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DURABILITY OF COLD PLASTIC MATERIAL FOR ROAD MARKINGS ON THE PART OF THE STATE ROAD D31 IN ZAGREB COUNTY

ABSTRACT

Road markings represents one of the most important component of traffic signalization because of their location situated in the central field of the driver's attention. Their important feature is the continuity along the entire length of the road which is an important fact in the orientation process. Road markings represent entity related to the pavement curtain composed of interconnected materials whose task is to ensure durability in poor weather conditions, durability, high value of skid resistance and more. This paper will present the analysis of plastic material durability (cold plastic) for road markings. Durability analysis implies a four-year retro-reflection value monitoring of performed road markings on the part of the state road D31 including their surface condition.

KEY WORDS

Traffic signalization; retroreflection; cold plastic; safety

1. INTRODUCTION

Maximum visibility is the most important requirement of road markings. There is also a minimum distance at which the driver must be able to detect and identify specific signalization. It can be concluded that drivers are using signalization in different ways depending on day or night conditions and it can be said that there are two main visual functions during the drive. One helps you in detection and recognition while another is used for routing orientation. Road markings can be defined as a set of longitudinal and transversal lines, signs and symbols which combined form the surface transportation infrastructure. They represent a part of the entire traffic signalization and cannot be replaced by other markings or regulations. Retroreflection research in various materials for road markings in wet conditions was showed by authors Gibson and Hankey [9].Their results showed that tapes have the best visibility and maximum detection distance in wet conditions. Similar results had thermoplastic materials while the worst was paint.

Road markings are having equal legal value as the traffic signs and traffic light signalization and they can be installed individually or in combination with them. Many traffic

accidents occur or can be correlated exactly with lower visibility of road markings. In order to increase the visibility of road markings in low visibility, when they are most needed drivers, road markings material are added retroreflective elements. These elements are having function to return light coming from the headlights of vehicle back to the eyes of the driver. In the continuation of this paper it will be shown the durability of one material for road markings (specific structure cold plastic) through the four-year monitoring of retro-reflection value and surface condition such marks on the part of the state road D31 in Zagreb County, Republic of Croatia.

2. GENERALLY ABOUT COLD PLASTIC MATERIAL FOR ROAD MARKINGS

Cold plastic is the material of the liquid state to which are added various additives and thickening mass. After initial densification, they are applied to the roadway where after twenty minutes they harden and can be driven over. Depending on the manufacturer can be embedded with glass beads or they can be added at the end of installation process. Their lifespan is relatively long, between 2 and 4 years. Cold plastic markings can be derived in various forms and regarding their form can be unprofaned and profiled.

General advantages of cold plastic markings:

- Excellent adhesion to concrete or asphalt;
- Very good dimensional stability, especially at high temperatures;
- Good adhesion to the existing solvent based paints and labels of cold plastic;
- Very good beads adhesion thanks to specially designed coating
- Good resistance to motor oils and fuels and other means for de-icing;
- Good resistance of agglomerate (accumulated) marking on snow ploughs;
- Weather resistance;
- Skid resistance and durability;

These marks are type II marks with improved visibility in wet or rainy night conditions and they have following characteristics (Figure 1):

- Open structure marking (agglomerates) have excellent results in drainage and high durability and dimensional stability with regard to specific stresses, such as snowplows;
- Possibility of simple restore with thin materials (such as paint film with high-strength, two-component paint or cold spray plastics)
- Very good price-performance ratio because of reduced material consumption
- calculated average layer thickness should be 2-3 mm.

Figure 1 - Profiled road markings made by cold plastic
Source: http://www.worldhighways.com/categories/road-markings-barriers-workzone-protection/features/reflective-road-markings-an-aid-to-road-safety/

3. DATA COLLECTION

Measurements analyzed in this paper were performed with Zehntner ZDR 6020 dynamic retroreflectometer which measures night visibility R_L in the day and night conditions.

Zehntner ZDR 6020 measures retroreflection in accordance with EN 1436 which defines measuring methods and conditions. In the standard measuring condition, the directions of measurement and illumination define a plane perpendicular to the plane of the field, the observation angle is 2.29° and the illumination angle is 1.24°[1]. Observation distance is 30 m for short lights.

In collaboration with Croatian Roads Ltd., intervals of retroreflection values (R_L) are made so that the quality of road markings can be evaluated. These intervals are related to the state of line (restored or existing) and line type (type I and type II).

Minimum values that certain types of lines in certain states must satisfy are defined in technical terms Croatian Roads Ltd.

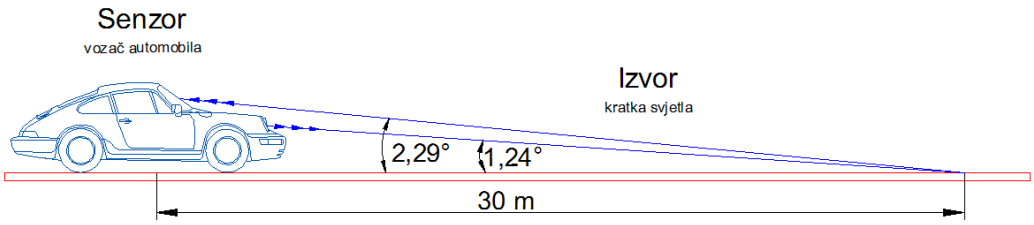

Figure 2 - Principle of measuring night visibility with dynamic retroreflectometer
Source: By authors

Table 1 - Minimum values of retroreflection for restored lines type I

VISIBILITY AND STATE OF PAVEMENT	MINIMUM VALUE	INTERVAL (mcd·m^{-2}·lx^{-1})
Nighttime visibility, dry pavement	**RL ≥ 200**	**180 ≤ RL ≤ 220**
Daytime visibility, dry pavement	**Qd ≥ 130**	**110 ≤ Qd ≤ 150**

Source: Guidelines and technical requirements for the works on renewing road markings, Croatian Roads Ltd.

Table 2 - Minimum values of retroreflection for restored lines type II

VISIBILITY AND STATE OF PAVEMENT	MINIMUM VALUE	INTERVAL (mcd·m^{-2}·lx^{-1})
Night time visibility, dry pavement	**RL ≥ 300**	**270 ≤ RL ≤ 330**
Daytime visibility, dry pavement	**Qd ≥ 160**	**140 ≤ Qd ≤ 180**

Source: Guidelines and technical requirements for the works on renewing road markings, Croatian Roads Ltd.

Table 3 - Minimum values of retroreflection for existing lines type I

VISIBILITY AND STATE OF PAVEMENT	MINIMUM VALUE	INTERVAL (mcd·m^{-2}·lx^{-1})
Night time visibility, dry pavement	**RL ≥ 100**	**90 ≤ RL ≤ 110**
Daytime visibility, dry pavement	**Qd ≥ 100**	**90 ≤ Qd ≤ 110**

Source: Guidelines and technical requirements for the works on renewing road markings, Croatian Roads Ltd.

[1] EN 1436

Table 4 - Minimum values of retroreflection for existing lines type II

VISIBILITY AND STATE OF PAVEMENT	MINIMUM VALUE	INTERVAL ($mcd \cdot m^{-2} \cdot lx^{-1}$)
Night time visibility, dry pavement	**RL ≥ 150**	**130 ≤ RL ≤ 170**
Daytime visibility, dry pavement	**Qd ≥ 130**	**110 ≤ Qd ≤ 150**

Source: Guidelines and technical requirements for the works on renewing road markings, Croatian Roads Ltd.

4. ANALYSIS OF COLD PLASTIC MATERIAL DURABILITY FOR ROAD MARKINGS ON THE PART OF THE STATE ROAD D31

Measurement were conducted on state road D31 between Velika Gorica (D408) and junction Velika Gorica (A11). All measurements were taken on middle line of listed state road (figure 2).

Figure 3 - Start position on tested field and structure of road markings (state road D31)
Source: By authors

In June 2011 on the part of state road D31 - section Velika Gorica (D408) and junction Velika Gorica (A11) road markings were applied in agglomerate cold plastic TIP II. When applying road marking, 4 kg/m² of agglomerate cold plastic and 0.45 dg/m^2 of glass beads (SOLIDPLUS 30 100-800 T18) were used.

First measurement was taken in July 2011. Measured values show excellent results (figure 3), 94% (bad results go to the crossing) of values are over the minimal value (270 $mcd \bullet lx^{-1} \bullet m^{-2}$) for restored TIP II lines for Croatian state roads and in interval 400 - max with overall arithmetic mean reaching 620 $mcd \bullet lx^{-1} \bullet m^{-2}$ which is 65% higher than minimal value (217 $mcd \bullet lx^{-1} \bullet m^{-2}$). Average value amounts 468 $mcd \bullet lx^{-1} \bullet m^{-2}$

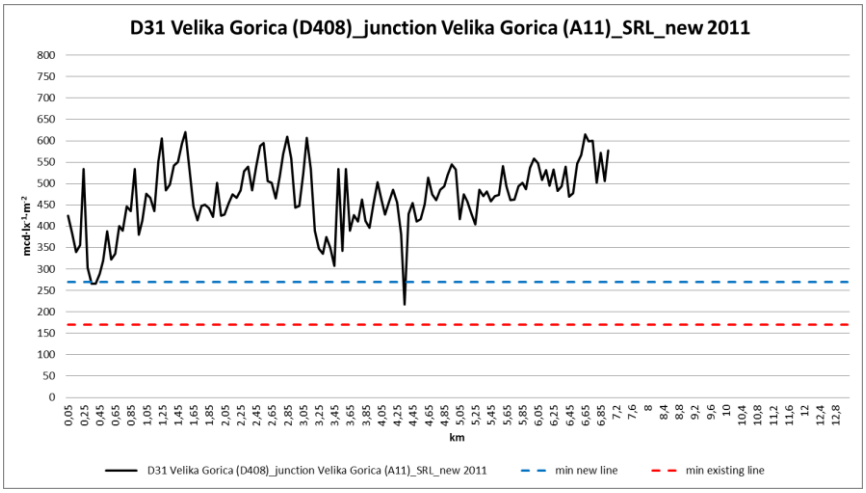

Figure 3 - Values of retroreflectivity for new cold plastic line 2011
Source: By authors

Second measurement on test field was taken in August 2012 when the line was one year old. Results of measured values are shown on figure 5. It is important to note that the results are presented in intervals for new line because of easier comparisons of fall retroreflection value.

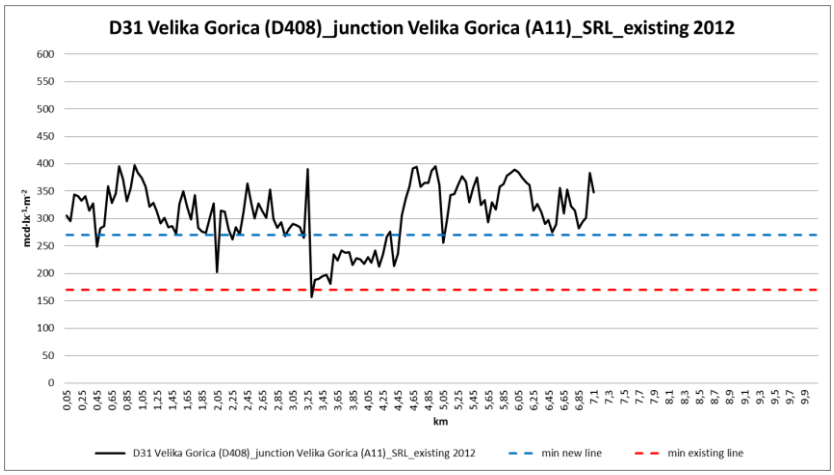

Figure 4 - Values of retroreflectivity for existing cold plastic line 2012
Source: By authors

Maximum measured value was 397 mcd•lx^{-1}•m^{-2} and minimum 157 mcd•lx^{-1}•m^{-2} and it is difference about 60%. Average value amounts 308 mcd•lx^{-1}•m$^{-2.}$

Third measurement was taken about two years after applying new line and it was in September 2013.

Reason for the poor results in Figure 7 is a classification of retroreflection values in the intervals for the new line (in this measurement center line was three years old). Better value display is shown in Figure 8 where it can be seen that the test data are mostly between the minimum requirements for a new and existing line.

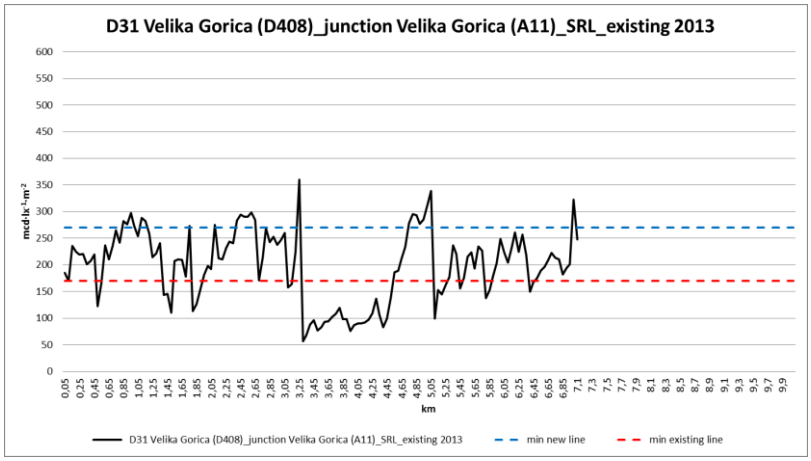

Figure 5 - Values of retroreflectivity for existing cold plastic line 2013
Source: By authors

Maximum measured value was 360 mcd•lx-1•m-2 and minimum 57 mcd•lx-1•m-2 what makes difference about 84%. Average value amounts 198 mcd•lx-1•m-2.

Fourth and last measurement was taken in May 2014. Overall arithmetic values of all measured values is 186 mcd•lx^{-1}•m^{-2} which is a slight difference compared to the last test in 2013 and marks age. Distributions of measured values are shown in figure 9 and 10.

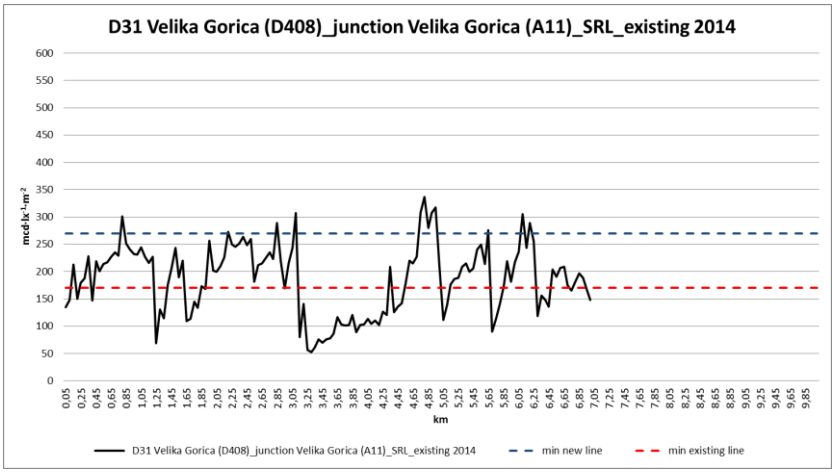

Figure 6 Values of retroreflectivity for existing cold plastic line 2014
Source: By authors

Last table shows the value distribution according to test year including average values of all measurements as well as the fall difference in the retroreflection values expressed as a percentage.

Table 5 - Value distribution according to test year

RESULTS ANALYSIS					The highest tested value (mcd·lx-1·m-2)	The average test value	Drop in value relative to the initial test (%)	Drop in value by test year(%)
New center line 2011								
Interval 0 - 50	Postotak	0,00%	AVG.:	0	620	467,96	-	-
Interval 50 - 270	Postotak	2,16%	AVG.:	249,33				
Interval 270 - 330	Postotak	3,60%	AVG.:	308,40				
Interval 330 - 400	Postotak	11,51%	AVG.:	367,69				
Interval 400 - max.	Postotak	82,73%	AVG.:	494,56				
Existing center line 2012								
Interval 0 - 50	Postotak	0,00%	AVG.:	0	397	308,09	34,16%	34,16%
Interval 50 - 270	Postotak	20,57%	AVG.:	225,10				
Interval 270 - 330	Postotak	42,55%	AVG.:	300,93				
Interval 330 - 400	Postotak	36,88%	AVG.:	362,63				
Interval 400 - max.	Postotak	0,00%	AVG.:	0				
Existing center line 2013								
Interval 0 - 50	Postotak	0,00%	AVG.:	0	360	198,34	57,62%	35,62%
Interval 50 - 270	Postotak	83,69%	AVG.:	179,83				
Interval 270 - 330	Postotak	14,89%	AVG.:	287,95				
Interval 330 - 400	Postotak	1,42%	AVG.:	349,50				
Interval 400 - max.	Postotak	0,00%	AVG.:	0				
Existing center line 2014								
Interval 0 - 50	Postotak	0,00%	AVG.:	0	337	186,33	60,18%	6,06%
Interval 50 - 270	Postotak	91,43%	AVG.:	175,76				
Interval 270 - 330	Postotak	7,86%	AVG.:	295,64				
Interval 330 - 400	Postotak	0,71%	AVG.:	337,00				
Interval 400 - max.	Postotak	0,00%	AVG.:	0				

Source: By authors

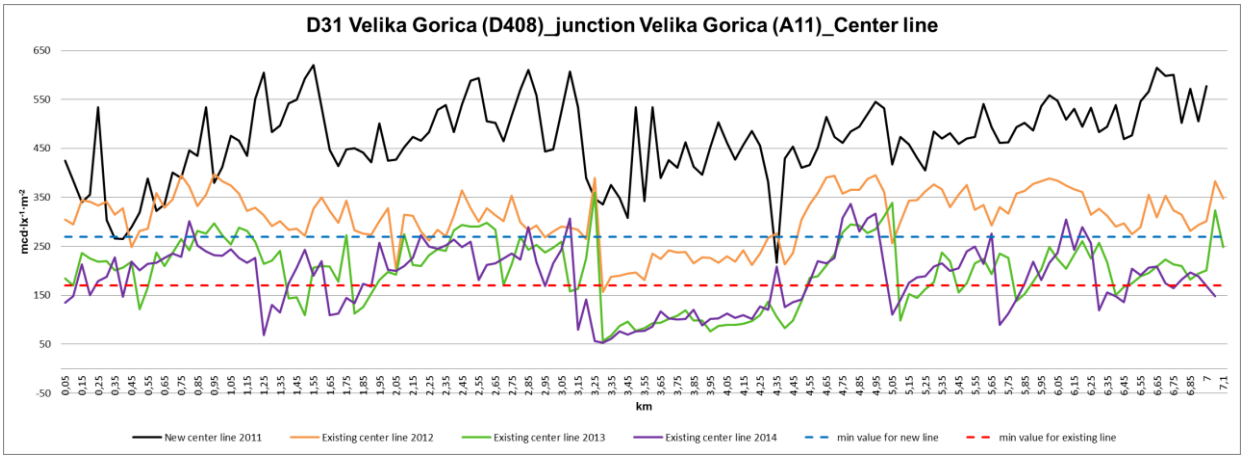

Figure 7 - Values of retroreflectivity for all measurements for period 2011 - 2014
Source: By authors

5. CONCLUSION

Testing road markings with a measurement vehicle (dynamic method) equipped with dynamic retroreflectometer offers the possibility of obtaining a continuous measurement results for the whole section intended to be measured, in a short time.

Measurements taken in period of four year with cold plastic material and “chicken shit” structure shows really good results. Testing of new center line in 2011 year has shown a very high value of retro-reflection in relation to the minimum set value for TYPE II markings. Regarding to the tested values of retroreflection they decreased by 34% in the second year of testing but still satisfying the conditions for new markings TYPE II. The decline in retro-reflection value is also recorded during the third year of testing (58% compared to the initial retro-reflection value). In this case, the retro-reflection value is within the set interval for the new and existing line providing good visibility in day, night and wet conditions. The smallest

decline in retro-reflection value in relation to the preliminary testing (testing in 2013) is recorded in the fourth year of testing. The value decrease is around 6%, while the average retro-reflection value is closer to the lower limit or minimum requirements for the existing line (170 $mcd \bullet lx^{-1} \bullet m^{-2}$).

Aldo, cold plastic road markings with "chicken shit" structure are at start more expensive and require complicated applying process, but they provide greater retroreflectivity values in day, night and wet conditions and because of that significantly improve road safety.

During 2015, the expected decline in retroreflection value is about 10%. Due to the fall in the retro-reflection value below the set minimum it is proposed to restore specified line.

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THE POSSIBILITIES FOR IMPROVING SAFETY ON CROATIAN STATE ROADS D3 AND D29 WITH THE ANALYSIS OF THE TRAFFIC SIGN QUALITY

ABSTRACT

Traffic accidents represent a significant social problem on the roads throughout the European Union and for this reason traffic safety is one of the key focuses of the European Commission which passed the fourth European Road Safety Action Programme in 2010, whose main task is to reduce the number of fatalities on the EU roads in the period from 2010 to 2020. One of the preventive actions of this program is aimed at improving road infrastructure, and thus at improving traffic signs as a vital part of traffic signalization. In order to achieve their main task, traffic signs need to be built and installed in accordance with the requirements for readability, clarity, easy visibility, and other essential requirements. All these requirements greatly depend on the visibility of traffic signs or the quality of retroreflective sheeting, proper positioning and maintenance.

This paper represents the analysis of the quality of traffic signs and traffic accidents on Croatian state roads D3 and D29. The main objective is to get an insight look in to the quality of traffic signs and the number of traffic accidents on these two state roads.

KEY WORDS

Traffic signs; traffic safety; traffic accidents

1. INTRODUCTION

Traffic signs as a primary means of communication between road and its users need to ensure safe, predictable, efficient, and orderly movement of drivers [1]. To achieve that, traffic signs must command attention, convey a clear simple meaning, command respect from road users and give adequate time for proper response. For this reason, many studies have been done to designee usable traffic signs, in terms of dimension, colour and shape.

Authors [2] conducted the study in which the analysis of interference effect produced by the position of the sign elements in traffic signage on response accuracy and reaction time was performed. In the study, sixteen drivers performed a flanker interference reaction time task. Incongruent graphical/space solutions lead to increased reaction time and a reduction in the proportion of correct answers. These results suggest that incongruent visual information should be avoided, as this might impair drivers' performance.

Similar study was done by authors [3], in which effects of signs design and driver factors on the comprehensibility of traffic signs was analysed. Results of the study showed that driving experience (years with driving license) and education level are significant predictors of sign comprehensibility. Factors as the driver's age, years of active driving, hours of driving, last time driving, driving frequency, and non-local driving experience had no effect on comprehension performance. Sign familiarity was correlated with comprehension score for licensed drivers, whereas sign concreteness, simplicity, and meaningfulness were not.

Apart from design, visibility is one of the key requirements for traffic signs. This is especially crucial in conditions of reduced visibility where the driving tasks are more challenging and complex because fewer visual cues are available.

To achieve visibility, retroreflective sheeting which contains spherical (glass beads) or micro prismatic reflectors are used. These retroreflective materials are moulded in durable transparent material and are produced in all colours that are used for traffic signs. Today, there are three types of retroreflective materials for traffic signs:

- Class I – RA1
- Class II – RA2
- Class III – RA3

To ensure proper visibility, traffic signs need to be periodically measured using dynamic or handheld (static) retroreflectometers. Dynamic measurement system uses retroreflectometer which is installed on the measuring vehicle and measures retroreflection during driving. For static measurements handheld retroreflectometers are used, which measure retroreflection when placed on the surface of the sign in order to exclude the impact of daylight.

To analyse the performance and deterioration characteristics of retroreflective sheeting materials, authors [4] conducted a study which overall goal was to help maintenance personnel to develop sign testing, maintenance, and replacement schedules. In addition, three other objectives including, an analysis of the interaction between various sign properties and environmental factors to determine the factors that affect the rate of traffic sign deterioration, an evaluation of cleaning on sign retroreflectivity, and the development of mathematical models to predict future sign performance were achieved. The analyses showed that, overall, the various sign sheeting was performing well relative to the specification criteria during and after the warrantee period. Also, no statistically significant links between key environmental factors such as proximity to the road or sign orientation to a pre-mature deterioration were found. However, the analyses results did support the concept that cleaning can significantly improve specification compliance. A set of performance models was developed to assess the rates of sign deterioration for specific conditions to assist highway agencies in focusing maintenance resources on specific groups of signs.

The factors that may affect road sign retroreflectivity, specifically age and physical orientation were analysed by authors [5]. The findings showed that over a twelve-year age span, most sign retroreflectivity readings were above the minimum standard and that retroreflectivity did not vary predictably with age. Also, some evidences that retroreflectivity may be affected by sign orientation (direction facing), due to the weathering effects of windblown dust and precipitation were obtained.

The goal of this study is to get an insight look into the quality of traffic signs and the number of traffic accidents on two Croatian state roads D3 and D29. The aim of this article is to collect the necessary data that represent the basis for further research related to the effect of traffic signs on traffic safety in Croatia.

2. DATA COLLECTION METHODOLOGY

To ensure the quality of transmitted message, traffic signs should be examined at least once a year to check their retroreflection quality and other technical characteristics using one of the mentioned methods. The data used in this paper was collected by the Department for Traffic Signalization at the Faculty of Transport and Traffic Sciences. The coefficient of retroreflection (R_A) was measured on the total of 973 traffic signs with handheld Zehntner's ZRS 6060 retroreflectometer using observation angle[1] of 0.33° and an entrance angle[2] of 5°.

The coefficient of retroreflection is defined as the coefficient of luminous intensity of a plane retroreflecting surface to its area or as a ratio of returned intensity to incident illumination divided by the area of the retroreflector. The metric unit for retroreflection coefficient is $cd \bullet lx^{-1} \bullet m^{-2}$ (candelas per lux per square meter) [6].

The minimum initial coefficient of retroreflection R_A ($cd \bullet lx^{-1} \bullet m^{-2}$) of retroreflective signs must match the values shown in Table 1, Table 2 and Table 3. The coefficient of retroreflection (R_A) of all printed colours, except white, shall not be less than 70 % of the values in tables [7].

Table 1 - Retroreflection coefficient R_A: Class RA1 ($cd \bullet lx^{-1} \bullet m^{-2}$)

Geometry of measurements		Colour							
α	β1 (β_2=0)	white	yellow	red	green	blue	brown	orange	grey
12′	+5° +30° +40°	70 30 10	50 22 7	14.5 6 2	9 3.5 1.5	4 1.7 0.5	1 0.3 #	25 10 2.2	42 18 6
20′	+5° +30° +40°	50 24 9	35 16 6	10 4 1.8	7 3 1.2	2 1 #	0.6 0.2 #	20 8 2.2	30 14.4 5.4
2°	+5° +30° +40°	5 2.5 1.5	3 1.5 1.0	1 0.5 0.5	0.5 0.3 0.2	# # #	# # #	1.2 0.5 #	3 1.5 0.9
# Indicates "Value greater than zero but not significant or applicable".									

Source: [7]

[1] The observation angle is the angle between the incoming light ray and the reflected ray.

[2] The entrance angle is primarily determined by the position of the sign on the side of the road and the geometry of an oncoming vehicle position and represents the angle that is formed between the light rays falling on the surface of the sign and the line that goes vertically from the surface.

Table 2 - Retroreflection coefficient RA: Class RA2 (cd•lx^{-1}•m^{-2})

Geometry of measurements		Colour								
α	β1 (β_2=0)	white	yellow	red	green	dark green	blue	brown	orange	gray
12′	+5° +30° +40°	250 150 110	170 100 70	45 25 15	45 25 12	20 15 6	20 11 8	12 8,5 5,0	100 60 29	125 75 55
20′	+5° +30° +40°	180 100 95	120 70 60	25 14 13	21 12 11	14 11 5	14 8 7	8 5 3	65 40 20	90 50 47
2°	+5° +30° +40°	5 2,5 1,5	3 1,5 1,0	1 0,4 0,3	0,5 0,3 0,2	0,5 0,3 0,2	0,2 # #	0,2 # #	1,5 1 #	2,5 1,2 0,7
# Indicates "Value greater than zero but not significant or applicable".										

Source: [7]

Table 3 - Retroreflection coefficient R_A: Class RA3 (cd•lx^{-1}•m^{-2})

Geometry of measurements		Colour					
α	β1 (β_2=0)	white	yellow	red	green	blue	orange
0.1°	+5° +20° +30°	850 600 425	550 390 275	170 120 85	85 60 40	55 40 28	260 130 95
0.2°	+5° +20° +30°	625 450 325	400 290 210	125 90 65	60 45 30	40 30 20	140 100 70
0.33°	+5° +20° +30°	425 300 225	275 195 145	85 60 45	40 30 20	28 20 15	95 65 49

Source: [8]

When measuring retroreflection, each sign was measured four times: up, down, left and right. The relevant value of retroreflection represents the average values of all four measurements. In addition to the retroreflection value, several other elements were analysed: sign name and code, graphic display (sign picture), dimension and height and distance from the sign edge, surface colour, edge and symbols, the way the sign is installed and fixed, information about the sign producer, retroreflective material, etc. [9].

3. ANALYSIS OF THE TRAFFIC SIGN QUALITY AS A FACTOR OF TRAFFIC SAFETY ON CROATIAN STATE ROADS D3 AND D29

On the state road D3 in Zagreb County, in a length of 17.8 km, on the section Dubovec (g.ž.) - Lužan (g.ž.), 414 traffic signs were measured, while on the state road D29 in Krapina-Zagorje County, in a length of 29 km, on the section Golubovec (D35) - Laz (g.ž.), 559 traffic signs were measured. Due to road works, traffic signs were not measured on the entire section of the road D29.

Table 4 shows the classification of measured traffic signs by meaning according to the Croatian regulations [10].

Table 4 - Total number of analysed traffic signs classified by meaning

Road	D3	D29	Total
Section	Dubovec (g.ž.) - Lužan (g.ž.)	Novi Golubovec (D35) - Laz (g.ž.)	
Sign classification	Number of signs		
Danger signs - A	110	124	**234**
Mandatory signs - B	74	78	**152**
Information signs - C	174	137	**311**
Guide signs - D	30	35	**65**
Additional panels - E	15	60	**75**
Traffic equipment - K	11	125	**136**
Total	**414**	**559**	**973**

As shown in Table 4, a total of 973 traffic signs were measured on the analysed state roads. Of a total of 973 traffic signs, 311 are information signs, 234 danger signs, 152 mandatory signs, 136 signs that are classified as traffic equipment, 75 additional panels and 65 are guide signs as shown in (Figure 1).

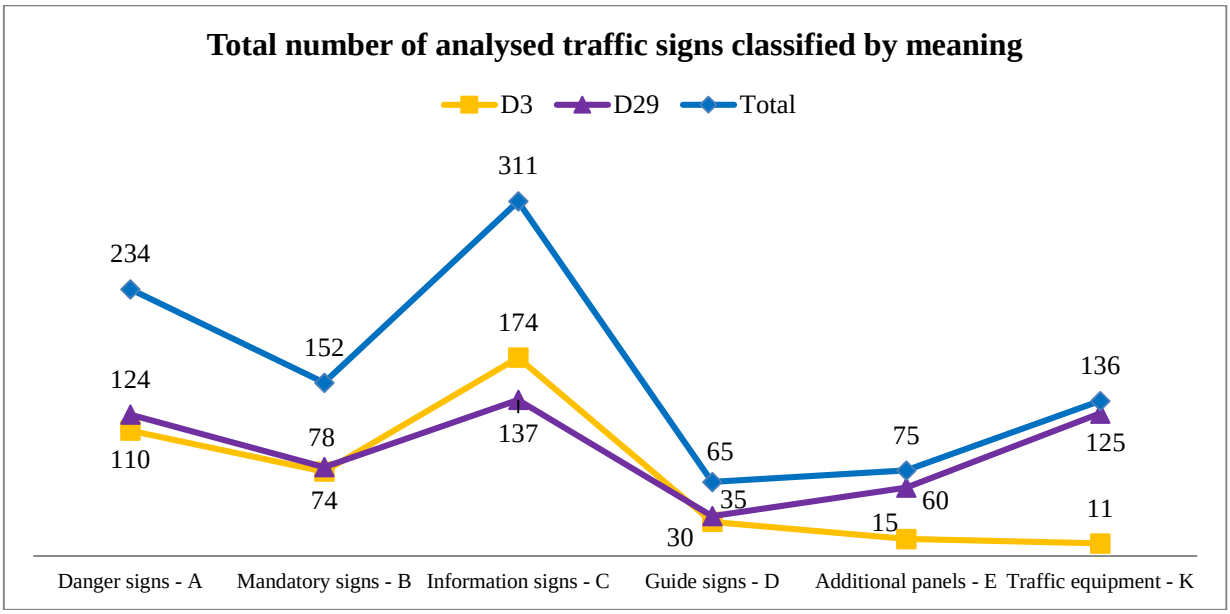

Figure 1 - Total number of analysed traffic signs classified by meaning

The analysis of the retroreflective sheeting from which traffic signs are made shows that 681 signs are made of class RA1, 203 of class RA2 and 89 of class RA3 sheeting, as shown in Figure 2. From the collected data, it can be concluded that 69.98% of traffic signs use, in relation to visibility, the worst class of retroreflective sheeting (RA1).

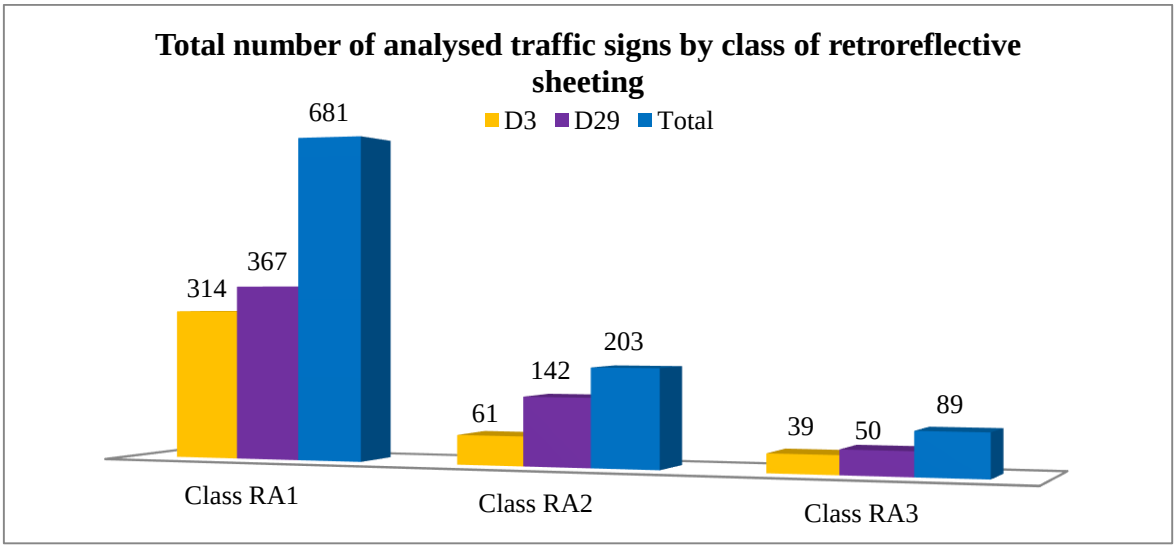

Figure 2 - Total number of analysed traffic signs classified by class of retroreflective sheeting

Upon the analysis of the retroreflection values of the traffic signs, it was concluded that 132 signs on state road D3 and 235 signs on state road D29 do not meet the minimum prescribed value of retroreflection. Overall, 62.28% of traffic signs meet and 37.72% do not meet the minimum values.

According to the meaning, most of the signs that do not meet the minimum values are information signs (113), then danger signs (92), signs that are classified as traffic equipment (62), mandatory signs (46), guide signs (38) and additional panels (16) as shown in Figure 3. It is clear that of all the signs that do not meet the minimum values, almost half of them (47,96%) belong to, from the driver's point of view, three main groups of signs: danger, mandatory and guide signs.

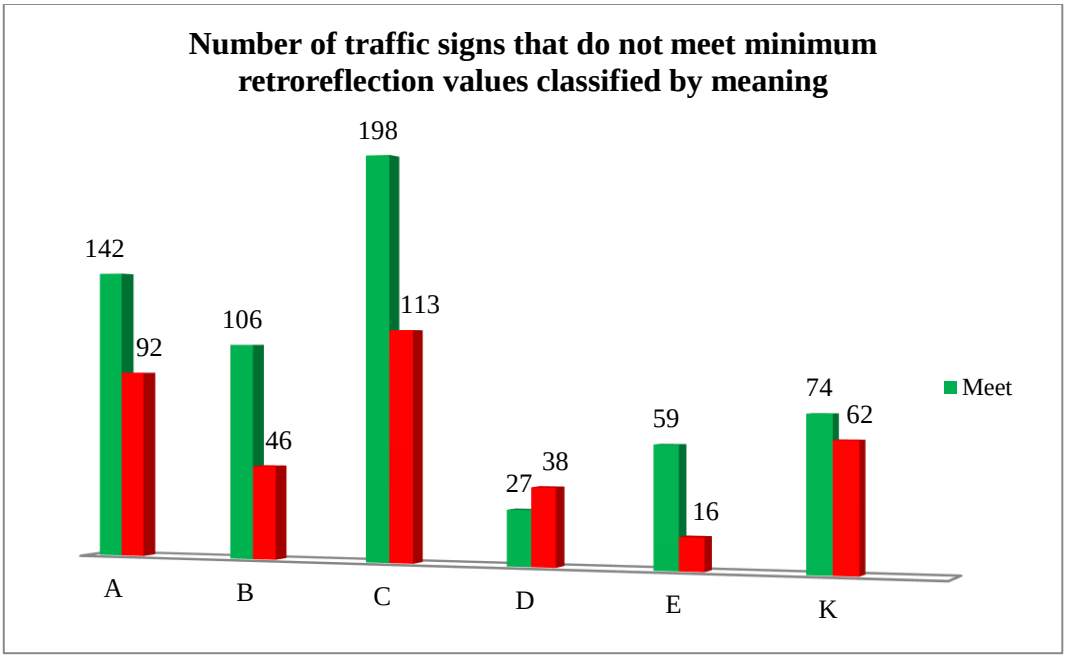

Figure 3 - Number of traffic signs that do not meet minimum retroreflection values classified by meaning

A deeper analysis of the collected data shows that most of the traffic signs that do not meet minimum values are built using RA1 sheeting, in total 257 signs. This was expected

because of the lowest retroreflection capabilities and warranty period of RA1 sheeting. Also, the majority of signs (69.99%) on the analysed roads use RA1 sheeting. A significantly lower number of signs that do not meet minimum values are built from RA2 and RA3 sheeting, with the total of 62 signs for RA2 and 48 for RA3, as shown in the Figure 4.

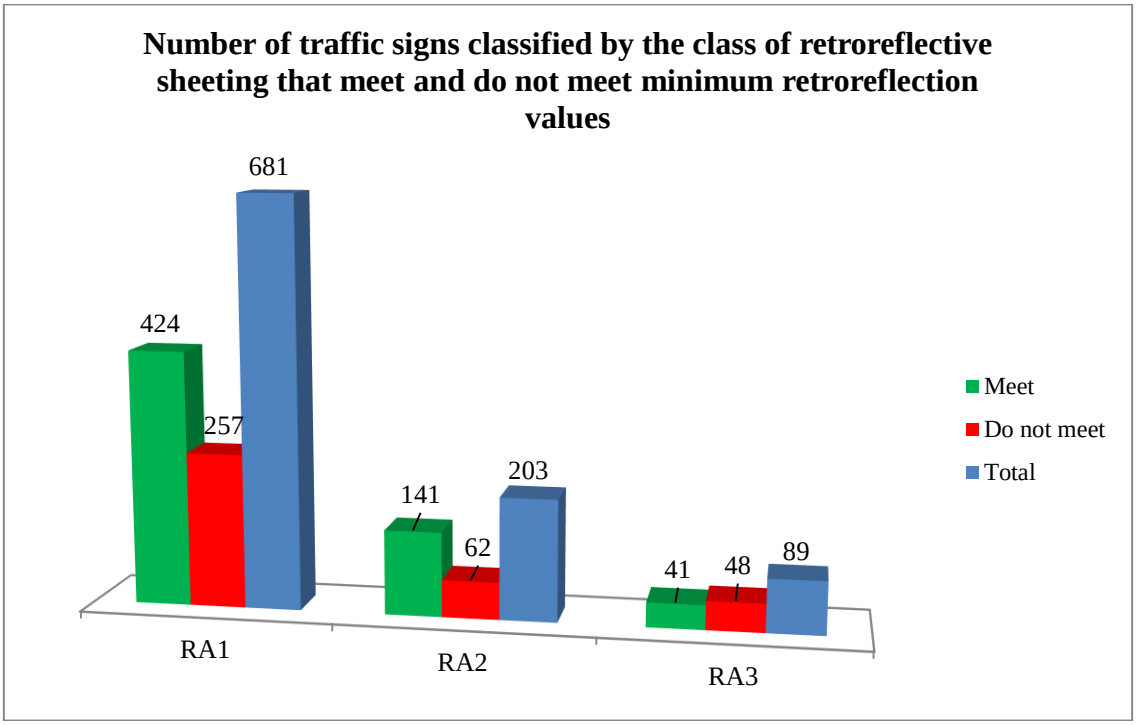

Figure 4 - Number of traffic signs classified by the class of retroreflective material that do not meet minimum retroreflection values

As mentioned earlier, in addition to the retroreflection, other technical characteristics were also analysed. From a technical point of view, the analysis showed that on the state roads D3 and D29, 106 or 10.89% of signs do not meet the technical specifications (signs are damaged, bent, blocked, not in accordance with the regulations, etc.).

From all the above, and based on the analysis of technical and retroreflection requirements of traffic signs it can be concluded that on the state roads D3 and D29, of 973 signs, there are 473 or 48.61% which do not meet the prescribed requirements[3].

4. TRAFFIC ACCIDENTS ANALYSIS ON THE STATE ROADS D3 AND D29

According to the data received from the Police Department in the period from 2010 to 2013, on the state roads D3 and D29, 226 accidents were reported, of which five fatalities, 112 with injuries (22 serious and 199 minor injuries) and 197 material damage, as shown in Table 5.

[3] Some signs do not meet prescribed technical and retroreflection requirements at the same time, some do not meet only retroreflective and some only technical requirements

Table 5 - The number and consequences of traffic accidents on the state roads D3 and D29

2010-2013 (data collected up to October 2013)		D3	D29	Total
		Dubovec (g.ž.) - Lužan (g.ž.)	**Novi Golubovec (D35) - Laz (g.ž.)**	
Number of traffic accidents	With fatalities	4	2	**6**
	With injuries	76	36	**112**
	With material damage	125	72	**197**
	Total	**205**	**110**	**315**
The consequences of accidents	Fatalities	4	1	**5**
	Serious injuries	11	11	**22**
	Minor injuries	118	81	**199**
	Total	**133**	**93**	**226**

Source: Adapted by authors

Table 6. shows the number of traffic accidents on analysed roads classified by the time of the day when they happened. From the data in the table, it can be concluded that most accidents, 180 or 57.14% happened during daytime. Of the remaining 135 accidents, 124 or 39.37% happened during the night, while 11 or 3.49% during the dusk and dawn. A total percentage of accidents that happened under the conditions of reduced visibility, which are the most complex driving conditions, is 42.86%.

Table 6 - Number of traffic accidents on the state roads D3 and D29 classified by the time of day when they happened

Road	D3	D29	Total
Section	**Dubovec (g.ž.) - Lužan (g.ž.)**	**Novi Golubovec (D35) - Laz (g.ž.)**	
Day	118	62	**180**
Night	79	45	**124**
Dawn	6	1	**7**
Dusk	2	2	**4**
Total	**205**	**110**	**315**

Source: Adapted by authors

5. CONCLUSION

Traffic signs are elements defined as a set of specially coded labels intended for traffic participants, located in the vertical plane with respect to the traffic area created out of a need for traffic management which is, besides traffic regulation, information and orientation/guidance, their most important function. As a primary means of communication between the road authorities and traffic participants, traffic signs must provide a clear and uniform message to the driver in all conditions, especially in the conditions of reduced visibility.

To ensure that traffic signs perform their functions, they should be inspected at least once a year to verify their retroreflection and other technical characteristics. Retroreflection is the phenomenon that occurs when light rays strike a retroreflective surface and are reflected from that same surface back to the light source and on traffic signs it can be measured using dynamic or static retroreflectometers (mainly static).

