is higher and therefore total costs are not optimal.

4. SIMULATION IN FLEXSIM

In order to realize simulation modeling of inventory levels of products that are kept at Milšped for a particular client it was firstly required to analyze one year data of those products relevant for simulation modeling. Analysis implied the determination of:

- The probability distribution of time between the inventory replenishments
- The probability distribution of replenishment quantities
- The probability distribution of daily quantities that exits the system

Observing the time between inventory replenishments, 72% of products are determined to follow the exponential distribution. Normal distribution is determined in a small number of items (16%), while for the rest of the items uniform distribution is found to be appropriate one.

The main problem in determination of the probability distribution of the replenishment quantities was that for some products the sample was small (less than 60 data) and therefore it was not sufficient number to determine the probability with required accuracy. Moreover, for products that have had sufficiently large sample to form a probability distribution, distributions did not match any known distribution pattern. The (figure 5) shows the probability distribution of replenishment quantities of product 3, and for other products distribution is similar to this. One amount appears with much higher probability. However, this amount is not the maximal, and is even lower than the average amount. For these reasons, the amount of the entrance is calculated as the product of the average time between the entry and the average demand.

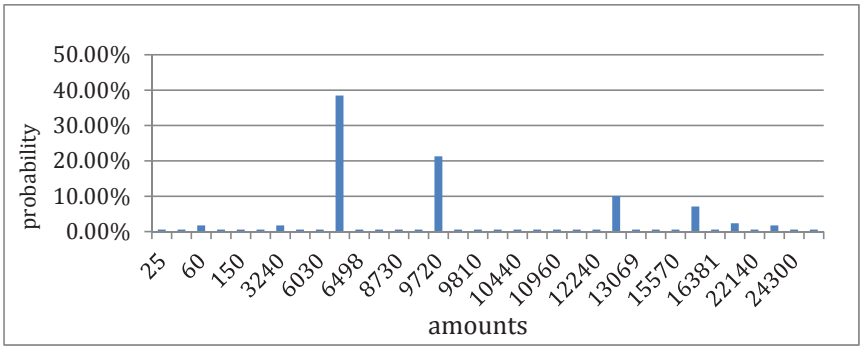


Figure 5. Probability distribution amounts at the entrance of the product 3

The probability distribution of daily quantities that exits the system turned out to follow the gamma and log logistics distributions. Data were processed in the program Minitab. This program gives loglogistic distribution parameters that cannot be implemented in the program FlexSim. Therefore, all products were determined by the gamma distribution with the most appropriate parameters.

According to the data obtained by the simulation model inventories of product 1 ranged from 0 to over 150 000, while product 16 inventory level moved in a different way. Inventories of product 1 are represented on figure 6, and inventories of product 16 are represented on figure 7.