In this article an analysis of traffic signs quality is presented, conducted by the Department for Traffic Signalization at the Faculty of Transport and Traffic Sciences, on two Croatian state roads D3 and D29. Measurements were done using handheld retroreflectometer Zehntner ZRS 6060 in accordance with the European and national standards and specifications. When measuring retroreflection, each sign was measured four times: up, down, left and right. The relevant value of retroreflection represents the average values of all four measurements. In addition to the retroreflection value, several other elements were analysed: sign name and code, graphic display (sign picture), dimension and height and distance from the edge of sign, surface colour, edge and symbols, the way the sign is installed and fixed, information about the sign producer, retroreflective material, etc.

The analysis showed that of 973 traffic signs measured on the mentioned roads, 367 or 37.71% of signs do not meet the minimum prescribed retroreflection values. The majority of signs that do not meet the minimum values, 257 or 70.03%, are made from class RA1 retroreflective sheeting which is the material with the lowest retroreflection properties and thus the lowest visibility characteristics. Also, of all the signs that do not meet the minimum values, almost half of them (47.96%) belong to, from the driver's point of view, three main groups of signs: danger, mandatory and guide signs.

From a technical point of view, the analysis showed that on the state roads D3 and D29, 106 or 10.89% of signs do not meet the technical specifications (signs are damaged, bent, blocked, not in accordance with the regulations etc.).

Based on the above data, it can be concluded that on the state roads D3 and D29, of 973 signs, there are 473 or nearly half (48.61%) which do not meet the prescribed requirements (either retroreflection or technical characteristics).

On the analysed roads, in the period from 2010 to 2013 (data collected by October 2013), 315 traffic accidents occurred resulting with five fatalities, 22 serious and 199 minor injuries. Most of the accidents, 180 or 57.14% happened during the daytime. Of the remaining 135 accidents, 124 or 39.37% happened during the night, while 11 or 3.49% during the dusk and dawn. In total, 42.86%, which is almost half of all the traffic accidents on the analysed roads, happened in conditions of reduced visibility.

Conditions of reduced visibility are the most complex conditions for drivers because the amount of visual information is significantly reduced due to the limited capability to use peripheral vision, possibility for depth perception and colour vision, thus affecting and decelerating the drivers' decision-making process.

For these reasons, technical accuracy of traffic signs (retroreflection values, proper installation of the sign, compliance of the sign with the regulations, etc.) is one of the key elements of road safety.

As stated earlier, nearly half of traffic accidents (42.86%) on the analysed roads occurred in the conditions of reduced visibility (night, dusk and dawn). Currently, most of the signs on the mentioned roads are made of class RA1 (total 681) and 70.02% of them do not meet minimum retroreflective values. To ensure and improve safety, traffic signs which do not meet the prescribed requirements must be replaced with new signs with better retroreflective properties such as class RA2 or RA3.

Also, in order to obtain a deeper insight into the influence of traffic signs on traffic safety, in future research it is necessary to perform a detailed analysis and comparison of the causes, consequences and the places of origin of traffic accidents with the quality of traffic signs in the immediate vicinity.

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IMPACT OF NEW POSTAL SERVICES ON DEVELOPMENT OF RURAL AREAS OF THE REPUBLIC OF CROATIA

ABSTRACT

The Republic of Croatia is emphasized unevenness population of certain areas. Urban settlements are increasing and developing rapidly, while rural lagging behind in terms of population as well as by development. This trend should slow down, primarily on the way to encourage development and improve living conditions in rural villages.

The European model of rural development, followed by the Republic of Croatia, based on encouraging the development of communal and social infrastructure and improving basic services, with emphasis on the development of information and communication technologies that will neutralize many advantages of urban areas. The European model of rural development aims to keep the population in rural areas and to equalize the quality of life in rural and urban areas.

In this paper the emphasis on business transformation of the postal services through the development of new postal services, and offer services and products from non postal sector through existing postal network. This will create preconditions for the promotion of economic development of rural areas, better education, better and faster service to the public administration and health care.

KEY WORDS

information and communication technologies; universal postal service; postal network; the new postal services; development of rural areas

1. INTRODUCTION

Insufficient development of rural areas, their continued population decline and population concentration in urban areas limits the uniform development of the Croatian. The spatial dispersion of the population requires high costs. It is complex for an organized and efficient use and provision of services in relation to urban areas.

The organization of the postal network and the availability of postal service vary significantly between rural and urban areas, and is determined on the basis of population, surface area covered, topographic conditions, population density, transport connections, the quantity of shipments, the possibility of using means of transport, local conditions and structure users who are serving. Diversified and accessible postal network and the provision of postal services have a positive effect on sustainable development, with particular emphasis on rural development.

The European model of rural development, followed by the Republic of Croatia, is based on encouraging the development of communal and social infrastructure and improving basic services, with an emphasis on the development of information and communication technologies that will neutralize many advantages of urban areas.

Improvement of postal services is reflected in the introduction of new e-services, such as e-mail, e-commerce, e-financial services and e-government.

2. THE CHARACTERISTICS OF RURAL AREAS IN THE REPUBLIC OF CROATIA

Development of rural areas is one of the strategic development priorities of the European Union. The European model of rural development aims to keep the population in rural areas, to equalize the quality of life in rural and urban areas. Today's rural development aimed at increasing the quality of products, market challenges, the use of new development opportunities and environmental protection. EU Member States and regions are obliged to ensure a balanced implementation of rural development policy.

In addition are providing funds for implementing the initiative LEADER ("Liaison Entre Actions de Développement de l'Économie Rurale", means "Links between actions for the development of the rural economy"), EU rural development model, which aims to keep the population in rural areas [1]. It is based on the approach from the bottom to up ("bottom up"), respecting local peculiarities and establishing of local development partnerships (local action group - LAG) for the implementation of local development strategy.

In Croatia, the difference between rural and urban areas is based on territorial division, where smaller administrative units, municipalities are considered rural, while the cities considered urban areas. Based on such administrative criteria, of the total population approximately 45 % of the population is considered rural population and 55 % is considered to be urban population [2].

Unemployment, high average age, low rate of education, unsatisfactory with basic services and infrastructure has resulted in neglected rural areas and the loss of younger and working-age population.

Rural development policy in the Republic of Croatia follows the European model of rural development. The goal is to balance the development of these areas. This can be achieved by encouraging the development of communal and social infrastructure and improving basic services. In particular, the emphasis is on the development of information and communication technologies.

2. CHARACTERISTICS AND STRUCTURE OF THE POSTAL NETWORK IN THE REPUBLIC OF CROATIA

Transport network generally make infrastructure buildings and equipment through which perform traffic, and operating services or transfer various entities between departure and destination. It is organized in a way that makes it unique technological whole in order to ensure quality postal services.

The specific feature of the postal network is its territorial distribution. Public operator shall establish, maintain and develop the postal network in a way to ensure the provision of universal postal services throughout the whole area of the Republic of Croatia.

Postal traffic cannot be identified with a special performance of roads or means of transport since in the postal traffic using almost all types of roads and almost all transport and

transmission means. Thus, for the transport of mail using traffic routes and means of transport; road, rail, water and air transport, as well as electronic communications network.

According to the number of inhabitants and the surface on which operates one post office, the Republic of Croatia is on average of the countries in the region, which is more favorable than those provided by the provisions of *Ordinance on Provision of Universal Service* [3].

The organization of the postal network and availability of postal services differs significantly between rural and urban areas, and is determined on the base of population, surface area that covers, topographic conditions, population density, transport connections, quantity of shipments, and possibility of using transport means, local conditions and structure of users.

Elements of the postal network consist of access points, postal centers and other elements that ensure the provision of postal services. Access points of the postal network are post offices, postal centers, self-service departments, postal suitcases and other devices and equipment intended for the reception of postal packages [3].

Post offices are access points of the postal network, or business premises in which the provider of the universal service or its contractual partner provides postal services. It operates under a number and the name of the village. Post office can be defined as: regular, seasonal, contractual, moving the post office of customs clearance: regular, seasonal, contract, moving and post office of customs clearance [3].

Universal services are of interest for Republic of Croatia and must be permanent, regularly and continuously available every physical and legal person throughout the country without any discrimination and on equal terms.

In the regular post office, a provider of universal service provides the universal service at least five days, which is available to all users in the entire Croatian territory. Seasonal post office typically performs the office without delivery area and opens up due to increased demand for services. Contractual post office operates on the basis of contracts concluded between the public operator and the legal and physical person who in the name and for the account of the public operator provides postal services. Mobile post office is located in the appropriate means of transport, which meet certain technical and other requirements. Service performs at a certain time and certain days of two or more settlements. Post office of customs clearance performs acquisitions, mediation, sorting and dispatch of mail in international traffic.

It is important to optimize the network of post offices in the postal network. This is accomplished by adjusting working hours to user needs, relocation of post offices in crowded locations and conversions of regular post offices in seasonal or contractual. Post offices in new locations shall be regulated in accordance with the new standards of design, offering greater functionality, higher quality of service and customer satisfaction, as well as create visually recognizable identity of the *Croatian Post*.

Universal service is obliged to open the post offices so that the area coverage with post offices meets the standards on the quality of postal services, or is obliged to establish a network of post offices so that one post office operates, on average, on an area up to 80 km^2 or a maximum of 6000 inhabitants [3].

Diversified and accessible postal network and the provision of postal services have a positive effect on sustainable development, with particular emphasis on rural area development. This results mainly from the provision of new e-services.

4. IMPLEMENTATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Information and communication technologies open many possibilities for innovation in rural areas and economic growth that is extremely important for the development of rural tourism, agriculture and ensuring services to the population.

Broadband Internet is the basis for development of new services. By good coverage of broadband network in rural areas would came out of the insulation, and e-commerce would be closer to potential customers.

The Digital Agenda for Europe is a planning document that the European Commission has adopted in the framework of *Europe 2020 Strategy* in order to achieve sustainable economic and social benefits based on the development of broadband markets and interoperable applications. The members of EU were given the task that develop operational strategies for high-speed Internet and ensure public funding, including structural funds for areas not covered by private investment [4].

The main goal of *Strategy for Broadband Development in the Republic of Croatia for 2012-2015* is to create preconditions for further development of broadband infrastructure and services can be made through optical access infrastructure and appropriate new generation wireless technologies. Strategy sets strategic goals for the development of broadband networks and services, particularly at the level of local and regional governments, which create the conditions for raising the competitiveness of small and medium enterprises, encouraging economic development of rural areas, better education, better and faster services of the public administration and health care [5].

Development of next generation networks will enable the creation of new services that will greatly contribute to the wider use of broadband services. Balanced coverage of the territory and the application of information and communication technologies will enable the performance of a large part of activities in residence users, thus reducing the load space traffic and allows decentralized development.

5. NEW SERVICES AND TRENDS IN PERFORMING OF POSTAL SERVICES

The development of information and communication technologies is a major challenge for postal services, which through innovative services and products adapted to new technologies.

The postal sector is an important infrastructure that provides access to networks and services that are crucial for the development of economic activities and the overall functioning of society. Ramification and the availability of a national network, its integration into the global postal network, as well as the quality of postal services, directly stimulate the growth of the economy.

Universal Postal Union has a strategic plan to promote innovative products and the development of three-dimensional network of postal services, and to encourage sustainable development. The basis for this is the *Doha Postal Strategy for the planning period from 2013 to 2016*. It encourages the use of information and communication technologies that is the development of e-services in order to provide affordable and high quality universal service and viability [6].

Croatian Post is a member of the *Universal Postal Union* since 1992, and through adjustment to technological environment brings new quantitative and qualitative changes in

the direction of the new strategy, user needs and new services that can meet the challenges of the modern market [7].

The development of ICT in the previous period has significant impact on reducing the amount of traditional letter mail. It initiates new trends in the performance of postal services. *Universal Postal Union*, in his study "*Measuring postal e-services development - A global perspective"* specifies e-services of interest to providers of postal services which are divided into four categories [8]:

- e-post services
- e-finance services
- e-commerce services
- e-government services.

World Postal Association defines e-service as a service that postal service providers offer their customers using information and communication technologies. Internet is a basic medium, while the other channels of electronic communication, such as mobile phones, call centers or television channels are used slightly less for those services.

Universal Postal Union Study lists e-services of interest to providers of postal services [8]:

- *e-post services* - public Internet access point in post offices, web information on services and tariffs, postal electronic mailbox, online direct mail, postal registered electronic mail, electronic stamp, customized electronic stamps, electronic postal certification mark, electronic signature, e-telegram, e-cards, online biro fax, hybrid mail (electronic to physical), hybrid mail (physical to electronic), postcode lookup, postal address validation, post office location lookup, address change online, holding of mail delivery online, track and trace, electronic notification to post of letter needing to be collected, electronic notification to addressee that letter is to be delivered, electronic notification to sender that letter has been delivered, electronic notification to post that parcel needs to be collected, electronic notification to addressee that parcel is to be delivered, electronic notification to sender that parcel has, been delivered, check mailbox contents online, web-based customer service and contact, applications on mobile devices.
- *e-finance services* - electronic invoicing, electronic account management, electronic remittance, online bill payments, bills management, e-payment of water bills, e-payment of electricity bills, e-payment of phone bills, electronic money transfer.
- *e-commerce services* - online shop for philatelic products, online shop for postal goods, online shop for non-postal goods, subscription for periodicals, e-commerce web-based customer service and contact, SSL web certificates.
- *e-government services* **-** digital identity, driving license renewal, online shopping for tickets to cultural and/or sports events, electronic university registration, electronic payment of retirement pensions, online passport application, management of patient's electronic medical files, electronic medical certificates, electronic collection of public medical fees, electronic export documents, electronic customs documents.

New technologies have prompted the development of e-commerce, which is an important factor in future economic growth. It affects the intensification of trade, increasing the amount of transferred packet services and growing competition in trade logistics and postal services. Some of the postal services of e-commerce are: online stores of postal products, online stores of non-postal products, subscriptions to magazines.

The Republic of Croatia has a significant market potential of e-commerce and significant business opportunities for merchants and providers of postal and/or logistics services. This is

both for traders and for the providers of postal and/or logistics services. For e-commerce is important to reach the level of development in a competitive economy of the European Union. This can be achieved through the affordable price of postal service, security, payment, quality and reliability of delivery of products through postal services, adequate choice of the method of delivery of the product, sufficient time and the timing of delivery, availability of information on the postal service and the possibility of return within a reasonable time.

Special emphasis is placed on cross-border package delivery in rural areas, or to e-commerce must be accessible to all citizens and enterprises, regardless of their size and location.

It is continuing the increase trend in international postal traffic in Croatia boosted international traffic packets by electronic commerce. In the domestic and international traffic, compared to 2012, in 2013 there was an increase of 16.5 %, a significant contribution to that gives international traffic packages with a growth of 123 %. At the same time, in the period of mail traffic and other items in national and international traffic decreased by 5 % as a result of technological change and increased use of electronic communications services (Table - 1) [9].

Table 1 - Comparison of the amount realized postal services in the Republic of Croatia for the period from 2004 to 2013

Year	Letters and other consignments, millions			Parcel consignments, '000 pieces		
	Total	National traffic, received	International traffic, total	Total	National traffic, received	International traffic, total
2004.	346	310	36	2552	2452	100
2005.	370	336	34	4653	4461	192
2006.	394	357	37	5058	4832	226
2007.	399	362	37	6461	6241	220
2008.	391	353	38	7628	7383	245
2009.	374	351	23	7684	7439	245
2010.	345	324	21	7689	7426	263
2011.	328	309	19	8059	7778	281
2012.	319	299	20	8929	8651	278
2013.	303	282	22	10398	9778	620

Services e-government/e-citizen speeds communication between the administration and citizens. Postal service providers assume the role of a trusted mediator between the government and citizens, what can result in significant savings and citizens get quality service.

Croatian Post offers an effective and simple communication with customers via *Service ePost*. It enables more comfortable and easier receiving, reviewing, keeping mail and paying bills with credit cards or forwarding account in Internet Banking [10].

Croatian Post, as a provider of universal service, allows the use of e-citizen to its customers. As part of e-citizens, all users have the option of simply and rapidly communicate electronically with public administration and securely access e-government services. The users included in the e-citizens currently can use the following services [11]:

- request electronic copies of birth or marriage certificates
- check their entry in the register of voters
- be informed about the scores of the child in school
- check the selected doctor
- order a European Health Insurance Card

- request your electronic working booklet
- be informed about the expected amount of pension
- register as a potential employee
- check paid contributions in the second pension pillar of insurance
- obtain confirmation of REGOS
- check your tax form
- check your data in the OIB system
- administer your electronic identity.

6. CONCLUSION

Most rural areas in the Republic of Croatia face a significant challenge. Significant differences in development levels between the village and the city led to the backwardness of rural areas. They have lower rates of employment and economic growth, which has resulted in the depopulation of rural areas. Rural development policy in Croatia follows the European model of rural development.

Information and communication technologies open up many opportunities for innovation in rural areas and economic growth. With good broadband network coverage, rural areas would come out of their isolation and it would also bring producers of goods and services closer to potential customers.

Balanced territorial coverage and application of new connection technologies would enable users to do most of their jobs in their residence. This would reduce the burden on area traffic and enable decentralized development.

The postal sector is an important infrastructure that provides access to networks and services. They are essential to the development of economic activities and the overall functioning of society. Ramification and the availability of a national network, and its integration into the global postal network, as well as the quality of postal services, directly stimulate the growth of the economy.

Initiate new trends in the performance of postal services by enabling a range of new postal services that are offered to end users. Among other things, new technologies have prompted the development of e-commerce. As part of the e-citizens, all users have the option of simply and quickly communicate electronically with public administration.

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THE INCLUSION OF THE KARLOVAC COUNTY IN AN INTEGRATED TRANSPORT THE CITY OF ZAGREB

ABSTRACT

The development of the structure transport systems and the causes and changes in individual transport modes in the transport market warn of the economic justification of transport by rail. The need for identifying the optimal transport system necessarily reaffirms railways in the future transport system.

The paper emphasis the urban and suburban rail transports in the City of Zagreb and connections to surrounding towns and villages. It primarily deals with the connection of Karlovac County with the City of Zagreb. In doing so, special importance is given to the application of integrated passenger transport which includes transport connection with more participants in the transport of passengers, the appropriate tariff policy according to the zonal division and well informed passengers.

Given the fact that the rail transport has significant advantages over road transport, with more aggressive marketing, the current users of transport services can find Railways Passenger Transport more satisfying. That will get new customers and rail transport will become increasingly popular compared with much stronger and competitive road transport.

KEY WORDS

Urban and suburban passenger transportation by rail; integrated passenger transport; the advantages of railways; marketing approach; the transport market.

1. INTRODUCTION

Public passenger transport is almost unimaginable without the active participation of urban and suburban railway subsystems as environmentally friendly, energy-efficient, competitive, fast, safe and oriented towards the needs of passengers. Its transportation capabilities that contribute to relieving the pressure of road traffic, reducing traffic jams and other negative consequences that entails individual transport, takes the place of the best carriers, but also the greatest protector of nature. Therefore, the development and the future

of urban and suburban railways can and should be provided with the support of the entire social and economic public.

Croatian Railways operate in very harsh conditions of business. This was influenced by many factors: many years of under-investment and as a result most outdated railway network unfavorable parameters, reduction in productivity, high costs of operations, transformation and privatization of the entire economy and reduced production. All this resulted in a reduction of income and dependence on the state budget.

An important factor in the development of the Croatian certainly the Strategy of Transport Development of the Republic of Croatian for the period from 2014 to 2030 as a strategic document, which aims to strengthen the country's economy and development through the establishment of intermodal, sustainable, efficient and safe transport system [1]. Compared to the previous strategy, with current transport sectors (rail, road, air transport, inland shipping, marine), was introduced a new sector of the public urban, suburban and regional mobility.

Croatia is demographic highly centralized state with a distinct center that covers almost a quarter of the population. In this framework is not easy to plan traffic development and traffic flows. In such a situation in the market of transport demand, rail transport is identified through primary competitive advantages: acceptable fare, acceptable length of travel, traveling comfort, safety and reliability.

Besides all the above advantages of the city and the suburban railway, the backbone of the transport system should be the rail, so that the development of mass transportation line now becomes imperative.

2. OVERVIEW OF KARLOVAC COUNTY

Karlovac County is located in central Croatia in the field Pokuplje, part of Kordun, Lika and Gorski Kotar, covers an area of 3,622 km^2 and is considered as one of the largest counties. Thanks to its transit, traffic and geo-strategic location it is one of the most important counties and at the same intersection and hub of major roads that connect Europe and Adriatic coast [2].

Karlovac County has both Croatian and European standards advantageous geographical position. Through it passes the most important Croatian roads and railways and those over Karlovac County connect the continental part of Croatian with Croatian Littoral, Dalmatia, Bosnia and Herzegovina and Slovenia. From the center of Karlovac County radial extend the main roads to Rijeka, Senj, Plitvice, Bihac, Sisak and Novo Mesto.

Karlovac County is one of the busiest traffic on Croatian territory. The position between the borders of neighboring countries, Slovenia and Bosnia and Herzegovina, the cause is that all traffic flows between north and south Croatian, as well as parts of Central Europe with the Adriatic Sea, passing just in this area. Traffic problems are extremely accented with pronounced extremes, from the lack of connection between individual regions of County (southern area) and to considerable density transport network (Karlovac with its immediate surrounding). Spatial and functional point of view, transport systems are not certain county itself, but are substantially the default and the default global functional systems of its environment, which due to geographical position of county far exceed its boundaries.

3. TRANSPORT SERVICES TODAY

Suburban Traffic is to our terms a new form of transport services, but in the world is very well known and developed. In Croatia, there is a need for the introduction of suburban traffic almost in all major cities, but for now exists only in the City of Zagreb and Split partially.

Railway infrastructure in the City of Zagreb is relatively well incorporated into the structure of the City. The main traffic lines pass through the central part and provide a good connection of the western and eastern part. This especially applies to the section Savski Marof - Dugo Selo.

For urban and suburban transport (UST) are used electric motor trains (EMT) series 6111. In addition to age (over 30 years), the main drawback of these EMT is their outdated concept. So far, was modernized a number of trains (interior design, increasing the number of standing places, installed new drive components, etc.), while in some vehicles are built carriers for bicycles.

Therefore, in recent times, in UST are introduced new four-unit EMT series 6112 (Figure 1) [3]. It is a modern concept for regional trains, suburban and urban traffic. This refers to the drive, control and specific suitability to passengers. There are 432 travel sites, of which 212 seating and 220 standing (4 places/m^2). The passenger compartment is air-conditioned and very functional. The train has 8 double door width 1330 mm, which allows the rapid exchange of passengers. Floor height is suitable for platforms of 550 mm. In the future, these trains should replace the old EMT.

Figure 1 - Electric motor train series 6112

In the system of urban and suburban transport are all local passenger trains that depart from the Zagreb to Novska, Križevci Zabok, Karlovac and Sisak. These are typically trains classical composition with locomotive traction.

Generally, the existing needs of passenger flows UST in the City of Zagreb junction, there is a lack of appropriate infrastructure (insufficient capacity of railway lines) as well as the poor state of quality track infrastructure which results in reducing the allowed maximum speed of operation. The result is a longer duration of revolutions of compositions and inefficient capacity utilization of existing means of transport.

Between Zagreb and Karlovac daily commute 37 trains, of which 25 passenger and 12 express [4]. Their number meets the daily needs, because almost every hour there is a train to Zagreb. However, the peak load capacity, that is the number of wagons cannot meet. Also did not meet the quality of wagons that cannot compete with air-conditioned, luxurious and

much "younger" buses. Comparing the number of trains with the number of buses, which runs 48 from Zagreb to Karlovac and 50 from Karlovac to Zagreb, shows that on average every 28 minutes drives a bus. At the time of arrival and departure of employees at work and students at universities and schools, buses operate every 10-15 minutes. Outside this period, buses are rarely at intervals more than 30 minutes [5].

By improving the mobile and stable rail capacity would achieve greater competitiveness in speed and security. This would result in a better service.

4. INTRODUCTION OF INTEGRATED PASSENGER TRANSPORT

One of the strategic priorities of the city transport policy should be the implementation of an integrated passenger transport (IPT) in urban and suburban transport. IPT is the way the coordinated use of several types of public mass transportation of persons who carried out multiple carriers (including links to the individual car transport) in order to provide a dedicated and cost-effective traffic coverage areas concerned from the standpoint of economic and non-economic needs of persons and institutions covered by the system. This implies effective integration of rail transport with other subsystems of public transport; with bus, tram, and in some cases individual traffic (passenger cars). This would increase the attractiveness of transport offers public transport and rationalize expenditure, and solve the problems of high-intensity individual transport in the center of the city and increase the quality of resident's life in the city and its agglomeration.

Given the advantages of rail UST that manifest themselves in transporting a large number of passengers in a short time, the rapid mode of transport, relieving the pressure on city roads and reduce pollution in relation to individual transport, railways should be the backbone of the said transport system. However, to integrate the railway traffic with other traffic subsystems, the constant cooperation between all the carriers in the transportation of passengers between starting point and destinations is necessary.

4.1 The introduction of common Transportation Tickets for all the carriers in the system of integrated UST

Basic proposal for the project area would be the introduction of tariff union of all transportation modes. The primary determinant of such a union would be the disposition of the observed area. All modes of transport should be integrated cost which would mean that a transport ticket is valid for all modes of transport and all operators in the area of tariff union. Price fares would be established on the basis of the analysis based on the average price of road passenger and passenger kilometer individual modes of transport. Based on the average cost of fares, fortified to prices for certain types of transport tickets, depending on the purpose and scope of services, arising from the respective fares. Prices for a single zone would be different, and travel through multiple zones would result in summing up, with a total cost should always be better than the one achieved by using the services of one or more operators at their respective prices. The introduction of compatible collection system in all modes of transport would provide price integration, and it's ultimately served to the calculation and distribution of revenues between all operators in an integrated transport system. This would attract more passengers from the area of Karlovac and the surrounding area since passengers in Karlovac could buy a single ticket for all transport modes, which will be valid for public transport of Karlovac, train and public transport of Zagreb (ZET).

4.2 Introduction of Zones and Zonal Tickets

The purpose of segmentation is the classification of consumers in certain homogeneous whole. In order to do this, it is necessary to carry out extensive researches with quality analysis. Using scientific marketing principles and methodology of the process of segmenting the current, potential and future users of railway transport services are classified into homogeneous units according to their features. The task of segmenting the passengers is to arrive at the elements on the basis of which it can accurately shape the needy transport services for each species and group of passengers according to their features. With the realization of these tasks it is necessary to provide answers to the following questions:

- What are the kinds of travelers?
- What are the groups of travelers?
- What are the characteristics of each type of traveler (their needs, requirements, preferences and ability to pay?
- What are the characteristics of whole groups of passengers?

When based on the given parameters and their elements perform the analysis, we can easily shape the types and categories of passengers as a homogeneous whole, or rather get the categories and names of passengers by types and groups. These categories of passengers are not equally distributed along the railroad Karlovac - Zagreb. The distribution depends on the structure of the population of these places and their kilometer distance from Zagreb. It should be mentioned that Karlovac with its primary and secondary, and to a lesser extent, the higher education system meets the needs of Karlovac County. This is the reason that in Zagreb leaving students out of a need for higher education, students for some specific occupations, while in Jastrebarsko feel greater proximity to Zagreb, which in addition to students results in a much greater number of high school trip, but from Karlovac.

As close to major cities formed the suburban areas from which and to which transports a large amount of passengers, that passenger flows depend on the deployment of these settlements, industry in them, or employment of its inhabitants in the center. In general, the intensity of passenger flows, decreases with increasing distance from urban agglomerations. Therefore, it is possible to organize traffic by zones. Such an organization according to the intensity of flows and zones are possible and for suburban traffic the City of Zagreb. Figure 2 shows the distribution zones that contribute to the intensity of flow of passengers and the distance from the city center [6]:

- Zone with a diameter around the center of 20 km
- Zone with a distance from the center up to 30 km (20 + 10)
- Zone with a distance from the center up to 40 km (30 + 10)
- Zone with a distance from the center up to 50 km (40 + 10).

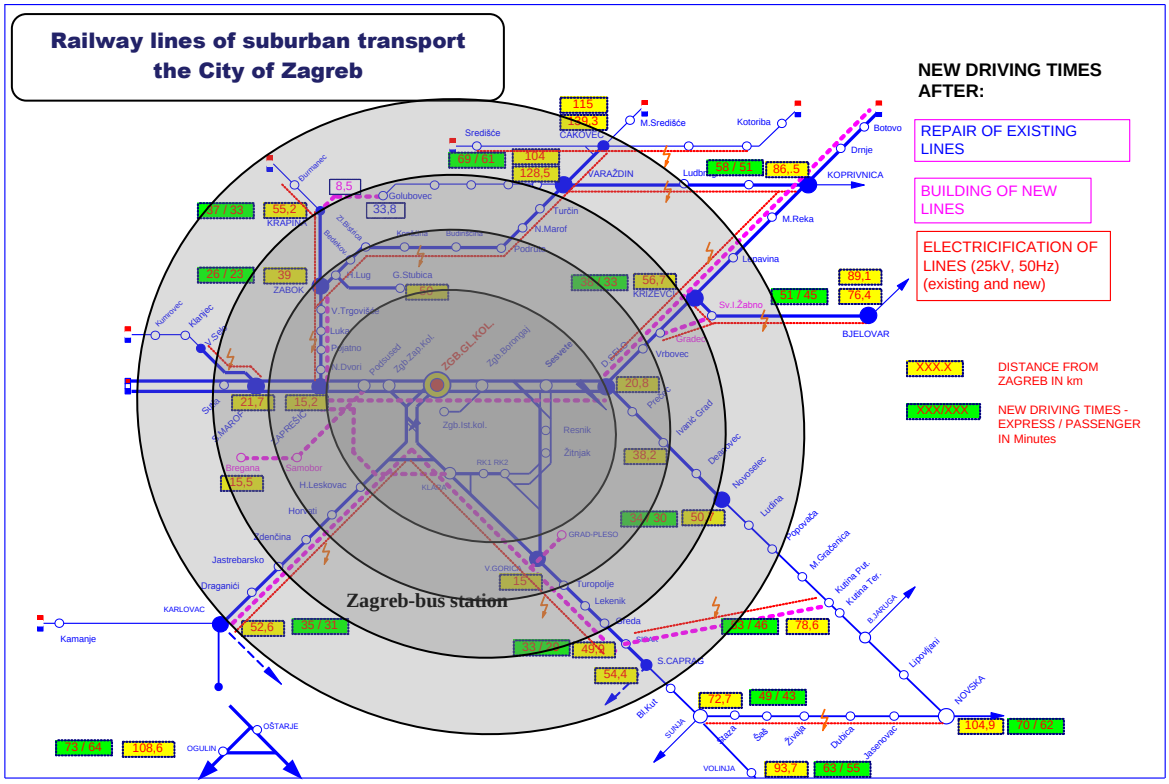

Figure 2 - Zonal distribution of suburban transport the City of Zagreb

When shown the model applied to the transport route Karlovac - Zagreb, according to research, zonal distribution would be as follows [6]:

a) Zone to 10 km, up to Hrvatski Leskovac, encompassing urban transport of passengers with a large number of trains. Because on that route passengers using HŽ-ZET pass, should take into account the regularity of trains and introduce additional lines as to Zaprešić or Dugo Selo;
b) Zone to 20 km, encompassing the Horvati, Mavračići and Zdenčina, would be zone with frequent traffic trains. Justification is evident from the analysis, where Zdenčina ships large number of passengers and indicates a significant increase in passengers carried;
c) Zone of 30 km, to Jastrebarsko, would be zone with increased number of urban and suburban trains;
d) Zone to 55 km, would include passengers of Karlovac, as well as travelers from other lines of Karlovac County.

4.3 The Modernization of the System for the Sale of Tickets for the transport of passengers by Rail

The integrated sales system should be the basis of future business of Croatian Railways Passenger Transport and development of the railway market in the Republic of Croatia, which in soon expects liberalization. Development and implementation of new sales channels in accordance with technological trends include:

- stable vending machines Ticket
- mobile devices to view and ticket sales
- online ticket sales
- expansion of the network of sale of railway tickets.

The users of rail transport will benefit by introducing new sales channels, remodeling websites and the possibility of membership in the Club loyalty (which will be able to use the privileges and be rewarded for their loyalty to railway transport), because ticket sale service will be much more accessible and faster. They will be able to buy a ticket from their homes and at stations use stable machines. The website will be more visual and the information will be accessible, as well as the possibility of easier communication between users and Croatian Railways Passenger Transport as a service provider.

4.4 New motor trains

Service users primarily expect fast, efficient, cost-attractive and accurate service. The European experiences show just that. Using motor trains instead of conventional trains in regional and metropolitan suburban transport brings multiple benefits: stable timetable, the possibility of increasing the frequency of trains and the number of passengers, reducing environmental pollution, all with significantly lower operating costs.

Train service in suburban traffic must meet specific requirements with regard to the specificity of the mode of transport. Characteristics of transport demand in the suburban traffic are:

- high demand in the peak period
- short time to start and stop
- high speed
- quick entry and exit of passengers
- comfort
- economical transportation.

The introduction of new trains in traffic would increase the satisfaction of passengers and their appropriation for the train ride, which is an important factor in increasing the number of passengers and inclusion of Karlovac in IPP City of Zagreb. The potential of passengers exists, but it is necessary to draw them on the railways. To achieve this, we need new, functional, modern, air-conditioned and safe trains.

4.5 Measures to improve infrastructure capacity

One of the measures to improve the infrastructure is upgrade and construction of new terminals with all necessary facilities and equipment for the needs of train and bus transport in the immediate vicinity to customers ensure the smooth travel and minimum time losses (Savski most, Remetinec, Zagreb, Zaprešić). Also it is necessary to enable well-functioning system ''Park & Ride'' in places where it is not enabled direct communication with bus and tram transport between settlements and stations.

Bus station in Karlovac is situated in the city center and railway station out of town, a 15-20 minute walk away from the bus station. Just accommodation of railway station significantly affected the number of passengers. The building of a new station Karlovac CENTER located opposite the bus station, railway transportation by train approached the greater number of existing and future users. Its appearance the railway station is a functional, high-quality and modern solution for the increasing number of users of railway transport services and the citizens of the city of Karlovac. The opening of the station Karlovac center, significantly reduce the number of cars parked at the railway station. Accommodation of the station Karlovac center in a residential zone facilitates to passengers an access to the train and Zagreb became more accessible.

4.6 Timetable

Optimization, i.e. quality compliance and connectivity of timetables is priority of all carriers involved in the IPT. They must have direct communication in individual terminals. This primarily refers to the timetables of buses and trams as the railway timetable in some cases arrangements at higher levels, or at the international level, and together with the local community, depending on their needs. All these elements must be coordinated between. Also, the timetables of bus and tram lines are more susceptible to change since there are no restrictions in the infrastructure capacity (throughput capacity of track) and the timetable of freight transport, as it is the case for rail transport.

The existing railway network in the City of Zagreb, in relation to its geographical position, has ideal conditions for the organization of an integrated urban transport. Train should be the framework of such a system because of its environmental, energy and infrastructure advantages. Other public transport vehicles (buses) serve as tributaries to the railway systems and thus use their great advantages over short distances. In order to achieve that, it is necessary to create a new organization of transport, in a way that train serves downtown, suburbs, surrounding towns and cities. Thus achieve high efficiency and synchronized timetable that allows a greater number of trains on the railway network. With the introduction of the tact timetable between Zagreb and Karlovac, and the introduction of synchronized timetable between the neighboring City of Zagreb, Karlovac and example Križevci, it is possible optimization of the network and increase transport offer. This will result in an increase in passenger numbers between Zagreb and Karlovac.

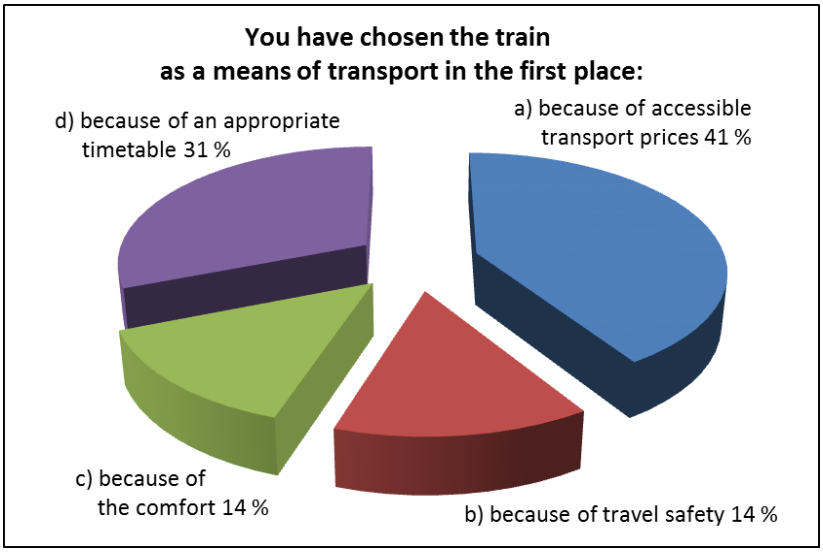

Figure 3 - Reasons of passengers to select the train as a means of transport

Railways Passenger Transport Ltd. cannot influence the reason why people travel, but certainly can influence the reason why travelers chose exactly the railways as providers of transport services and the train as a means of transport. Research has shown that passengers primarily select the rail because of accessible transport prices and appropriate timetable (Figure 3) [6].

4.7 Information system

Since according to research, existing system of passenger railway stations relatively satisfies, it is necessary to devise a fully passenger information in all official places of

junction and terminal stations. The same should give correct information to the traveler in each locality about timetable of all participants in the transport chain and in one place, connections from one to another means of transport, delays, alternative transportation and more. The same system should be linked and integrated into the information system embedded in railway vehicles. Research has shown a rating of passenger information at stations, as shown in Figure 4 [6].

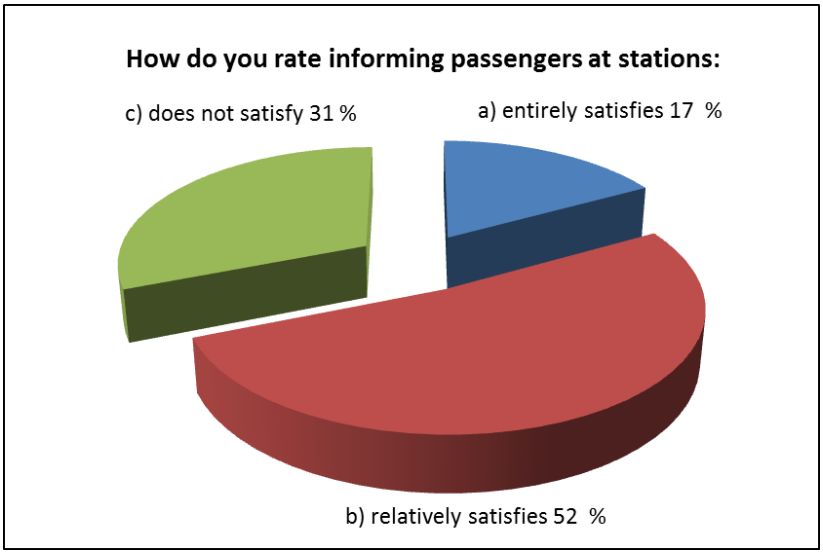

Figure 4 - Assessment of quality passenger information at stations

5. CONCLUSION

By upgrading the existing infrastructure of the railway UST, with the realization of technical-technological and infrastructure integration with other subsystems, introducing new trains in the UST while better use of the existing timetable and application of modern marketing knowledge it is possible to increase users satisfaction of transport, build a long-term relationship with them but also with employees, and all segments of the rope and the wider community. Likewise, business orientation is necessary to focus on the environmental, economic and energy advantages of railways. These guidelines will also contribute and ensure the successful positioning and business operation of company in the market.

Road transport causes high costs arising from the crowd while at railway crowds are not a problem because traffic is carried in a predetermined timetable. When calculating of boundary costs congestion in rail transport, stand out the costs incurred due to delays or braking of the train. Electrified railways have higher throughput in terms of the number of trains that can drive on them, and in terms of the number of passengers carried and transported tons of goods. Added to the economic and environmental factors such as the lowest transportation costs and with fewer wagons because their turnover is faster and without harmful emissions into the atmosphere, then electrified railways show their advantages over the non-electrified, especially in relation to the road traffic.

Railway is energy efficient and based on their environmental advantages can be realized more appropriate and environmentally friendly transport in urban and local passenger transport, for long-distance (intercity) traffic and for passenger traffic at high speed. Rail is the most efficient form of transport due to the fact that at least polluting, occupies the smallest geographic area and uses the least energy.

Rail transport greatly saves energy and it is the greatest contribution of railway to environmental protection and natural economies. At the present time it is more necessary to emphasize the fact that in order to effectively protect the environment, priority should be given to mass transport of passengers who best can perform exactly the railway. We can say for railway that relieves roads, preserves nature and non-renewable natural resources from destruction, and reduces the number of road accidents and environmental disasters. In a word, respects people and nature.

The integration should be carried out through several steps. To make this possible it is necessary to prepare the legal requirements for IPP. Should design and establish management and functional organization of the IPT then determine and establish the area of integration. To begin it should do so by zones. Gradually should be adapted tariff system and established a unified tariff and single ticket. It is necessary to harmonize, determine and establish a unique timetable in Karlovac and Zagreb County as well as the City of Zagreb. It is also necessary to automate and computerize the IPT. It should be developed the Master plan for infrastructure dynamic adjustment of the transport infrastructure for needs of the IPT. In this way, it would bring the optimization of the total supply of public transport of Karlovac and the Karlovac route. This is to ensure the use of the various subsystems of public transport of passengers.

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ABC/XYZ CROSS ANALYSIS IN SPARE PARTS INVENTORY MANAGEMENT

ABSTRACT

Inventory management is becoming more and more important part of managing company business, especially in retail industry. High customer service level starts to be crucial in surviving on market. High customer service level asks for big assortment of items available all the time. Automotive industry is very demanding when it goes about customer service. Spare parts assortment in this industry is huge, and not so cheap. That is why inventory management and corresponding analysis to optimize inventory attracted the attention of managers.

In this paper possibility of applying ABC/XYZ cross analysis in automotive spare parts retail company is shown.

KEY WORDS

Inventory management; ABC/XYZ analysis; spare parts in automotive industry

1. INTRODUCTION

Stocks are materials in a supply chain or in a segment of a supply chain, expressed in quantities, locations and/or values, not used at present, but kept for the future use (consumption/sale). Inventory Management is a buzz word these days. As much as the industry focuses on revenue, profits, top lines and bottom lines there is more focus these days on inventories, working capital and efficiencies. Complexities of managing these supply chains have increased because of various factors like globalization, increased product portfolio, decentralization etc.

In this paper, inventory management of spare parts in automotive industry is analyzed. Problem of this kind of items is a big number of different items, small and big by volume, and cheap and very expensive by price. As supply chain of spare parts in automotive industry is often large, orders are done as consolidate consignments, good planning of items to order is very important. In this paper ABC/XYZ cross analysis and classification of spare parts with the biggest activity ratio, demand and value is shown, in order to adjust quantity and type of items in the procurement.

Authors [1] in their research suggest AHP analysis instead of ABC. They state that ABC analysis suggests different criteria of management for some products, depending on the pairs of factors used for the Cross Analysis. To overcome this limitation, they use AHP Analysis,

which allows simultaneously consideration of many criteria all at once for the optimal choice of materials management. Moreover, they clame that another advantage of AHP Analysis is the possibility of making a detailed analysis for each material, while ABC-Cross Analysis requires splitting the stocks into classes that have the same characteristics.

The spare part company faces three major demands of spare parts from the complex; the first is demand from a transport company. Spare part companies cater for their failure (down time for spare parts) and maintenance demands. The Spare parts company gives this transport firm highest priority so as not to incur any type of costs or consequences as the case may be. The second demand comes from the maintenance section of the company. Demand from the maintenance section is as a result of spare parts demands for maintaining their vehicles, for maintaining after-sales service of vehicles whose owners had service level agreement with the company as well as those that just take their vehicles to their maintenance workshop for either regular servicing or for repairs when they have broken down completely. The third is from the external customers that directly buy spare parts from the complex for their personal use [2].

The inventory management has strategic importance for business success since it gives the media more diverse production systems by increasing or reducing inventories and generating factor of production and financial gains [3].

2. ABC AND XYZ ANALYSIS

Even the simplest and most highly automated inventory control system needs some effort to make it run smoothly. For some items, especially cheap ones, this effort is not worthwhile. Very few organizations include, for example, routine stationery or nuts and bolts in their stock control system. At the other end of the scale are very expensive items that need special care above the routine calculations. For example, companies should for products that are most expensive and have the biggest value control their stocks very carefully [4].

2.1 ABC Analysis

An ABC analysis puts items into categories that show the amount of effort worth spending on inventory control. This is a standard Pareto analysis or ‘rule of 80/20’, which suggests that 20% of inventory items need 80% of the attention, while the remaining 80% of items need only 20% of the attention [4], [5].

ABC analyses define [4], [5]:

- A items as expensive and needing special care,
- B items as ordinary ones needing standard care,
- C items as cheap and needing little care.

Rules of the ABC analysis [4],[5]:

- establish a criterion,
- rank and sort assortment according to the established criterion,
- calculate a total sum,
- calculate cumulative sums,
- calculate percentage share of cumulative sums in the total sum,
- assign to group A items responsible for 80% of the criterion value, to group B – items responsible for further15%, and the remaining items – to group C.

Typical results for an ABC analysis are shown on figure 1.

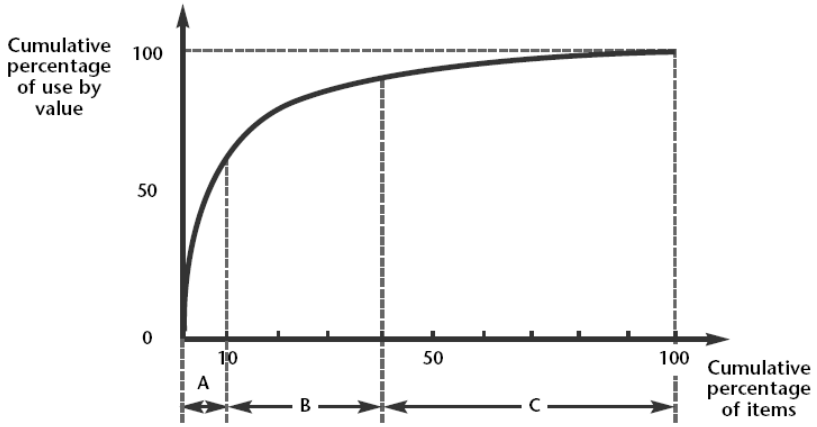

Figure 1 - Typical results for an ABC analysis
Source: [4]

2.2 XYZ Analysis

The XYZ analysis is a procedure of inventory management in the management economics, with which on the basis empirical experiences, results are usually assigned to a classification by bill explosions or by the determination by variation and/or fluctuation coefficients of goods and articles concerning its turnover regularity (consumption and its predictableness) [4], [5], [6], [7].

Articles, which are sold very regularly and in to some extent constant numbers of items (e.g. Bulbs), are called X-articles, while the Z-class contains such articles, whose sales runs very irregularly or even stochastically (like e.g. Spare parts) [4], [5], [6], [7].

Classes become summarized as follows [4], [5], [6], [7]:

- X constant consumption, fluctuations are rather rare,
- Y stronger fluctuations in consumption, usually for trend moderate or seasonal reasons,
- Z completely irregular consumption.

XYZ analysis is one of the basic supply chain techniques, often used to determine the inventory valuation inside stores. It's also strategic as it intends to enable the Inventory manager in exercising maximum control over the highest stocked item, in terms of stock value. A system of categorization, with similarities to Pareto analysis, the method usually categorizes inventory into three bands with each band having a different management control associated. Although different criteria may be applied to each category the typical method of “scoring” an inventory item is that of annual stock value of said item (quantity in stock X cost of item) with the result then ranked and then scored (X, Y or Z) [4], [5].

Bandings may be specific to the industry but typically follow a 70%, 90%, 100% banding in that X class items represent 70% of the stock value (although they may account for 20% number wise), Y class items fall between 70% and 90% of the annual stock value with C class the remaining. In practical terms the complex high cost materials typically fall into the X class items, with the consumable, low cost (and typically fast moving) classed as X class. Not all stock is equally valuable and therefore doesn’t require the same management focus. The results of the XYZ analysis provide information that helps evaluate how each inventory part should be monitored and controlled. These controls are typically [5]:

- X class items which are critically important and require close monitoring and tight control – while this may account for large value these will typically comprise a small percentage of the overall inventory count.
- Y class is of lower criticality requiring standard controls and periodic reviews of usage.
- Z class require the least controls, are sometimes issues as "free stock" or forward holding.

Simple insight into the patterns of movement of demand, obtained graphic illustration of results XYZ analysis which is visible in the figure 2.

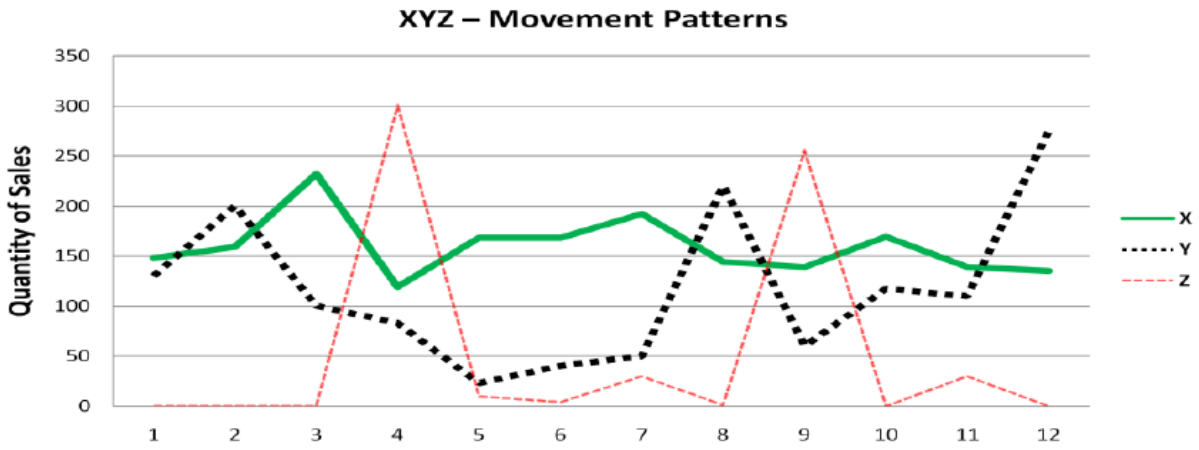

Figure 2 - Patterns of XYZ products
Source: [6]

3. APPLICATION OF ABC/XYZ CROSS ANALYSIS

In order to provide a fuller interpretation of the results obtained with the ABC and XYZ analyses it is necessary to make the ABC/XYZ cross analysis matrix. From this analysis we get nine groups of products with the characteristics of ABC and XYZ analysis, to which one can approach individually and determine the strategy of procurement and warehousing for each and every of them separately. When these two analyzes (ABC and XYZ) are combined, additional insights can be obtained as well as the opportunities to act on specific groups of items through specific strategies for each of the categories [4].

Interpretation of such analysis is shown in the table with the ABC/XYZ cross analysis (Figure 3).

Materials in group AX, AY and BX have a medium or a large share in total values, stable consumption and medium to high reliability of forecasting the demand. This group accounts for a quite large share of all items and it should be given adequate attention in order to achieve as favorable purchasing prices as possible and supply with as lower inventories as possible. The AX group is particularly important because it has characteristics of the A products (i.e. large share in turnover) and X products by which it is easy to predict sale in future. This group has a very high potential to optimize inventories and their costs [8].

The middle AZ, BY and CX group is quite heterogeneous, both as regards the share in total consumption value and variations in sale. This group should be given a normal (average) attention and to organize individual supply to meet customers' demand [8].

	A	B	C
X	▪ Very high share in total value ▪ constant usage ▪ High reliability of forecast of demand	▪ Medium share in total value ▪ constant usage ▪ High reliability of forecast of demand	▪ Low share in total value ▪ constant usage ▪ High reliability of forecast of demand
Y	▪ Very high share in total value ▪ neither constant nor sporadic usage ▪ Medium reliability of forecast of demand	▪ Medium share in total value ▪ neither constant nor sporadic usage ▪ Medium reliability of forecast of demand	▪ Low share in total value ▪ neither constant nor sporadic usage ▪ High reliability of forecast of demand
Z	▪ Very high share in total value ▪ Sporadic usage ▪ Low reliability of forecast of demand	▪ Medium share in total value ▪ Sporadic usage ▪ Low reliability of forecast of demand	▪ Low share in total value ▪ Sporadic usage ▪ Low reliability of forecast of demand

Figure 3 - Characteristics of the item categories under the ABC/XYZ matrix
Source: [8]

BZ, CY, and CZ groups are given relatively little attention, the needs are determined stochastically, i.e. from need to need and supply is realized from own inventories. After this detailed analysis of inventories it is much easier to determine whether some inventories are too high, and perhaps others are too low. In the following steps we will go into determining the optimal or desired level of inventories [8].

4. ABC/XYZ CROSS ANALYSIS OF SPARE PARTS IN THE AUTOMOTIVE INDUSTRY

4.1 Problem Description

In this paper inventory management of spare parts in automotive industry is observed. The possibilities of applying ABC/XYZ cross analysis in optimizing inventory management is demonstrated in the case study of one automotive and machinery spare parts retailer in Croatia. The company has international network of suppliers (more than twenty) and is ranked second by market share in Croatia. The company stocks over 56.000 articles, which are distributed to the market via three marketing channels: retail shop, web shop and telephone orders. The problem of spare parts stores in this industry is a large amount of different products that the market demands. The problem increases with increasing types of brands and types of vehicles (LKW, PKW) that the company serves. Additional challenge is that the vehicles which company serves are different ages. The demand for spare parts is stochastic and is very difficult to do a good prognosis needs. In order to compete on market it is trying to get purchase price as smallest as possible (than selling price is lover). Reducing transportation cost is realized with collective consignment. In the aim of review of ABC/XYZ analysis appliance possibilities, all information about sale in last 12 months has been analyzed. It has been analyzed 56,000 products.

The company currently listed a total of 56,000 items, but generally 25,000-30,000 items are in circulation. It is about so called industrial products (different types of bearings) and automotive assortment (oils, filters, strapping, spark plugs, seals, accumulators...). 14

categories of different types of items are defined in stock, 13 categories plus last additional category that are not used.

The value of sold goods (all items) during 2014 was 27 million KN, but average value of goods in stock was 13 million KN. On the 01.01.2015. activity ratio was 2,077.

The company currently operates without a certain amount of safety stock for individual products. Based on past experience, the company gave up of defining amount of the minimum maximum and optimal inventory.

4.2. Analysis Steps

First ABC analysis was done by two criteria:

- Sales ratio
- Quantity ratio

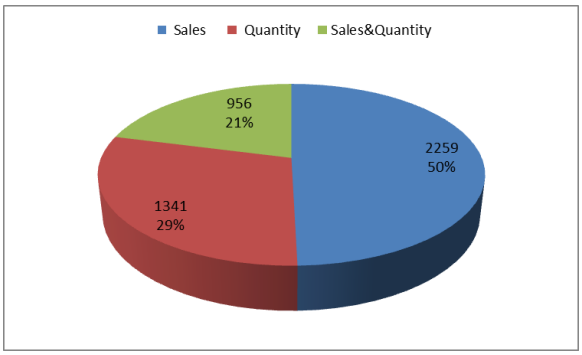

Figure 4 - Numbers of items in A category by criteria

In figure 4 numbers of items in A category by sales, quantity and sales&quantity criteria is shown. When merged this two criteria (sales and quantity) only 956 items were categorized as A category, and were further analyzed.

For XYZ analysis more information was needed. This analysis is necessary for making further decisions and procedures in stock management. Precisely the definition and conduction of automatic orders are based on XYZ analysis (for example for products from X category which have low coefficient of variation applies automatic order).

From the inventory data first standard deviation and coefficient of variation was calculated in order to analyses stability of demand of each item. Coefficient of variation (CV) shows the relation of standard deviation and average sales during the period and XYZ categorization is defined on the basis of it. This coefficient shows variability of demand. As the coefficient is lower, demand for product is stable. In X category products have CV to 0.1, in Y category products have CV to 0.25 and in Z category products have CV over 0.25.

While calculating CV, amounts bigger than 1 occurs, which shows greater dispersion of numbers, or smaller representativeness of arithmetic means. Coefficient of variation may not exceed the value 100% in cases where it is a very heterogeneous series, which is the case here. A sale of some items was only one or two months in the year. In figure 5 range of CV for A category items by sale and quantity criteria is shown. In this category 956 items were identified.

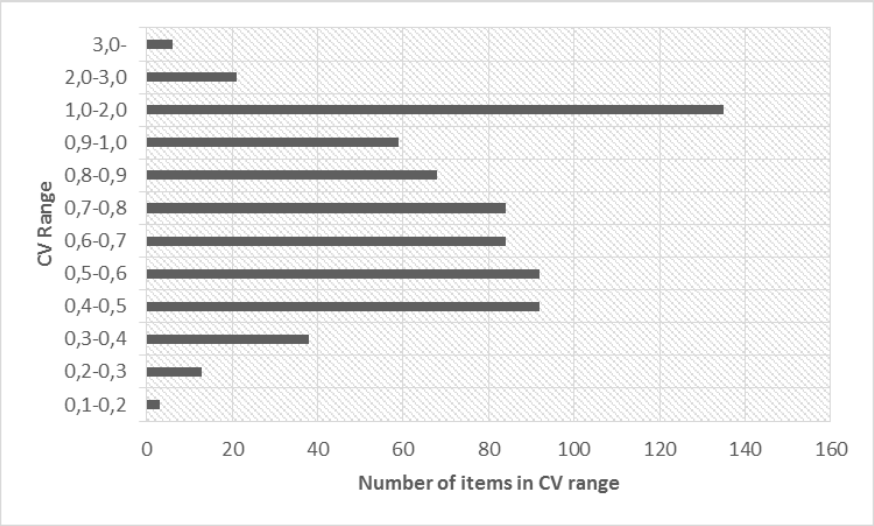

Figure 5 - Number of items of A category by merged criteria

Last step was to do cross analysis. As can be seen from figure 5, because of no heterogeneity data it is impossible to follow theoretic range of CV. For observed group of articles modification in range of CV is made.

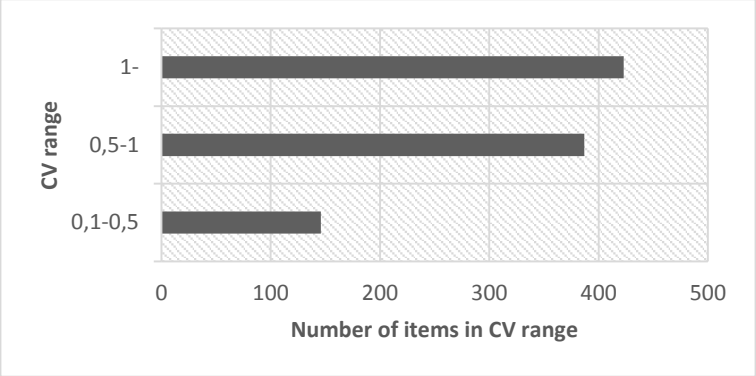

Figure 6 - Cross Analysis results

4.3. Result Discusion

The method chosen for the study of spare parts is ABC/XYZ cross analysis. From the whole sale of the respective company through the period of 12 months data it is concluded that :

- AX, BX and CX category contribute to the total sale with 52,97%. AX category has total sale from 126928 products which is 48,79% and the highest demand is in seventh month. CX category has the smallest total sale from 3486 products which is 0,88%and the highest demand is in fifth and seventh month.
- AY, BY and CY category contribute to the total sale with 37,22%. In this category AY category has the biggest total sale too, from 168532 products which is 18,33%. The highest demand for this category is in fourth month. BY and CY categories have approximately the same share of sale which are 10,05% and 8,84% and the highest demand for this products are in first and third month.

- AZ, BZ and CZ category contribute to the total sale with 8,88% and they all have pretty small percentage of sales. CZ category has the biggest total sale, from 8697 products which is 4,39% and AZ and BZ have 2,81% and 1,68% of total sale. The highest demand for CZ category is in tenth month.

The all information about categories and about fluctuations through 12 months are shown in figure 7.

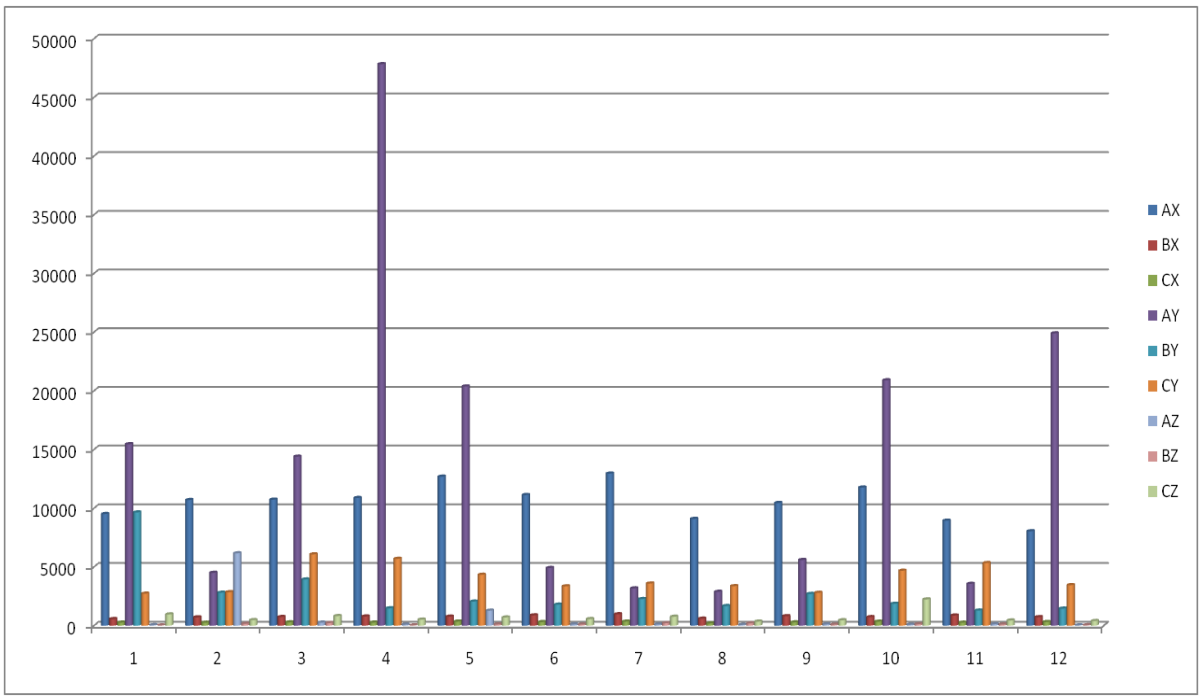

Figure 7 - ABC/ XYZ Cross Analysis shown on spare parts

What is seen from CV calculation, is that sale of spare parts has high variability and is almost impossible to forecast demand neither in quantity nor in kind of item. As XYZ theoretical range could not be applied in this observed case, some modification in category ranges was suggested. Cross analysis show that only A category items are worth to be cross analyzed so some kind conclusion for optimizing quantity of respective assortment can be stated only for this category of items.

5. CONCLUSION

The initial purpose of this study was to identify and organize the procurement processes in the automotive spare parts industry. Information about quantity of products, sales and demand through 12 months were used. By combining the ABC and XYZ analyses groups of items that involve the common features of both analyzes (ABC and XYZ) are obtained. These common characteristics can help to define strategies for sale and procurement and inventory policy for each group of items, according to their characteristics, specifics and needs. Using this combined analysis can provide company with the improved availability of items, the basis for more efficient inventory management, reducing number of non-moving items, improving the delivery schedules and for "shaking" the item range.

For the cross analyze to be done, good and heterogeneous data about the sale or demand are needed. Otherwise, is very hard to get reasonable value of coefficient of variability which indicates stability of demand.

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RAIL AND ROAD TRANSPORT PERFORMANCES AT THE CROSS-BORDER TRANSITS POINTS IN CROATIA

ABSTRACT

The aim of this paper is to analyze rail and road transport performances at the cross-border transit points in Croatia. In this paper were obtained real data based on the results of ACROSSEE project in which Croatian transport operators were interviewed.

A research has shown that there are present problems that significantly affect the quality of service and waiting times on cross-borders. Series of infrastructural, administrative and management criticalities accumulate at borders. Railway interoperability represents a priority to be achieved for the entire area and particularly for the West Balkans.

The importance of cross-borders in international trade was explained in short analysis of transport sector in Croatia. Transit times at the main rail and road cross-borders transit points in Croatia were observed from the questionnaires and at the end, rail and road transport performances at the cross borders in Croatia were defined.

KEY WORDS

Cross-border; international trade; transit time; waiting time; border accessibility; road; rail.

1. INTRODUCTION

The circulation of goods is slowed by the presence of many borders (Border Crossing - BC). Documentation problems, procedures, lack of technological equipment and infrastructures, etc. contribute to slow circulation, lengthen trip times, increase costs and create barriers in transport.

On the example of the European Union (EU) it can be noticed how the removal of borders between Member States had a positive effect on the transport of goods, eliminates the bottlenecks which were located at the borders and the flow of goods accelerated, leading to lower costs and higher quality of service. A bottleneck is any obstacle to freight and passanger transport logistics services, whether administrative, operational, legislative, local, national, Europe-wide or the like[2].

Border accessibility, together with the conditions of road and rail infrastructures are fundamental in guaranteeing the efficiency of all transport activities. By stimulating the interoperability and investments in the modernization and improvement of these key factors good basis for the application of intermodal transport and the ability to provide 'door to door' services can be obtained.

Borders are important for Croatia's development, because of its specific geographical shape and lengths of borders According to the Statistical information (2010) of the Central Bureau for Statistics, Republic of Croatia, the total length of the land boundaries of the Republic of Croatia is 2.375 km (incl. Bosnia and Herzegovina 1.011,4 km, Hungary 355,5 km, Slovenia 667,8 km, Serbia 317,6 km, and Montenegro 22,6 km) and the total lengths of the sea coast incl. islands is 5.835 km (wherefrom 1.777 km belongs to the mainland) [3]. Croatia and its transport system has great importance in the European transport network, due to its geo-strategic position. Especially now when it has become the external border of the EU[4] .

In this paper were obtained real data based on the results of ACROSSEE project. In it, the data were collected through a questionnaires from the national associations and individual transport companies. The results were analyzed in order to compile a summary of the main

problems at BCs that have a negative impact on freight transport in Croatia so that useful conclusions can be drawn.

2. STUDY METHODOLOGY

Two questionnaires were used to collect the data necessary for a homogenous comparison of the different contexts in which national operators carry operate. The questionnaires were respectively addressed to the single operators and the national associations representing categories of operators in each country.

The survey, conducted as a standard interview based on a questionnaire was divided into different topics, yielded great amounts of dishomogenous data from the different countries participating, with items being completely compiled, partially compiled or completely absent.

The overall picture that emerges is in any case representative of the complex situation of freight transport in South East Europe (SEE) and the West Balkans (WBs) and highlights both the diversities and the critical points present in the entire area.

Data collection process in Croatia was done until August the 20th 2013 when two associations and ten enterprises filled questionnaires were collected for the ACROSSEE.

Although the data collection was completed successfully, that process didn't pass without some serious difficulties. Many enterprises refused to cooperate. Fifteen of them finally decided to give the data for the questionnaires, only ten of questionnaires was collected in the end.

Four main problems were detected during the data collection: lack of interest from the side of the enterprises to enter the survey and the similar surveys in general, the absence of thorough transport surveys in Croatia and the regular transport data collection and, in the end, the fear of the enterprises from the data leakage which can damage their business-customer relations.

3. SHORT ANALYSIS OF TRANSPORT SECTOR IN CROATIA

3.1 Types of Enterprises and Commodities in Croatia

Ten enterpises who filled out questionnaires were: Transport Javoric, Hum na Sutli; Kos Transporti, Varazdin ; Renato p.p., Karlovac ; Klanatrans d.o.o., Rijeka; Stragatrans International transporti, Lipik; RALU Logistika d.o.o., Zagreb; Intereuropa, logisticke usluge d.o.o.; Express Interfracht Croatia, Zagreb; Schenker d.o.o. (DB Schenker Croatia), Zagreb; HZ Cargo d.o.o., Zagreb.

Of the nine transport companies interviewed (tenth company did not give enough information to be taken into account), eight operate both on rail and on road (even though road transport prevails). One, however, operates only on rail, namely HZ Cargo run by Croatian Railways, and the total volume of freight it handles exceeds the combined volume of all the others and also determines the dominant commodity category, that of processed animal and vegetable products, which are exported to the Europian Union (EU) and the WBs.

The other sectors are, in decreasing order of importance, chemical products, plastics, miscellaneous manufactured articles and textiles. Together these five main categories cover over 83% of all products transported, while the remaining 16% consists of small quotas of other commodities[1].

3.2 Commercial Speed and Transport Costs in Croatia

The destination of the commodities transported shows how Croatian trade relations are mainly with border countries in SEE (Slovenia, Serbia, Hungary and BIH) and bordering EU countries like Austria and Italy, even though trade is also extended to the Germany, the natural endpoint of many commercial connections with SEE countries, and to France, even though to a lesser extent.

The distribution of commercial speeds does not differ significantly between EU and extra EU countries, due to the fact that in any case it is necessary to transit at BCs, where the necessary controls are carried out, and this influences total trip time.

The only exception is the lower commercial speed for BIH destination due to the limits of the traditional road system.

It should be noted that the data refers to average statistical values before the entry of Croatia in the EU, and that these changed, due to the fact that the weight of customs transits appears to be homogenous at about 10%. In this respect it is significant to note the low percentage incidence of BCs in trips towards France and Germany, in which the relative value at BCs decreases due to a higher total trip time and the higher speeds guaranteed by the German motorway system. The average cost of road transport in Croatia is approx. 0,8 euro per ton/km, which largely corresponds to the modal cost registered for the different destinations indicated by the companies that supplied data on this point.

It also seems that EU or extra EU destinations have no influence, given that the majority of trips are towards destinations within the EU.

It is significant to note, however, that the lowest average rail cost registered is 0,6 euro-ton/km, which again is a natural trend in the road – rail comparison.

The only significant difference in both road and rail connections between Zagreb and Belgrade is the lack of a difference in the road and rail unit costs, even though both are higher than the respective Croatian average values.

3.3 Factors Affecting Transport in Croatia

The statistical distribution of the statements made by the companies interviewed tends to classify transport reliability as the major factor, with the two secondary factors being transport costs and waiting times at BCs. It was thought that the last component will disappear with the Croatian accession to the EU, but the waiting times towards the WBs are increased in order to strengthened controls, while waiting at the borders with other EU states negligibly reduced since Croatia has not yet been entered in the Schengen.

Competitive rates play an intermediate role together with the lack of availability of combined transport and the poor quality of the rail services offer.

Breaking bulk, when it occurs, is not considered an important factor.

4. TRANSIT TIMES AT THE MAIN RAIL CROSS-BORDERS

The interviews on which this paper is based allowed to identify amount of cross-borders (CBs) points where controls on the vehicle and goods are exercised by a number of customs and police authorities directly depending from the administrative fragmentation of the SEE and WBs, being the last ones sometimes recent became CBs points, where the physical infrastructure – road and rail – did not exist previously, and where often few investments have been done.

The list of CBs – in Figure 1 – does not represent the total amount of the existing CBs but surely it includes most of the main CBs transit points for the existing international trade in the area.

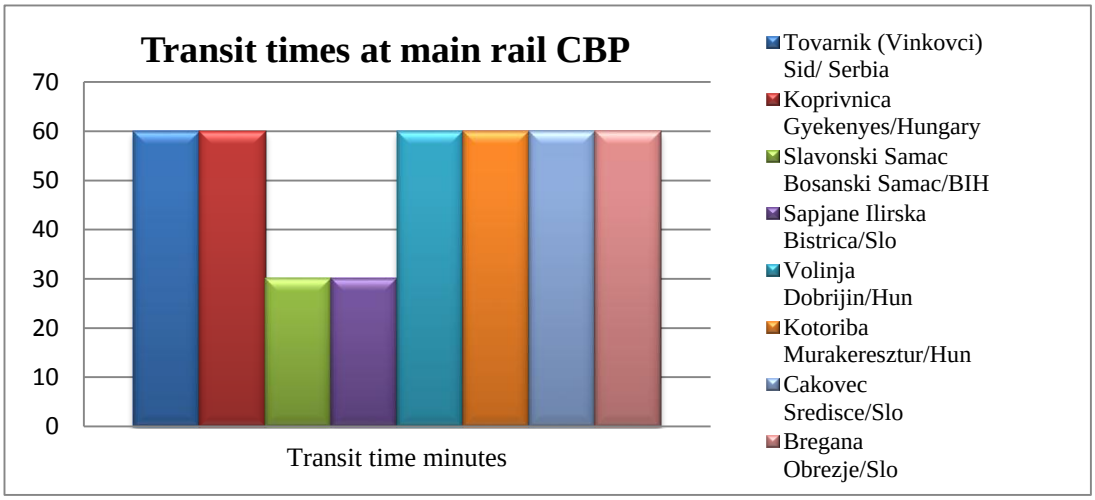

Figure 1 - Transit times at main rail cross-border points in Croatia

Source : Made by authors

In the Figure 2 it can be seen that as compared to countries in the region, waiting time at Croatian BCs is about equal to waiting times at BCs points of the EU, unlike the other SEE where waiting times are significantly higher

The transit times vary substantially for all the non EU countries where for EU countries only several bottlenecks due to the infrastructure or seasonal congestion may occur. Not necessarily the times shown in the Figure 1 represent the experience of every non EU transit point, but the range of the registered variations must be assumed as a good map of the substantial existing brakes to the freight circulation and to the economy integration in the area.

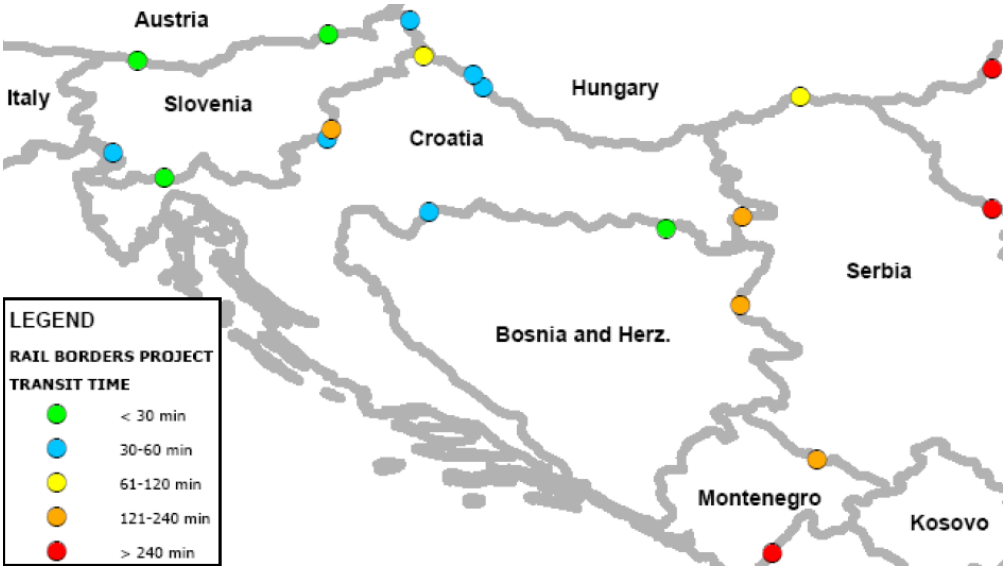

Figure 2 - The map of Border Cross Points
Source: ACROSSEE project, Transnational Cooperation Programme SEE

Railway transport to other countries is penalized by the technological and organizational differences between national rail systems. This becomes evident at border transits, where administrative procedures, together with technological adjustments and personnel organization cause lengthy downtimes on international routes, to the detriment of a service which is not competitive. This has direct effects on the prospect of integration with the EU, whose standards are destined to progressively become a reference for all European countries in order to guarantee greater trade integration.

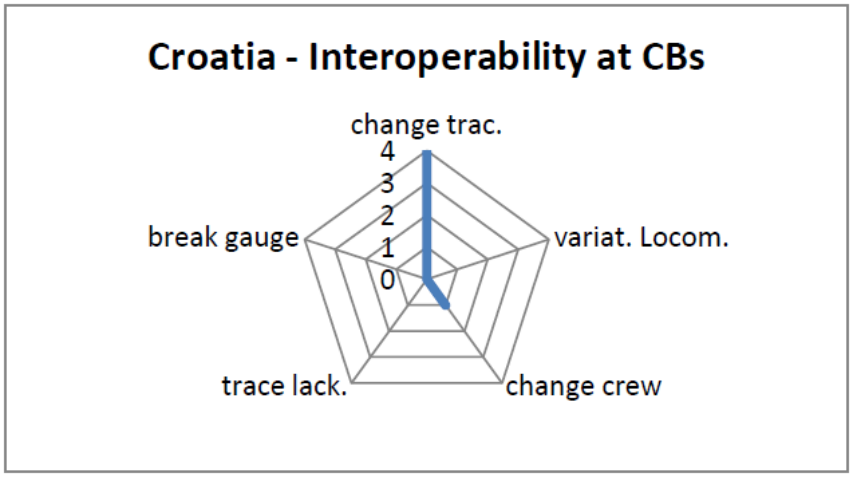

Figure 3 - Railway interoperability in Croatia
Source: ACROSSEE project, Transnational Cooperation Programme SEE

In the case of Croatia, as shown in Figure 3, the main problems are changes in locomotives and crew changes.

These problems are present in all SEE, together with problems of available tracks and variation in the number of locomotives. This means that trips with more than one border transit are not convenient and therefore, even if trips are compatible with rail transport, they are not compatible with the functions of an entire European corridor which is designed to cross many borders. In summary, the main problems throughout SEE, but in particular in the WBs, are the changes in locomotives and crew changes.

The fact remains, however, that railway interoperability represents a priority to be achieved for the entire SEE area and particularly for the WBs.

5. TRANSIT TIMES AT THE MAIN ROAD CROSS-BORDERS

The following figure (Figure 4) shows the average transit time, in minutes, at the main cross-border passages. In particular, it is possible to note that the border of Slavonski Brod (Croatia) has the longest transit time (200 minutes), while the borders at Dimitrovgrad (Bulgaria), Obrezje (Slovenia) and Batrovci (Croatia) are those with the shortest transit time (respectively, 100, 105, 115 minutes). The average value of the transit time at cross border passages is 137 minutes.

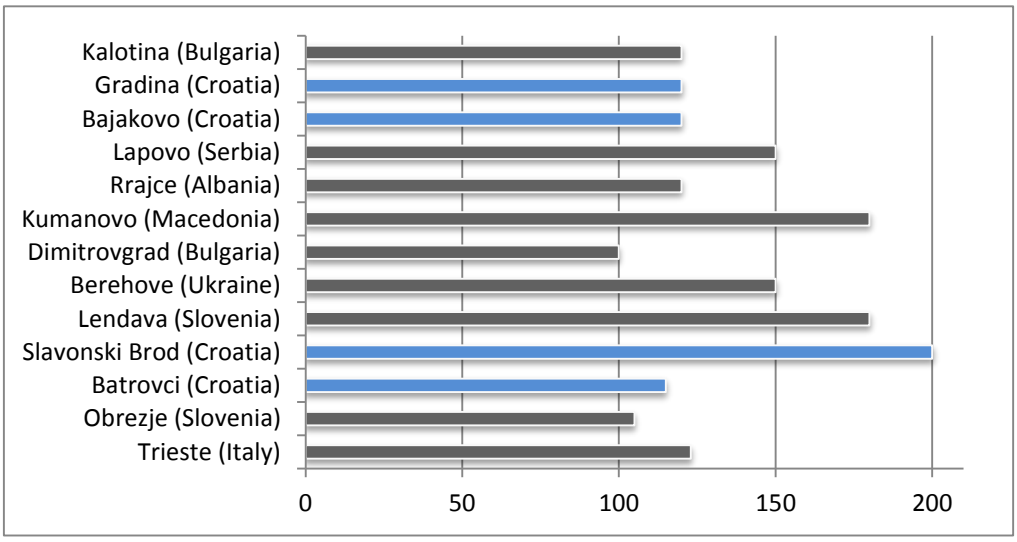

Figure 4 - Average waiting times at the main cross-border passages in SEE (in minutes)
Source: Made by authors

6. RAIL AND ROAD TRANSPORT PERFORMANCES AT THE CROSS BORDER TRANSIT POINTS IN CROATIA

It can be observed from the questionnaires that the transit times on the border crossings were significant. It must be emphasised that all the data gather regarding the road transit times on the road border crossings were from the experiences before July the 1st 2013 when Croatia entered European Union. From that date on there was a significant change of road border crossing procedures which was expected to simplify the border crossing and in the end to speed it up. The change of procedure was not explained in this paper due to insufficient information currently available.

The procedure of crossing the **road border crossings** was dependable weather the lorry was performing the customs procedures on the border or the procedures was done in one of the customs houses somewhere in Croatia. If the customs procedure was done on the border crossing this could take up to several hours. In the case were customs procedures were done elsewhere, the document check up preformed by the border crossing police officers took from two to ten minutes.

Also, traffic delays on the road border crossing were possible due to a limited customs and police check up capacities. The traffic congestion especially starts the day after the day when lorries are banned from driving (weekends and holidays). On these days traffic congestions are causing for many drivers to spend more time waiting in the queue than to

perform border crossing procedures. Traffic delays for lorries were reported from the explorers in the field who were performing "truck (lorry) drivers questionnaires".

From the questionnaires several interesting points can be observed. For example, Express inferfracht Croatia reported only minor waiting times on the road border crossings. It can be concluded that they did not performed custom procedures on the border crossing but somewhere else. The only case that they could lose time on the border crossings is due to traffic congestions.

Regarding the **rail border crossing** points no custom procedure is not to exceed 60 minutes due to a simplified customs procedure which is applied on every Croatian railway border crossing point. Delays on railway border crossings are common, but they are practically always produced because of traffic difficulties regarding the insufficient number of locomotives in the fleet of the domestic railway operator or some other infrastructure or operational limit.

From the questionnaires it can be observed that the custom procedures in the railway stations in which the procedures were done always took between 30 and 60 minutes.

The changes through which has customs procedures undergone after Croatia joined the European Union are still not entirely implemented because Croatia has not yet been entered in the Schengen.

7. CONCLUSION

If a series of infrastructural, administrative and management criticalities accumulate at borders, it is obvious that border opening times and phytosanitary controls represent a common problem. The areas at the centre of the WBs report behaviours that are completely arbitrary and not attributable to insufficient technological equipment or infrastructures, but rather to unjustifiable delays or improper forms of duty collection.

One should, however, bear in mind that the opinions of the interviewees can differ also depending on the size of the company. Smaller companies are certainly more exposed to the effects of the ill functioning of certain borders compared to larger companies, which are usually structured to handle customs procedures and everything that accompanies them.

Regarding the road border crossings two cases must be differentiated. The first case is when lorries stop not only for the border police check up but also for the customs check up as well. In that case it can take up to several hours for the lorry to pass the border. Otherwise, when custom procedures are done elsewhere, it only takes from two to ten minutes for a lorry to pass the border point. The problems can occur due to traffic congestions that can appear due to infrastructure or organisational deficiencies. The traffic congestion especially appear the day after the days when lorries are banned from driving (weekends and state holidays).

On the most of railway border crossings a simplified customs procedure is being applied. This means that custom procedure cannot exceed 60 minutes. All the other delays are regarded to operational and infrastructural problems. The main problems are changes in locomotives and crew.

Croatia joined the EU on July the 1st 2013. After that, many of the operations on the border crossing changed. Average transit time on CBs was slightly changed, because waiting times on EU borders were shortened but with the fact that Croatia became very important border with WBs, waiting times beetwen Croatia and other SEE greatly increased because of enhanced controls.

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CRITICAL POINTS OF THE LOGISTICS CHAIN IN THE FOOD STORES

ABSTRACT

This article deals with the critical points in the logistics chain of discount food stores. At first, the importance of the logistics chain for the supply of stores is theoretically supported, then it is followed by a theory that binds to the inventory management in food companies in terms of the analysis of individual items and in terms of the relevant systems of the inventory management. The final section provides the research, which concerns the identification of the critical points at the end of the logistics chain, directly to the stores where customers buy the goods.

KEY WORDS

Logistics chain; critical point; food stores; inventory management; ABC analysis; XYZ analysis.

1. INTRODUCTION

The logistics chain is a key concept of the logistics. It represents a dynamic link with market consumption markets of raw materials and parts in its tangible and intangible aspect. It always comes from demand, order or final consumer and binds to a specific contract or product.

The material page of the logistics chain is engaged in the preservation and moving things, the intangible page binds to the relocation information. Both sides of the logistics chain are indispensable to each other and the due attention must be given to them.

The authors of this article had as a main aim to identify the critical points in stores with groceries that affect the availability of goods for customers, therefore they performed this research on an unnamed discount store because of the confidentiality of information. The authors focused on the critical points in the logistics chain, only at the end, at the point where customers buy goods and depending on order and retail supply stores from its warehouse to the sales area.

The availability of goods in the stores is closely linked with the issue of inventory theory, and in the next chapter there is a supporting theory, which binds to inventory management.

2. THE INVENTORY MANAGEMENT IN FOOD STORES

The food companies have hundreds or even thousands of stocks, so it is not possible to devote an equal attention to all items. It would not be effective. That is why their distribution

uses one of analytical tools, such as the ABC analysis or its complement, which is the XYZ analysis.

2.1 ABC Analysis

This analytical tool to divide the storage range into groups is most commonly used. In this case, the stock range is divided into three basic groups although in practice it can be divided into a larger number of categories (Sixta and Žižka, 2009).

The ABC analysis is based on the so-called Pareto rule, according to which very often about 80% of the implications implies approximately 20% of the number of possible causes (80:20 rule). In the inventory management this means that a small part of the number of items constituting a majority consumption value, or that a large part of the total volume is taken from a relatively small number of suppliers. Then it is necessary to concentrate an attention on a limited number of inventory items and suppliers, which have a decisive influence on the overall result (Sixta and Žižka, 2009).

An Italian economist Pareto conducted a computational estimate in 1906 that 80% of the property rests in the hands of 20% of the population (Emmett, 2008).

Based on the Pareto rule, individual inventory items are usually divided into three categories (A, B and C), although in some cases it is possible to allocate another category.

Category A represents a very important item inventory, which makes up about 80% of the consumption or sale. These items must be monitored constantly. In managing of these items the Q-inventory management system is usually applied (Sixta and Žižka, 2009).

Category B includes moderately important items of inventory, which represent more about 15% of the consumption or sale. The simpler methods are used. For items of the category B a control system is often applied. It is based on ordering in solid moments (P-inventory management system), (Sixta and Žižka, 2009).

Category C indicates a few important items of inventory, which represent about 5% of the value of consumption or sale. In terms of the number of items there are many more. To control items of the category C are used very simple methods such as those based on an estimate of the order quantity according to the average consumption in the previous period. In this category of inventory management it is applied the P-inventory management system or a system of two reservoirs (Sixta and Žižka, 2009).

In some cases, there is category D, which contains entries with zero long-term consumption or sale. This is a "dead" unusable inventory, which needs to be sold at a reduced price or to dismiss it (Sixta and Žižka, 2009).

Selected items can be moved to another category or higher one according to other aspects such may be as high price of the item, its importance, difficulty of procuring, very long lead time, high risk unsaleability or inapplicability or limited storage time. These additional criteria are not always selected according to specific situations (Líbal and Kubát, 1994).

The analysis of the ABC method does not answer the question when and how much to order, but it is a highly effective way of improving inventory management system (Hýblová, 2006).

2.2 XYZ Analysis

As an additional analysis of the ABC we can also use the so-called XYZ analysis. It divides the total range according to the regularity of consumption in classes X, Y and Z. In the class X there are entering items with the most uniform consumption, it means items that have a high predictive ability. The class Y includes items with fluctuations in consumption. The predictive

ability is already reduced. The class Z contains items of the completely irregular consumption and therefore the worst prediction capabilities (Hýblová, 2006).

In the case of implementation of this method for the class X we can hold the minimum safety stock, without having a negative impact on emergency supplies (Hýblová, 2006).

In cases where the consumption during a particular period is precisely known, the relationship no. 1 (see below) between the frequency of supply and the size applies (Sixta and Žižka, 2009).

$$v = \frac{Q}{x} \tag{1}$$

In such situations, however, in practice we encounter rarely. In most cases, consumption stocks have got a probabilistic character, so the consumption fluctuates. Then the relationship no. 1 only applies to the mean value of these quantities (Sixta and Žižka, 2009).