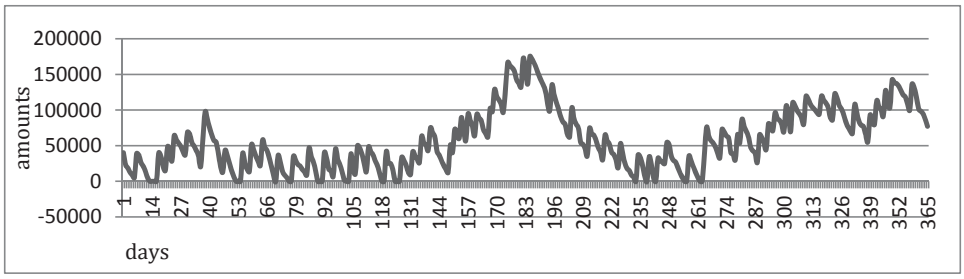


Figure 6. Inventories of product 1

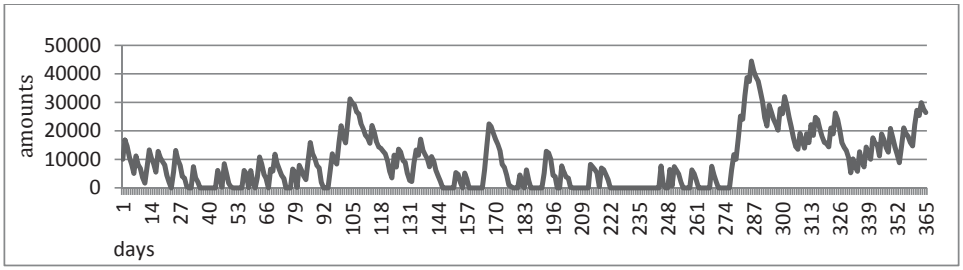


Figure 7. Inventories of product 16

On the inventory level graph of figure 8, each products are determined by the number on the end of the days when inventories were equal to zero. Only two products (36 and 56) at the end of each day were at the stocks, while product 16 at the end of 99 days wasn't in stock.

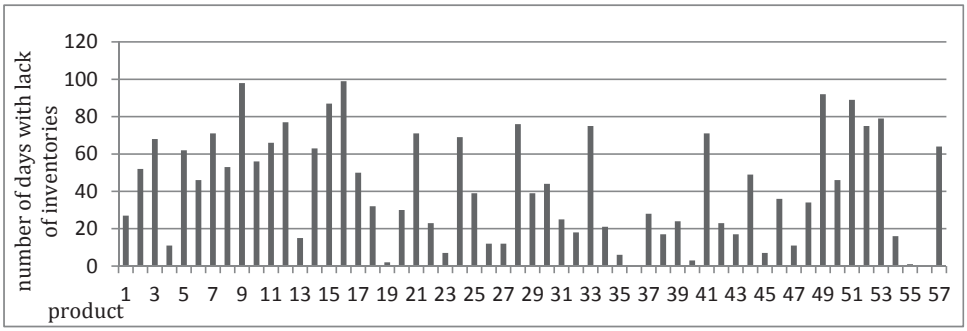


Figure 8. number of days when inventory were equal to zero

If user requests the amount of goods that is larger than the state of the stocks, he gets an available quantity of goods. Amount that was missing (the difference between the required and delivered quantities) is calculated and only product 56 is always supplied in the required quantity (picture 9).

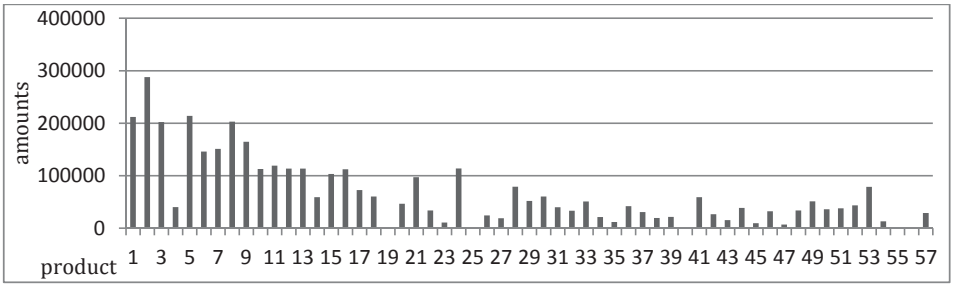


Figure 9. The quantities of the products that have been missing in the formation of the required orders for a period of one year

5. CONCLUSION

If company wants to manage inventory in a future period, it would be necessary to make as much precise history data analysis as it is possible. The data should be related to a longer period of time, because, the larger sample gives greater chance of accurately determining the probability distribution. Also, it is necessary to know the delivery time and cost to order that the company could implement a strategy of inventory management. With all this improvements the simulation results would be much more realistic (lack of stock would be lower, so instead of one, most of the products would always be supplied in the required quantity).