Fluctuations in fuel consumption and actual state of the stock around its mean value must be faced. Basically, there are two basic ways of coping: either changing the frequency of deliveries in their constant size, or you can change the size of supply at a fixed interval between them. The advantage of both approaches is the fact that any bad decisions can be remedied in the next step.

According to the chosen system of balancing we talk about: Q-inventory management system, P-inventory management system (Sixta and Žižka, 2009).

The two aforementioned inventory management systems are discussed in the following chapters.

2.3 The Q-inventory management system

Q-system (from English fixed-order model Quantity) works with fixed sizes of orders and deliveries, and fluctuations in consumption compensates for changes in the frequency of orders. When applying this system we provide a signal level that is used to cover the demand during the interval of inventories and when the true state of the stock reaches the signal level, then there is a new order (Sixta and Žižka, 2009).

Q-inventory management system is generally considered as suitable for the case of relatively steady demand. A fundamental prerequisite for the functioning of this system is a continuous survey on stocks. For this reason it applies especially with important inventory items for which a company cannot afford a deficit supply (Sixta and Žižka, 2009).

2.4 The P-inventory management system

P-system (from English fixed-time period model) is based on the principle that, in a pre-fixed order terms lengths exhibit orders of unequal size. It is a system with periodic monitoring of stocks. The size of the order is determined as the expected consumption per interval of uncertainty, which is equal to the value, taking into account the size and layout of the insurance reserves, see link no. 2 (Sixta and Žižka, 2009).

$$x = \left(t_p + t_k\right)\bar{p} + X_p - x_d \tag{2}$$

The P-inventory management system is applied in practice, especially when stores buy from one supplier a larger number of items of material. Then, in terms of ordering and transportation costs advantageous to aggregate all the items in a single order and delivery (Sixta and Žižka, 2009).

Since the P-System and Q-system is rather difficult to obtain and accuracy of input data, so it is not very suitable for controlling inventory items of the category C. For these items there was developed a simple but very reliable inventory management system using two tanks (Sixta and Žižka, 2009).

2. 5 The system of two reservoirs

In a system of two reservoirs (in English two-bin system) there exist either physically or off balance sheet, two different sized trays. In a large container the common stock is stored, a small reservoir plays the role of safety stock. In the event that the emptying of a large container, it is a signal for automatic exposure order. By the time of arrival of new supplies the consumption of a small container is realized. After the arrival of the new supply is supplemented by a small reservoir first and the rest is stored in the large container. This system is very simple and its advantages are the low cost of inventory control (Sixta and Žižka, 2009).

3. THE RESEARCH

The authors conducted a study on the discount store, which sells goods of daily use, whether it is food or non-food goods nature.

The aim of the research was to focus on the failures of the food products and to identify the causes of outages of this product.

The research was conducted in November 2014, from 1st to 30th November 2014. Opening hours of the shop during this period corresponds to the time from 07:00 am to 8:00 pm seven days a week. Within each of the selected control points that were identified on the basis of turns in stores, distribution customers of the day and in terms of supply. Checkpoints were set each day at the following times:

- 09:00 am,
- 11:00 am,
- 3:00 pm,
- 5:00 pm,
- 7:00 pm.

Altogether, 5 checkpoints were established, which were controlled by the number of missing goods on the shelves. When the goods on the shelves is missing, then the customer cannot buy it, the shop loses some money, the customer is not satisfied and he can spread negative publicity.

The following Table 1 shows the number of missing goods on individual days within the period from 1st to 14th November.

Table 1 – Number of missing goods within checkpoints – November 2014 (first half)

Den	9:00	11:00	3:00	5:00	7:00	Arithmetic average	Max	Min
01. 11.	28	15	14	17	8	16,4	28	8
02. 11.	11	10	10	8	12	10,2	12	8
03. 11.	14	12	12	6	4	9,6	14	4
04. 11.	10	14	16	16	18	14,8	18	10
05. 11.	18	16	12	8	10	12,8	18	8
06. 11.	15	27	35	25	18	24,0	35	15
07. 11.	9	13	7	5	12	9,2	13	5
08. 11.	39	21	20	24	11	23,0	39	11

Den	9:00	11:00	3:00	5:00	7:00	Arithmetic average	Max	Min
09. 11.	7	6	6	5	7	6,1	7	5
10. 11.	20	17	17	8	6	13,4	20	6
11. 11.	5	7	8	8	9	7,4	9	5
12. 11.	11	10	7	5	6	7,7	11	5
13. 11.	9	16	21	15	11	14,4	21	9
14. 11.	17	25	13	10	23	17,5	25	10

Source: authors

Within the checkpoints it is clearly visible when there is the greatest failures of goods and what are the maximum and minimum values of the missing goods.

Subsequently, the authors focused on the reason for the outage of the goods. If the article on the shop was missing, they find out why there is a problem.

These reasons were divided into the following categories:

- the goods is at warehouse stores and it is not supplemented at the store,
- the goods is not in stock in stores, it has not been ordered,
- the goods is not at warehouse stores, it was ordered but not delivered from the distribution center.

Altogether 2,127 cases of loss of goods in the month of November 2014, of which according to the above criteria:

- 720 times (33.85%) the goods is at warehouse stores and the store is not completed (the bad work of the organization and the human failure),
- 451times (21.20%) the goods is not in stock in stores, because it was not ordered, the wrong predictions of ordering employees, the human failure,
- 956 times (44.95%) the goods is not in stock in stores, but it was ordered, the failure is on the side of the distribution center (central warehouse), which supplies stores.

4. CONCLUSION

The authors conducted the research on the discount chain store in November 2014 to identify where there is the greatest failure in the logistics chain, and they specialized in the final part of the logistics chain, in the part of the distribution centers to the stores and directly to customers.

From the research, it is possible to state that the said shop there in terms of loss of goods in the largest number of cases because of the administrative order goods but which have not been delivered from the distribution center (central warehouse), which was quantified in 956 cases, which consists of 44.95% of the total lack of goods in the period. The failure on the side of the shop, in the other cases, that is, both because of incorrect execution orders, goods store cannot order (21.20%) and because of replenishing the goods from the warehouse stores directly to the sales area (33.85%).

Finally, it is clear that the true lineage workers affect significantly the supply of goods to final customers. They also affect their satisfaction from buying and turnover for the shop.

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HINTERLAND CONNECTIONS OF ADRIATIC-IONIAN REGION

ABSTRACT

The different historical and economic dynamics during last century and dissimilar geographical orography can be considered as some of the reasons that contributed to an unbalanced development of the infrastructure system and of the transport modality between the shores of the Adriatic. The general objective of the research is to improve the accessibility and the mobility of passengers across the Adriatic area and its hinterland, through the development of new cross border, sustainable and integrated transport services. The specific objectives are achieved through the development of integrated actions: the evaluation of the integration among Adriatic ports and their hinterland that allows to identify needs and priorities, bottlenecks, potentials for passenger transport services/lines and their integrations, to outline scenarios and interventions for more sustainable and efficient passenger transport services in the Adriatic area aimed at improving Adriatic port system, its integration with hinterland, airports, rail network, other destinations, intra Adriatic connections.

KEY WORDS

Mobility; Hinterland; Passenger transport services; Adriatic region

1. INTRODUCTION

Due to the lack of intraregional connectivity within the Adriatic basin, certain parts of the region have limited access to regional, European and global markets. Imbalance of accessibility to services, markets and opportunities for further social and economic progress is an obstacle for overall development of the Adriatic region. The paper is thematically oriented on the assessment of road, rail and air passenger transport accessibility and ports hinterland in the Adriatic Ionian region (Albania (Saranda, Vlore), Croatia (Dubrovnik, Krk, Mali Losinj, Pula, Rab, Rovinj), Greece (Igoumenitsa), Italy (Ancona, Bari, Chioggia, Pescara, Ravenna, Termoli, Trieste), Montenegro (Bar), Slovenia (Koper)) with the aim of providing overview of current regional transport network connectivity serving as basis for further

identification of potential improvement measures. Generally it is shown that road traffic is still predominant on the Adriatic basin network since this is the only transport mode connected to all observed ports. Railway traffic is quite less used since the infrastructure is not equally developed in the whole region and this market is still deregulated which in some connections require much more travel time compared to other modes, specially with air transport.

1.1 Description of the Scenarios

The creation of scenarios (Figure 1) allows the identification of influencing factors that could have the effect on the development of passenger shipping in Adriatic-Ionian region as well as the determination of the activities that should be done to shape this development in a desired way. Multi-criteria analysis (MCA) was used in the creation of three different scenarios – pessimistic, realistic and optimistic, for passenger shipping development in the Adriatic-Ionian region.

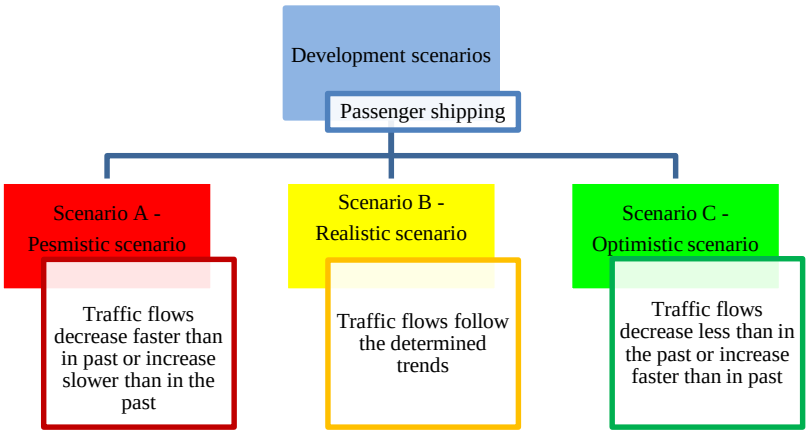

Figure 1 - Development Scenarios for the Passenger Shipping in the Adriatic-Ionian Region

The construction of the passenger shipping development scenarios consisted of three phases. The first phase included the analysis of current situation with the cross impact assessment among different transport modes while the second phase incorporated the analysis of the influence of expansion and modernization plans in ports' hinterland to the port development. The last phase is the combination of first two phases with the qualitative forecast given. Observed results are shown below by transportation mode.

2. SCENARIO ANALYSIS FOR ROAD TRANSPORT IN ADRIATIC-IONIAN REGION

Generally, the total realized traffic volume on the road network for the certain area depends on a number of factors which can be divided into several groups: geographical and location parameters, socio-economic and socio-political characteristics, deployment activities, the characteristics of the transport network, the parameters of the movement of passengers and cargo [1]. Most of the mentioned factors in the prediction of traffic or transport volume on the road network are based on TRANSTOOLS transport model based on the most important inputs:

- multimodal transport network with associated attributes per link, as well as the distribution of traffic across the network for the base year obtained by modeling,
- adopted zonal system consisting of 275 districts with associated data: the name of the county, population, household size, number of passenger cars, number of employees, number of motorized and non-motorized members of the household; zoning outside the

territory of the Adriatic-Ionian region was performed at NUTS3 level or the number of inhabitants in the zone that ranges from a minimum of 150000 to a maximum of 800000,

- origin-destination matrix (internal and international) passenger traffic for the corresponding year by defined scenarios,
- information about travel to the base year: the origin and destination by modes of transport, purpose of travel (business or otherwise), the level of motorization, generating travel from home,
- growth rate of gross domestic product in the countries of the Adriatic-Ionian region for the period of modeling transport demand or sub periods if the forecast period is longer than four years,
- the value of time for business trip and other purposes trip with the corresponding coefficients of elasticity for the forecasting year, etc.

Three development scenarios are considered: pessimistic, realistic and optimistic scenario. As a first step it was provided current situation overview (2010, 2011, 2012) as well as the forecast of the future transport volume (short-term until 2020 and mid-term until 2030) at the level of entire territory of the countries whose ports are located in the Adriatic-Ionian region. The results obtained in the first step are therefore the results of real scenarios. Pessimistic scenario results are obtained by subtracting the traffic volumes for 10% while the optimistic scenario results are obtained by increasing the traffic volumes for 10%. For the modeled road network values of the traffic volume by categories of vehicles (passenger cars, buses and trucks) are calculated and a sample is shown in Figure 2 (realistic scenario).

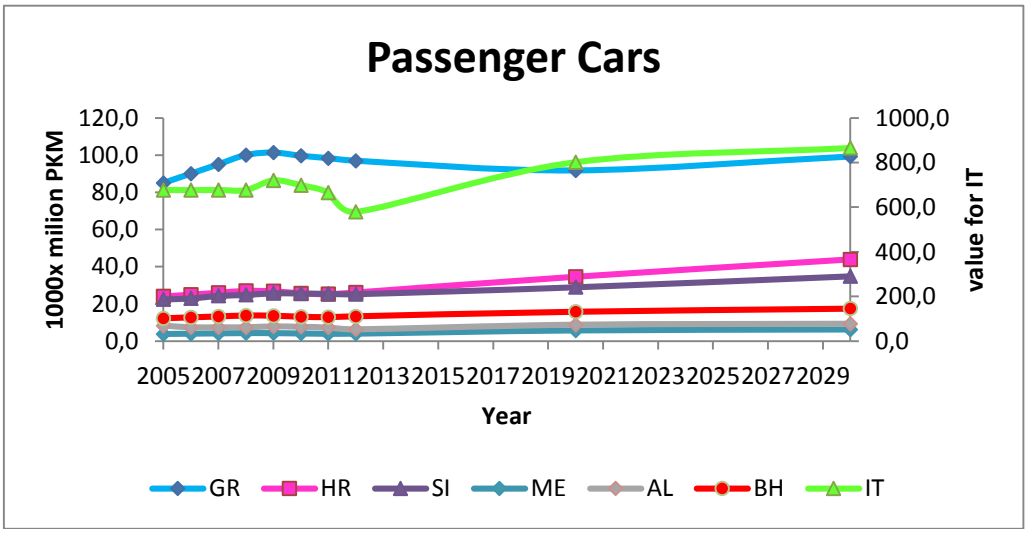

Figure 2 - Revenue and Forecasted Car Passenger Traffic – Adriatic-Ionian Region
Source: Statistical pocketbook 2011, 2012 and 2013 transport in figures EU, International Transport Forum, Eurostat, Transtools Model

3. SCENARIO ANALYSIS FOR AIR TRANSPORT IN ADRIATIC-IONIAN REGION

Air transport in the Adriatic region is evolving from year to year by application of EU legislation. However, the problem of intraregional connectivity prevails, where majority of destinations from and to the Adriatic airports are in the Western Europe and minor of all air transport operations in the region are realised within the Adriatic network [2]. Underdeveloped connections between the Adriatic ports and major cities represent a barrier for fast and convenient travel within the region**.** The highest frequency air transport

connections in the Adriatic region are linking the Adriatic region and Western Europe, with the largest number of flights to European nodal airports (Rome, Frankfurt, Munich and Vienna). Whilst number of destinations served from airports in Slovenia, Croatia, Montenegro, Albania coast are less than 50 per airport (for example: Rijeka-10 destinations in 2010, Split-50 destinations in 2010, Tivat-11 destinations in 2010, Dubrovnik-49 destinations in 2010, Tirana-35 destinations in 2010), Italian coast is more developed by the number of served destinations (for example: Bari-32 destinations in 2014, Venice-64 destinations in 2014). The overall goal of future transport development within the Adriatic region should be based on attracting international transport flows and increasing regional development. Air transport is recognized for adequate tool for connecting ports and hinterland due to the easiest of new routes establishment. The existing capacity of airports and aircraft is sufficient for the forthcoming period. Three potential scenarios are related to air transport development within the Adriatic-Ionian region:

- International and Intercontinental flights development (optimistic scenario): It is not possible to expect that the future development of airports in the Adriatic region would be equal for all countries, but there is still great opportunity to develop new routes which will continue to expand the number of potential passengers use ports services. The possible way of future development should be based on hub connectivity (Rome, Milan, Belgrade, Zagreb, etc.) with the expected growth rate of 5% RPK.
- Regional and International flights development (realistic scenario): This scenario considers existing flights routes between Adriatic region and other European cities. The expected growth rate is evaluated as 2% of RPK growth, according to GDP and forecast until 2032. This scenario will cover minor growth of passenger using port services, while the growth rate is perceived on the basis of tourist destinations within the region.
- Municipal and local oriented airports (pessimistic scenario): This scenario is not expected to be held within the large number of airports within the Adriatic region, but still some future trends should bring reductions in RPK or number of operations for some seasonal airports. Above all, some global economy drivers, Ukrainian crisis, etc. could provide reductions in larger airports but not more than 5% in the total RPS within the region.

Comparative analysis of air, rail and road transport accessibility among the Adriatic-Ionian region network shows that travel time is the most significant factor of influence which in the main aspect is determining air/rail/road market share. Travel time has been analysed in correlation to transport price which is defined as second most important factor of influence on passenger choice (Figure 3). However, since among Adriatic-Ionian region airports only road transport is available on all port connections while rail and air transport is available majority but not at all connections, it should be taken into account that passengers are given reduced choices of available transport services.

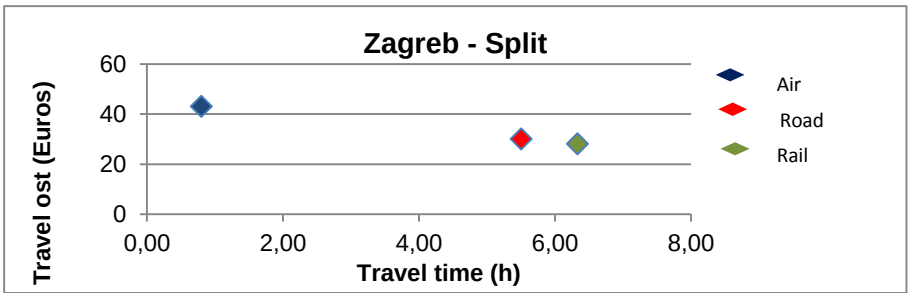

Figure 3 - Ratio of Travel Time and Cost on Two Sample Connections

4. SCENARIO ANALYSIS FOR RAIL TRANSPORT IN ADRIATIC-IONIAN REGION

In the last few years, certain traffic developments have been recorded in railway sector. Table below presents these developments in Adriatic-Ionian area. Analysis performed recently in the region by SEETO (2014) showed lower traffic increase than GDP per capita in relation to the railway services [3]. Following that, maximum range of scenarios should be from current status 0.2-0.5% (low scenario) annually, over 2-2.5% annually (medium scenario) to max 5% annually (high scenario). Experience in the last period in the region showed that traffic demand growth on passenger railway traffic relates to max 65% of GDP per capita growth.

Table 1 - Railway Passenger Traffic Volume on Corridors or Routes

Corridor or Route	Passenger traffic volume (mil/km)			Index 2012/2011
	2010	2011	2012	
Corridor Vb	245.636	176.859	143.862	0.81
Corridor Vc	117.72	53.002	43.417	0.82
Corridor VIII	33.683	33.973	26.897	0.8
Corridor X	1555.683	1352.455	1388.119	1.03
Corridor Xb	81.954	71.123	69.719	0.98
Corridor Xc	1.374	1.315	1.315	2.45
Corridor Xd	60.966	61.92	31.156	0.50
Route 1	70.518	38.509	45.965	1.19
Route 10	61.134	53.117	61.015	1.15
Route 11	6.198	5.517	5.714	1.04
Route 12	19.645	14.144	14.019	0.99
Route 13	-	0.855	0.693	0.81
Route 2	9.02	10.958	9.82	0.89
Route 4	213.335	111.383	113.762	1.02
Route 9a	14.371	37.521	14.786	0.39
Route 9b	0.635	0.457	0.174	0.38

5. SCENARIOS FOR PASSENGER SHIPPING DEVELOPMENT IN ADRIATIC-IONIAN REGION

While majority of ports in Adriatic-Ionian region has lost the number of ferry passengers in recent years (the trends are inconclusive and the drop in number of passengers is especially visible in 2013 in comparison to 2012), completely the opposite is happening in the cruise sector; the total number of cruise passengers has increased by almost 25% in the period from 2010 to 2013 according to Beškovnik and Twrdy [4]. In general, the investments in ports, airports and linking infrastructure should aim to (ERDF, CF & ISPA): promote local development either because it provides a direct service to productive activities or because it aims to satisfy the wider transport needs of the local population (in the case of tourist ports, these needs are by far the most important and consequently the analysis should show and

quantify a positive impact locally); and to complete and permitting maximum utilization of national/international transport networks. On the other hand, in the cruise shipping, marketing brings in visitors and gets them to come back for return visits. Successful marketing efforts aim at staying in business for most heritage attractions, particularly those not totally supported by local governments or other governmental agencies. Cruise shipping is gaining share especially among American, Canadian and European tourists. Certain routes calling to Adriatic-Ionian ports are very global and the visiting passengers are international, while with 6.4 million passengers being sourced from Europe, an estimated 6.1 million passengers embarked on their cruise from European ports. Adriatic-Ionian region is one of the most recent cruise shipping destinations and many of the ports in the region do not have their passenger terminals well developed. Minimum requirements for transit ports are clean and safe quay/pier/berthing and safe anchorage/tender spot, however many other criteria, such as parking area, infrastructure, ISPS zone and simple port procedures are additionally required from transit ports/destinations by more than 75% of cruise lines by SeaConsult [5]. The provided study considered development scenarios for ferry transport and cruise shipping in Adriatic-Ionian region. For the illustration, optimistic cruise shipping scenario is presented below:

- Improved tourist offer (more attractions, better packages etc.) resulting in increased interest for the Adriatic-Ionian destinations,
- Better rail and road connections with the hinterland, together with better transport services and options resulting in the expansion of the catchment area,
- The improvement and modernization of the existing passenger terminals or the construction of new dedicated passenger terminals,
- Good airways connections from the closes international airport (especially important for the ports that have an ambition to become a home, meaning that they have adequate in port facilities),
- The improvement of determined trends in terms of cruise ship calls and cruise passenger arrivals.

6. CONCLUSION

This paper foresees the assessment of the Adriatic port system and its integration with hinterland, based on the following issues: passengers behaviours and maritime/IW traffic flows in the Adriatic basin, current and potential traffic volumes related to existing infrastructures and services; current and potential integration of Adriatic port system with hinterland, regional/local airports, rail network and main tourist destinations taking into account the system characteristics and market demand; legal framework related to maritime passenger traffic (safety, security, passenger rights, passenger terminal services, info mobility) and possible initiatives for the harmonization of regulations in partner countries; and scenarios linked to the development of passenger traffic, transport modal choices, physical infrastructures and services. Results of assessment will be used for defining the contents of the new strategy, promoting the subscription of cross – border agreements for the optimization of passenger services and for outlining road maps of the identified priorities and coordinated action plans of the future pilot projects and actions.

Acknowledgment

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OPTIMIZING THE CROSS-DOCK DOOR ASSIGNMENT BY APPLYING MATHEMATICAL MODEL

ABSTRACT

Because of the growing competition on the global market and more complex customers' requirements logistic companies must constantly improve their operations and create competitive advantages. In a cross-docking facility goods are moved by forklift from incoming truck platforms (strip doors) to temporary holding areas and then to outgoing truck platforms (stack doors) or directly from strip to stack doors. Optimal cross-dock door assignment can improve the performance of the cross-docking facility. The cross-dock door assignment can be optimized by applying linear programming mathematical model. The methodology is outlined on a practical example of an I-shaped cross-dock facility, where the mathematical model was used to minimize the transport distances that forklifts pass within the facility. The optimization of the mathematical model was performed by software tool.

KEY WORDS

Optimization; cross docking; dock-door assignment; mathematical model.

1. INTRODUCTION

For an LTL (Less-Than-Truckload) carrier, the allocation of doors at a consolidation facility to outgoing trucks assigned to various destinations, and to incoming trucks arriving from various origins, has a significant impact on its operations [1]. LTL carriers rely on a network of hubs [2] to transfer cargo. A hub is typically a cross-docking terminal in which shipments from incoming trucks are unloaded, reassigned and consolidated onto outgoing trucks going to the correct destinations. Freight handling in a hub is labor intensive, and workers must quickly transfer freight during a short time period [3].

The cost of the labor-intensive freight consolidation operation accounts for about 15-20% of the operational costs of an LTL carrier [4]. It is very complex because dock workers must quickly process a large amount of freight in a short time window. Since the margin of an LTL carrier is very low, consolidating freight efficiently is critical for the carrier's profitability. In addition, there are many other benefits resulting from efficient freight consolidation such as higher on-time delivery rate and customer satisfaction. This paper deals with the issue of improving the efficiency of freight consolidation operations of hub-and-spoke LTL carriers by providing optimal stripping door allocations to incoming trucks.

Optimization of the cross dock door assignment is performed by using a mathematical model of linear programing, the resource allocation model. Generally, the feasible values of

the decision variables are limited by a set of constraints that are described by mathematical functions of the decision variables. The feasible solutions are compared using the objective function that depends on the decision variables. For a linear program the objective function and constraints are required to be linearly related to the variables of the problem. Resource allocation problem is a type of the problem most often identified with the application of linear program and it represents the problem of distributing scarce resources among alternative activities [5]. The problem is solved by optimizing the mathematical model applying MS Excel software tool Solver which uses Simplex method to find the optimal solution. Prior to using Solver, all components of the problem (decision variables, objective function, constraints) have to be included in the model.

2. DESCRIPTION OF THE LOGISTIC PROBLEM

Trucks with shipments from five different hubs in the logistic operator's European LTL network arrive at cross-docking terminal in Zagreb (Figure 1), to be cross-docked and delivered to the final destinations within Croatia. When trucks arrive on CD terminal they are directed to a particular dock door to be unloaded. After that, workers on forklifts transfer cargo to appropriate consolidation zone. In each consolidation zone pallets for particular destination are collected. After that pallets are transferred to the shipping area, loaded to outgoing trucks and shipped to destinations.

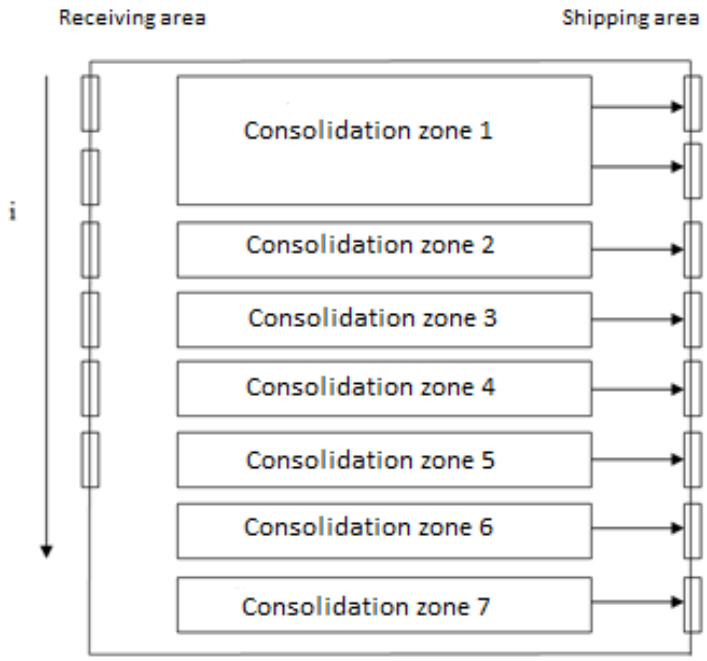

Figure 1 - Cross docking terminal

The decisions regarding dock door assignment is made by warehouse manager before trucks arrive, since the information about quantities of goods and their destinations are known in advance. Warehouse manager makes decisions based on past experience and evaluation and assigns strip doors 1 to truck from Budapest, doors 2 to truck from Zaragoza, doors 3 to truck from Vienna, doors 4 to truck from Hamburg and doors 5 to truck from Logatec. Quantities of goods (number of pallets) are given in Table 1.

Table 1 - Quantities of goods (number of pallets)

	A	B	C	D	E	F	G	H	I
1			Quantity of goods (pallets) by destination zone (q)						Total
2	Truck	D1 - ZG.	D2-ST	D3-RI	D4-ZD	D5-OS	D6-DU	D7-VŽ	
3	T1_Vienna	10	7	4	4	2	2	3	32
4	T2-Logat.	10	6	5	1	3	5	2	32
5	T3_Budim.	12	6	4	4	2	3	1	32
6	T4_Hamb.	11	9	5	2	1	2	2	32
7	T5_Zarag.	12	7	4	3	1	3	2	32

Since the assignment is based on operator's experience and evaluation, it may not be optimal. Optimal assignment of dock doors to incoming trucks depending on the quantity of goods (pallets) for each of eight destinations across Croatia and Manhattan distance between each dock door and appropriate consolidation zone makes sure that the distances that workers must travel on forklifts in order to reassign and consolidate shipments for each destination is minimized. That of course reduces shipment transfer time in hubs and offers the opportunity to reduce labor costs, improve customer service, and increase competitive advantages.

As shown in Figure 2, **Manhattan Distance** is the distance between two points measured along axes at right angles. The name alludes to the grid layout of the streets of Manhattan, which causes the shortest path a car could take between two points in the city. Manhattan distance between two vectors $p = (p_1, p_2, \dots, p_n)$ i $q = (q_1, q_2, \dots, q_n)$ in *n* dimensional vector space is given by equation (1).

$$d_1(p, q) = \|p - q\|_1 = \sum_{i=1}^{n} |p_i - q_i| \tag{1}$$

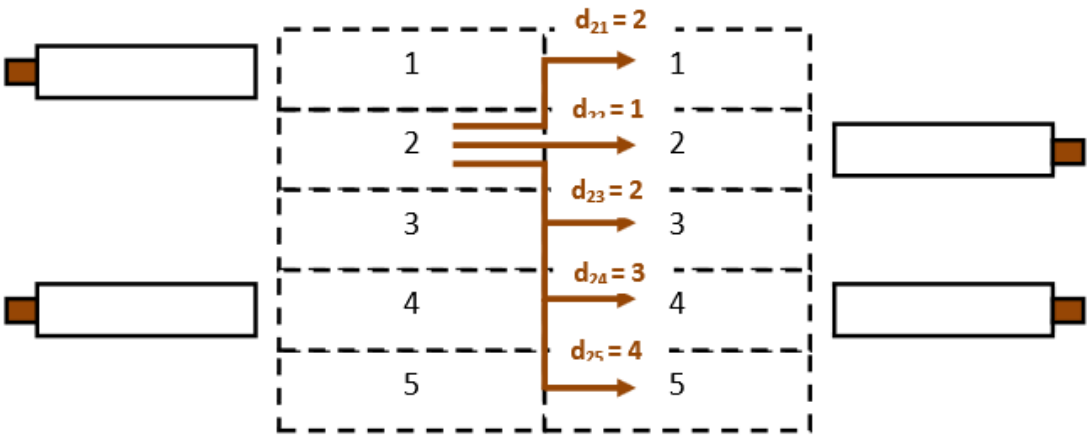

Figure 2 - Manhattan distances in cross-dock [3]

Manhattan distances for the a.m. problem are given in Table 2. Each destination zone matches one consolidation zone (so in consolidation zone 1 goods for destination zone 1 or Zagreb are being collected). Also, each consolidation zone matches one strip door except consolidation zone 1 that matches doors 1 and 2.

Table 2 - Manhattan distances in the cross-docking terminal

11		Manhattan distance from strip door to consolidation zone (d)						
12	**From/To**	**CZ1-ZG**	**CZ2-ST**	**CZ3-RI**	**CZ4-ZD**	**CZ5-OS**	**CZ6-DU**	**CZ7-VŽ**
13	**Door 1**	1	2	3	4	5	6	7
14	**Door 2**	1	2	3	4	5	6	7
15	**Door 3**	2	1	2	3	4	5	6
16	**Door 4**	3	2	1	2	3	4	5
17	**Door 5**	4	3	2	1	2	3	4
18	**Door 6**	5	4	3	2	1	2	3

The problem task is to minimize the distances that workers on forklifts travel during the consolidation phase in cross-docking facility. The conditions, constraints, elements of the problem and decision variables are given in Figure 3.

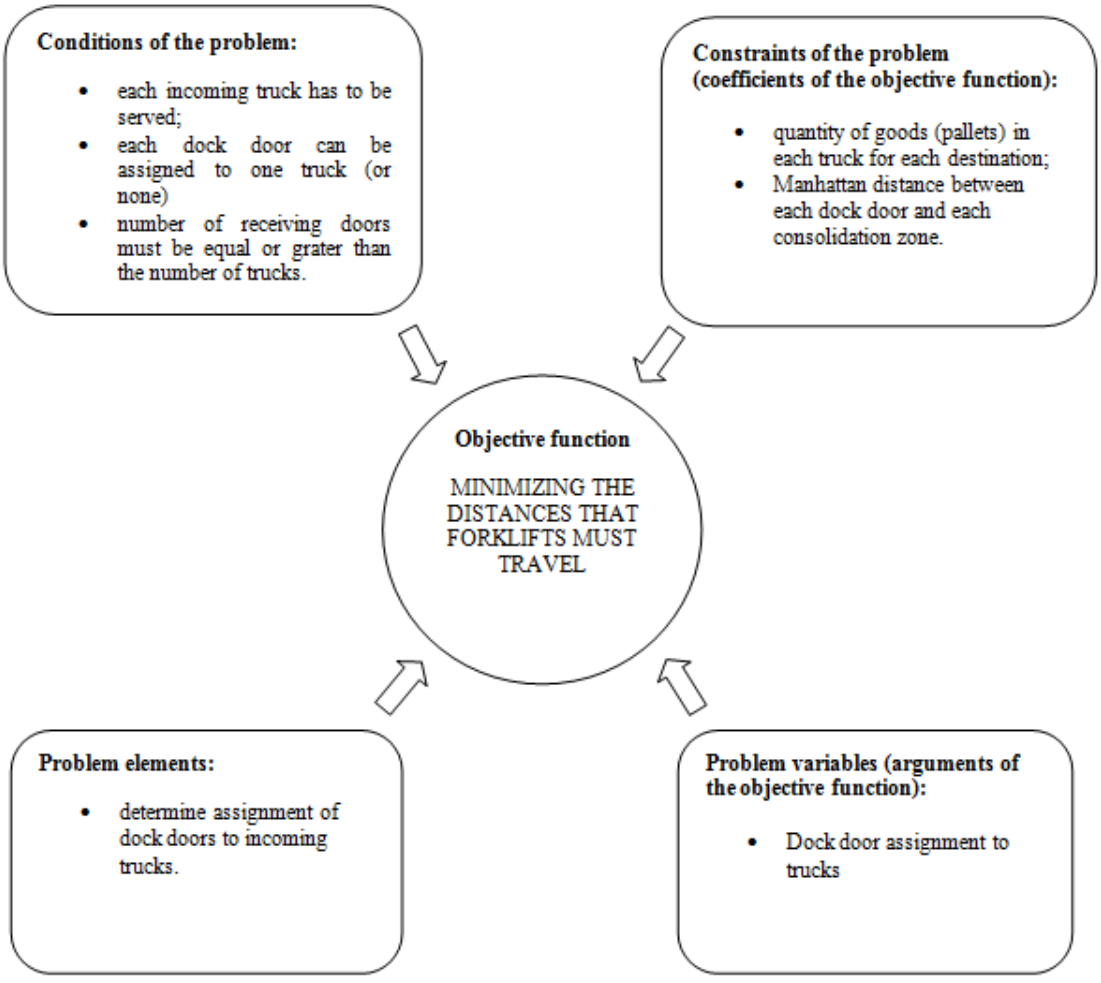

Figure 3 - The problem task

3. PROPOSED SOLUTION OF THE LOGISTIC PROBLEM

The mathematical model of the task that encompasses all the elements of the defined problem is defined by the following mathematical structure:

Objective function:

$$minF = \sum_{i=1}^{n}\sum_{j=1}^{m}\sum_{k=1}^{l} q_{kj} \times d_{ij} \times x_{ik} \quad (2)$$

Subject to the constraints:

$$\sum_{i=1}^{n} x_{ik} = 1 \; for \; every \; k = 1, \dots, l \quad (3)$$

$$\sum_{k=1}^{l} x_{ik} \leq 1 \; for \; every \; i = 1, \dots, n \quad (4)$$

$$x_{ik} \in \{0,1\} \; for \; every \; i = 1, \dots, n \quad (5)$$

$$n \geq l \quad (6)$$

Where:

$q_{kj} = quantity \; of \; goods \; from \; incoming \; truck \; \boldsymbol{k} \; for \; consolidation \; zone \; \boldsymbol{j} \; (pallets)$
$d_{ij} = Manhattan \; distance \; between \; strip \; door \; \boldsymbol{i} \; and \; consolidation \; zone \; \boldsymbol{j}$
$x_{ik} = desiscion \; variable: \; strip \; door \; \boldsymbol{i} \rightarrow incoming \; truck \; \boldsymbol{k}$
$n = number \; of \; strip \; doors, n = 6$
$m = number \; of \; consolidation \; zones, m = 7$
$l = number \; of \; trucks$

Equation (3) expresses the constraint that each incoming truck is served (one strip door must be assigned to each incoming truck), inequity (4) expresses the constraint that each strip door can be assigned to maximum one truck. Expression (5) constraints the decision variable to be binary, meaning each strip door can be either assigned or not assigned. Inequity (6) expresses the condition when trucks don't wait to be served (otherwise a queue is to be considered).

4. DISSCUSION OF THE RESULTS

The solution obtained by the warehouse manager is tested on the model and results are shown in Table 3. The value of the objective function for cross dock door assignment in this case amounts 436 (Number of pallets times Manhattan distance).

Table 3 - Operator's solution of the logistic problem

		Količina robe po zonama odredišta (q)							Ukupno											
Kamion		Z1 - ZG.	Z2-ST	Z3-RI	Z4-ZD	Z5-OS	Z6-DU	Z7-VŽ			Every destination zone matches one consolidation zone									
K1-Beč		10	7	4	4	2	2	3	32		Every consolidation zone matches one stack (receiving) door except consolidation zone 1									
K2-Logat.		10	6	5	1	3	5	2	32											
K3_Budim		12	6	4	4	2	3	1	32		Funkcija cilja:									
K4-Hamb.		11	9	5	2	1	2	2	32		min F=	436	(quantity of goods*Manhattan distance)							
K5-Zarag.		12	7	4	3	1	3	2	32											
		Manhattan distance from strip door to consolidation zone (d)									(q*d)					Truck->Doors				
From/To		CZ1-ZG	CZ2-ST	CZ3-RI	CZ4-ZD	CZ5-OS	CZ6-DU	CZ7-VŽ	Truck n1	Truck n2	Truck n3	Truck n4	Truck n5	Truck n1	Truck n2	Truck n3	Truck n4	Truck n5		
Door 1		1	2	3	4	5	6	7	95	100	87	83	87	0	0	1	0	0	1	
Door 2		1	2	3	4	5	6	7	95	100	87	83	87	0	0	0	0	1	1	
Door 3		2	1	2	3	4	5	6	83	88	79	73	79	1	0	0	0	0	1	
Door 4		3	2	1	2	3	4	5	85	88	83	81	85	0	0	0	1	0	1	
Door 5		4	3	2	1	2	3	4	95	98	95	99	99	0	1	0	0	0	1	
Door 6		5	4	3	2	1	2	3	113	110	115	121	119	0	0	0	0	0	0	
														1	1	1	1	1		

The optimal solution of the cross dock door assignment problem, obtained by applying *MS Excel* software tools *Solver* on the mathematical model is given in Table 4.

Table 4 - Optimal solution of the logistic problem

		Količina robe po zonama odredišta (q)							Ukupno										
Kamion		Z1 - ZG.	Z2-ST	Z3-RI	Z4-ZD	Z5-OS	Z6-DU	Z7-VŽ											
K1-Beč		10	7	4	4	2	2	3	32										
K2-Logat.		10	6	5	1	3	5	2	32										
K3_Budim		12	6	4	4	2	3	1	32										
K4-Hamb.		11	9	5	2	1	2	2	32										
K5-Zarag.		12	7	4	3	1	3	2	32										
		Manhattan distance from strip door to consolidation zone (d)										(q*d)							
From/To		CZ1-ZG	CZ2-ST	CZ3-RI	CZ4-ZD	CZ5-OS	CZ6-DU	CZ7-VŽ	Truck n1	Truck n2	Truck n3	Truck n4	Truck n5						
Door 1		1	2	3	4	5	6	7	95	100	87	83	87						
Door 2		1	2	3	4	5	6	7	95	100	87	83	87						
Door 3		2	1	2	3	4	5	6	83	88	79	73	79						
Door 4		3	2	1	2	3	4	5	85	88	83	81	85						
Door 5		4	3	2	1	2	3	4	95	98	95	99	99						
Door 6		5	4	3	2	1	2	3	113	110	115	121	119						

														Truck->Doors					
From/To		CZ1-ZG	CZ2-ST	CZ3-RI	CZ4-ZD	CZ5-OS	CZ6-DU	CZ7-VŽ	Truck n1	Truck n2	Truck n3	Truck n4	Truck n5	Truck n1	Truck n2	Truck n3	Truck n4	Truck n5	
Door 1		1	2	3	4	5	6	7	95	100	87	83	87	0	0	0	0	1	1
Door 2		1	2	3	4	5	6	7	95	100	87	83	87	0	0	1	0	0	1
Door 3		2	1	2	3	4	5	6	83	88	79	73	79	0	0	0	1	0	1
Door 4		3	2	1	2	3	4	5	85	88	83	81	85	0	1	0	0	0	1
Door 5		4	3	2	1	2	3	4	95	98	95	99	99	1	0	0	0	0	1
Door 6		5	4	3	2	1	2	3	113	110	115	121	119	0	0	0	0	0	0
														1	1	1	1	1	

Every destination zone matches one consolidation zone																			
Every consolidation zone matches one stack (receiving) door except consolidation zone 1																			
Funkcija cilja:																			
min F=	430	(quantity of goods*Manhattan distance)																	

As shown in Table 4. the value of the objective function in the optimized solution amounts 430, which is less than the operator's solution. It means the optimized solution is better and it yields 1,4% savings in forklift operations (Number of pallets times Manhattan distance). The optimal solution defines the following strip door assignment:

- door 1 to truck 5 from Zaragoza instead to truck 3 from Budapest,
- door 2 to truck 3 from Budapest instead to truck 5 from Zaragoza,
- door 3 to truck 4 coming from Hamburg instaead to truck 1 from Vienna,
- door 4 to truck 2 from Logatec instead to truck 4 from Hamburg and
- door 5 to truck 1 from Vienna insted to truck 2 from Logatec.

Four iterations more were performed and the analyses showed that in almost every case the operator's solution wasn't optimal (Figure 4). In second iteration the optimized solution was better by 0,5%, in third iteration by 1%, in fourth iteration by 2,3%, while in fifth iteration the operator's solution was equal to optimal. Even though it doesn't seem much of improvement per one iteration, these are regular operations, performed several times daily in cross-docking terminals, so on monthly basis the total savings achieved by applying mathematical model can significantly improve the cross docking terminal performance and efficiency.

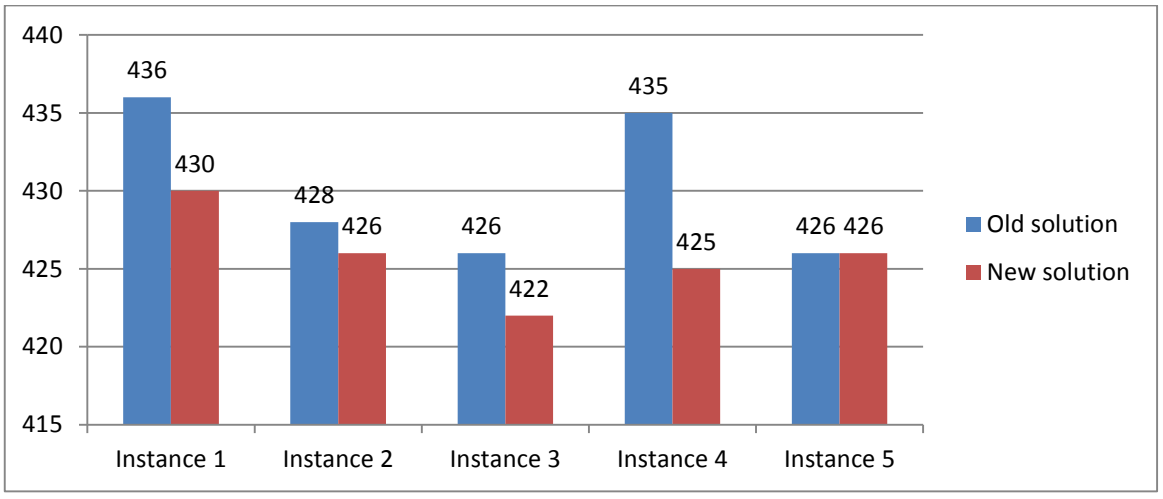

Figure 4 - Comparison of the results

5. CONCLUSION

Operator's logistic solution for dock-door assignment that was analyzed, didn't fully meet the demands of efficiency and effectiveness (allocation based on operator's assessment and experience). The optimal solution of the cross-dock door assignment problem was obtained by applying the MS Excel software tool Solver on the mathematical model. In order to quantify the improvements, the solution implemented by the warehouse manager was been tested in the model and the results were compared to the optimal solution obtained by software tool. In almost every iteration, the optimized solution was better than the operator's solution. For this reason, the forklifts pass longer distances when shifting goods from inbound doors to consolidation zones, spending more working hours and lifting more weight than actually needed. Optimal dock door assignment (allocation of strip doors to incoming trucks) results in shortening internal paths of cargo flows in the cross docking terminal, which reduces working hours and the total duration of the cross docking process. Due to the simplicity of use, flexibility and speed of problem solving, the model is particularly suited for daily use in real situations, when there deviations in planned schedule of trucks arrivals.

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FUNCTION OF DECISION SUPPORT SYSTEM IN TRAFFIC SIGNS MAINTENANCE

ABSTRACT

Basic principles of mutual relations and behavior of participants and other stakeholders in the road transport determined by the Law on Road Traffic Safety. Provisions of the Act prescribes the basic conditions that road must met regarding to the traffic safety; regulated rules for road traffic; road signs system and signs given by authorized persons; duties in the case of road accident; conditions which must be met by drivers and vehicles. This paper will propose a Decision Support System in case of replacement old and inadequate road signs with new. Proposed Decision Support System in the traffic signs maintaining function based on specific parameters (after testing signs at a certain section) will develop a plan for maintenance and replacement of traffic signs which do not meet the minimum legal requirements of retro-reflection, those who are not technically correct or will give warning for those signs who are on the verge of meeting all these requirements.

KEY WORDS

Traffic signalization; retroreflection; DSS; maintenance

1. INTRODUCTION

Traffic signs use shapes, colors, words, and symbols to communicate with the driver. The only way an object is visible at night is if it is artificially illuminated and if some light that falls on the object is reflected back the driver's eyes. Maintenance of public roads shall be conducted in accordance with the Rules[1] and other regulations in the field of road, construction, planning, road safety, environmental and other regulations, standards, technical requirements, specifications and standards governing the maintenance issues and protection of public roads. The big problem, in financial term, in the traffic signalization maintenance is data about the traffic signs number required for maintenance. This paper will propose a Decision Support System whose operation principle is based on a database of tested traffic signs and their parameters, and results in a decision or a maintenance plan on certain section of the tested road.

[1] Road maintenance regulations, NN 84/2011, 22/2013, 54/2013 i 148/2013

2. GENERALLY ABOUT DECISION SUPPORT SYSTEM

Decision support system is a type of information system designed to support decision-making. The system does not perform decision-making than the leader provides all the relevant information and allows you to study the impact of possible decisions.[2] The system uses the database and documents, stored knowledge and built-in models and procedures to display different views of the requested information. System has the ability to interact with the user exploring and analyzing the consequences of possible decisions on the business environment. The definition and scope of the DSS were changed over the decades with the increasing complexity of the supply chain network. In today's environment, various information systems and point applications produce huge data transactions amounts in a typical manufacturing organization. DSS users receive their information from databases and other sources. If the user has a problem, the problem is evaluated and DSS system is made. Data is entered by sources and models. Existing knowledge in relation to certain problems is stored in the corporate knowledge base. Solving the problem, more knowledge is accumulated in the organizational knowledge base. DSS can be used for different types of decisions made by different managers.

The basic properties of decision support systems are:

- Designed specifically for decision-making processes;
- Interactive assist in decision-making, but not automating decision-making;
- Quick adaptation to user needs.

The most common reasons for introduction and using the DSS include:

- New and accurate information;
- Quickly information (immediately);
- Simultaneous monitoring of many business operations in the company becomes more severe;
- Company’s unstable economy operate;
- Increasing foreign and national competition;
- Existing computer systems do not fully satisfy the objectives of increasing efficiency and profitability.

3. TRAFFIC SIGNS RETROREFLECTION TESTING

Traffic signs should be inspected at least once a year to verify the retroreflection and looks using short lights of vehicle. Criteria for review should include good visibility from a distance, especially considering the environment characters, clear, unmistakable and not evaporated colors, clear and readable symbol or message of the sign, absence of stripes, spots or other damage that distracting light reflections and the absence of a smooth surface of the sign within a distance from which the sign can be read.

Although all of the characteristics of the sign can be determined by visual inspection of signs at night, it is also necessary to measure the retroreflection, determine the type of character and its exact location.

For field measurement of retroreflection of traffic signs there are several retroreflectometers (Zehntner, Delta ...). Such instruments should have a source of light that corresponds to the standard source A according to CIE-in, and photoreceptor should have a

[2] Imamagić E.: Sustavi za potporu odlučivanju, FER, Zagreb, 2010.

spectral sensitivity that fits standard photo-optical observer according to CIE[3]. Geometry should be selected so that it corresponds to the values that are listed in national specifications which mean viewing angle of 0.33° and the angle of 5°. Entrance angle is primarily determined by the position of the sign in the edge of the road and geometry of an oncoming vehicle and it is formed between a light beam that falling on the surface of the sign and the line that comes out vertically from the surface. Viewing angle is the angle between the incoming light beam and reflected light beam and it is a function of the height of driver eye compared to the vehicle headlights. As it is assumed that most of the retroreflectors material reflects light directly back to the source, the optimal viewing angle is zero. However, in reality it is not so considering that the driver's eye is higher than the vehicle headlights.

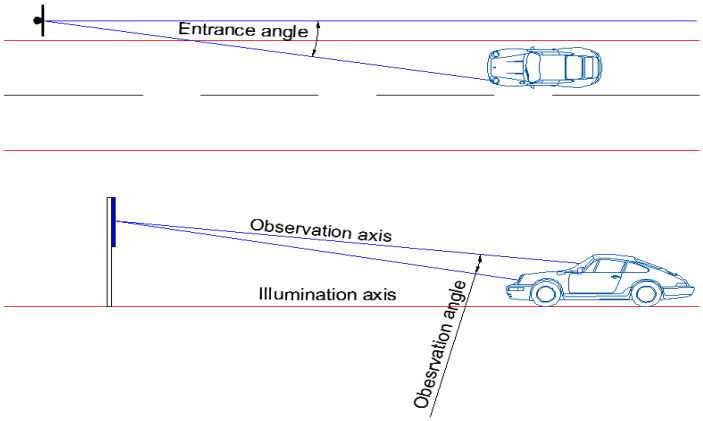

Figure 1 - Entrance and observation angle for a traffic sign
Source: By authors

Minimum initial coefficient of retro reflection RA (cd • lx-1 • m-2) of traffic signs measured in accordance with the procedure using CIE standard light source A, must match the values in Table 1., Table 2. or Table 3.

Table 1. - The coefficient of retroreflection RA: Class I units cd•lx^{-1}•m^{-2}

Geometry of measurement		Color							
α	β1 (β$_2$=0)	white	yellow	red	green	blue	brown	orange	gray
12′	+5°	70	50	14.5	9	4	1	25	42
	+30°	30	22	6	3.5	1.7	0.3	10	18
	+40°	10	7	2	1.5	0.5	#	2.2	6
20′	+5°	50	35	10	7	2	0.6	20	30
	+30°	24	16	4	3	1	0.2	8	14.4
	+40°	9	6	1.8	1.2	#	#	2.2	5.4
2′	+5°	5	3	1	0.5	#	#	1.2	3
	+30°	2.5	1.5	0.5	0.3	#	#	0.5	1.5
	+40°	1.5	1.0	0.5	0.2	#	#	#	0.9
# Signifies "Value greater than zero but not meaningful or not applicable "									
α = observation angle ; β = entrance angle									

[3] CIE, Maintained Night-time Visibility of Retroreflectivity Road Signs, Brussel, 1995

Table 2. - The coefficient of retroreflection RA: Class II units cd•lx^{-1}•m^{-2}

Geometry of measurement		Color								
α	β1 (β_2=0)	white	yellow	red	green	dark green	blue	brown	orange	gray
12′	+5°	250	170	45	45	20	20	12	100	125
	+30°	150	100	25	25	15	11	8,5	60	75
	+40°	110	70	15	12	6	8	5,0	29	55
20′	+5°	180	120	25	21	14	14	8	65	90
	+30°	100	70	14	12	11	8	5	40	50
	+40°	95	60	13	11	5	7	3	20	47
2′	+5°	5	3	1	0,5	0,5	0,2	0,2	1,5	2,5
	+30°	2,5	1,5	0,4	0,3	0,3	#	#	1	1,2
	+40°	1,5	1,0	0,3	0,2	0,2	#	#	#	0,7

Signifies "Value greater than zero but not meaningful or not applicable "

α = observation angle ; β = entrance angle

Table 3 - The coefficient of retroreflection RA: Class III units cd•lx^{-1}•m^{-2}

Geometry of measurement		Color					
α	β1 (β_2=0)	white	yellow	red	green	blue	orange
10′	+5°	850	550	170	85	55	260
	+20°	600	390	120	60	40	130
	+30°	425	275	85	40	28	95
20′	+5°	625	400	125	60	40	140
	+20°	450	290	90	45	30	100
	+30°	325	210	65	30	20	70
33′	+5°	425	275	85	40	28	95
	+20°	300	195	60	30	20	65
	+30°	225	145	45	20	15	49

Signifies "Value greater than zero but not meaningful or not applicable "

α = observation angle ; β = entrance angle

3.1. Database Creation

On each sign shall be made three random selection measurements of the retroreflection coefficient on all colors that contains a character other than black (black does not reflect light). As a reference value of the retroreflection coefficient for each color on the sign takes the average value of three measurements. After testing follows entering data into the software "Retrorefleksija". Access to the system is possible with the appropriate user name and password that will be assigned to the relevant persons involved in the process of traffic sign testing.

The goal of new software is a clearer display of examined values of traffic signs retroreflection a way by combine more measurements on one traffic sign and displayed as a whole with one or more traffic signs which are associated with the test data.

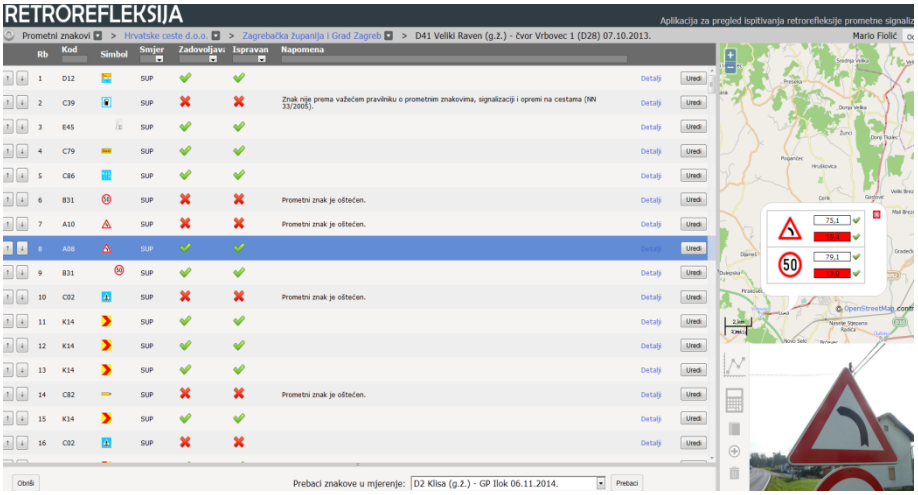

Figure 2 - Interface appearance of software tool "Retrorefleksija"
Source: By authors

In addition to these data device records temperature and humidity and GPS coordinates that make it possible to position the sign on interactive map. This web application represents a database for further research related to traffic signs and to create a Sign database of installed and measured traffic signs on existing and redesigned roadways. All of measuring results conducted will be available in one place (web applications) at all times. The software is designed in such a way that the end user gets clearer measurement results presented in an interactive overview which allows administrators to get more detailed analysis. Reports can be printed also.

4. DECISION SUPPORT SYSTEM IN TRAFFIC SIGNS MAINTENANCE

After testing prescribed minimum retroreflection values and technical conditions of traffic signs they are stored in the database, specifically on the web application "Retrorefleksija". The evaluation procedure of traffic signs quality is shown on the figure 4 and on the grounds that we can get clear picture of the correct and incorrect number of road signs on the tested section. Absolutely correct traffic sign must meet the minimum prescribed value of retroreflection and technical requirements (not damaged, bent, appropriate class films). During the operation of the system decision support models retrieve the required data from the database of traffic signs. Decision Support System uses the following data:

- Retroreflection value of the tested road signs;
- Age of tested traffic signs;
- Height settings;
- Distance from the roadway edge;
- Traffic signs condition (damaged, different retroreflective properties, non-compatibility with the relevant Regulations ...).

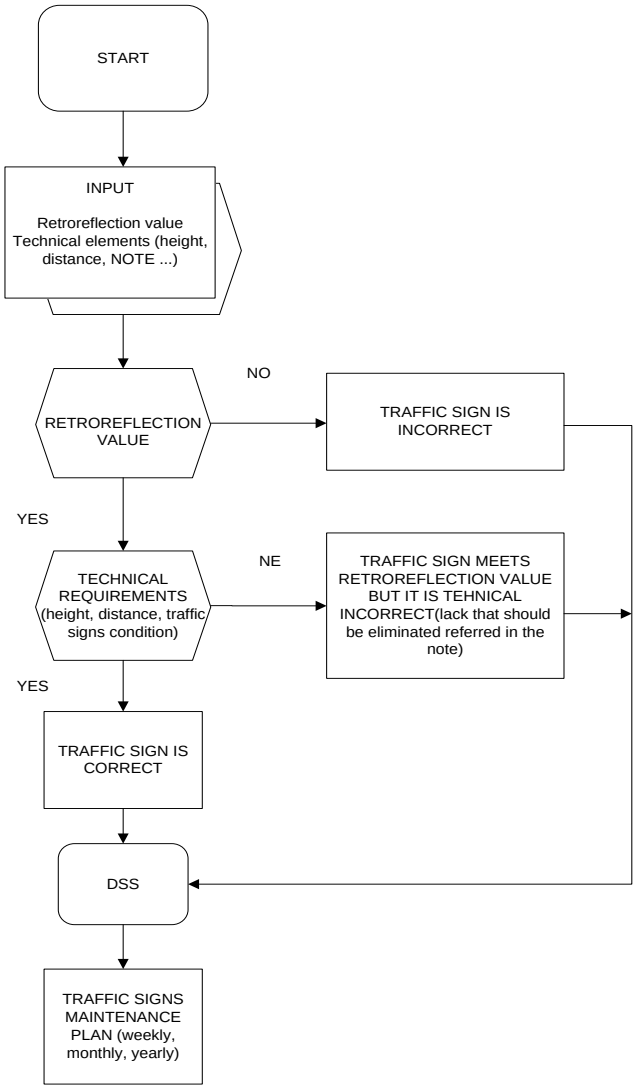

Figure 3 - Evaluation procedure of traffic signs quality and DSS support
Source: By authors

After performing the test results are stored in the database. Based on the results, maintenance managers for the traffic signs and equipment on the roads is much easier to make a decision or make a maintenance plan (financial plan) on the tested section. The maintenance plan can be done on a weekly, monthly or yearly basis depending on the urgency and the available financial means. Maintenance managers receive a report with all the traffic signs that need to be replaced but those road signs that are on the verge of meeting the required conditions and because of their age they need to be replaced in the near future.

This web application represents a database for further research related to traffic signs and to create a Sign database of installed and measured traffic signs on existing and redesigned roadways. All of measuring results conducted will be available in one place (web applications) at all times.

To keep data in the database correct after the conducted test a new control system of traffic signs is needed. Accuracy term implied that a traffic sign is in the same location at which was recorded (removed for some reason) or it has been damaged, replaced by a new...

A system that would allow daily check consists of camera mounted on the vehicle and a tablet with internet connection. By connecting to the traffic signs database (Retrorefleksija) it will be given the precise location of the traffic sign which includes chainage and GPS

coordinates. If there is a lack or surplus (newly installed road sign) of a traffic sign system automatically ejects message and recorded this change for further intervention.

Example of such system is shown in Figure 5 and 6.

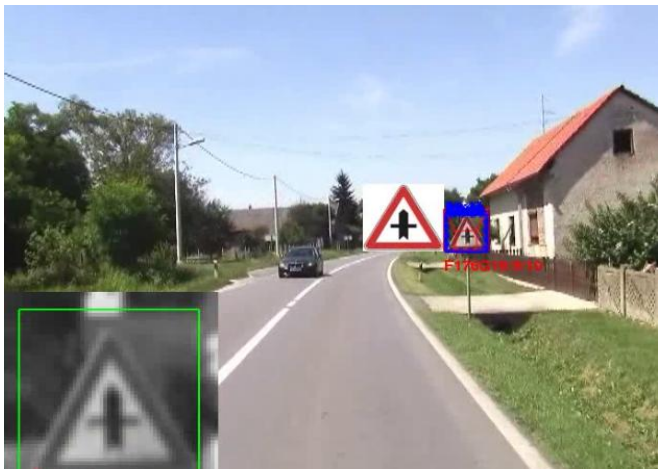

Figure 5 - Automatic detection of traffic sign
Source:By authors

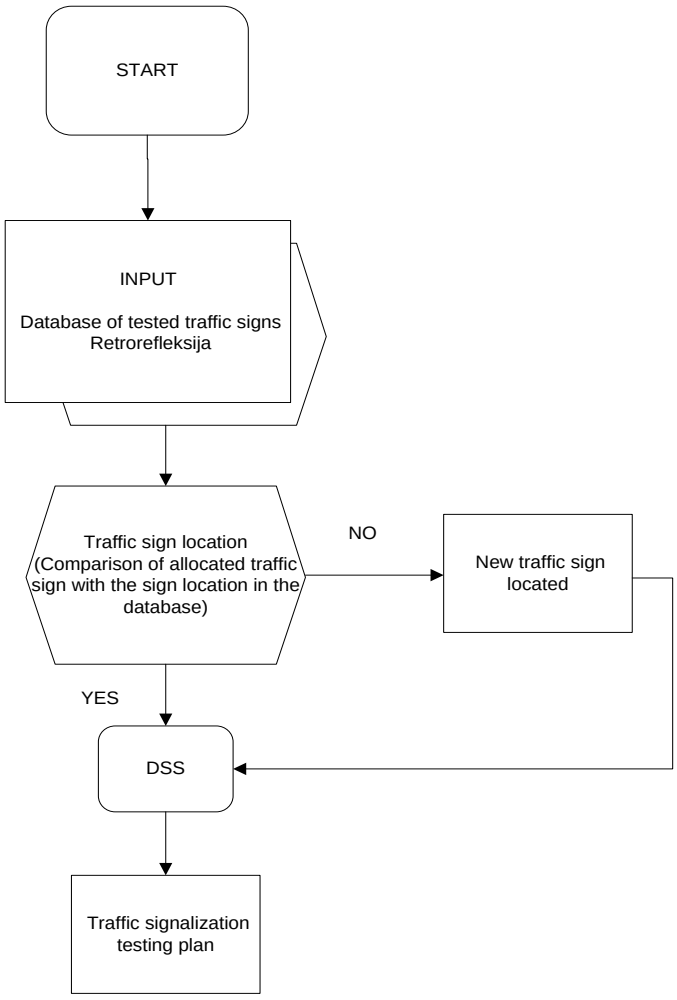

Figure 6 - Traffic signs automatic detection and DSS support
Source: By authors

The software is designed in such a way that the end user gets clearer measurement results presented in an interactive overview which allows administrators to get more detailed analysis. Reports can be printed also.

5. CONCLUSION

Traffic signs should be inspected once a year to verify reflection and appearance of characters while using low beam headlights. Criteria for review should include good visibility from a distance, especially considering the environment characters, clear, unmistakable and not evaporated colors, clear and readable symbol or message of the sign, absence of stripes, spots or other damage that distracting light reflections and the absence of a smooth surface of the sign within a distance from which the sign can be read. Although all of the characteristics of the sign can be determined by visual inspection of signs at night, it is also necessary to measure the retroreflection, determine the type of character and its exact location. All these elements make the record upon which sign replacement is determined, cleaned or traffic sign present a certificate of satisfactory condition of until the next check.

Development of new software for sign database from the Department for Traffic Signalization is significantly improved and accelerated the process of testing results, analysis and preparation report of tested traffic signs. This means simpler interactive survey of traffic signs and future database for all tested traffic signs, or cadaster of traffic signs. The database of traffic signs is very helpful in determining the replacement of traffic signs, budgeting for maintenance and in traffic signs management.

By applying the retroreflection test results of traffic signs it can be organized system of road maintenance that provides a constant, high level of traffic signs visibility which effects on the driver safety, especially while driving in adverse weather conditions.

Decision Support Systems enable you to generate better options and taking into account a large number of options in deciding, and therefore increase the quality of decisions. Systematic data collection on traffic signs in a few years will enable greater elaboration and analysis of data and thus making the DSS system based on multi-criteria decision-making, creating a maintenance plan for traffic signalization on a weekly, monthly or annual basis.

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GENERIC MODEL TO ESTIMATE TOTAL COST OF OWNERSHIP OF CELL PHONE PLANS IN CROATIA

ABSTRACT

As competition has developed there has been increased attention by some regulators on the demand side. This kind of attention is important because well-informed consumers prepared to choose between competing providers are necessary to stimulate operators to innovate and compete in terms of prices. This article proposes a general model for estimating total cost of ownership (TCO) of residential cell phone plans for mobile services. In addition, authors identify important cost drivers to calculate TCO for three-part plans. Proposed model may prove as a starting point to regulatory authorities as a part of pro-competition policy measures and when developing price comparison services to help consumers in choosing communication services. Hence aspect of consumer empowerment and protection is critically important in market regulation from an economic rationale.

KEY WORDS

Mobile; Total cost of owership; Three-part tariffs; Consumer empowerment

1. INTRODUCTION

Nowadays, mobile telecommunication sector is offereing wide array of numerous cell phone plans. These cell phone plans often compete with one another by including numerous parameters, such that the total cost of ownership (TCO) becomes a complex function of numerous cost drivers, including fixed monthly fees, usage-based fees for calls and messaging, differenty types of billing unit and numerous optional fees. The goal of TCO approach is to identify, quantify, and ultimately reduce the overall costs associated with ownership of a cell phone plans.

One fundamental problem may arise from calculating TCO which may prove to difficult task for an average user. Most users are looking for best ratio between cell phone plans parameters and cost. Users may calculate this ratio in substantially different ways, so they are keenly interested in cost predictability. This is particularly important when they wish to decide which of numerous available tariff plans to adopt, or whether to switch from one plan to another.

The mobile market in Croatia is currently comprised of three mobile network operators (MNO): HT being the main operator (market share: 46.88%), Vipnet as the main competitor (37.53%) and Tele2 (15.59%) as the alternative competitor [1]. Since Tele2 entry on the market, Herfindahl-Hirschman index (Fig. 1) suggests high market concentration but slightly increased competitiveness. Other factors contributing to increased competitivenss are lower mobile termination rates (MTR), thus enabling alternative operators to set more competitive off-net prices and furhter market liberalization by introducing mobile number portability [2].

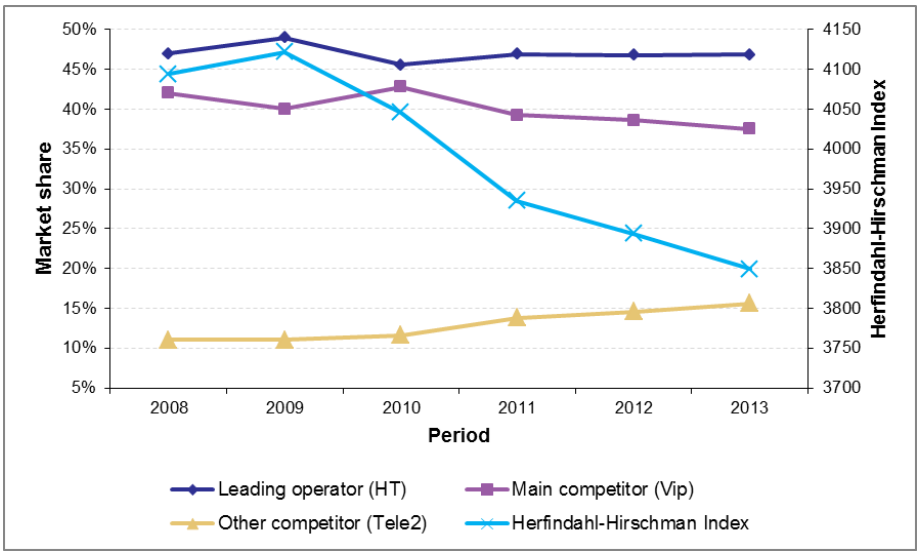

Figure 1 – Mobile operators market share and Herfindahl-Hirschman index in Croatia for 2008-2013. Data from [1].

Importantly, users of mobile services in Croatia switch mobile service operators primarily because of cost [3], suggesting that cost-conscious users are most likely to use the TCO model. This has led to a proliferation of tariff models that can confuse and bewilder the average user, in Croatia and many other countries. Moreover, there is many empirical evidence claiming that most of the users are makin biased decision in choosin the most cost-effective cell phone plan [4], [5], [6], [7]. In addition, these previous studies suggest that most of users' decision about choosing cell phone plan are biased. This highlights the importance of neccessary model to qauntify the cost related with cell phone plans. By analyzing TCO of cell phone plans, users can estimate more accurately the cost of using mobile services and better compare the cost-effectiveness of different cell phone plans on the market.

The likelihood that a Croatian residential user is considering a switch of operator depends to some extent on how much he or she currently pays per month [8]. Among users who spend €40+ per month, 29% are considering switching, which is substantially lower than the percentages for other segments: users who spend €7-10 per monthly, 48%; €13-20, 41%; €20-27, 37%; €27-40, 40%. While a relatively high percentage of 37% of users spending €7 or less also think about switching, these users historically decide against it, presumably because they do not believe it would bring substantial savings. These data suggest that users who spend €7-40 (48%) monthly may be particularly likely to use the TCO model.

Some previous studies suggest that if users had access to adequate information, they would make more rational decisions about their mobile phone operator and cell phone plan [9]. However, no such cost-estimation model has been published for the telecommunications market in Croatia. Therefore we wished to design a model optimized for this market.

The main purpose of this paper is to provide the framework for estimating TCO for residential cell phone plans in Croatia and to identify all important cost drivers. This framework should lead to a development of a more sophisticated and flexible model for different types of cell phone plans. In addition, the presence of such model on the market may be used by end-users and expert alike to choose the most cost-effective cell hone plans. Presented model may prove as a starting point to regulatory authorities when developing pro-competition policy measures and providing price comparison services to help consumers in choosing communication services.

2. TARIFF PLANS ON THE MARKET

2.1 Definition and classifications

In the context of mobile telecommunications, a tariff plan can be defined as a regulated and well-defined billing method based on the usage of specific mobile telecommunications services. Other researchers have defined a tariff plan or model as a scheme of rates and regulations governing the charging of telecommunication services [10].

A tariff plan comprises a (1) calculation schema, which defines a charging function to calculate costs; and (2) the cost or price so calculated. Tariff plans can be classified into three groups [11]: (1) linear tariff-plans, (2) non-linear tariff and (3) discounts. All three models are important parts of tariff plans available in the Croatian market. Most tariff plans on the Croatian are three-part tariffs which are combination of linear and non-linear tariffs. In other words, they include a fixed fee (monthly subscription), a free allowance of traffic units (minutes, messages and megabytes) and positive per-unit price for additional demand beyond allowance within certain tariff plan. The tariff plans analyzed in this report are the prevailing ones available for residential users in Croatia the three largest operators.

These tariff plans reflect the two contracting modalities for mobile services in Croatia:

- Post-paid (retroactive): the user signs a contract for a minimum period, usually 12 or 24 months, and pays a monthly obligation (subscription). The monthly fee usually includes a certain amount of telecommunications traffic.
- Prepaid (proactive): Users purchase a mobile device at much higher cost than as part of a post-paid tariff plan, and they pay for services using vouchers, also known as refill/prepaid cards, available in different denominations, e.g. 25, 50, and 100 KN. Prepaid cards are popular because they allow users to control TCO and do not require consumer creditworthiness checks. Therefore prepaid cards are especially attractive to young people, who have limited budgets for mobile services [10].

2.2 Charging and billing

Charging is the process of determining the total cost for telecommunication services for a certain period of time [12]. Billing is the legally required process of notifying the customer about the charges [10]. The tariff plan refers to the general structure of prices and charges used to calculate the total cost of telecommunication services used by a customer.

To calculate the total fees for a user for a given billing period, a rating engine analyzes call detail records (CDR) and synthesizes data from four components. First, voice - voice communications and voice transmissionm. Second, messaging - short message service (SMS)

and multimedia messaging service (MMS). Third, data - data transfer services via mobile broadband. Fourth, content type - e.g. ringtones, games, access to certain Internet sites.

For each of these components, an operator can define incentives, such as traffic volume of that component, in order to encourage service usage. For example, an operator may offer free/flat traffic, such as free calls within the home network or to all networks, free messaging, and unlimited data transfer via mobile broadband. The operator may also offer a specific allowance, such as 100 minutes of calls, 500 Mb of data transferred, or 100 text messages. Such allowances are deducted from the usage during charging. Incentives may already be included in the tariff plan or the existing tariff plan can be upgraded (tariff option) by paying a one-time or monthly activation fee.

These incentives may be distributed over different time periods. For example, an operator may offer a certain number of free minutes or messages per month, or they may offer daily promotions for using mobile broadband at the highest available bitrate. Incentives may also be valid during only certain times of the day (peak vs off-peak), on a particularly day (birthday), for a certain network, or they may be unconditional or one-off.

During charging, incentives reduce the billable amount of telecommunications service usage, and the remaining volume is billed according to the tariff plan for the given operator. In addition to paying a fee, users who exhaust their incentives may also suffer drastic reduction in connection speed (known as "throttling"), mainly GPRS speed [13].

3. DEVELOPMENT OF A GENERAL MATHEMATICAL MODEL TO ESTIMATE TCO

To generate a model to analyze and predict TCO for a given tariff plan, we assume that users do not spend money to purchase the mobile device itself, such as when they receive it for free as a part of a post-paid tariff plan, nor do we take into account costs due to roaming or placing or receiving international calls or messages. In addition, we do not take into account the cost of voice mail services or of the mobile device itself. Our unit of analysis is individual post-paid tariff plans available for residential users in Croatia, as described on operators' official websites. Tariff plans were analyzed from the three largest mobile operators in the Croatian market based on numbers of users, according to the Croatian Regulatory Authority for Network Industires (HAKOM) [14]: HT (main operator), Vipnet (main competitor) and Tele2 (alternative competitor).

Numerous factors must be taken into consideration when calculating TCO [15]. Our strategy was to set up a general model with universal factors, and then customize it later by including new factors as needed. At the beginning, we included the most significant cost drivers of TCO: calls, billing unit, messages (SMS and MMS), data transfer (via mobile broadband) and monthly subscription fee.

The basic model for calculating TCO and for graphically representing the relationship between TCO and average monthly traffic for a given period of t months of use is:

$$\begin{aligned}\text{Total cost of ownership } (t) = (&\text{Monthly fee} + \text{Average cost of calls} + \\ &\text{Average cost of messages} + \text{Average cost of data transfer} + \\ &\text{Use of radio frequency fee}) \times t\end{aligned} \tag{1}$$

This equation can be expanded to take into account the fact that the cost of a call depends on call duration, *call price* (based on the *billing unit*), number of calls and *call set-up fee*; while the cost of a message depends on the number of *messages* (text or multimedia) and

message price (a certain number of KN per message). The cost of transferring data depends on the *amount of data transferred* and the *price of data transfer* (based on the *billing unit*). Taking these factors into account in equation (1) leads to

$$\begin{aligned} &Cost\ of\ ownership = (Monthly\ fee + Call\ duration \cdot Call\ price + Number\ of\ \cdot \\ &the\ calls \cdot Set\ up\ call\ fee + Number\ of\ textual\ messages \cdot Message\ price\ (textual) \\ &+ Number\ of\ multimedia\ messages \cdot Multimedia\ message\ price + The\ amount \\ &of\ transferred\ data \cdot Data\ transfer\ price + The\ use\ of\ radio\ frequency\ fee) \cdot t \end{aligned} \quad (2)$$

or more simply

$$TCO(t) = (M + TC_{calls} + TC_{messages} + TC_{data\ transfer} + \omega) \cdot t \quad (3)$$

Where

TCO ≡ Total cost of ownership
TC_x ≡ Total cost of specific service
M ≡ Monthly subscription fee
Ω ≡ Fee for radiofrequency use (set by national law)
t ≡ Time period [months]

The formula for calculating the cost of calls is

$$TC_{calls} = T \cdot R_{calls} + N_{calls} \cdot F \quad (4)$$

where

T ≡ Call duration [min]
R_{calls} ≡ Price for the particular type of call [KN/min]
N_{calls} ≡ Number of calls
F ≡ Call set-up fee [KN/call]

The formula for calculating the cost of messaging is

$$TC_{messages} = N_{SMS} \cdot R_{SMS} + N_{MMS} \cdot R_{MMS} \quad (5)$$

where

N_{SMS}, N_{MMS} ≡ Numbers of SMS and MMS messages, respectively
R_{SMS}, R_{MMS} ≡ Cost of each SMS and MMS message, respectively [KN]

The cost of transferring data (TCdata transfer) is given by

$$TC_{data\ transfer} = N_{data\ transfer} \cdot R_{data\ transfer} \quad (6)$$

where

$N_{data\ transfer}$ ≡ Volume of data transferred [Mb]
$R_{data\ transfer}$ ≡ Unit price for data transfer [KN/Mb]

Combining equations (4)-(6) into (3) yields

$$TCO(t) = (M + T \cdot R_{calls} + N_{calls} \cdot F + N_{SMS} \cdot R_{SMS} + N_{MMS} \cdot R_{MMS} + N_{data\ transfer} \cdot N_{data\ transfer} + \omega) \cdot t \quad (7)$$

4. FURTHER DEVELOPMENT OF THE MODEL

To further develope proposed general model, numerous additional cost drivers must be included in the general model to calculate total cost of ownerhsip for three-part tariffs more precisely. Table 1 proposes main cost drivers that should be included in the model. This is because in three-part cell phone plans are two types of traffic: subsidized traffic (allowance), which is covered by incentives in the tariff plan, such that the volume depends on the particular service involved; and chargeable traffic, which is billed at standard rates. Subsidized traffic usually must satisfy a zone condition, e.g. it must involve one or more network(s) of the same operator. Once subsidized traffic reaches the limit stipulated in the post-paid plan, it becomes chargeable traffic.

Table 1 – Main cost-drivers for three-part tariffs

Denotation	Unit	Description
TCO	KN	Total Cost of Ownership
TC	KN	Total Cost
M	KN	The amount of the monthly subscription
ω	KN	The fee for radiofrequency use
t	months	Time period
T	minutes	Call duration
R_{calls}	KN/minute	Price depending on the type of call
N_{calls}		Number of calls
F	KN	Fee for setting up a call
$TC_{messages}$	KN	Total cost of messaging
$N_{SMS\text{-}SUB}$	messages	Subsidized volume of SMS messages
N_{SMS}		Number of SMS messages
N_{MMS}		Number of MMS messages
R_{SMS}	KN/SMS	Price of SMS message
R_{MMS}	KN/MMS	Price of MMS message
$TC_{data\ transfer}$, TC_{dt}	KN	Total cost of data transfer
$N_{data\ transfer\text{-}SUB}$	Megabyte	Subsidized volume of data units
$N_{data\ transfer}$	Megabyte	Volume of transferred data
$R_{data\ transfer}$	KN/Megabyte	Price of data transfer
TC_{calls}	KN	Total cost of call(s)
X_k		Portion of calls to a particular zone
y	minutes	The average increase in call duration based on billing unit

Denotation	Unit	Description
A_k	minutes	Subsidized volume of minutes to a particular zone(s)
$R_{calls\text{-}k}$	KN/minutes	Call price per minute for particular zone(s)
m		Total number of zones
T_{OBR}	seconds	Billing unit
S	seconds	Remaining (unused) time in the billing unit
P	minutes	Duration of each call
$\overline{P}$	minutes	Mean call duration

Another important factor significantly contributing to the amount of TCO is billing unit. The existence of a billing unit means that call duration increases (is "overbilled) for certain values. The choice of billing unit (T_{OBR}) determines the way how the cost of calls are calculated, since actual call durations are converted into chargeable traffic based on the billing unit. As suggested by [16] the cost of a call (TC_{calls}) must capture effects of differences in billing units by adding the additional adjustment factor (y) reflecting the average overbilling value.

5. CONCLUSION

Calculating TCO for mobile service tariff plans provides a metric that can be used to compare plans and analyze how different user behavior affects TCO. Here we present a framework for determining TCO based on user habits and historical data. The framework can be further improved by including proposed cost drivers in the TCO model.

Confusion about tariff pricing structures, incomplete information about actual call use and even simple bias toward particular pricing structures often lead users to make cost-inefficient choices to change or remain with a given operator or tariff plan. The proposed general TCO model, by additional improvement in order to provide a comprehensive yet easily understandable analysis about the various cost drivers, should help users avoid incorrect estimations and assumptions about past usage.

Future work should consider to develop the TCO model by including all cost drivers presented in Table 1. Importantly, the model should include the effect of different types of billing unit. The model should also be applicable to other types of cell phone plans, including prepaid, and epecially business plans. This may increase business users' bargaining power when negotiating their mobile service contracts, analyze staff usage of mobile services and perhaps even adjust existing contracts based on actual use.

Ultimately we hope that this TCO model can be made available to users through, for example, a free price-comparison web-based service or smartphone application. This may help regulatory authorities to help consumers in decision-making process of the most cost-effective cell phone plan, and it may exert pressure on operators to provide more transparent billing and pricing practices, and cost-cutting options for users. This kind of model, although developed based on the Croatian mobile market, should prove readily adaptable to markets in other countries and to other cell phone plans.

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THE NEW ATCO TRAINING REQUIREMENTS

ABSTRACT

Air traffic controller (ATCO) training is strictly regulated since air traffic controllers provide air traffic control service and influence safety. During their training, air traffic controllers (ATCOs) have to acquire competences with specific rating and endorsement. This enables them to gain ATCO license for independent provision of air traffic control service. The paper will analyze the current ATCO training requirements and licensing procedures as well as the new European regulation that has entered into force in March 2015 and shall apply from 30 June 2015. The new regulation reinforces the procedures for ATCOs training and certification in three major fields: requirements for the licensing of air traffic controllers, requirements for competent authorities and requirements for air traffic controller training organizations and aero-medical centers. Major differences between the current and the new regulations regarding the initial part of ATCO training and training organizations will be defined and analyzed.

KEY WORDS

Air traffic controller; training; requirements; regulation; licensing; training organizations

1. INTRODUCTION

Air traffic control is a part of a widespread air traffic management system, with safety as its primary concern, i.e. maintaining separation between aircraft, but also an orderly and expeditious traffic flow. Air traffic controllers have to be highly trained and skilled professionals since they are directly involved in aircraft operations. They decide on resolving conflicting situations and maintaining separation between aircraft. Poor, late or incomplete decisions may potentially affect the safety of a flight and persons on board. For that reason, controllers go through extensive and encompassing training in order to obtain their license. Due to the specificities and constant changes in technical and technological systems and work functions, controllers are often subjected to competence checks and refresher courses during their professional career, in order to develop automatic skills for routine and common situations, and procedures. During the last few decades, the ATCO training process and conditions for obtaining an ATCO license have often differed and changed with time, taking into consideration different legal, technical and technological characteristics of ATCOs' work. Their work is characterized by two major features: safety and the amount of traffic they can

handle (traffic demand). ATCOs must be trained and capable of effectively coping with the workload and routine tasks in the periods of high and low traffic demand, but also with unusual and emergency situations if safety is jeopardized. According to the statistical data provided by EUROCONTROL (European Organization for the Safety of Air Navigation), there has not been a single accident caused by air traffic management services for the last three years [1].

In order to ensure the high level of safety as well as ATCO's high level competences in service provision, international organizations and authorities have recognized the need to introduce detailed uniform standards and requirements for ATCO training, which include ATCO training organization requirements, medical centre requirements and competent authority requirements. The lack of uniformity could cause a different way of providing air traffic services and, naturally, a different way of providing air traffic controller training, including duration and content. In other words, air traffic controllers were trained for the type of equipment, procedures and technology which were used in the working positions in specific national conditions[2]. The International Civil Aviation Organization (ICAO) has prescribed the minimum requirements for ATCO training in Annex 1 - Personnel Licensing for All Member States. Over the course of the last decade, the European Union (EU) has harmonized the process of ATCO training and licensing in the way that all persons and organizations involved in their training, testing, checking and medical examination, and assessment must adhere to the relevant safety requirements [3]. As an EU member, Croatia is obliged to comply with all the requirements prescribed in all ATCO related regulations.

2. AIR TRAFFIC CONTROL SERVICE

As stated earlier, the main function of air traffic control is to maintain separation between aircraft but also to ensure orderly and expeditious conduct of flight. ATCOs oversee and control the assigned airspace by making use of the license obtained upon completion of ATC training, and also the license to use radiotelephony communications, which is the means of operations for both them and the pilots. ATCOs also give advice on traffic resolution and information to aircraft during flight. The provision of these activities is called flight information service (FIS). In case of an emergency, when there is reasonable doubt that aircraft is experiencing a difficult time, ATCOs start one of the emergency phases (uncertainty, alert, or distress phase) and notify appropriate organization if aircraft is in need for search and rescue. Provision of these activities is referred to as alerting service (ALRS). These three services are called air traffic services. Air traffic control services are divided into three different types provided by three different air traffic control units:

1. Aerodrome Control Service provided by Aerodrome Control Tower (TWR)
2. Approach Control Service provided by Approach Control Unit (APP)
3. Area Control Service provided by Area Control Centre (ACC)

ATCOs are trained and certified for one of these services and this is indicated in the ATCO license as a rating and endorsement that prove one's competence in specific service provision.

3. CURRENT ATCO TRAINING AND LICENSING

The ATCO training requirements are defined on global, regional and national level. Due to the uniqueness of air traffic characterized by high standards of safety, a long-term increase in traffic demand and its global character, the ICAO as the leading international organization

in the field of civil aviation prescribes minimum standards and recommended practices for 19 different fields and likewise for aviation personnel licensing.

As ICAO prescribes minimum requirements, it is left to the specific region of the world and individual countries to develop these requirements in more detail. Therefore, the European Union as political and economic union has brought out own set of rules and regulations regarding ATCO training and licensing, which are based on the ICAO's minimum standards and recommended practices. The major international and European regulations regarding ATCO training are:

- ICAO Annex 1 - Personnel Licensing
- Regulation (EC) No 216/2008+ Amendment Regulation (EC) No 1108/2009
- Commission Regulation (EU) No 805/2011
- EUROCONTROL Specification on Common Core Content Initial Training

3.1 ICAO Annex 1– Personnel Licensing

Chapter 4 of this document prescribes the minimum requirements for licenses and ratings of personnel other than flight crew members such as aircraft technicians, engineers, mechanics, **air traffic controllers** and aeronautical station operator. The field of air traffic controller training defines the following areas: *Student ATC license, ATC license* and *Ratings*.

Student ATC License is the first license ATCOs obtain during their training. It is a prerequisite to start the training in live traffic situation in real ATC environment and at the real working position. It is the most sensitive part of training because ATCO candidates directly influence safety, so it must be provided under the supervision of certified instructors. That is the reason why ICAO prescribes a candidate does not constitute a hazard to air navigation. Before acquiring a Student ATCO license, a candidate must hold a current ICAO Class 3 Medical Assessment Certificate.

ATC License is obtained after the successful completion of ATCO training and it gives ATCOs privileges to provide particular air traffic control service within a specific area of responsibility. The ICAO defines in more detail several areas within this part of training such as *age*, k*nowledge*, e*xperience* and *medical fitness*, with each requirement defining its own conditions. The trainee must be 21 or older and has to demonstrate a minimum knowledge of the aforementioned topics, i.e. the subjects and their content (Air Law, General Knowledge, ATC Equipment, Human performance, Meteorology, Navigation and Operational Procedures). At the same time, it prescribes that the future ATCOs are required to complete the training for a particular endorsement and spend at least 3 months at their working position and provide ATC services in real-world environment under supervision of an ATCO in charge [4]. The same as for Student ATC license, ATCOs that apply for ATC license must hold ICAO Class 3 Medical Assessment certificate.