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ANALYSIS OF WAREHOUSE LAYOUT IMPACT TO ORDER PICKERS ROUTING: THE CASE STUDY OF MILŠPED

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***Abstract**: The order picking process represents the most expensive and most voluminous activity in a warehouse management, where quality of service greatly depends on this process. Layout of warehouse can have significant impact on the order picking. In this work we analyse the impact of warehouse layout for warehouse with racks, regarding the aisles and client storage zone, to routing of order pickers. Analysis is based on the real case data of Milšped company which is one of the leading logistics provider in Serbia. We observed 4 variants of layout for 4 different size clients with 50 orders each. To determine order picker routing we used the combination of several common heuristics where this routing resembles to real movement of order picking agent. The results were compared with optimal solutions.*

***Keywords**: Order picking, Warehouse layout, Routing.*

1. INTRODUCTION

Order picking is the acquisition process of certain goods based on the user's purchase order from already existing range of products located in the warehouse (order picking area). This process is very important for the warehouse management since it represents the most expensive and time consuming activity, where service quality greatly depends on it. The presence of new philosophies and strategies such as the delivery of small quantities of goods in a shorter period of time and the expansion of product range in stock in many ways makes order picking one of the most difficult warehouse processes to manage.

Forming a list of order picking and scheduling of goods in order picking zone has a major impact on the quality of the picking process. Allocation of goods in order picking zone is a task in which the goods are located in certain parts of the warehouse. In practice, there is a large number of approaches for allocation of goods in a warehouse and every approach should take care of characteristic factors concerning goods like complementary, compatibility, popularity and size. There are two basic ways for allocating goods in warehouse: (1) Dedicated storage policy - it is known beforehand where specific goods are located (the storage zones are known for certain groups of articles); (2) Randomized storage policy - goods can be stored in any warehouse location and this decision can be made when goods come into the warehouse. Before the order-picker gets the command for picking goods, the order must be processed. Customers purchase

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order is made of number of goods and amounts that must be selected. In the warehouse management system, customers purchase order is usually being converted in order picking list which contains (besides of the name and amount of goods) picking locations of pallets with goods (from which goods should be taken). Also, in regards to what order-picking strategy is being used, the lines in the command can be sorted in a way that order-picker can go from location to location and pick goods. Command for order picker can be just one customers purchase order or few of them and that depends on order-picking strategy, size of the orders, customers demands and other factors. Typical way for order-picking is sequential, where order-picker gets picking list that contains one customer order. For processing the order in this way order picker is processing one order list at a time and no additional sorting is needed. This is the mostly used method in practice.

The selection of order picking systems depends on a number of factors such as the volume of goods, flow, the size and number of orders and etc. The typical order picking system, regarding the movement of pickers and goods, are based on a system of "man-to-load" (in the aisle), which means that the picker with hand pallet trolleys goes to the location of the product and takes certain goods. The typical storage technology for goods on pallets are selective racks with single depth (one pallet can be stored in depth of a rack). The lower parts of these racks (usually the floor level) are designed for order picking requirements (order picking zone), while the higher rack locations serves as the reserve zone for replenishment of order picking zone. Order picking can be done with so-called technologies with paper or paperless. Order picking with the paper is based on the fact that the picker receives the order that includes rows with the name of the item, quantity, number of location in the warehouse and sorted so that the order picker takes items from the list by order. Sequence of order picking is usually determined on the basis of heuristics which will be discussed later. Order picking with paperless technology means that picker receives tasks by the warehouse management system by audio or visual commands, or on hand held terminal. In any case, picker must have the order picking list in some form with the sequence of locations from where goods should be picked. This sequence is in fact the routing of order picker in the aisles of warehouse. Minimizing total warehouse routing needed for order picking influences greatly on the efficiency of warehouse processes, by lowering the costs and order fulfillment time.

2. ORDER PICKER'S ROUTING

Order picker routing problem consists of finding shortest path in a given warehouse to visit all picking location in some picking list. The visiting order of locations from a picking list has a big influence on the order picker productivity and the quality of operations. In practice, we can use heuristics or optimal algorithms to solve this problem. Heuristics obtain solutions that are applicable in warehouse, but are not optimal. Optimal algorithms are developed for specific layout characteristics of order picking zone but can have solutions that are not "close" to the human reasoning (it is hard for an order picker to fully accept the logic behind the routing sequence). In order to apply the appropriate heuristics in a particular warehouse we must consider characteristics such as picking density, type and characteristics of the technology, characteristics and units of goods, warehouse layout etc. In the following we describe commonly used heuristics in order picker routing. The first heuristics is transitory strategy (S-Shape). In this case, the order picker starts from the base, visits all aisles (until the end) in which there is a requirement for the picking of goods. Order picker doesn't go in aisles in which there is no requirement for picking. When he finishes the last item, he comes out from the pass and returns to the base from which he started. This heuristic is carried out in warehouses where there is bilaterally order picking, which means that the order picker has a requirement for separation on both sides, and, at the same time he collects products on both sides. This heuristic is the easiest to use in practice and it's the most frequent. The next strategy is the return strategy in which the order picker always enters in storage from the front, where the base is. Picker enters into the

aisle up to the last picking location and turns back to exit on the same side. The next strategy is midpoint strategy in which the warehouse zone is divided in two parts. Order picker passes through the entire aisle only in the first and last pass. In other aisles, on both sides, picker enters up to half way and then returns. It could be used instead of S-shape if there exists only single picking location per aisle. In the third picking strategy, the largest gap, order picker travels over the entire length of first aisle, and in the each following aisle travels up to the picking location with the largest gap to next picking location in the same aisle. In the last aisle, order picker travels over the entire length, and then enters the rest of the aisles again to up to the largest gap. Fourth picking strategy is the combined strategy which represents the combination of transitory and return strategy. In this strategy, decision maker must decide whether it is better to go through the entire length of warehouse aisles or not. This strategy, in most cases represents the lowest risk strategy. The optimal strategy is a strategy in which there are no restrictions as in the above mentioned strategies. To get the shortest possible solution it is necessary to analyze all possible options of movement. This strategy cannot be applied to all types of layout and it can confuse order picker. The time required to carry out the order picking requests, in some cases depends more than 50% on order picker route of movement, and a lot less on other activities such as taking out the racks, searching for products. (Figure 1.)

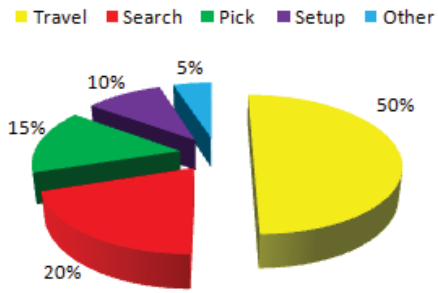


Figure 1. Typical distribution of an order picker's time (Koster et al. ,2006)

3. CASE STUDY MILŠPED

Milšped is the leading logistics company in the region. Successfully operating for 21 years and has more than 1000 employees. The modern way of work, organization of work, challenging ideas and skills to adapt to the market contributed to the successful operations of the company and has built up a unique market approach that integrates services of international road transport, air, sea and rail transport, tariff representation, warehousing and distribution and logistics car. Great work capacity and appropriate technology are able to respond to all the requirements of modern markets and to provide a complete logistics service. Milšped provides a range of integrated services in the field of storage and distribution. It has 70 000 m^2 of closed warehouse space and 40 000m^2 of open warehouse space located at many locations. The fleet consists of 150 vehicles of the latest generation. The company provides warehousing and order picking services, which is the topic of this work.

3.1 Test instances

In our test instances we had predetermined layout, client zoning and goods locations for all 4 variants (se Figure 1) are predetermined. Based on these data, it is necessary to determine the order picking list (sequence of picking) for each of the 4 variants so that the order picker's total routing is minimized. In all variants, warehousing is based on a single selective racks. In the first

layout variant storage consists of one block of parallel storage areas where the transition from one aisle to another is possible only at their ends (Figure 1.a). As for the second variant, the previous block is divided in half and order picker can only enter a aisle at one side of aisle (Figure 1.b). A third example is a layout in which the block selective racks are divided with middle aisle, where picker can enter an aisle from three pints (Figure 1.c). Finally, we have a warehouse that is similar to first variant, but with the difference in aisle length (Figure 1.d). In the last two variants, due to the layout with middle aisle, total storage capacity of the picking area is decreased by 80 pallet positions (on one line racks 4 places in the first and 4 places in the second level). We analyzed four customer with 50 orders where each order has a minimum of 5 locations for picking. Clients have different sizes of picking zones, namely: 1 client has 216 locations, the client 2 has 193 locations, the client 3 has 143 locations, and the client 4 has 181 location.