Ratings are defined with the category of air traffic controller ratings, requirements for air traffic controller ratings, privileges of the holder of the air traffic controller rating(s) and the conditions to be observed in exercising such privileges. As stated earlier, the rating is defined as specialized knowledge and skill related to a type of air traffic control and ATS working environment. The ICAO defines following categories of ratings: aerodrome control rating, approach control procedural rating, approach control surveillance rating, and approach precision radar control rating, area control procedural rating and area control surveillance rating.

To have *experience* means that ATCO candidates have provided air traffic control service (in number of hours required) in real environment and live traffic under the supervision of a

certified ATCO. Minimum number of periods for aerodrome control rating is minimum 90 hours or one month (whichever is greater), for approach control surveillance and area control surveillance is minimum 180 hours or three months (whichever is greater) [4].

Skills define a level appropriate to the privileges being granted, taking into consideration judgment and performance required to provide a safe, orderly and expeditious control service, including the recognition and management of unusual situations and errors.

3.2 Regulation (EC) No 216/2008+ amending Regulation (EC) No 1108/2009

The regulation is the groundwork for air traffic safety in Europe and it concerns all licensed personnel involved in air traffic. The EU regulation defines common framework in civil aviation and foundation of EASA, hence the name EASA Basic Regulation. It is essential for establishing and maintaining a unique high level of civil aviation safety in Europe. Furthermore, it regulates the free movement of goods, persons and services in aviation and promotes cost-efficiency in the regulatory and certification processes to avoid duplication at national and European level [5]. It provides a detailed procedure for training and licensing of pilots.

Training and licensing of air traffic controllers is defined by the amending *Regulation (EC) No 1108/2009.,* which refers to the following areas in aviation that have not been included in the EASA Basic Regulation: *Aerodromes*, *Air Traffic Management* and *Air Navigation Services*. The regulation refers to all *Airspace users,* services (AIS, MET, CNS, ATM, ATFM, ASM, *Airspace Design*), the required qualifications that ATCOs have to obtain as well as requirements for organization providing training, and providers of air traffic services [6]. Annex Vb of the regulation states the essential requirements and demands for ATCOs and organizations providing training, examination and medical testing, which are under supervision of the EASA. The following contents of ATCO training are regulated: *General*, *Theoretical Knowledge*, *Practical Skills*, *Language Proficiency (English and national*), *Synthetic Training Devices* for practical part of training, *Training courses*, *Instructors*, *Assessors*, *Medical Fitness*, ANSP and *Training Organizations*.

3.3 Commission Regulation (EU) No 805/2011

Commission Regulation (EU) No 805/2011 (further on Current Regulation**)** is still valid and it is the basic document that defines the detailed specifications on the licenses of student ATCOs and ATCOs for European Union member states, and it is based on EASA Basic Regulation. It lays down the area of certification and qualifications of ATCOs based on three reasons. The first reason is to ensure the highest level of safety in providing Air Traffic Control service, which is based on the simple rules of conduct, training supervision and licensing. The second is increasing confidence in ATCO training and ATC service provision in member states, since the basic knowledge and competences and learning objects that the ATCOs acquire are unified during training. The third reason arises from the market competition and ATCO license, which is unified in the EU and enables ATCOs to seek employment with the EU, thereby increasing the employment prospects.

The regulation defines training as "…the entirety of theoretical courses, practical exercises, including simulation, and on-the-job training required in order to acquire and maintain the skills to deliver safe, high quality air traffic control services. It consists from *Initial Training, Unit Training, Continuation Training, Training of On-the-Job Training Instructors* and *Training of License Holders*.

Initial training consists of basic training and rating training. Upon successful completion of Initial training, a candidate obtains a student an ATCO license. As stated earlier, this license is a prerequisite for working in real ATC environment and live traffic, which is a part of training (unit training) [5]. Unit training is provided at air navigation service provider's training organization and consists of transitional training, pre-on-the-job-training (Pre-OJT) and on-the-job-training (OJT). After successfully completing the unit training, a candidate obtains an ATCO license for specific type of air traffic control service with specific ATS environment. An ATCO license ensures that every air traffic controller has the privilege to work individually in live traffic and provide specific type of air traffic control service. Continuation Training is used by certified ATCOs, after obtaining an ATCO license. It comprises refresher courses, emergency training and conversion training when certified ATCOs change job category (rating discipline, rating endorsement or unit endorsement), or system capabilities.

The regulation prescribes minimum requirements for Student ATCO license application. Only persons that are 18 or older, and have valid medical certificate can apply for the license. These persons must satisfy the following conditions also: they have successfully completed the initial training course in the certified organization, hold at least a diploma granting access to university and have the required level of language proficiency. The regulation defines training requirements concerning initial, unit training and continuation training, language proficiency requirements as well as for ATCO training organizations and competent authorities.

In Annex II, Part A of Current Regulation it is stated that Initial training program must be conducted in accordance with EUROCONTROL's Specification for the ATCO Common Core Content Initial Training. The learning objectives of the subjects and topics differ during training for each type of air traffic control service. The basic part of training can be integrated with the rating training or separately provided by one or two training organizations. If provided separately, a certified training organization has to issue a certificate that certifies one has completed basic or rating training. In the case that basic and rating training are integrated in a single training, a certified training organization has to issue a certificate that certifies one has finished initial training. The Initial Training consists of theoretical subjects and practical simulation exercises. The duration of the complete training and individual subjects is not prescribed and it is left up to the training organization. Acquired skills shall ensure that the candidate be considered competent to handle complex and dense traffic situations, facilitating the transition to unit training [5].

3.4 EUROCONTROL'S Specification for the ATCO Common Core Content Initial Training

EUROCONTROL'S Specification for the ATCO Common Core Content Initial Training (further on Specification) contains the curriculum for the initial ATCO qualification training. The Specification defines all the phases of the ATCOs training and their progress.

As stated earlier, Current Regulation defines that initial training in EU member states must be provided in accordance with this Specification and that will ensure the level of competence the candidate must possess at the end of the training. The Specification requirements are prerequisites for obtaining a Student ATCO License in accordance with this Regulation. According to the Specification ATCO training has 4 different phases: initial training as the first type of training a candidate attends, followed by unit training, continuation training and development training [7]. *Development training* has not been listed under that name in

Current Regulation although it is held as a set of various qualification trainings, which enable ATCOs to professionally develop further as part of their life-long learning process.

Initial training is the first phase of ATCOs qualification training, which comprises both basic and rating training, and it is intended for the so-called *ab initio candidates.* As stated earlier, these can be a part of an integrated training or conducted separately. Upon successful completion of both parts of qualification, candidates possess competences to handle complex traffic situations and have all necessary prerequisites for obtaining a Student ATCO license. Basic training focuses more on theoretical subjects, and less on practicing skills on a simulator, which is what Rating Training aims to do. The latter can be referred to as specialized training for acquiring knowledge and skills needed for a particular type of air traffic control and live environment.

Unit training is the second phase of training, which encompasses transitional training, pre-on-the-job-training and on-the-job training. This type of training is only available for candidates that have already obtained their ATCO license. After successfully completing all three parts of the training, candidates possess competences to handle very complex traffic situations using the one type of air traffic control service then emergency procedures, procedures specific for the location and environment they are working at. After finishing unit training candidates have all necessary prerequisites for acquiring an ATCO license with specific endorsement and location where ATC will be provided. Within the curriculum of initial training, the Specification defines the topic, subtopic and learning objectives, and the level of knowledge (taxonomy) for each subject.

4. ATCO TRAINING IN CROATIA

In the Republic of Croatia there are two certified air traffic control training organizations: Croatia Control ltd. (CCL) and Croatian Air Traffic Control Training Centre (HUSK). Certification and continuous supervision of these two organizations is done by national competent authority – Croatian Civil Aviation Agency (CCAA). The process of issuing and maintaining certificates is done in accordance with earlier stated international and European requirements but also according the national Regulation on licenses, rating and endorsements of air traffic controllers [8] (further on National Regulation). National regulation prescribed all subjects that were not defined in European regulations but were defined in Specification.

4.1 CCL

CCL is Croatian air navigation service provider, whose ATCO training organization is certified for provision of Unit Training. CCL as the national air navigation service provider is certified for air navigation services but also for ATCO training. The main objective of this ATCO training is to educate and train new ATCO stuff, whose competences are at the highest level which will ensure safe and high-quality air traffic control services within its area of responsibility.

4.2 HUSK

HUSK is a unit established at the Faculty of Transport and Traffic Sciences of the University of Zagreb that is certified to provide basic training. HUSK is certified for two different training programs: an integrated training program incorporated in undergraduate study of aeronautics (air traffic control module) and a modular training program provided as a separate course lasting for 14 weeks. Upon successful completion of the basic training,

candidates receive a certificate with a list of all the subjects of the approved program according to requirements of Current Regulation [9]. Specification and the ATCO training organization certificate number approved by CCAA.

When ATCO training phases necessary to obtain ATCO license defined in Current Regulation are compared to the ATCO training phases provided in Croatia, it is evident that there is not one certified organization that provides rating training. That is why Croatian air traffic control candidates, after finishing basic training in Croatia, attend rating training abroad in a certified foreign ATCO training organization. After successful completion of rating training they return to Croatia and gain student ATCO license at the competent authority. That enables them to start unit training in CCL.

5. NEW EUROPEAN ATCO TRAINING REQUIREMENTS

The currently valid Current Regulation has been introduced to harmonize the requirements of training ATCO in the EU, which ensures competences that enable them to provide air traffic control services as well as safe and regular traffic flow in routine procedures of an aircraft. The implementation of Current Regulation and precisely defined demands for all training organizations and personnel involved in conducting training with other factors (sophisticated safety nets within ATM Systems) have brought to improvement of the ATM system in Europe, which is evident in the data of accidents caused by air navigation service providers, as stated earlier.

The main European organizations dealing with ATCO training, EUROCONTROL and EASA (European Aviation Safety Agency), which are aid organizations to the European Commission at passing regulation, had initiated a work group several years ago, with an aim of keeping the good and developing the improved demands, falling back on the previous practice.

All interested parties were able to take part in public talks registering through EASA. A following regulation is the result of the talks: the new Commission Regulation (EU) 2015/340 relating to air traffic controllers' licenses and certificates (further on: New Regulation). New Regulation that has entered force, and shall apply from 30 June 2015 goes further in that it regulates the area even more strictly, insisting on greater competences of ATCOs in provision of ATC service. Due to the larger number of changes and additions to the currently valid regulation, the EU has enabled its state members to, in cooperation with their own training organization, decide whether to postpone (derogate) the new regulation to a year and a half for its application. Besides ATCOs and training organization requirements, New Regulation also defines requirements for competent authorities and aero-medical centers.

In the Table 1 major differences between Current regulation and New Regulation requirements regarding Initial Training are analyzed. Since the Current Regulation is not as precisely defined as the new one, some of the requirements were taken from National Regulation or Specification. In the left-hand column of the table the new requirements regarding Initial Training are stated. On the right-hand column of the table there are three different rows. The first row (green color) connects New Regulation requirement with Current Regulation. The second row (red color) connects New Regulation requirement with the National Regulation or Specification. The third row (blue color) gives an explanation of the new requirement. N/A stands for not applicable.

Table 1 - Major Differences Between Current And New Regulation Regarding Initial Training

	REQUIREMENT ACCORDING TO NEW REGULATION	Current Regulation
		National Regulation or Specification
		Explanation of New Regulation
1.	Requirements for instructors and assessors	N/A - left for national regulations
		Theoretical and practical instructors
		In Subpart C, Section One requirements for instructors (theoretical, practical, OJTI and STDI) are prescribed In Subpart C, Section Two – requirement for assessors are prescribed
2.	Theoretical instructors - conditions	N/A - left for national regulations
		3 years of experience in the field of aviation and applicable to competent authority)
		Demonstration of instructional skills to the training organization
3.	Practical instructors - conditions	N/A - left for national regulations
		Practical instructor for unit training (a person that holds valid ATCO license and worked at least 5 years as OJTI) and practical instructor for initial training (a person who holds or had hold valid ATCO license and has minimum 3 years of experience as ATCO)
		A person that holds an air traffic controller license with an on-the-job training instructor (OJTI) endorsement or a synthetic training device instructor (STDI) endorsement.
4.	STD instructors - conditions	N/A
		N/A
		Persons providing practical training on synthetic training devices that has exercised the privileges of an air traffic controller license in any rating for at least two years and successfully finished within the year preceding the application a practical instructional techniques
5.	Assessors endorsement	N/A - left for national regulations
		Used in assessments during unit training
		Used in assessing the: - initial training for the issue of a student air traffic controller license or for the issue of a new rating and/or rating endorsement , - unit training, for assessing student air traffic controllers or air traffic controllers for the issue of a unit endorsement and rating endorsements, - the competence of an applicant for the issue or renewal of an STDI endorsement
6.	STD – Synthetic Training device definition	N/A - left for national regulations
		Simulation devices
		Device by which operational conditions are simulated, including simulators and part-task trainers.
7.	STDI endorsement	N/A
		N/A
		Authorization entered on and forming part of a license, indicating the competence of the holder to give instruction on synthetic training devices
8.	License endorsements	Unit Endorsement, Language Endorsement, Instructor Endorsement
		Unit Endorsement, Language Endorsement, Instructor Endorsement
		OJT Instructor endorsement, STDI endorsement, Assessor endorsement
9.	Basic training definition	N/A
		N/A
		Theoretical and practical training designed to impart fundamental knowledge and practical skills related to basic operational procedures
10.	Initial training composition	N/A
		N/A
		Consist of basic and rating training comprising all defined the subjects, topics and subtopics
11.	Initial training plan	Initial training requirements
		N/A - given as a part of ATCO TO Operations manual
		Detailed plan of training structure, duration, training methods, examination and assessment process etc.
12.	Examination of basic and rating courses	N/A
		N/A

		Separate or integrated basic and rating training.
13.	Basic training examinations and assessment	N/A
		N/A - only theoretical examinations (simulations included)
		Theoretical examinations and assessments
14.	Basic training performance objectives	N/A
		N/A
		During assessments candidates will be evaluated in the many performance objectives such as detecting potential conflicts between aircraft, applying separation, use RT communication etc. (ATCO.D.030)
15.	Rating training examinations and assessment	N/A
		N/A - only practical examinations on simulation devices
		Theoretical examinations and assessments
16.	Rating training performance objectives	N/A
		N/A
		Defined for each rating training course. Candidates must be able to demonstrate the ability to manage air traffic in a manner that ensures safe, orderly and expeditious services; and handle complex and dense traffic situations (ATCO.D.040)
17.	Training of instructors and assessors	N/A
		N/A - given as a part of ATCO TO Operations manual
		Detailed plan of training (ATCO.D.090 and ATCO.D.095)
18.	Language proficiency	Expert level (level six) for the English language and national language unlimited
		N/A
		Expert level (level six) for the English language - nine years from the date of assessment, Expert level (level six) for the national language – unlimited
19.	Age – air traffic controller license	Candidate must be at least 21 years old.
		Candidate must be at least 21 years old.
		Not prescribed
20.	Examination and assessment results and certificates – Basic training	N/A
		N/A
		A separate certificate must be issued

As it can be seen from the table New Regulation requirements in more detail and more strictly prescribe and supplement Current Regulation. Conditions for training organization and persons evolved with ATCO training are strengthened in New Regulation.

Requirements regarding Synthetic Training Device (STD) are prescribed for the first time with the main aim to differentiate simulation training from an on-the-job training as well as STD instructors (STDI) from OJT instructors. A person who fulfills required conditions gains STDI endorsement which is a part of license endorsements. Another difference that must be pointed out is process of assessment during initial training (even during basic part of training) provided by person who has a assessor endorsement. English proficiency is different in New Regulation since it prescribes that ATCOs with expert level need to be evaluated after 9 years. After successful finishing of unit training student ATCOs can apply for ATCO license even before they are 21 years old.

Every training organization certified for initial training must prepare its organization structure, documentation, responsible persons, procedures, plans and programs to be able to implement and comply to these novel requirements. Organizations within ANSPs that provide unit training must consider the rest of requirements.

6. CONCLUSION

Based on the analysis of the valid and new regulations, ATCO training is a strictly defined area on a global and European level. The ICAO standards as well as recommended practices listed in Annex 1 define the minimum requirements in ATCO qualification. The only condition

that is wholly accepted and does not adhere to the stricter standards on the regional level is Medical fitness Class 3, which ATCOs have to maintain during a year of work.

The ATCO training has been defined in legislation in more detail on the European scale than on the global (The ICAO), with an aim to harmonize and develop equal requirements of training and certification for ATCOs in all its state members. This strict regulation will ensure a high level of knowledge and competences, which are to be applied in air traffic control service provision with main objective to maintain required safety level and efficiency. The organizations that conduct certain phases of training are going to have to adapt in the months to come, or they will request to postpone the application of the new regulation until 31 December 2016. In that case current regulation EC805/2011 will still be used. Initial training organizations must take into consideration major differences between the new and the current regulation, as analyzed in previous chapter and adapt to it.

At the end it can be concluded that New Regulation will strengthen and stricken the requirements of licensing and certifying ATCOs, which will in turn affect the adjustment of the existing training providers – if they wish to keep hold of their current certificates and continue to train ATCOs for the phases of qualification that they are certified to do. To ATCOs the new regulation enables a much clearer and easier competence development, which should be equally acceptable in all EU state members, which will in turn improve employment prospects as well.

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AIR FREIGHT ROUTE QUALIFICATION FOR TIME AND TEMPERATURE SENSITIVE PHARMACEUTICAL PRODUCTS

ABSTRACT

Qualifications in transportation are not only a compliance topic addressed in regulatory documentation, it equally serves better understanding of distribution environment. Qualified shipping systems and transportation modes will enhance supply chain visibility both upstream and downstream. Understanding transportation industry, relationships and responsibilities provides all involved stakeholders with an opportunity for developing quality driven communication platform. Article provides a review of main stream regulatory documents on topic of qualification requirements. It contemplates on the necessity of having qualifications addressed in a systematic and structured manner starting from defining the subject and methodology of qualification.

KEY WORDS

Regulatory requirements; pre-qualifications and qualifications; risk assessments; stakeholders and transportation modes.

1. INTRODCTION

Qualification of shipping system, transportation route or model is a regulatory requirement for pharmaceutical manufacturers. This requirement derives from the need for enhanced visibility in overall supply chain from active pharmaceutical ingredient being imported for production to the last mile distribution of finished product. Enhanced visibility in distribution network provides more control over engaged stakeholders and defined handing and shipping processes and systems. This consequently helps creating qualitative communication platform and improves service level and product safety.

As an example, air transportation industry is, like pharmaceutical manufacturing, one of highly regulated industries. Still, just in recent years, qualifications of defined handling and shipping processes for Time and Temperature Sensitive Pharmaceutical Products (TTSPP) came to a focus of International Air Transport Association (IATA). Main publication issued by this organization called Perishable Cargo Regulations (PCR,) is a comprehensive document offering minimum compliance standards for shipping TTSPPs but just on the level of guidance compared to Dangerous Goods Regulations (DGR) issued by the same organization being globally accepted as a binding legal document. Other transportation modes like ocean freight and road transportation are also used in global distribution network for TTSPPs. This article provides authors view on qualification requirements for air transport.

2. REGULATORY REQUIREMENTS

Requirement for qualifications in transportation of TTSPPs can be found in different regulatory documents for pharmaceutical manufacturing either addressed directly or being incorporated in quality management system components. For the reference, just a few were taken into consideration in this article. European Commission issued on the 13th of November 2014 a revised document EU DIR 2013/C 68/01 on Good Distribution Practice (GDP) for medicinal products. Highlights of this document implicate requirement to use qualified equipment for transport of temperature sensitive medicinal products. Temperature monitoring system shall be regularly inspected and calibrated for its accuracy. To be able to understand how shipping system or transport equipment or vehicle operates, temperature mapping of loading area shall be performed as a part of qualification process. Combined with those activities, a comprehensive risk assessment exercise on delivery routes should be performed to understand process specifics related to involved stakeholders and services offered.

World Health Organization highlights requirements for qualification of active and passive shipping systems in Technical Report Series 961, Annex 9, from 2011, Storage & transportation for TTSPP. Technical Report Series, No. 917, Annex 2, "Good trade and distribution practices for pharmaceutical starting materials", WHO document from 2003 in Chapter 12 entitled: "Dispatch and transport" emphasizes the expectations of the regulator in the field of transport; "Materials should be transported in a manner that will ensure the maintenance of controlled conditions where applicable (e.g. temperature, protection from the environment). The transport process should not adversely affect the materials. The supplier of the materials should ensure that the contract acceptor for transportation of the materials is aware of and provides the appropriate storage and transport conditions." Based on the mentioned regulatory emphases of the world health organization it is possible to consider the transport of medicinal products as the component of good production and distribution practice, considering the transport task performers as directly responsible for the regulatory bodies of countries on whose territories the transport is performed. In such circumstances WHO issued in the document: WHO Technical Report Series, No. 908, Annex 9, "Guide to good storage practices for pharmaceuticals", from 2003 the following recommendation: "Where appropriate, the use of devices to monitor conditions such as temperature during transportation is recommended. Monitoring records should be available for review."

The emphases of the USA regulative in the field of pharmaceutical products distribution are contained, among others, in the US pharmacopoeia document (United States Pharmacopeia – USP), "General Chapter 1079 Good Storage and Shipping Practice". The document presents the standards and defines the procedures in the field of medicinal products distribution accepted by the US Food and Drug Administration – FDA. In its documents, USP publishes the results of research regarding storage of medicinal products, validation of transport means and the respective technological processes. It carries out the risk analysis in the distribution of temperature-sensitive pharmaceutical products.

Summarizing on regulatory requirements related to qualified distribution systems following highlights are provided:

- Validation and thermal performance qualifications are required.
- Transport system should be continuously monitored by calibrated monitors (continuous verification). Shipping system should be qualified based on historical data.
- Operational and performance shipping studies – generic level should be performed accounting standard loading profile, conditions and expected ambient extremes.

- Testing on both active and passive shipping systems is required.
- Three dimensional temperature mapping for: facilities, vehicles, shipping containers, refrigerators, freezers, other confined shipping systems.
- Fleet family approach might be acceptable for road transport vehicles.
- To minimize risk of product exposure to damaging temperatures during transports, dedicated containers/vehicles cargo space shall be mapped.

3. TRANSPORT PROCESS QUALIFICATION

Qualification of a transport process comprises of documented testing of each single activity in the technological process in order to confirm and document process compatibility end efficiency with the defined conditions and shipping requirements. Subject of qualification may equally be standard technological processes defined in order to satisfy the main requirements in the handling of general cargo shipments, or specially designed technological processes with a requirement to accommodate special conditions defined by the product specifics, regulatory expectations or manufacturer instructions. Development of a validation master plan is thus regulatory expectation in the field of quality management system. Elements of Master Validation Plan are shown in Figure 1.

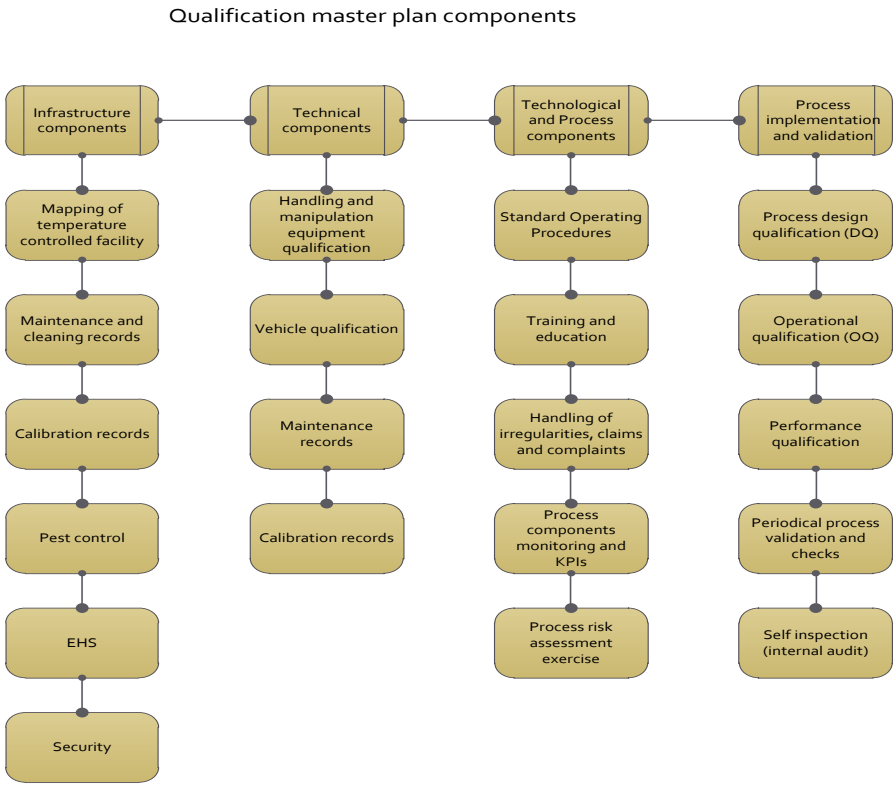

Figure 1 – Qualification master plan components

Level of qualification is determined by the requirements stipulated by the product manufacturer and filed under marketing authorization. In general, main decision factor on a qualification subject and methodology is defined storage and distribution conditions. IATA defines several temperature regimes generally accepted throughout the industry as shown in Table 1.

Table 1 – Identifiable temperature regimes in the carriage of TTSPP shipments in air traffic

Temperature regimes	Temperature
Frozen	-190°C, -80°C
Standard frozen	-20°C
Cool	+2°C to +8°C
Ambient temperatures	+15°C to +25°C, +10°C to +20°C, +15°C to +30°C
Heated	+30°C

Defined shipping temperature regime based on the label storage conditions might influence complexity of the shipping route qualification. All qualification levels however, Design qualification (DQ), Installation qualification (IQ), Operational qualification (OQ) and finally Performance qualification (PQ) shall be performed irrespectively. Design Qualification is documented verification that proposed design of equipment or system is suitable for intended use. Installation qualification is documented verification that equipment or system as installed complies with defined user requirements and manufacturer specifications. Operational qualification is documented verification that the equipment or system operates/performs according to its intended use as defined in user requirements and manufacturer specifications and Performance qualification, represents documented verification that equipment or system when used in accordance with its user requirements and manufacturer specifications and purpose performs according to declared requirements and specifications.

It could be concluded that in order to be compliant towards regulatory requirements, understand distribution conditions and their impact on the product integrity, preserve the product integrity and thus consequently the patient, a shipping route qualification is required. Typical air freight route qualification for shipping time and temperature sensitive pharmaceutical products comprises usually of operational and performance qualification. Design qualification could be exercised in cases where the route and all its components are designed by the shipper, i.e. pharmaceutical manufacturer which is rare case. Instead, airlines like airports are undertaking steps to qualify their handing and transportation processes to address requirements deriving from product characteristics and shipper requirements.

4. AIR FREIGHT ROUTE QUALIFICATION PROCESS

Air freight route qualification process comprises of three main groups of activities. Prequalification activities comprising of route risk assessment, preparation of qualification activities, qualification protocol definition and documentation of qualification process. Qualification process or qualification execution comprising of definition of information flows, qualification process monitoring and corrective activities and irregularity handling for cases deviating from the process. Last group of activities is listed under post-qualification activities. These are data collection and analysis, qualification exercise evaluation and new knowledge gathering. Qualification conclusion is formatted in a Qualification report. Training may be performed on qualification protocol and report latter on. Figure 2 shows all three activity groups on a time bar.

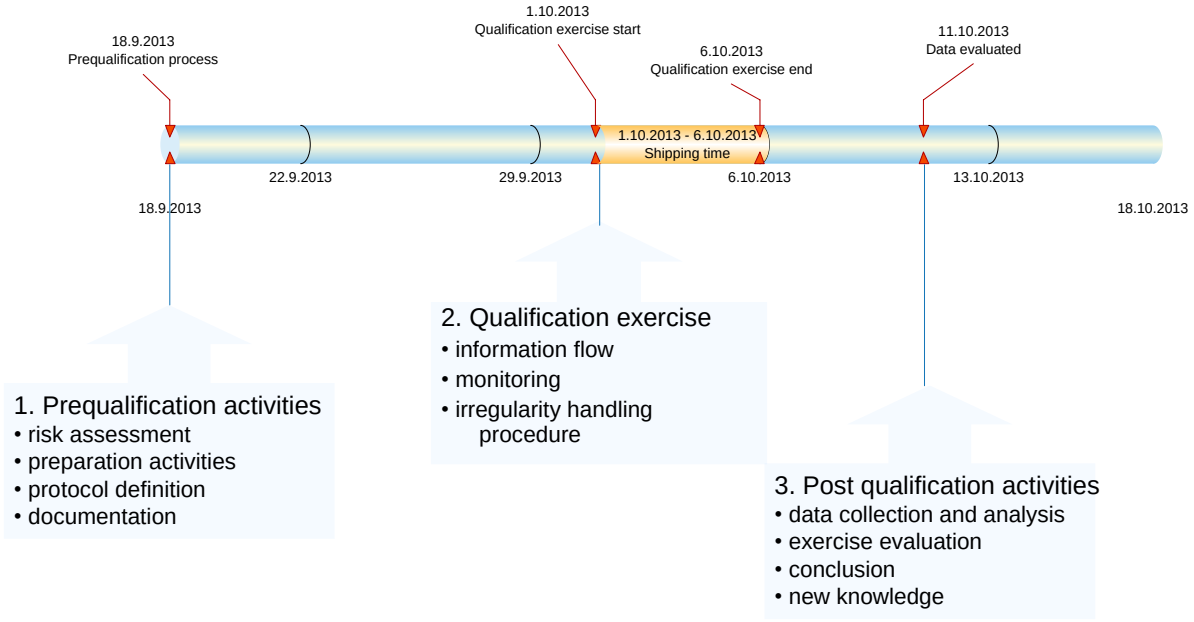

Figure 2 – Air freight route qualification phases

The prequalification risk assessment exercise is an important predisposition for a successful qualification exercise and it comprises of following activities:

- Transport service supplier evaluation (new, existing, used by another affiliate within the company)
- Experience with supplier (handling irregularities, route cause analysis, corrective and preventive action - CAPA response time and handling)
- Quality, service level and costs evaluation (availability of temperature printout from the cool trucks is important for multimodal qualification routes)
- Role of logistic service provider (LSP) and their level of support
- Route (trip duration), origin, transit and final destination airport (new route or re-qualification)

Risk assessment exercise starts with process definition followed by decomposing it to an activity level. Each stakeholder involved in qualification process should be made aware of its role and responsibilities from the qualification preparation to qualification data evaluation.

Overall prequalification process comprises of activities summarized in following highlights:

- Define qualification protocol (scope, application, responsibility matrix, primary and secondary goals)
- Identify involved stakeholders (carriers, LSP)
- Define responsible persons on shipper and consignee side (internally and externally)
- Define route details (multimodal transport considerations)
- Prepare schedules
- Define and describe roles and responsibilities for all stakeholders involved
- Prepare check list and define check points (critical control points or milestones)
- Define security elements (procedure for handling seals where applicable)

Qualification exercise is a main event in qualification process and it comprises of following highlights:

- Maintain information flow (shipment preadvices in defined form and distribution protocol)
- Continuous monitoring (role and support of LSP needs to be defined in advance)
- Irregularity handling procedure (backup plan is required in case of irregularity)

Key elements of an air freight route qualification exercise for shipping time and temperature sensitive pharmaceutical products are shown in Figure 3. To define critical control points or process milestones a risk assessment exercise is required together with the LSP and the carrier involved to define zones of responsibility, responsibility transition points and detailed activities schedule. Basic rule for critical milestone definition is less access to an activity, less visibility and control hence the higher risk in the process.

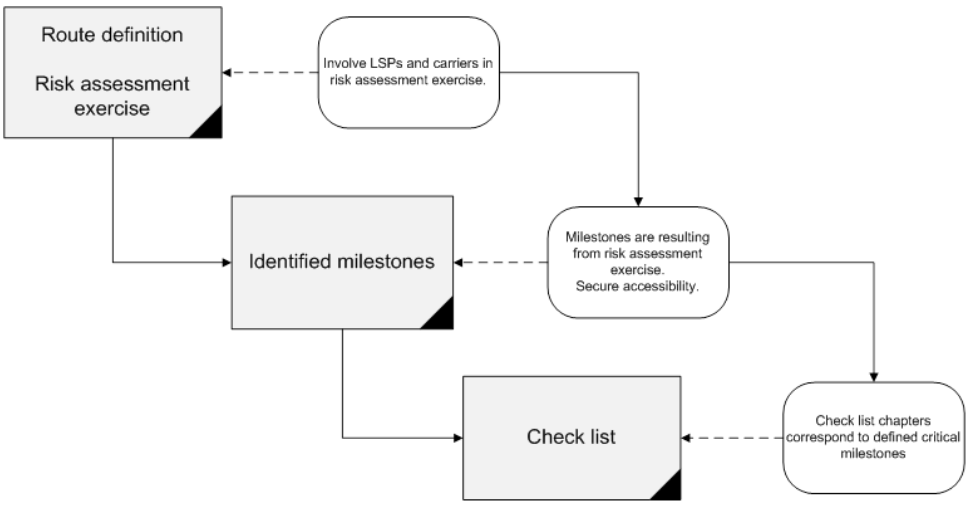

Figure 3 – Main elements of air freight route qualification exercise

Qualification data mainly check list records and records from the temperature measuring and recording devices attached to shipment, are evaluated against defined qualification criteria. Qualification report will comprise of the results evaluation and acceptance criteria matrix.

5. CONCLUSION

Shipping route qualification is a regulatory requirement for pharmaceutical manufacturers. The qualification process comprises of not only route qualification itself but comprehensive qualification system which includes evaluation of direct service providers (contract acceptors), their infrastructure (warehouses) if used in shipping and processes designed for shipping time and temperature sensitive pharmaceutical products.

Multimodal shipping routes combining road segment and air freight route is the most complex shipping environment due to a number of stakeholders involved, different types of transport vehicles, exposures to environmental conditions during regular tarmac time operations and overall capabilities of aircraft in maintain defined temperature regime during flight. For road transportation part positions in the trailer close to truck door might have an impact on the level of recorded temperatures and it has been proved to be temperature deviation sensitive. Cargo hold load configuration may have an impact on temperature

distribution special for loads in the cargo hold door zones. Handling, manipulation and storage at transit airport within the set temperature regime represents a challenge as well. Tarmac operations and handling time is an area of highest risks hence most of temperature excursions from a defined shipping temperature regime might occur during this process milestone. Handling and manipulation activities on passenger airports could take up to 3 times longer than on a predominately cargo airports. Temperature excursions were recorded in cases where aircraft parking position was of a distance from the carrier inbound cargo terminal. Those were caused by the long towing time. Last out (from the warehouse) – last loaded (on an aircraft) ensures appropriate storage under temperature controlled conditions to the largest possible extend but also loading position close to the compartment door which was found more sensitive to temperature deviations during flight.

Since qualification of an air freight route is not a common and widely accepted industry best practice in air transportation, qualification exercise requires predefined information flows, dedicated trained employees and commitment of all involved stakeholders. Such commitment could be achieved through open minded communication with all involved parties.

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MULTI-PERIOD DESIGN OF OPTICAL WDM NETWORK VIRTUAL TOPOLOGY BASED ON SERVICE PROVIDER'S PROFIT MAXIMIZATION

ABSTRACT

We study the virtual topology design problem in wavelength-routed all-optical WDM networks with the objective of maximizing the service provider's profit in a case of multi-period traffic demands and variable service prices. This could be a highly important problem from the point of view of service providers which are faced with the problem to satisfy as much demands as possible within limited resources such that the best possible revenue is achieved. In this paper, we solve the considered optimization problem using the swarm intelligence based Bee Colony Optimization (BCO) meta-heuristic. Performances of the proposed optimization algorithm are tested on example of a realistic size optical WDM network throughout simulations.

KEY WORDS

Optical WDM network; lightpath; routing and wavelength assignment; service provider; service price; profit.

1. INTRODUCTION

Optical wavelength division multiplexing (WDM) networks based on wavelength routing technique are considered to be promising solution for deployment of future backbone networks [1,2,3]. During the last years, there has been growing interest to solve the problem of virtual topology design in these networks. The virtual (or logical) topology consists of a particular set of lightpaths that need to be established over a given physical network. A lightpath is all optical connection established between two end nodes such that it can traverse several physical links, but information travelling on a lightpath is carried completely in optical form. In absence of wavelength conversion capability at network nodes, a lightpath has to be assigned the same wavelength over each physical link on a path between the end nodes. It is known as the wavelength continuity constraint. A crucial problem concerned with the virtual topology design is related to the lightpaths routing and wavelength assignment (RWA). The routing problem is to find a feasible path between end nodes and the wavelength assignment implies the allocation of an available wavelength to the lightpath. A path is said to be feasible if there exists at least one free wavelength over each physical link. It was shown that the exact solving of RWA is NP hard problem. Therefore, the heuristic approaches have to be used to solve this problem efficiently, particularly in a case of realistic size networks. In this paper, we use the Swarm Intelligence (SI) based Bee Colony Optimization (BCO) metaheuristic to solve

the RWA problem in which the traffic demands are known in advance [4]. This is also known as the static RWA problem.

We consider the static lightpath establishing problem in which the traffic demands are pre-specified during the multiple time periods. Such situation could be found in practice when there is no need to establish the lightpaths for infinitely duration, but rather for a particular period during a day, for example several hours or for some other unit of time. Our goal is to find the best routing and wavelength assignment plan for the lightpath demands such that a service provider's (SP) profit is maximized. We assumed that service price is time dependent during the considered multi-periods (for example, preferential prices during the light traffic periods and higher prices during the busy hours) and that the SP's revenue depends on service duration (i.e. occupation time of network resources).

The paper is organized as follows. In Section 2, the statement of the considered problem is introduced. Section 3 gives a brief description of the BCO metaheuristic as a tool that we used to solve the problem. In Section 4 the BCO based meta-heuristic algorithm for lightpath establishing problem is described. Section 5 contains the numerical results obtained by testing the algorithm on realistic size network example. Finally, conclusions are given in Section 6.

2. PROBLEM STATEMENT

We consider an optical WDM physical network topology that consists of given set of network nodes, N interconnected by corresponding fiber links, L in an arbitrary (or mesh) topology. The objective is to maximize the SP's revenues, R that could be achieved by satisfying the set of pre-defined traffic demands, D between node pairs (s,d), where $s,d \in N$. We make the following assumptions: each link in a physical network consists of pair of optical fibers, each for one direction; the number of available wavelengths, W is the same for each fiber link in a given network; wavelength conversion is not allowed at network nodes; there is no limit on the number of optical transceivers at network nodes; each lightpath is exclusively used for one node pair; the set of lightpath demands is pre-defined and each lightpath request has random duration, T with precisely defined the starting and ending times (if the starting or ending times of a lightpath demand do not coincide with the beginning/ending times of multi-period unit ΔT, it is assumed that whole corresponding unit period is allocated for that lightpath); the set of shortest paths between each source-destination nodes pair is pre-determined using the k-shortest path algorithm.

We assumed that the SP' revenue when establishing a lightpath depends on connection duration T that is defined by the number of unit time periods ΔT, as well as the service price, sp_t per unit time period, which could be a variable during the considered multi-periods. Hence, the possible SP's revenues per a lightpath demand i, R_i could be obtained as:

$$R_i = \sum_{t=1}^{T} sp_t \quad \forall i,\ i=1,2,\ldots,D, \tag{1}$$

where:

T - duration of a lightpath to be established, expressed by the number of unit time periods ΔT,
ΔT – unit time period (for example, one hour during a day)
t – ordinary number of a unit time period ΔT during T,
sp_t – service price during time period t,
i- ordinary number of a lightpath demand,
D- total number of lightpath demands.

In our study, we simplified the profit maximization problem by neglecting the costs that SP could have during establishing the lightpaths (such as the costs of optical transmitters/ receivers in network nodes, routing costs due to wavelength occupation over fiber links, etc). Thus, we assumed that the SP's profit fully equals to total revenues which could be obtained by establishing the given set of lightpaths. The connection requests were generated randomly for node pairs. We assumed that multiple lightpath demands could be requested simultaneously for a given node pair. Based on the above assumptions, the considered multi-period optical virtual topology design problem can be formulated as follows: for the given optical network physical topology and given traffic demands (source node *s*, destination node *d*, starting time t_s and ending time t_e for each lightpath request), determine the best routes and wavelengths for lightpath demands such that the objective function *F* that represents the total SP's revenues:

$$\max F = \max \sum_{i=1}^{|D|} R_i \qquad (2)$$

is maximized for a given number of available wavelengths *W*. The total revenues *F* depends not only from the number of established lightpaths in a given network, but also on the time periods when the lightpaths demands have to be established as well as on their durations and service price during the considered multi-periods. Because of assumed service price variations during the multiple time periods, different revenues could be obtained for the lightpaths with same durations, but established through different periods. Also, two lightpaths with different duration times may provide the same revenues. Therefore, the goal of the optimization task is to find the best set of possible lightpaths, jointly with their routing and wavelengths assignment plans, such that this set of lightpaths could maximize the SP's revenues under given number of wavelengths.

3. BEE COLONY OPTIMIZATION (BCO)

Bee Colony Optimization is a SI-based meta–heuristic inspired by the foraging process of honeybees in nature [7]. The BCO metaheuristic was initially proposed by Lučić and Teodorović [5,6] for solving the travelling salesman and vehicle routing problems. So far, the BCO metaheuristic is widely used for solving various hard combinatorial optimization problems. A detailed survey of the BCO metaheuristic applications could be found in [7]. BCO is a population-based stochastic random-search technique. In BCO method, the artificial bees explore the search space looking for feasible solutions. In order to find promising solutions, bees perform cooperative activities by exchanging the information about the quality of individually generated solutions. During the search process, bees progressively focuse on more promising solutions and slowly abandon from less promising solutions. BCO performs the search procedure in iterations until some predefined stopping criterion is satisfied. A more detailed description of the BCO metaheuristic principles could be found in [7].

4. BCO METAHEURISTIC APPLIED TO MULTIPERIOD LIGHTPATH ESTABLISHING PROBLEM

In this section, we describe the BCO-based algorithm developed for solving the static lightpath establishing problem in a case of multi-period traffic demands with the objective to maximize the total SP's revenues obtained by satisfying the set of lightpath demands. This

algorithm is an extension of the BCO-based algorithm proposed in [8], modified here to solve the considered profit maximization problem.

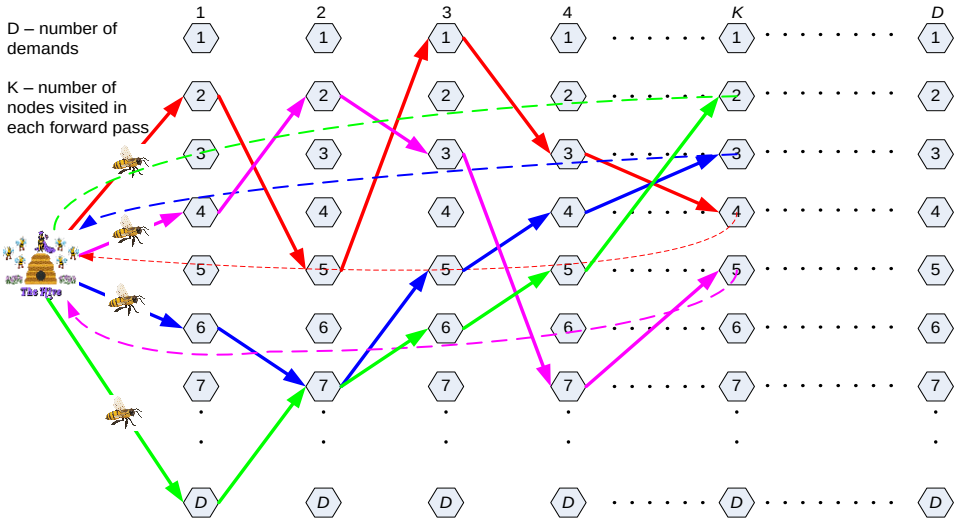


Figure 1 - The BCO artificial network [8]

The BCO optimization procedure is based on particularly created artificial network throughout the bees are flying (Fig.1). The artificial network is created in a matrix form and contains *D* nodes in each column and row. Each artificial node in this network represents one lightpath demand that need to be established between two end nodes in physical optical network topology [2]. The algorithm starts by pre-specifying several input parameters, such as the number of bees engaged during the search process (*B*), the number of artificial nodes (*K*) a bee visits during each fly (forward pass), the number of algorithm iterations (*I*), as well as the data related to traffic demands, such as the total number of lightpath demands requested between end nodes, starting and ending time of each lightpath demand, service prices during the considered multi-period time, physical network topology with the set of pre-defined *k*-shortest paths for each node pair and the number of available wavelengths in a given physical network.

The searching procedure begins with all the bees situated in the hive. Each bee starts to fly from the hive and visits one or more nodes in created artificial network. Each bee's flight represents one forward pass of algorithm. The order by which the bees are visiting the artificial nodes is in a random manner, but with higher chance to visit earlier the nodes (lightpaths) with greater revenues. It is accomplished by multiplying each lightpath revenue with a randomly generated number between [0,1] and than sorting all the lightpath demands by revenues in descending order.

By visiting an artificial node, a bee is trying to establish the considered lightpath demand [2]. The lightpath will be established if there exists a feasible route during the considered multi-period interval. Route selection is based on the following rule: for every node pair (*s*, *d*), the set of *k*-shortest routes is pre-determined. Then, the first feasible route (with at least one same free wavelength over each link on the route) is chosen. The rationale behinds this rule is that the required number of wavelength occupations over fiber links for a given lightpath is minimized. Thus, the routing costs of a lightpath are minimized, too. For the wavelength assignment problem, we used the first-fit (FF) strategy. Within this strategy, a wavelength with the lowest index that is free on each link on the route is assigned to a lightpath.

When bees finished the visiting of artificial node(s) during one forward pass, they return back (fly) to the hive. This is the so-called bee's backward pass. In the hive, all the bees exchange the information about the quality of individually generated solutions [7]. Based on the solutions quality, each bee makes in the hive one of the following decisions: whether to abandon the created partial solution and become uncommitted follower, or to continue to expand the same partial solution and recruit other bees. Depending on the solutions quality, every bee possesses certain level of loyalty to the path leading to the previously discovered partial solution [7].

To compare the solutions qualities obtained by different bees, we use the probability that *b*-th bee at the beginning of the new forward pass *u* is loyal to its previously generated partial solution, as follows [8]:

$$p_b^{u+1} = e^{-\frac{F_{max}-F_b}{u}} \tag{3}$$

where:
F_{max} – the maximal revenue obtained by any bee from the beginning of the search process,
F_b- the revenues obtained by the bee *b* from the beginning of search procedure,
u – the ordinary number of forward pass.

Using the equation (3) and a random number generator between [0,1], for each artificial bee it is decided whether to become uncommitted follower (abandon its previously found solution) or to continue flight along its previously generated path (continue further to build its solution). After such decisions, all bees are now disjointed into two groups: uncommitted followers and recruiters. In the next step of the BCO procedure, the recruiting phase is performed. In the case when a bee decides to abandon from its previously generated solution, that bee will follow some other bees which performs the recruitment process (in nature, recruiter bees make some type of dancing in order to attract other bees to follow them). The probability p_b that *b*'s partial solution will be chosen by any uncommitted bee is equal to [8]:

$$p_b = \frac{F_b}{\sum_{i=1}^{R} F_i}, b = 1,2,...,R \tag{4}$$

where:
F_i - the objective function value of the *i*-th advertised partial solution and
R - the number of recruiters bee.

Using the equation (4) and the random numbers generated from interval [0,1], every uncommitted follower is "assigned" to one of the recruiting bees. Using the bee collective knowledge and sharing information among them-selves, bees in such a way gradually concentrate on more promising solutions and slowly abandon less promising ones [7]. When all bees visit every artificial node, the iteration is finished. At the end of iteration, one or more feasible solutions are created. The best discovered solution during *I* algorithm iterations gives the final output solution [4,7,8].

5. NUMERICAL RESULTS

In this section, we provide the numerical results obtained by testing the proposed algorithm in case of the given optical WDM network with *N*=15 nodes and *L*=26 bidirectional links with separate fibers for each direction. The physical topology of the considered optical

network is shown in Fig.2. We assumed that the number of available wavelengths could be varied between 1 (the case without WDM multiplexing) up to *W*=16 wavelengths per each fiber link.

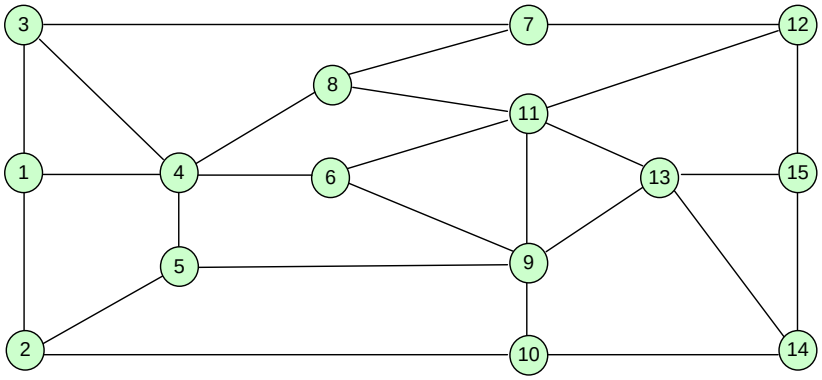


Figure 2 - An example of optical network physical topology

We performed the simulation tests with totally of *D*=300 lightpath demands, which are randomly generated between network nodes with the most of 3 demands between each node pair. We assumed that each lightpath request has a random duration and a random starting time. The unit time period is assumed to be *ΔT*=1 hour and the total considered period used in simulation is limited to 24 hours. The following service prices assumed to be during this period are given by Table 1.

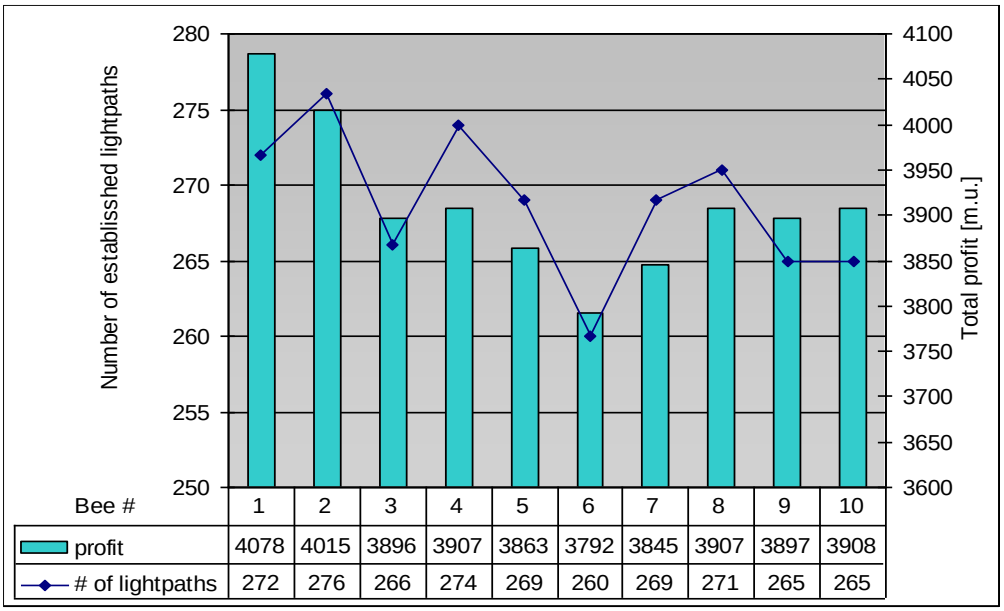
Table 1 - Service price variations during the considered period (ΔT=1 hour)

Period of day [h]	0-8	8-12	12-16	16-20	20-24
Service price [m.u./*ΔT*]	1	2	3	2	1

Further, we assumed the following input parameters for the BCO algorithm: number of engaged bees is set to *B*=10, number of artificial nodes visited by each bee during each forward pass is *K*=5, total number of algorithm iterations *I*=10 and number of shortest routes for each node pair is chosen to be *k*=3.

We performed several simulations in order to test the performances of the proposed algorithm. We consider the SP's profit depending on the established lightpaths. It is important to highlight that greater number of established lightpaths does not necessarily provide the maximum SP's profit. This is due to fact that different lightpaths provide different revenues. It is clear that the lightpaths with greater service price during several time periods could produce lower profit than some other lightpaths with lower service prices, but longer durations. Therefore, the optimization task is to find the best set of lightpath demands that could maximize the SP's profit with a limited number of available wavelengths in a given optical WDM network.

We present firstly the results of the SP's profit obtained by different bees during one algorithm iteration (Fig 3). It is only a sample of the results obtained during the iterative searching procedure in order to illustrate the diversification of the solutions qualities generated by different bees in the typical algorithm iteration. Note that obtained profit for individual bees, expressed in monetary units [m.u.] (right axes on Fig. 3) is not always in correlation with the number of established lightpaths of corresponding bee. For example, the bee #1 has found the solution with the best objective function value (4078 m.u.), but the number of lightpaths she established (272) is not maximal compared to some other bees (# 2 and #4).

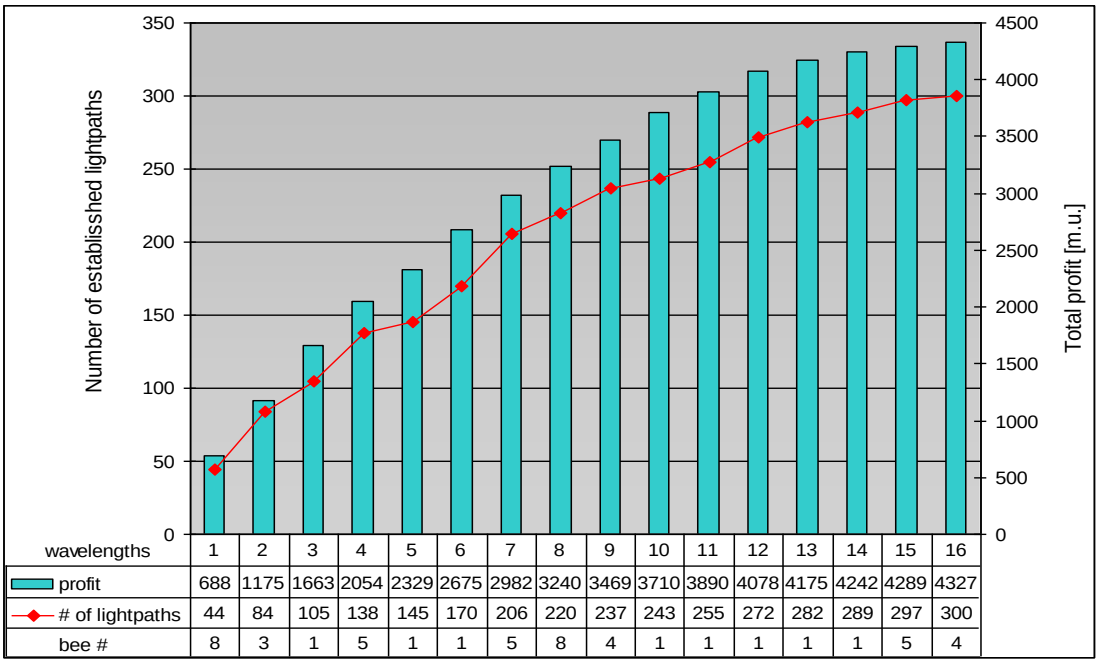


Bee #	1	2	3	4	5	6	7	8	9	10
profit	4078	4015	3896	3907	3863	3792	3845	3907	3897	3908
# of lightpaths	272	276	266	274	269	260	269	271	265	265

Figure 3 - The comparison results of individual bees during one iteration (W=12)

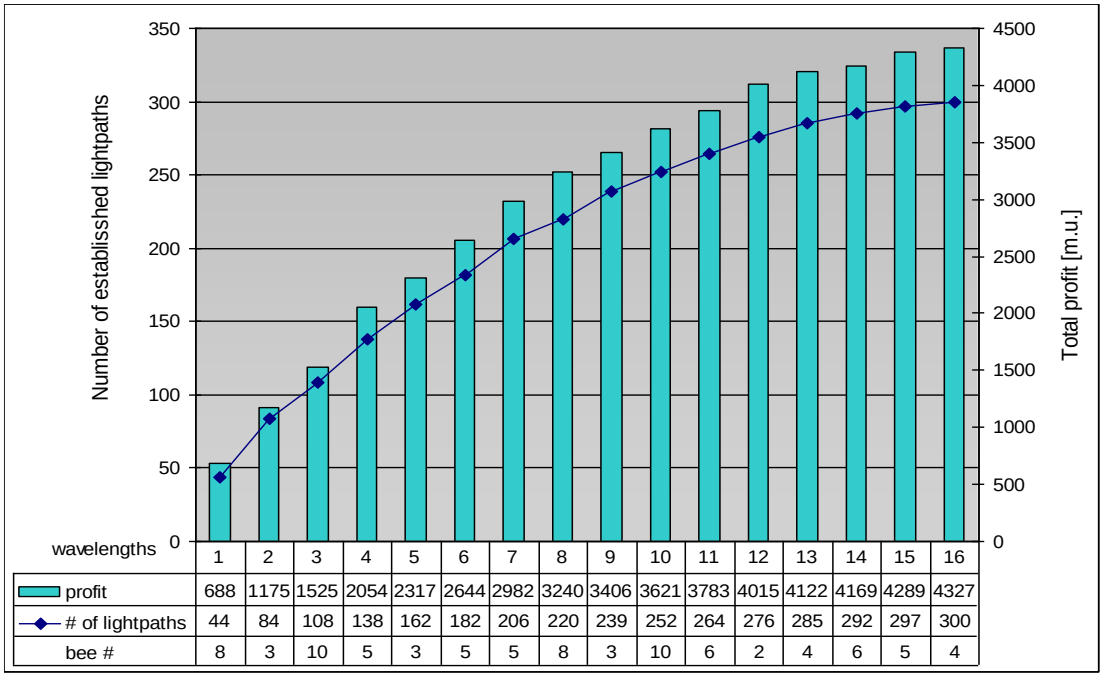
In this way, we are able to find the best set of lightpaths, jointly with their routes and wavelengths, which could maximize the SP's profit with a given number of wavelengths. The searching procedure for finding the best objective function value is repeated through independent iterations and than the best solution obtained during this process is identified as the final output solution of the optimization problem.

It is obvious that the number of established lightpaths and consequently the objective function value that we try to maximize highly depends on the number of available wavelengths in a given network. We found that the minimal required number of wavelengths to establish all the lightpaths demands is the case when W=16. If all the requested lightpaths are established, than the total SP's profit is maximal and the objective function takes value F=4327 m.u. In order to investigate what impact the number of available wavelengths has on SP's profit, we varied the available number of link wavelengths W between values 1 and 16 and compare the results. Fig. 4 shows the best obtained results for SP's profit, which bees were able to find throughout $I=10$ iterations. The numbers of established lightpaths for the achieved profits are also illustrated by Fig. 4 together with the bee's ordinary number which gives the best result. Furthermore, Fig. 5 illustrates the similar results, but in this case the results are compared between bees which gave the maximal number of established lightpaths, rather than the best possible SP's profits.



wavelengths	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
profit	688	1175	1663	2054	2329	2675	2982	3240	3469	3710	3890	4078	4175	4242	4289	4327
# of lightpaths	44	84	105	138	145	170	206	220	237	243	255	272	282	289	297	300
bee #	8	3	1	5	1	1	5	8	4	1	1	1	1	1	5	4

Figure 4 - Optimization results for the best SP's profit values in function of the number of wavelengths W



wavelengths	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
profit	688	1175	1525	2054	2317	2644	2982	3240	3406	3621	3783	4015	4122	4169	4289	4327
# of lightpaths	44	84	108	138	162	182	206	220	239	252	264	276	285	292	297	300
bee #	8	3	10	5	3	5	5	8	3	10	6	2	4	6	5	4

Figure 5 - Optimization results for the maximal number of established lightpaths in function of the number of wavelengths

By comparing the results given by Fig. 4 and Fig. 5, it could be seen that only in several cases (*W*=1, 2, 4, 7, 8, 15 and 16) there is full matching between the results related to the maximal SP's profit and the number of established lightpaths. It means that best results are obtained simultaneously according to both, the SP's profit and the number of established lightpaths However, in other cases (*W*=3, 5, 6, 9, 10, 11, 12, 13 and 14), there is not the direct correlation between the SP's profit and the maximal number of established lightpaths. Even more, it could be seen that although the greater number of established lightpaths is obtained, it always results in lower profits. For example, in the case when *W*=9, the maximal SP's profit

that could be found was 3469m.u obtained by establishing 237 lightpaths (see Fig. 4), while in the same case the maximal number of established lightpaths obtained by the bees was 239, but it results in a lower profit of 3406 m.u. (see Fig 5).

It is also interesting to comment the results concerned with the bee's number which found the best results. In performed simulations, we used the random rule for the bee's choice mechanism when selecting the individual artificial nodes as described in section 4. However, we abandoned this rule only for one bee engaged in the search process (we chosen for this purpose the bee #1). In other words, we applied for bee #1 the greedy heuristics for the node selection mechanism, which chose the artificial nodes one by one from the list of lightpaths sorted in descending order according to theirs' profit value. From the obtained results (Fig 4.), we can see that this greedy heuristics does not always provide the best results (bee #1 does not always give the highest value of SP's profit). Thus, it is not optimal to use this rule when choosing the next artificial node during the searching procedure. However, it could be seen that some other bees (apart from the bee #1), which use the random choice rule when selecting the artificial nodes could lead to better results for maximal SP's profit values.

Although the complexity of the problem is very high, the optimization process is computationally tractable, which means it could be efficiently used for solving problems of large dimensionality. For example, the CPU times required to perform simulation tests were in the range from CPU_time=15s (W=1) up to CPU_time=120s (W=16). In addition, the number of bees engaged in the search process greatly affects the required computational time, but does not provide better results if the number of bees is increased too much. Therefore, the suitable and sufficient number of bees should be carefully pre-defined by analyst. The simulation code is developed using the MATLAB program package. All simulation tests were performed using the hardware processor with 2.4Hz and 3GB of RAM memory.

6. CONCLUSION

In our study of optical WDM network virtual topology design, we have modelled the SP's profit which could be obtained by the accepted multi-period traffic demands under a limited amount of available network resources and variable service prices (lightpath revenues). With a SP profit optimization objective, we can identify profitable traffic demands and provide optimized routing and wavelength assignment decisions for the accepted traffic demands. Using the suggested BCO metaheuristic method, we are able to efficiently solve the considered NP-hard optimization problem in case of fairly large networks. The required computational time to obtain the results is acceptable, even in the large problem complexity. Through performed simulations, we have analyzed how the SP's profit depends on the number of available wavelengths in a given optical network. The obtained results show that the maximal number of established lightpaths could not guarantee the maximal SP's profit, too. Thus, the important feature of this investigation is that it enables us to identify the set of favourite traffic demands which could lead to maximal SP's profit under limited network resources.

Acknowledgement

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BASE FOR DEVELOPMENT OF PREDICTION TOOL FOR CIVIL-MILITARY FLYING OPERATIONS PLANNING

ABSTRACT

Paper deals with the flexible use of airspace concept and the necessity of military flight operations planning concerted with civil traffic predictions. Military flights impact on civil operations is researched at the airport and in reserved airspace, modular and target-centric one. Set of internal and external factors, their mutual impacts and influence on decision making during military flights planning process is studied in order to indicate the scope of further research.

KEY WORDS

Flexible use of airspace; air traffic management; air policing; military flight operations planning

1. INTRODUCTION

Air traffic planning relies upon not only local aviation needs but reflects scope picture. There are numerous relevant factors to be taken into consideration, much of these originating from vast region that spreads outside state borders. Forecasting of aviation demand, as one of these factors, includes future levels of aircraft operations by air carriers and general aviation aircraft at an airport and in airspace. Aircraft operations estimates usually include the number and types of aircraft, daily peak periods, peak periods volume of operations, traffic distribution during days of the week, and weeks of the year. Relevant forecasts are made for the expected military aircraft operations, mostly based on past military traffic [1].

Future traffic forecasting is subject to volatility and therefore marked with uncertainty in the contemporary free-market environment. Simple extrapolation of the previous trends, typical for long-range planning of 1950s proved not to be reliable in volatile environment just as the 1970s/80s top-down approach did. Hard data had to be enriched with the soft information, operating managers introduced the combination of top-down and bottom-up, just as inside-out and outside-in. Uninterrupted participation of the line management is considered unavoidable [2].

Co-ordination of civil and military air traffic implies that the airspace, defined facilities and services can be used by both civil and military aviation in safe, regular and efficient manner. Close co-operation of military authorities and air traffic services providers is

recommended in [3] for military activities that (may) affect civil flights. The coordination is aimed towards minimisation of civil and military operations interference and it has to be organised in a way to enable timely promulgation of necessary information.

Each state exercises the right to use its own airspace in sufficient volume and structure for adequate education and training purposes is denied by no international regulation [4]. Nevertheless, military use of specific portions of airspace should be in times and durations that do not disturb civil traffic, specially most economic portions and altitudes specially during peak periods, in order not to create delays of scheduled civil aircraft operations [3], [5]. As airspace has limited capacity and civil and military user's requirements have to be considered in order to maintain its optimum and efficient exploitation. The size of the designated airspace for military activities varies with the type of the aircraft and the mission performed in it, but it should be kept as small as possible related to the surrounding airspace traffic [3], [6].

Single European sky, according to [4], was created, among other purposes, in order to enhance air traffic safety to improve performance of air traffic management with safety and efficiency as cornerstones. The application of it does not reflect on state's sovereignty over its airspace and the requirements due to public security and defence matters. Furthermore, [4] does not cover military operations and training.

Explicitly listed among other measures that state can apply when needed for essential security or defence interests there is the capability to detect, identify and evaluate any aircraft inside the state's airspace. Another one is the conduct of military operations and training whose safe and efficient performance should be protected and exception from the application of common principles and criteria. Other measures, regarding war and maintaining of peace and international security need not be specifically discussed due to implied deterioration of optimised and efficient use of airspace [4].

Flexible use of airspace, an airspace management concept developed by Eurocontrol - the European Organisation for the Safety of Aviation, recognises airspace not as civil or military, but as one continuum. This concept seeks to fulfil requirements of all users, as far as possible. Application of flexible use of airspace through civil-military coordination procedures relies on clear and consistent rules and standards. The best use of the available airspace is performed through the temporary airspace reservation for specific users during periods of time limited on actual use, as close as feasible, and released as soon as the concerned activity ends [7].

Airspace management in the flexible use of airspace concept is performed at separate strategic, pre-tactical and tactical levels with interdependent management functions [7].

Strategic airspace management ensures the overall application of the flexible use of airspace concept at all three levels. At this level flexible airspace structures and procedures for airspace reservations and route options are defined. Important function of this level is to assess and review airspace procedures and performance of flexible use of airspace operations.

Pre-tactical airspace management allocates airspace in accordance with the conditions and defined procedures.

Tactical airspace management performs the real-time activation, deactivation or reallocation of the airspace allocated at pre-tactical level through established civil-military coordination procedures between appropriate air traffic service units and controlling military units.

This paper elaborates peculiarities of military flying operations and their impact on civil operations in order to indicate the scope of further research for creation of prediction tools for assistance in planning and performing flexible use of airspace.

2. CIVIL-MILITARY TRAFFIC INTERACTION

2.1. Airport Operations

Airliners operations can be organised in schedule structure and wave-system structure. [2] Furthermore, certain military airport operations peculiarities tend to interfere and create delays unacceptable for other airport users. Both civil and military airport operations are to be examined and the possible window of opportunity to be spotted.

Organization of the flight schedule at an airport in such a manner to enable a certain number of indirect connecting flights by concentration of flight schedule in certain period(s) during a day represents a wave-system structure in the flight schedule. Number of waves during a day can vary. Number of flights in peak is limited by the airport peak capacity, therefore additional flights can be added to the lateral boundaries of the peak, creating the widening effect. Wave-system structure can be determined by creating the fictional wave fix and counting the arrival and departure flights for the fix's time frames.

Besides the daily distribution of the airport traffic the distribution during the year is of particular significance. Figure 1 presents an example of the traffic distribution during weeks of the year 2013.

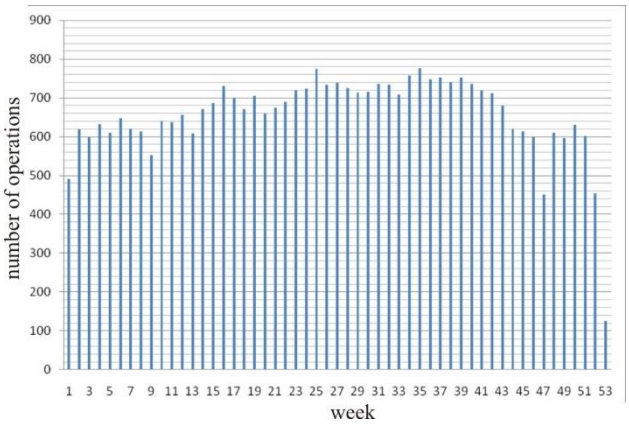

Figure 1 - LDZA[1] IFR[2] GAT[3] traffic distribution during weeks of the year 2013, prepared by author, data source CROCONTROL Statistics

Volume of the traffic varies inside 25% of the maximum. The upper portion of the traffic volume is maintained during half of the year, the lower portion during the winter's three month period, and the winter-spring and autumn-winter transitions are transient periods. Increased amount of operations is settled in the period of the year with typically favourable meteorological conditions for flight training. It is of significant importance for the fighter aircraft that use the airport as the home base.

Figure 2 presents an example of the traffic distribution during weeks of the year 2013 with more emphasized difference between extremes. Number of operations increases ten times throughout a year. Greater portion of the traffic volume is settled from spring (beginning at 12th week) through the autumn (beginning at 39th week), while the low traffic is maintained during the remaining period. Number of operations steadily increases from the beginning of the spring until it reaches its peak in the middle of the summer (33rd week), after which

[1] LDZA - ICAO designation for Zagreb Airport
[2] IFR - Instrument Flight Rules
[3] GAT - General Air Traffic

decreases at the same rate until 43rd week (in the autumn) with steep downfall to the winter minima. In this case there is significantly increased amount of operations settled in the period of the year with typically favourable meteorological conditions for flight training. Even though this airport is also flight training centre there is significantly lower number of operations compared to the previous example.

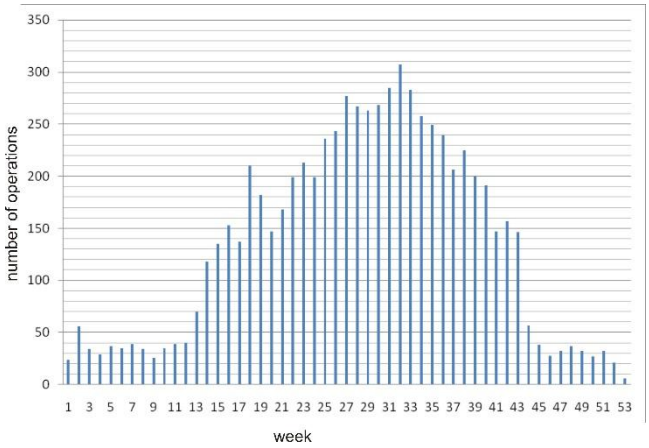

Figure 2 - LDZD[4] IFR GAT traffic distribution during months of the year 2013, prepared by author, data source CROCONTROL Statistics

Figure 3 presents an example of the daily traffic distribution on Fridays, 5th, 22nd and 33rd week at Zagreb airport. It is noticable that there is uneven traffic distribution. There are hours with low number of operations in all three of these days.

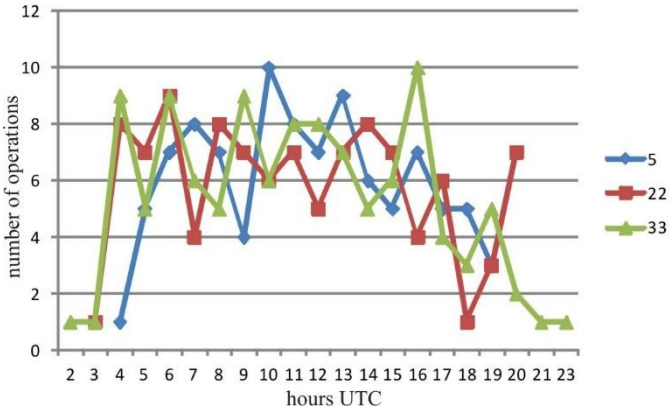

Figure 3 - LDZA IFR GAT daily traffic distribution on Fridays, 5th, 22nd and 33rd weeks, prepared by author, data source CROCONTROL Statistics

Figure 4 presents another example of the daily traffic distribution on Fridays, 5th, 22nd and 33rd week at Zadar airport. There is more significant difference in traffic between selected weeks. Gaps with low traffic during the day present oportunity for other, military operations to be performed with reduced potential interference with civil traffic.

[4] LDZD - ICAO designation for Zadar Airport

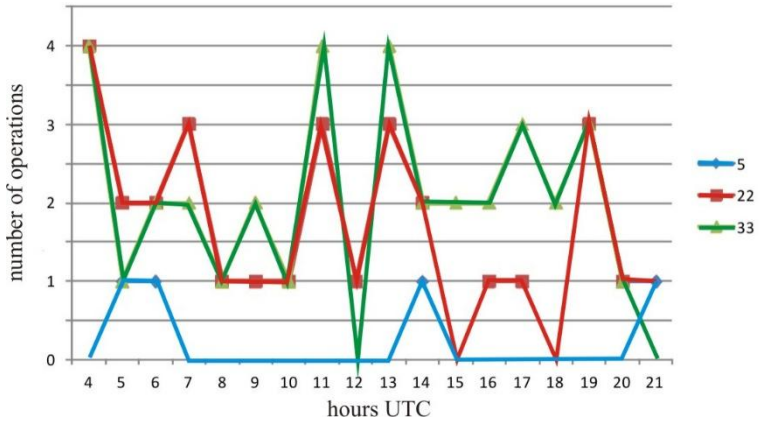

Figure 4 - LDZD IFR GAT daily traffic distribution on Fridays, 5th, 22nd and 33rd weeks, prepared by author, data source CROCONTROL Statistics

Even though being settled in the middle of the high season, traffic at the busier airport during on Fridays in weeks from 28th to 37th have significant difference of hourly traffic distribution as figure 5 presents Zagreb airport traffic. This also enables potential scheduling of the military traffic to reduce potential interference with civil traffic.

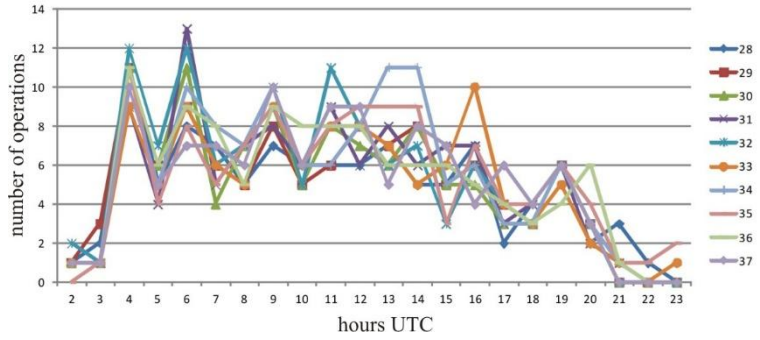

Figure 5 - LDZA IFR GAT daily traffic distribution on Fridays, 28th - 37th weeks, prepared by author, data source CROCONTROL Statistics

Air force flight training, regarding airport operations, is performed in two basic ways: one is consisted of take-off and departure from the airport towards the targeted area outside the airport area followed by returning to the airport and landing; the other is repetitive set of uninterrupted traffic patterns, commonly performed by chain-group of the same type aircraft.

If the flight training mission is performed outside the take-off/landing airport military users appear in the manner similar to the other traffic. Significantly greater speed of jet aircraft during take-off and especially during landing procedures creates increased separation minima from other, civilian, traffic.

Figure 6 represents time-space diagram [1] of mixed landing and take-off operations. Faster military aircraft-S_b converges to preceding slower commercial aircraft S_{k1}. Following commercial slower aircraft-S_{k2} diverges from the faster military aircraft-S_b. There is one departing aircraft placed in available time window between two succeeding arrivals. Figure is principal, not intended for the comparison of distances and speeds.

Picture shows the problem of harmonisation of fast aircraft with other, slower, civilian traffic during the approach phase.

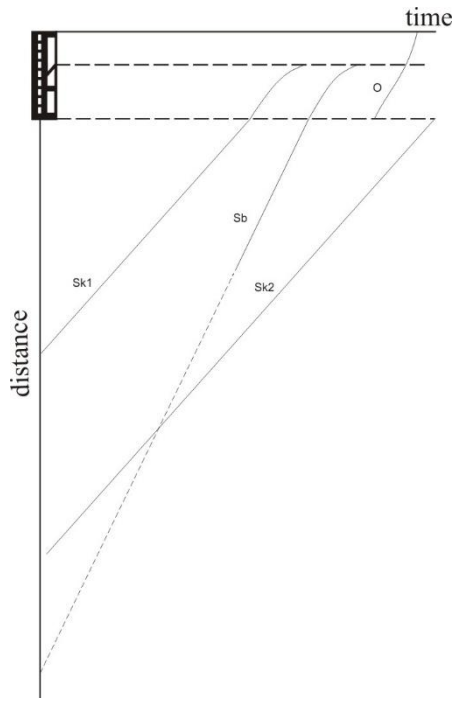

Figure 6 - Time-space diagram of landings and take-off with divergence and convergence of landing operations fighter aircraft related to preceding and following slower aircraft, prepared by author

There is typical example of the use of manoeuvring area in flight training that practically blocks runway use for other participants shown in figure 7. Time-space diagram shows the runway occupancy during traffic pattern practising flights of the same-type aircraft chain.

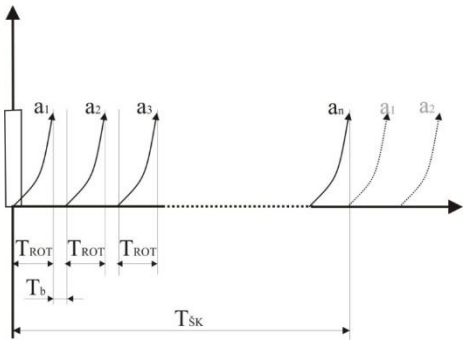

Figure 7 - Time-space diagram of runway occupancy during traffic pattern flights of sequence of same-type aircraft, prepared by author

If there are *n* aircraft (of the same type) performing *m* traffic circuits, total runway occupancy time is:

$$T_{ROTtot} = T_{ROTD} + mT_{SK} + T_{ROTA} \qquad (1)$$

where:

T_{ROTD} - runway occupancy time of aircraft group on take-off,

T_{SK} - traffic circuit duration for one aircraft,

T_{ROTA} - runway occupancy time of one (last in chain) aircraft after landing.

If traffic patterns are performed after return from the mission performed outside airport zone total runway occupancy time is:

$$T_{ROTtot} = nT_{SK} + T_{ROTA} \quad (2)$$

Flight training is organised in groups of aircraft performing same type of missions. Those groups can be sent as a formation at the same sortie or as solo flights that perform the same type of mission.

Figure 8 presents the principal scheme of a flight schedule for a period of time in one day. The first group of lines represents aircraft performing the same type of mission each aircraft for itself either in different blocks of airspace after departure or separated on the same route. Once returned from the mission aircraft are prepared for the second round performed in pairs. Finally, flying ends with traffic patterns.

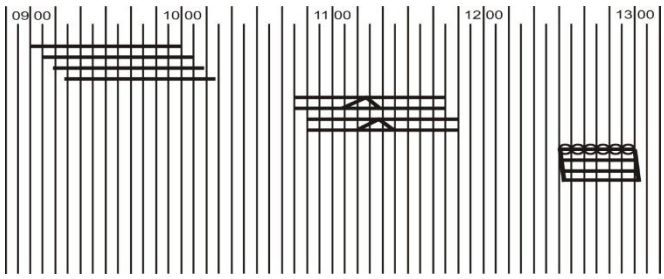

Figure 8 - Generic flight plan for training flights, prepared by author

2.2. Civil-Military Use Of Airspace

Flexible use of airspace in [6] shows the flexible use of airspace scenario with following versions:

- modification of the time of use of the airspace in accordance with civil and military requirements,
- vertical modification of the total volume of the airspace, dependent on traffic and military users needs, without changes of the airspace dimensions (figure 9a);
- 2D modular design of the airspace (figure 9b), and
- 3D modular design of the airspace (figure 9c).

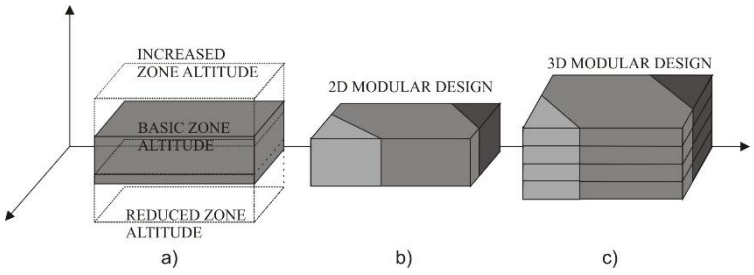

Figure 9 - Reserved airspace volume adjustments, prepared by author, based on [6]

Either modification of the operating altitudes the airspace or modular structuring of it enables only that the used airspace is fit to the requirements of the task military aircraft perform. Air-to-ground missions request generally lower altitudes than air-to-air ones. Still, there are missions that require smaller airspace that actually moves along, often not predefined, trajectory.

Such a special case of the reserved airspace, used for Air Policing missions, is a volume of airspace created around moving object-intercepted aircraft. That special moving zone can be used for the purpose of separation of other traffic from renegade aircraft. Guidance of other,

surrounding traffic requests additional effort due to difference of airspeeds of the moving zone and other traffic. Additional complication is created if the referent aircraft manoeuvres instead of straight and level flying.

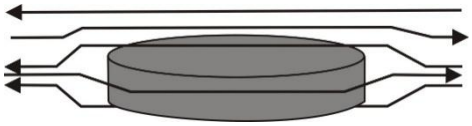

Figure 10 - Avoiding the reserved airspace, prepared by author

3. MILITARY FLYING OPERATIONS PLANNING FACTORS

Planning of the military flying operations requires information on various factors, external and internal. External factors are such as meteorological conditions and forecast and expected civilian traffic in the area of operations. Internal factors are such as the number and the level of training of crews, implied task(s), training goals, number of available aircraft, availability of supporting units, working time etc.

If the military activities are planned in respect only to internal factors interference depends only on the amount of civil traffic in the area or airport of operations. Flexible use of airspace or airport is reduced to the simple shrinking of the time window and the dimension of the airspace in use.

In order to understand the possibility of military flight operations planning one external and one internal factor and their influence on the planning of military flying operations are described. The first one is the data on forecasted civil traffic and the second one is the syllabus.

Airspace is functionally divided into air traffic control sectors. These sectors are defined by altitude and lateral boundaries. Sector has ultimate capacity dependable on multiple factors, such as navigation equipment or the shape and dimensions of the sector or the layout and number of inherent airways. Activation of the restricted zone in a sector can significantly decrease the sector capacity causing re-routing of civil traffic and related queues and additional costs or loss.

Table 1 presents an example of sectors' traffic prediction throughout the certain period of time. Sectors' traffic is not represented in numbers of aircraft or operations per hour but in colour code representing recommendations regarding interference of military flights and civil traffic in defined sector during specified period of time. Colour code is previously arranged at the certain instances and related to the percentage of the maximal number of operations or aircraft. Colour coded table is periodically delivered by the appropriate air traffic unit to the concerned military (flying) unit(s) that perform flying activities in related sectors. Colours used in the example are chosen in respect to the traffic light: green - "proceed", yellow - "caution" and red - "no go!". The right to use the airspace regardless of the recommendations remains untouched.

Table 1 - Generic colour coded sector traffic data, prepared by author

Sector	Time							
Sector 1 Upper	Green	Green	Green	Yellow	Yellow	Red	Red	Yellow
Sector 1 Lower	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Green
Sector 2 Upper	Red	Red	Red	Yellow	Yellow	Yellow	Red	Red
Sector 2 Lower	Red	Yellow	Yellow	Yellow	Red	Red	Yellow	Yellow
Airport 1	Green	Yellow	Yellow	Red	Yellow	Yellow	Yellow	Red
Airport 2	Yellow	Yellow	Red	Red	Red	Red	Yellow	Yellow

Flight training is performed in accordance with certain rules and the planning is done related to prescribed sequenced syllabus. A generic syllabus is presented in figure 11. There are tasks T (1, 2...10) presented and sorties (1, 2, 3) they are consisted of. The path prescribed for the training is from the Task T1 through all three branches (B1, B2 and B3) to the final Task - T10. In the syllabus there are three possible options after T 3, training can be continued through any of three branches. Furthermore, training can be interrupted during any branch and continued in any other branch. There are also Tasks such as T 5 or T 8 that can be performed only after completion of previous tasks, B 3 T 4 plus B 2 T 3 and T 7 plus B 3 T 3, respectfully.

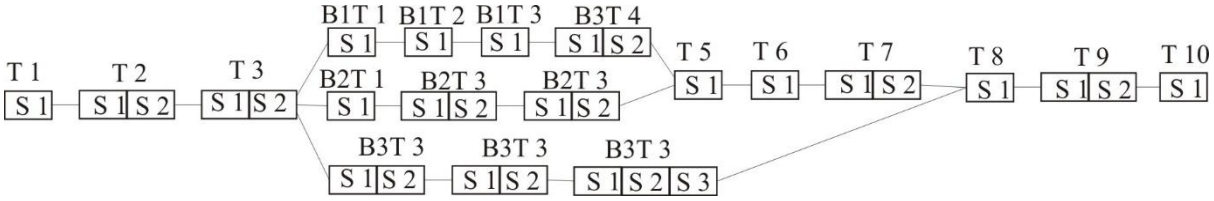

Figure 11 - Generic branching syllabus, prepared by author

At certain conditions training process can be performed in various versions depending on the crews' status and level of training. Choice between available alternatives in syllabus are often made due to meteorological conditions and, of greater importance for this paper, could be made due to civil traffic predicted in available airspace during the targeted period of time.

4. CONCLUSION

In order to function in a new environment and not to produce additional costs air traffic participants have to adapt, to be flexible. Searching for the new, acceptable way of functioning becomes continuous planning that represents an approach to the air traffic management that enables short-term commitment in order to enable the long-term decision making.

Operating at the same airport, air force alongside civilian users, remaining rigid, unfavourable to adaptation, stresses the possibility of interference. Certain flexibility and adaptation to new circumstances, without degradation of operational capabilities, can enhance the airport operations and lead to undisturbed mixed operations even in increased volumes of traffic.

Shrinking of reserved airspace, its modular architecture and target-centric zone has nearly reached its ultimate contribution to the reduction of military operations impact on civil traffic. Flexible use of airspace becomes of paramount importance, especially in the area of mutual civil-military planning of the use of airspace. Civilian traffic distribution in space and time represents its reflexion of the market demands. Detailed prediction of civil traffic on day by day basis or even longer periods, coupled with data on prevailing meteorological conditions and forecasts for targeted area of operations for military flights represent one set of inputs for military planners.

Once developed prediction tool, preferably expert system, could significantly increase functionality and efficiency of military operations planning and enable increased adaptability to the civil users' demand on mutual airspace use.

This paper elaborates peculiarities of civil and military flying operations interaction and represents the base for further research.

Following research should be directed to define relationship and mutual impacts of internal and external factors with the decision making process of flying activities. Once created it represents the base for programming a useful planning tool.

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TRANSPORT AND ITS IMPORTANCE ON NON-TRADITIONAL INVESTMENTS

ABSTRACT

This paper deals with the question of non-traditional investments, focusing on antique cars. Nowadays, when there is often economic turbulence and volatility in financial markets, investors are looking for investment opportunities where they can make the most of their own, or external, financial resources. The increasing uncertainty of return on investments today is forcing investors to alter their investment habits. The result is a search for new options in the field of investment that the transportation industry is able to offer. The aim of this paper is thus to promote the importance of non-traditional investments in transport focused on antique cars in the Czech Republic. The main issue that appears here is an ignorance of such investments by investment companies.