3.2 Routing methods and computational results

Data analysis was done in Excel, since the test data submitted in Excel. The first step was to determine exact location of all gods in picking area for each of the four layouts, in accordance to the rules given in advance from company Milšped. In the second step, for variant and client, it was necessary to determine order picker routing for each of the 50 orders. This step represents the goal of the work. To determine the movement of order picker we used two approaches: using the heuristic method described in Section 2; and applying the optimal algorithm (Roodbergen and de Koster, 2001), which was specially developed for layouts that are observed in this study. Figure 2 presents the optimal movement of order picker for one order of client 1. The reason for observation of heuristic and optimal approach lies in the fact that some studies show that order pickers harder accept the picking determined by an optimal algorithm. That is, heuristic solutions are more "friendly" from pickers point of view and therefore more acceptable. On the other hand, observing the optimal order picker's routing can obtain insight into the quality of heuristic methods, regarding total routing distance. There are often difficulties with order pickers to adopt optimal movement because it is natural that a human has a resistance and suspicion to computer guidance. In heuristic approach, we determined the picking sequence of each order which included enter/exit points at each aisle (see Figure 2). Based on this sequence, by using Excel, we determined length of each order picking observing Euclidian distance. By summing order picking distances for all 50 orders in each variant we obtained results presented in Table 1. Additionally, results from optimal algorithm is also given in Table 1.

Table 1. The total distance of order picker's routing for each layout variant and each client (50 orders per client)

	LAYOUT 1		**LAYOUT 2**		**LAYOUT 3**		**LAYOUT 4**	
CLIENT	Heur.*	Opt.**	Heur.	Opt.	Heur.	Opt.	Heur.	Opt.
1	6286.6	6209.0	7715.0	7437.1	6275.8	6161.4	6742.8	6427.7
2	5587.8	4631.9	7016.7	6506.1	5236.1	4950.0	7250.6	5449.4
3	5331.4	4858.7	5224.0	4976.7	5098.5	4629.3	4750.7	4190.8
4	7068.8	6570.1	9333.4	8978.5	7036.6	6601.1	9243.3	7372.8
Sum	24274.6	22269.6	29289.1	27898.3	23647.0	22341.7	27987.4	23440.7

* Total order picker's routing distance obtained by heuristic method
** Total order picker's routing distance obtained by optimal algorithm

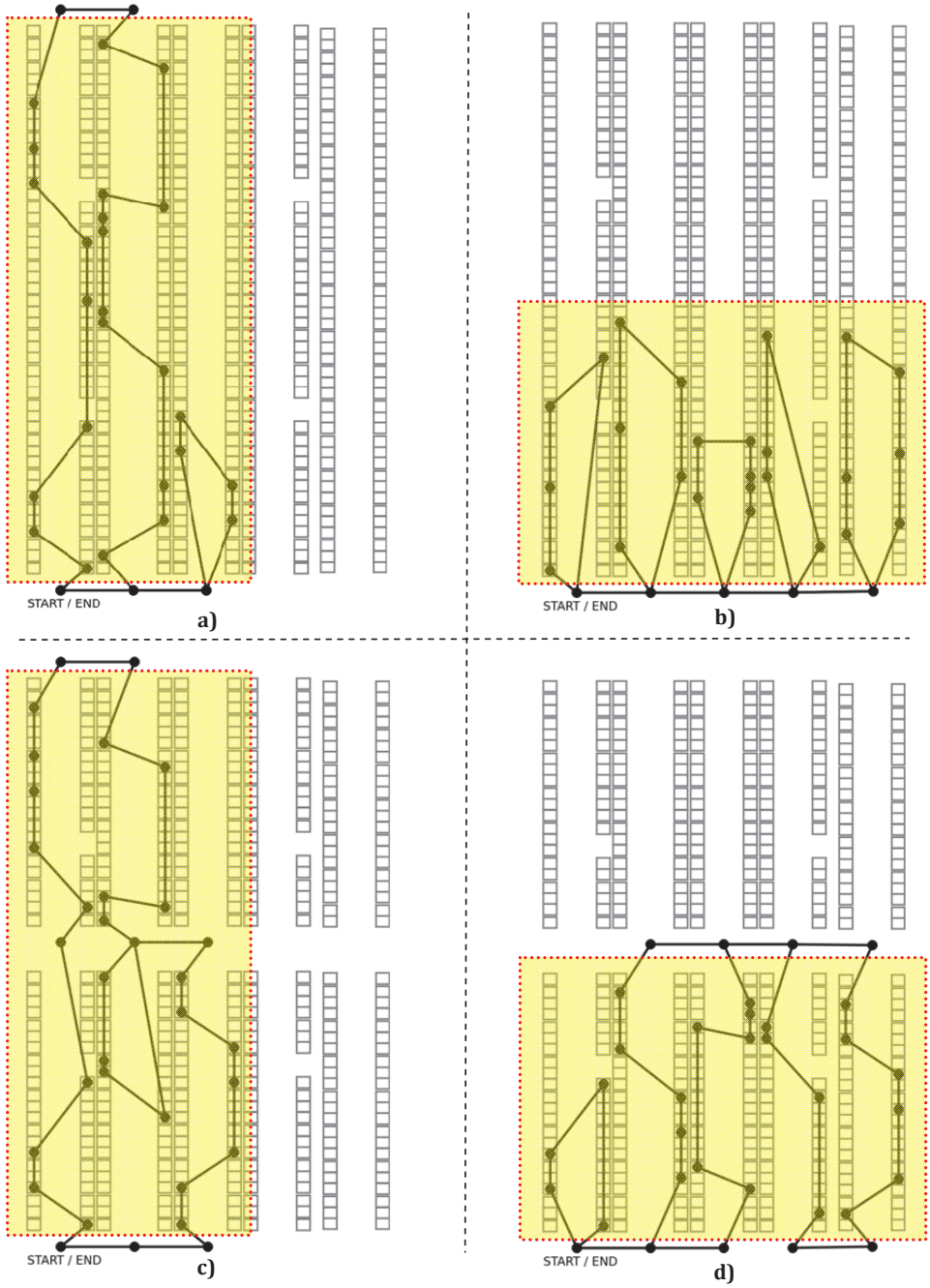


Figure 2. Example of order picker's optimal routing for an order of first client for four observed layouts (in each variant picking zone for first client is marked)

4. CONCLUSION

From the obtained results the best are layout 3 and layout 1 with a small difference between them. On the other hand, layout 2 proved to generate largest order picker's routing distance. Result are not consistent over all clients and all layout variants. For the third client layout 4 gives best results, while the layout 1 gives worst results. All other clients results per each layout variant is generally consistent to total rang. Considering the quality of heuristic approach to optimal algorithm, results show the following: for layout 1 heuristics gives 9.0 % higher routing distance, for layout 2 heuristics gives 5.0 % higher routing distance, for layout 3 heuristics gives 5.8 % higher routing distance, for layout 4 heuristics gives 19.4 % higher routing distance. In the limits of this analysis, which layout is the best, decision maker should consider the loss of locations in picking zone (for layouts 3 and 4) as well as ratio of solutions quality to "solution friendliness" (heuristics gives more human "friendly" solutions and largest travel distance compared to optimal algorithm). The results inconsistency is related to relatively small sample of observed orders and for more reliable analysis future research should include more clients and orders. Additionally, in depth and more detailed simultaneous observation of layout, goods location and orders batching, together with order picker's routing could lead to better optimization of warehouse processes.

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