KEY WORDS

Transport; non-traditional investments; antique car; specialised fund; investor

1. INTRODUCTION

In today's market economy, where there are frequent and unpredictable changes as a result of global processes on financial markets, investors are forced to change their tried and tested investing decision-making processes. Evaluating one's funds, or those entrusted to one, through traditional investment instruments such as shares or bonds seems to be very risky or sometimes less profitable. Furthermore, some instruments such as shares or government bonds are at risk of speculative bubbles and when such a bubble bursts, it will have a negative impact primarily on the majority of investors and even some governments, which in the case of antique cars, in a physical form, is quite unlikely.

The current turbulence in financial markets, inaccurate predictions and the increasing uncertainty of some investments are changing the investment behaviour of many investment companies. These changes bring financial capital outflows from some traditional areas, seeking better value for non-traditional investment options.

The main objective of this paper is to promote the importance of non-traditional investments in the field of transport, focusing on antique cars. The problem that arises from this type of investment is a certain lack of support, awareness, and experience and a limited number of investors in the Czech Republic. However, the current economic situation supports and encourages innovation, not only in non-traditional investments, which over time can transform into traditional investments with a wide application, such as in the form of shares, bonds, funds, or derivative securities.

2. THEORETICAL BACKGROUND

The issue of non-traditional investments focusing on antique cars was, in the past, primarily an activity for enthusiasts who participated in it rather as a hobby than as a source of funds. Currently, this investment is gaining importance and significance for investment companies, as hundreds of billions of dollars are being invested into this business around the world.

This is evidenced by the establishment of a fund relating in the first phase only to antique cars. This is a fund of qualified investors called BBI (Best Buy Investments) CLASSIC, where five founding members have put 80 million CZK into the Fund. Investors who are interested in this investment must invest at least two million CZK. The funds are evaluated at approx. 15% per annum and the Fund will focus mainly on automobiles manufactured in Europe. The Fund is based in Malta, because of more favourable taxation and fees compared to the Czech Republic. An increasing interest in the establishment of a Fund in the Czech Republic is evidenced by business done at auction in California in the United States, where just over a thousand cars have been sold for 400 million US dollars. (BBI, 2014)

The company Patria draws attention to the high rate of return on this investment demonstrating an average profit for the last three years of 21%, although the first quarter of this year reached an astronomical appreciation value of 40.7%. There is growing interest among investors not only for antique cars, but also for newer, "classic" cars, investment cars whose age does not exceed 30 years. (Patria, 2014). Due to crisis and turbulence in the markets, including increasing risk, antique cars represent a suitable investment and can re-evaluate the investment plans of investors. (Ekonom.Ihned, 2013). Age is not the only aspect considered; another important attribute is the number of models of a certain car produced, and it must have all required documents, two photos in the certification papers and must be operable. Every year the documents are renewed by a specialist workshop, which focuses on antique cars. (Auto.Idnes, 2006). The most valuable antique cars from Eastern Europe are listed in Table 1.

Table 1 - The Most Valuable Antique Cars in Eastern Europe

Order	Name	Year of Production	Price in Euro
1.	Chayka 13/14	1959-1988	29,000 – 33,000
2.	Tatra 600	1948-1952	28,500
3.	IFA F8/F9 Luxus Cabrio	1950-1956	24,800 – 25,000
4.	Tatra 603	1956-1975	20,900 – 22,500
5.	IFA Sachsenring P240	1956-1959	21,800
6.	Škoda 450/Felicia	1958-1964	19,000 – 20,200
7.	Wartburg 311/312	1957-1967	15,200 – 17,600
8	Tatra 613	1969-1984	12,700 – 15,000
9.	IFA F8/F9 Cabrio-Limousine	1950-1956	14,900
10.	Wartburg 311	1962-1965	12,900

Source: (Česká televize, 2010)

However, the business with antique cars can also be invested in badly. It happens to investors who purchase cars which desperately require renovation, but the cost of this renovation could reach into millions of CZK, which many investors don't realise. As well, these renovations can be carried out unprofessionally and the investor will not be able to reach the anticipated return. (Auto.Idnes, 2007) Another risk when making such an automotive investment is the same as for most other securities such as shares, bonds or derivatives, and

that is, the proper timing of the sale and purchase. This moment in time will either prove or disprove the investments made.

The price of antique cars is greatly affected by the influences of fashion supported by the film industry, acting on consumer purchasing behaviour. These three factors - price, fashion and advertising - contribute to the interest in antique cars. It is therefore good to invest in those cars which are in the phase of stagnation or growth. Figure 1 explains where it is good to invest in non-traditional investments selected on the basis of the development cycle of an average car. The price reflects production and resembles a letter U, but for successful cars it resembles a letter J. (Finexpert, 2013)

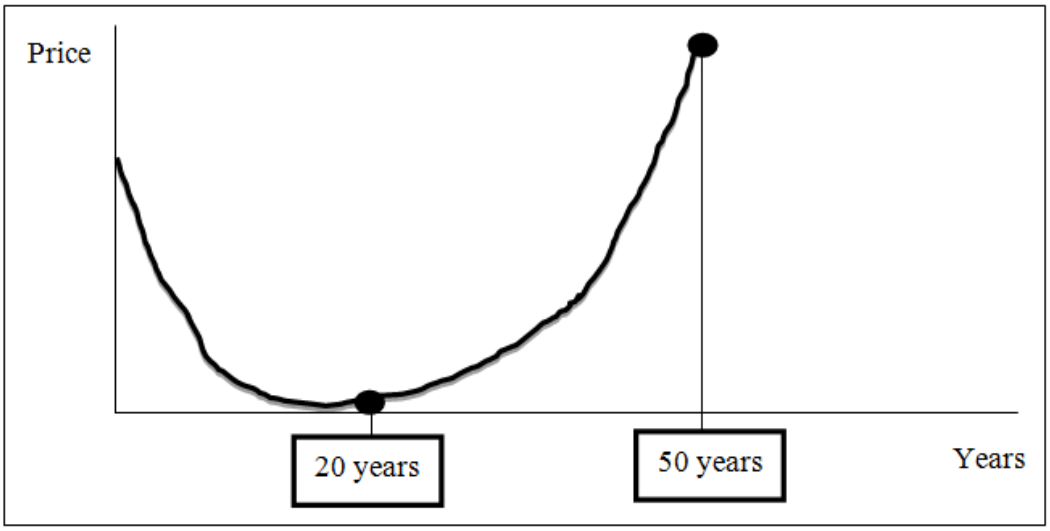

Figure 1 - The life cycle of an average car
Source: Author's own work based on (Finexpert, 2013)

3. METHODS

This article applies the method of comparing the incomes of selected funds. Another method that is applied in the article is the analysis of the issue based on available Internet resources. Based on this analysis, an absence of literary sources was found for the issues examined. As well, the principles of logical thinking were applied.

4. INVESTING IN ANTIQUE CARS AND THEIR IMPORTANCE FOR INVESTORS

The popularity of investing in antique cars has a rich history in countries with developed market economies, and an index of vintage cars, HAGI (Historic Automobile Group International), has been developed for the needs of investors. This is an important index as the Top HAGI Index is published once a month on the Financial Times website. (Investyčník, 2013) An important aspect of this index is its comparison with the development of the S & P 500 index since 1980. (Historic Automobile Group, 2014)

At present there are a large number of funds where it is possible to develop one's available resources. We will assume that the appreciation of the fund for qualified BBI investors offers a gross return of 15% per annum. Comparison is made with the most successful funds operating in the Czech Republic in 2013 in the given categories in Table 2.

Table 2 - Comparing Funds

Order	Category	Successful Fund	Gross Revenues
1	Share Fund	Franklin Templeton Investment Funds - Franklin European Small - Mid Cap Growth Fund	48.49 %
2	Progressive Bond Fund	ESPA BOND EUROPE - HIGH YIELD	17.31 %
3	**Qualified Investor Fund**	**BBI (Best Buy Investments) CLASSIC (antique car fund)**	**15 %**
4	Mixed Fund	J&T MONEY CZK open share fund, J&T INVESTIČNÍ SPOLEČNOST, a. s.	5.73 %
5	Progressive Short-Term Fund	GE MONEY Conservative Fund	2.11 %
6	Conservative Bond Fund	KBC Multi Interest CSOB CZK Medium	1.24 %
7	Conservative Short-Term Fund	Conseq Invest Conservative Short-Term Fund	1.03 %

Source: Author's own work based on (Investice roku, 2014)

As can be seen from the table, the fund focused on antique cars is ranked third among successful funds in the Czech Republic provided that it will generate the anticipated gross proceeds of 15% per annum. A significant drawback is the amount which the investor must invest in the Fund, namely at least 2 million Czech crowns. The limit of the amount restricts mainly the small investors, to whom the investment is inaccessible. These investors will look for other alternatives on the market, where they could develop their available funds.

5. DISCUSSION

The issue of transport-related investments with a focus on antique cars in the Czech Republic is not as popular as it is in countries such as the U.S.A. or Great Britain. However, the boom in the Czech Republic justifies the creation of this fund. One of the main pitfalls of this investment is the minimum amount. On the other hand, for high net worth investors, this is a very interesting and highly profitable investment that can improve one's finances. Expanding investment opportunities leads to a richer investment portfolio and risk diversification. In current market conditions, this is a more stable investment instrument which can prevent a loss of financial resources.

6. CONCLUSION

Professional literature lacks an analysis of non-traditional investments focusing on antique cars on the Czech market. Information on this issue is available only on the Internet, as evidenced by the list of sources used in this article. Therefore it would be appropriate to link knowledge with practice and theory, which would help boost interest in non-traditional investments aimed at antique cars by publishing professional literature. Literary sources should facilitate the path for neophytes as well as professional investors when investing in non-traditional investments. A lack of resources is one of the factors that limit the popularity awareness of non-traditional investments. On the other hand, the given fund supports the expansion of investment opportunities for investors in the Czech Republic. A certain disadvantage is registering the fund in a tax haven as it has an impact on the government budget in a smaller tax compliance.

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MID-AIR COLLISION RISK ANALYSIS IN TERMINAL AIRSPACE

ABSTRACT

Automatic Dependent Surveillance – Broadcast (ADS-B) will be the basis of the future surveillance system all over the world. One way to create incentives for users to equip with the required ADS-B avionics is to create and implement ADS-B applications that are of high value to the operators. One such application is the airborne traffic alerting application named Traffic Situation Awareness with Alerting (TSAA). As a first step in the development of this application, an analysis of ten years of NTSB mid-air collision reports was conducted to identify areas of high mid-air collision risk. Similarly, ten years worth of ASRS and NMACS near mid-air collision reports were also analyzed. The airport environment is where most mid-air collisions occurred (59% of NTSB reports) and most near mid-air collisions were reported (64% of ASRS reports and 47% of NMACS reports). As such, most benefit from traffic alerting can be gained from alerts in the airport environment. Encounters between Commercial Aviation and General Aviation aircraft were most often reported between a cruising General Aviation aircraft and Commercial Aviation aircraft transitioning through that same altitude. General Aviation/Commercial Aviation encounters make up 14% NMACS as well as ASRS reports.

KEY WORDS

Automatic Dependent Surveillance – Broadcast; Aviation Safety Reporting System; General Aviation; Commercial Aviation; Mid-Air Collision; Near Mid-Air Collision.

1. INTRODUCTION

As part of modernization program of the Air Traffic Control (ATC) system, Automatic Dependent Surveillance – Broadcast (ADS-B) will be the basis of the future surveillance system all over the world, supplemented by the current radar system. Much of the benefit delivered from ADS-B is dependent on the overall equipage of all the aircraft in the airspace system. Unless the majority of aircraft transmit ADS-B, ATC will have to continue using radar surveillance. Also, benefit from aircraft-to-aircraft ADS-B applications will be reduced. Therefore, creating incentives for aircraft operators to equip with ADS-B is crucial.

For operators to equip early and voluntarily, the benefit received from the system has to be equal to or greater than the cost of the equipment. One way of creating benefit for users is to create and implement ADS-B applications that are of high value to the operators [1, 2].

The initial work presented in this document was conducted to identify where the risk for a mid-air collision (MAC) is highest and thus to identify where a traffic alerting system would be most beneficial. The work was done based on the data from American databases – National Transportation Safety Board (NTSB), ASRS (Aviation Safety Reporting System) and NMACS (Near Mid-Air Collision System).

2. METHODOLOGY

In order to identify where the risk for a mid-air collision is highest, an analysis on where MACs most frequently occur, was conducted.

This analysis focused on documented mid-air and near mid-air collisions that occurred between 2000 and 2010. Based on the results, a set of representative scenarios was generated.

2.1 Analysis of NTSB Accident Reports of Mid-Air Collisions

NTSB mid-air collision accident reports from January 2000 until June 2010 were analyzed. This resulted in a total of 112 accident reports. The reports did not contain any mid-air collisions involving an aircraft operating under Instrument Flight Rules (IFR).

The narrative of each of the 112 reports was reviewed. For each mid-air collision, the horizontal encounter geometry was reconstructed. The description of aircraft heading differed between reports (Table 1): some reports gave exact headings, others used cardinal directions (North, Southwest, etc.) and others yet only gave descriptions of the relative location of the aircraft with respect to each other. Some reports did not have any radar data or eyewitnesses available and thus did not have track information at all. To allow for the comparison of the horizontal encounter geometries, the accidents were grouped into bins of 45° based on flight track intersection angle. The 5 groups were centered on the 5 cardinal directions of one half of a compass rose (Figure 2). In addition to geometry reconstruction, external factors that contributed to the collision were identified (such as the absence or malfunction of equipment).

Table 1: Format of Heading Information

Description of Heading	Percentage
Cardinal Directions	19%
Exact Radar Data	11%
No heading information available	7%
Implied from description in report	63%

The description of vertical motion of the aircraft was much less consistent. Many reports never mention vertical movement while others simply state that the aircraft was climbing or descending. In many cases, however, it was possible to extract at least the relative vertical motion of the two aircraft based on the narratives.

2.2 Analysis of ASRS and NMACS database Near Mid-Air Collision Reports

In an effort to widen the scope and validate the findings of the NTSB report analysis, Aviation Safety Information Analysis and Sharing (ASIAS) reports categorized as near mid-air collisions were also analyzed. The ASIAS Aviation Safety Reporting System (ASRS) and ASIAS Near Mid-Air Collision System (NMACS) databases were searched for every event classified as a near mid-air collision (NMAC) during the same time period used for the NTSB report analysis. The ASRS database yielded 2,059 reports and the NMACs database yielded 1,527 reports. The reports in the ASRS database contain a set of fields that the individual creating the report fills in as well as a narrative of the event. The reports in the NMACS database contain a similar set of data fields but do not have a publically available narrative.

The data fields were analyzed for the frequency by which a given characteristic appeared. For example, the reported flight phases of the own-ship were plotted versus the reported flight phases of the intruder aircraft.

One interaction that was not observed in the NTSB database was encounters between commercial aircraft and general aviation aircraft. A secondary analysis of GA/CA aircraft encounters in the ASRS and NMACS databases was conducted in order to understand the nature of this interaction.

Since the aforementioned databases are voluntary reporting systems, care needs to be taken when interpreting the results. Filing an ASRS report gives the reporter certain protections against possible charges and as such creates a reporting bias toward events where the pilot violated a regulation. Also, because of the subjectivity of the reports, the reports "…represent what the reporter believes he/she saw or experienced" [3, 4]. Lastly, a cross analysis showed that IFR report rates are higher than the percentage of IFR hours flown which indicates some over reporting or higher sensitivity by the IFR population.

3. RESULTS

3. 1 Results from NTSB Report Analysis

3. 1. 1 Location Analysis of NTSB accident reports

All accidents reported in the NTSB database were separated into three categories based on their proximity to the airport (Figure 1). The category defined as "Pattern" only includes accidents with aircraft that were flying the airport pattern with intention to land or having recently departed that same airport. As can be seen, the area surrounding an airport is where mid-air collisions most often occurred (59%). As a single category, the airport pattern was the location with the most accidents (45%). This implies that the Traffic Situational Awareness Application needs to be operational in the area surrounding an airport.

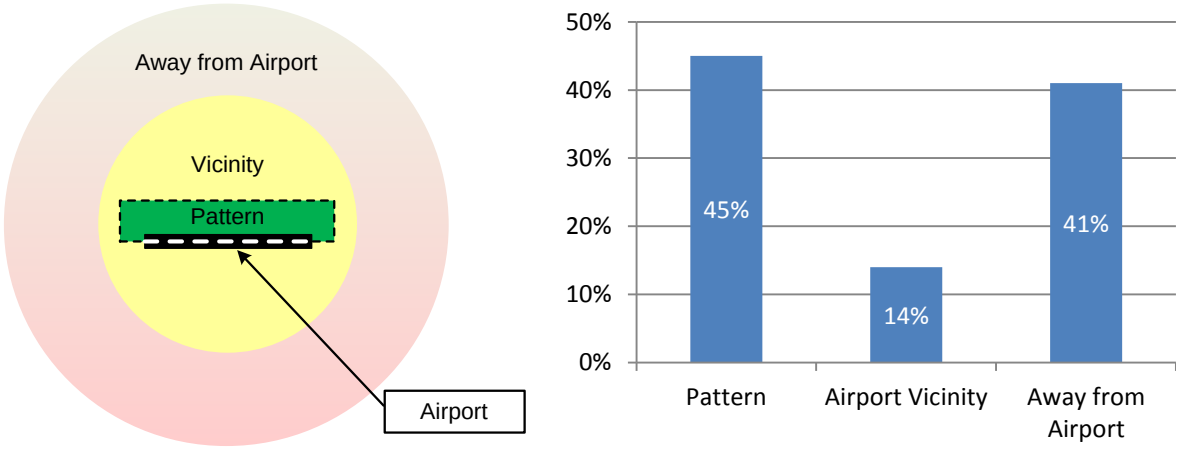

Figure 1 - Percentage of Mid-Air Collisions by Location

3. 1. 2 Geometry Analysis of NTSB accident reports

The intersect angle between the tracks of the two aircraft for all accident reports is summarized in Figure 2. The own-ship is the aircraft in the center and the intruder aircraft for a given mid-air collision is one of the aircraft along the perimeter of the compass rose. The colors and percentages indicate the frequency at which a given intersect angle was reported. As can be seen, over half (54%) of mid-air collisions occur between aircraft flying in the same direction. No collisions were observed where both aircraft were operating under IFR.

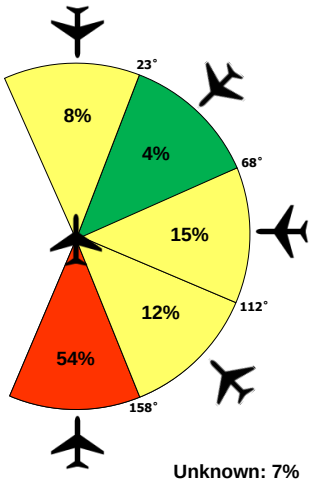

Figure 2 - Track intersect angle summarized for all NTSB mid-air collision reports

To gain a better understanding of the characteristics of encounters based on their location, each of the three environments identified in Figure 1 was analyzed individually. The results are discussed in the following sections.

3. 1. 3 Detailed Analysis of Mid-Air Collisions Reported in the Airport Pattern

Out of the 112 reported cases, 50 occurred in the airport pattern. This section analyzes those 50 accidents in more detail. As can be seen in Figure 3, over 80% of the mid-air collisions in the airport pattern happened on final, short final or on the runway. As a result, the track intersection angle most often observed is that of two aircraft going in the same direction. The narratives of these reports paint a similar picture for most of these accidents: two aircraft on approach to the same runway settling into each other as they get closer to the runway. This type of encounter is characterized by a rather small relative velocity which often results in the two aircraft only “bumping” each other. As a result, 31 of the 50 accidents in the airport pattern were non-fatal.

Out of the 50 accidents, 9 (18%) involved at least one aircraft that did not have a radio. According to the 2007 FAA Avionics Survey [5], only 2% of the GA fleet did not have a radio installed. 6 accidents (12%) involved at least one agricultural aircraft. According to the FAA Avionics Survey, 5% of GA hours are flown by agricultural aircraft.

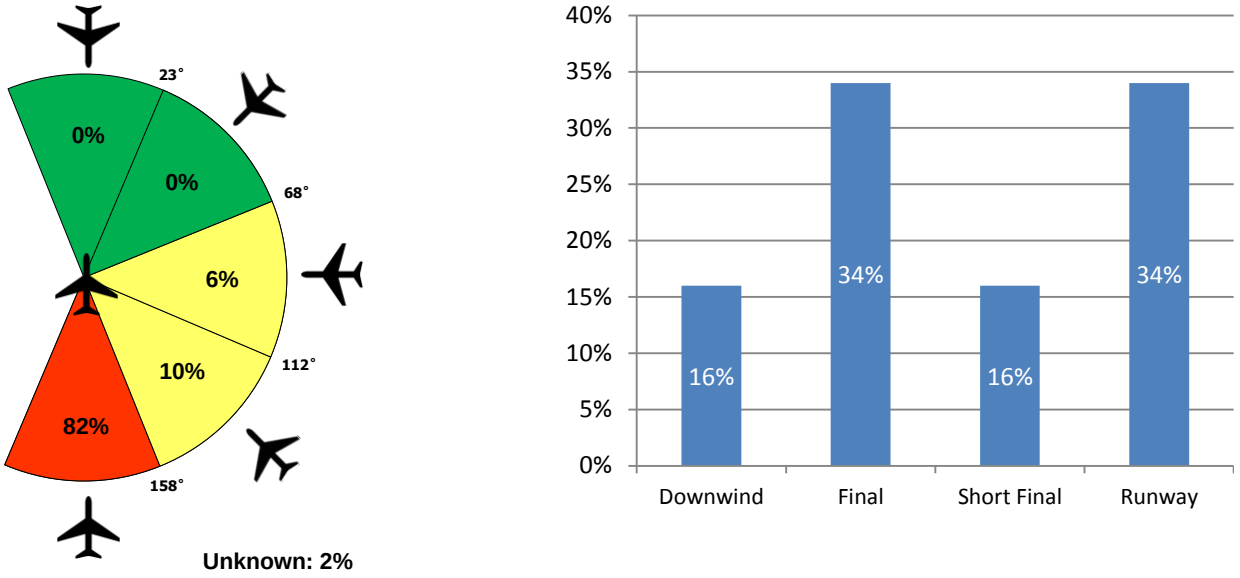

Figure 3 - Location Distribution and Geometry of Mid-Air Collisions in the Airport Pattern

3. 1. 4 Detailed Analysis of Mid-Air Collisions Reported in the Airport Vicinity

A total of 16 accidents happened in the airport vicinity. 9 of those were between aircraft that had identical flight phases, i. e. both aircraft were departing or arriving at the airport. 3 accidents occurred inside the bounds of the airport pattern, but the aircraft were not actually flying the pattern. Specifically, one collision was during a race, one during parachute operations and one during practice for an airshow above the airport. The last 4 accidents involved one aircraft that was arriving to or departing from an airport and another aircraft in cruise or performing maneuvers around that same airport. Figure 4 shows the geometry distribution for the accidents reported in the airport vicinity.

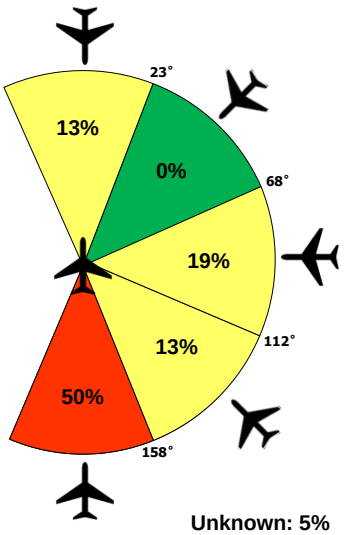

Figure 4 - Geometry of Mid-Air Collisions in the Airport Vicinity

3. 1. 5 Detailed Analysis of Mid-Air Collisions Reported Away from the Airport

A total of 46 accidents occurred away from the airport. The accidents included aircraft that were in cruise as well as aircraft engaging in flight training, surveying, firefighting, EMS transport, aerial application or news reporting (all referred to as "Maneuvering" in Figure 5). As Figure 5 shows, out of the 46 accidents, 24 (52%) happened between two aircraft that were both in straight and level cruise. One fifth (9 accidents) of the accidents away from the airport were between aircraft that were deliberately engaging in close flight, such as pilots practicing formation flight or friends going to a similar destination. Those accidents are labeled as "Formation Flight" in Figure 5 and Figure 6.

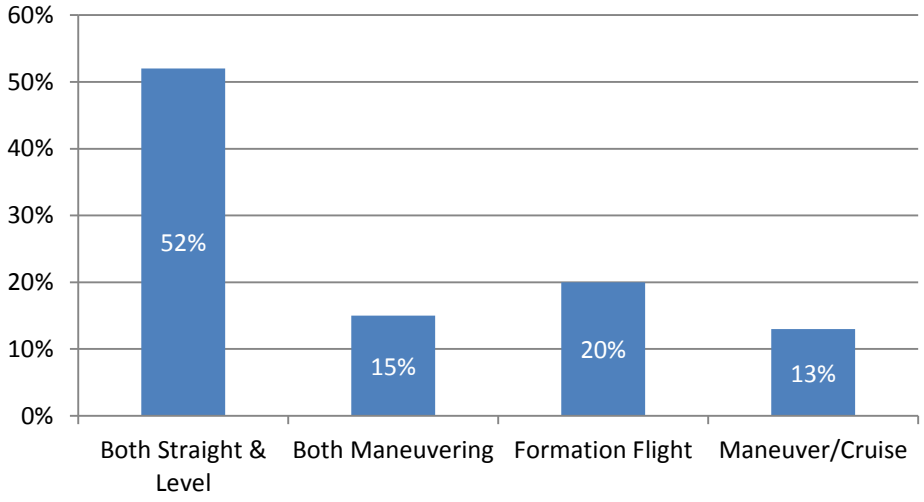

Figure 5 - Frequency of Flight Phase for Mid-Air Collisions away from the Airport

Of the 46 accidents, 13 (28%) involved at least one aircraft conducting maneuvers such as surveying, firefighting or flight instruction. The intersect angle most often observed is that of two aircraft with perpendicular tracks (29%). This may be due to blind spots resulting from wings and/or window frames out the side of the aircraft. A recurring theme in the narratives (6 cases) was that witnesses or survivors mention sun glare as a contributing factor.

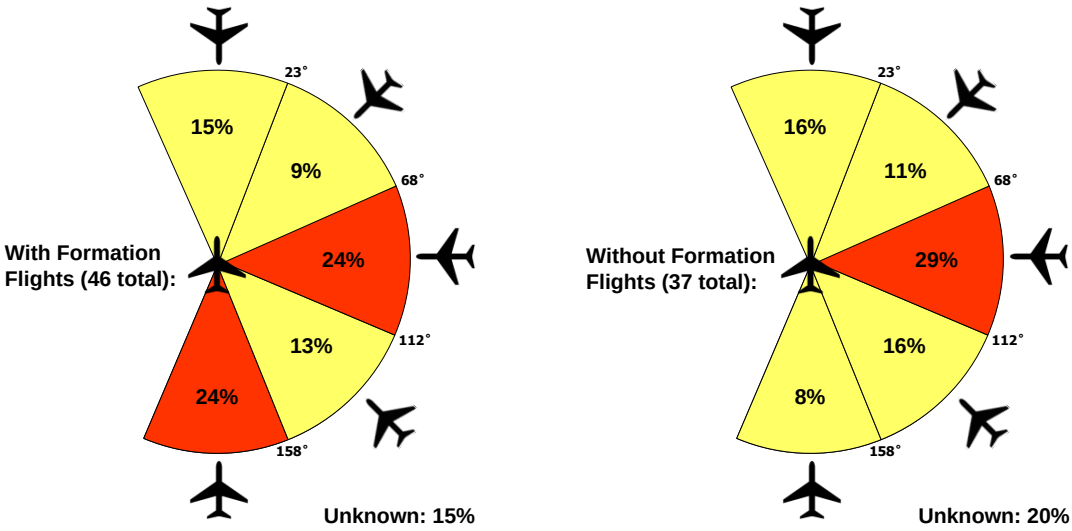

Figure 6 - Track intersection angle for mid-air collisions away from the airport with and without formation flights

3.2 Results from the ASRS and NMACS Database Analysis

The ASRS and NMACS databases were first evaluated based on the flight phases of the reporting and target aircraft. Reports that included a field left as "unknown" are not shown. Figure 7 and Figure 8 show the near mid-air collision reports for both databases with flight phases on the X and Y axes. The Z axis is the percentage of a given interaction. The flight phases on both axes are aligned such that the diagonal represents the encounters between two aircraft on the same flight phase. In the ASRS as well as the NMACS data, the flight phase interactions most often observed are those of two aircraft on "Initial Approach" (24% and 14% respectively). Note that in the NMACS data "Approach" has one category where in the ASRS data an approach is split into three sub-categories. The second most common interaction was between two aircraft in "Cruise" (11% and 13%, respectively). A review of the ASRS narratives showed that reports with flight phases categorized as "Initial Approach" were most often in the pattern.

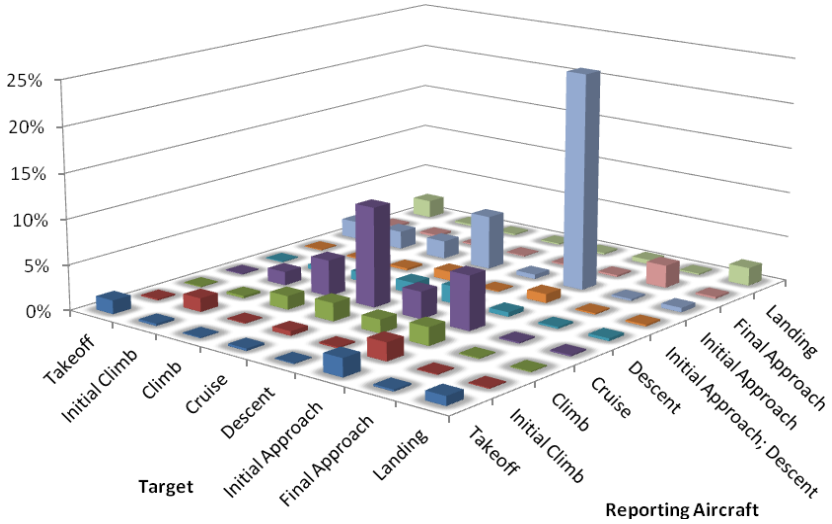

Figure 7 - Near mid-air collisions reported in the ASRS database by respective flight phase Encounters along the diagonal are between aircraft in the same flight phase

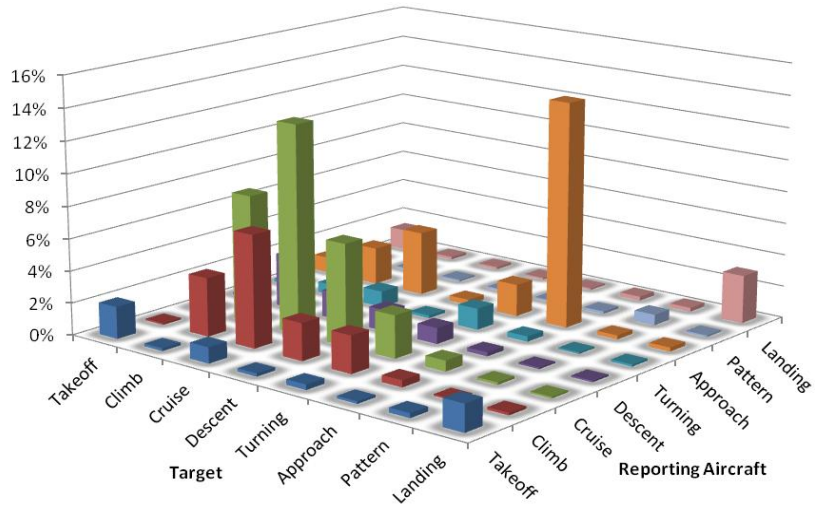

Figure 8 - Near mid-air collisions reported in the NMACs database by respective flight phase Encounters along the diagonal are between aircraft in the same flight phase

Both figures underscore the observation made from the NTSB reports that the airport environment is the location where most encounters are reported. Table 2 shows the percentages of encounters reported in the airport environment in the ASRS and NMACS databases. For comparison, 59% of the NTSB reported accidents occurred in the airport environment.

Table 2 - Near Mid-Air Collisions Reported in the Airport Environment

Database	Percentage
ASRS	64%
NMAC	47%

Table 3 shows the percentages of encounters by FAR (Federal Aviation Regulation) under which the aircraft were operating. Both databases indicate that encounters between GA aircraft are most common which is consistent with the NTSB mid-air collision data. However, unlike the NTSB data, interactions between GA and civil aviation aircraft were also observed in the near-miss data.

Table 3 - NMAC encounters ranked by percentage

ASRS Database	
Interaction	**Percentage**
GA/GA	44%
GA/CA	14%
CA/CA	5%
At least one aircraft unknown	36%

NMACS Database	
Interaction	**Percentage**
GA/GA	28%
GA/CA	14%
GA/Military	8%
CA/CA	3%
At least one aircraft unknown	47%

The flight phases of the GA/CA encounters were analyzed in more detail and are shown in Figure 9. The largest interaction observed in the ASRS database was between a CA aircraft on “Initial Approach” and a GA aircraft on “Cruise” (20%). The data indicates that the encounters are most likely when the GA aircraft is in cruise and the CA aircraft is in any other flight phase, specifically climbing or descending. This is likely due to CA aircraft often transitioning through altitude layers where GA aircraft would be cruising. Also shown in Figure 9 is the altitude distribution where the GA/CA encounters took place. Again, encounters were most often reported at altitudes that are typical for GA cruising altitudes.

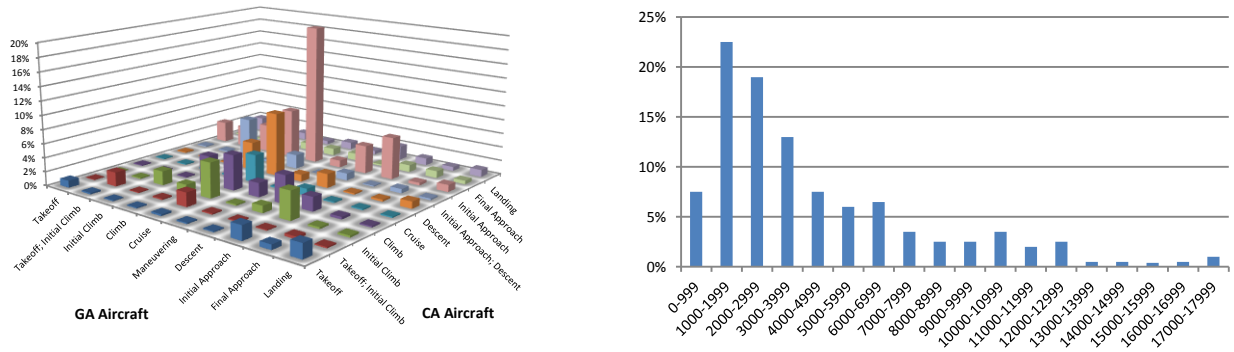

Figure 9 - Flight Phase and Altitude Distribution of GA/CA Encounters in the ASRS Database

Figure 10 shows the same GA/CA analysis using NMACS data. Here, the largest interaction was between two aircraft on “Approach” to an airport (12.5%). The encounter between cruising/transitioning aircraft observed in the ASRS data is not as pronounced, but

can still be observed. The altitude distribution of the NMACS reports shows a distinct second peak around 10,000ft MSL. Upon reviewing the narratives, the low level peak is mostly from VFR traffic while the mid-altitude peak is from cruising IFR traffic as well as sailplanes. Additionally, the second peak may be a result of increased aircraft velocities due to the airspeed restriction of 250 kts below 10,000ft.

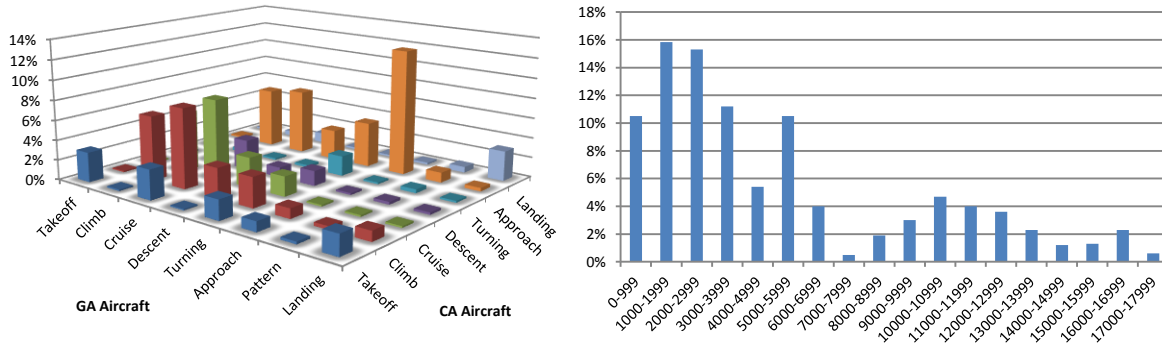

Figure 10 - Flight Phase and Altitude Distribution of GA/CA Encounters in the NMACS Database

4. CONCLUSION

In summary, the airport environment is the location where most mid-air collisions occurred (59%) and where the most near mid-air collisions were reported (ASRS, 67%). Encounters between CA and GA aircraft were most often reported to occur between GA aircraft cruising at a constant altitude and CA aircraft that were transitioning through that same altitude. These interactions are most often observed in two distinct altitude layers: low altitude (1,000 feet to 4,000 feet MSL) and mid-level (9,000 feet to 13,000 feet MSL).

A system that is to provide ADS-B based Traffic Situation Awareness would therefore have to be operational in the airport environment. One major challenge in designing such systems is that the airport environment is a high density environment with aircraft performing frequent and abrupt maneuvers. Most currently available systems such as TAS or TCAS (transponder based) are of limited usefulness in the airport vicinity, because of their high false alarm rate in high-density environments.

ADS-B's position information is much more accurate than that based on transponders – as a result, it is expected that ADS-B will enable reliable traffic alerting in the terminal area of an airport and even in the airport pattern. This ability has the potential to provide a substantial benefit to General Aviation. ADS-B based traffic alerting would therefore provide significant benefit and an incentive for GA to equip with ADS-B avionics. The work was done based on the data from American databases – National Transportation Safety Board (NTSB), ASRS (Aviation Safety Reporting System) and NMACS (Near Mid-Air Collision System).

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A VISSIM BASED FRAMEWORK FOR SIMULATION OF COOPERATIVE RAMP METERING

ABSTRACT

Due to the increase of vehicle numbers in recent decades, there exists a significant problem of reoccurring road traffic congestion. Such congestions are a characteristic of densely populated urban areas. They occur daily during the morning and afternoon rush hours. The road traffic congestion problem can be solved by applying new traffic control approaches from the domain of intelligent transportation systems (ITS). One of the applied services from the domain of ITS related to road traffic management is known as ramp metering. It is used to increase the throughput of urban highways with many nearby on- and off-ramps. In order to obtain better control results, several nearby on-ramps are combined together into a cooperative control system. Prior to implementation, such cooperative traffic control systems have to be tested in simulations using appropriate traffic data. One of the simulator tools, which can be used for this task, is VISSIM. It enables a microscopic simulation of road traffic and the implementation of various approaches for traffic control. In this paper the VISSIM simulator is used to implement a framework for simulation of cooperative ramp metering between two nearby on-ramps. The implemented framework is tested using traffic demand values characteristic for rush hours.

KEY WORDS

Ramp metering; cooperative control; microscopic simulation; VISSIM; urban highways

1. INTRODUCTION

The increase of the number of vehicles in urban environments in the recent decades created significant problems with daily congestions in road traffic. Such congestions reoccur regularly in so called rush hour periods. There are usually two rush hour periods. The first one is in the morning when people travel to their working and education places and the second one is in the afternoon when people travel back to their homes. Classical solution to this problem is in expansion of the existing road infrastructure. But such an approach only attracts more vehicles increasing the problem. Today new traffic control approaches from the domain of intelligent transportation systems (ITS) are used in order to ensure the optimal usage of the existing infrastructure. One of the application areas are urban highways with many nearby on- and off-ramps. Problem is that in rush hours a bottleneck can occur in the area near an on-ramp. That can create a congestion shock-wave on the mainstream, which propagates

upstream closing nearby upstream on- and off-ramps. Additionally, a queue on the on-ramp can occur that can overspill on the adjacent urban arterial roads. The described situation is presented in Fig. 1.

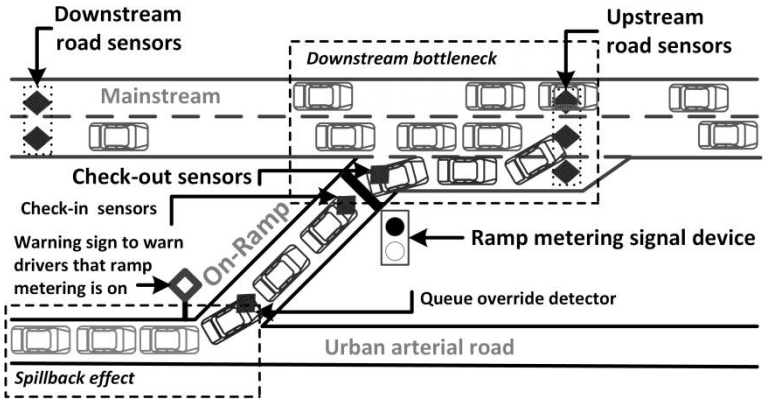

Figure 1 - Illustration of potential problems near an on-ramp [4]

To prevent the creation of or to reduce the congestion on the mainstream and the queue length on the on-ramp, the on-ramp can be equipped with a traffic light. This traffic light reduces the number of vehicles, which enter the mainstream, preventing so the congestion build-up. Such a control structure is called ramp metering (RM) and is usually implemented on urban highways with increased traffic demand. RM implementations are generally simulated by using various traffic simulation programs with the ability to simulate interaction of all existing traffic flows in a highway system. Traffic simulators can be divided into two major categories: macroscopic and microscopic [1]. Macroscopic simulators compute cumulative traffic flow parameters (e.g. speed, flow, and density) and their relationships to each other according to traffic flow equations. Individual vehicles are not considered. Most used macroscopic simulators are: CTMSIM, FREFLO, AUTOS, METANET and VISUM. Microscopic simulators continuously or discretely compute parameters (e.g. position, speed, maximum acceleration rate, etc.) of every individual vehicle during simulation. Most used microscopic simulators are: PARAMICS, MITSIM, CORSIM, VISSIM, AIMSUN and TRANSIM.

In order to obtain simulation results, which correspond to the real world situation, an appropriate simulation framework has to be used. In this paper the microscopic simulator VISSIM is used, since it can simulate different behaviour of each individual driver of a road vehicle. Each vehicle is simulated as an individual entity and so more realistic simulation results can be obtained. This property makes VISSIM suitable for simulation of urban highways with RM on their on-ramps. To alleviate the creation of various simulation setups, a framework has been proposed in this paper. It consists of an urban highway model including traffic data and the control logic. With such a framework, each part can be changed separately and reused in other simulations. This is important when the control logic has to be adjusted to a particular highway segment. In this paper a cooperative control logic is implemented in the framework. It consists of two levels. A low level that contains a local RM algorithm (ALINEA in this paper) for each on-ramp in cooperation and a high level logic that enables cooperation between on-ramps.

This paper is organized as follows. Second Section describes the concept of RM and cooperative control in RM. The third Section presents the basic features of the VISSIM simulation environment used in this paper. Following fourth Section describes the proposed framework for simulation of cooperative RM. The fifth Section presents the simulation model and obtained results. Paper ends with a conclusion and future work description.

2. COOPERATIVE RAMP METERING

Main goal of RM is to reduce the impact of a downstream bottleneck on the mainstream highway traffic. In order to accomplish this, RM uses special traffic lights at on-ramps to control the rate or size of vehicles platoons entering mainstream traffic according to current traffic conditions [5]. While reducing the downstream bottleneck, RM may cause the traffic to spill over into feeder arterial roads as the on-ramp queue length increases. This situation occurs especially when the mainstream highway traffic flow is high [6]. Location of the downstream bottleneck close to the on-ramp and the spillback effect on the adjacent local urban road network is given in Fig. 1. Furthermore, Fig. 1 presents a general local RM system installation on an urban highway. Most important part of the RM system is the algorithm that determines the "access rate reduction" for the on-ramp flow [5].

Traffic light used on the on-ramp contains only the red and green light. So, only two phases exist in the signal plan. The duration of the green light phase is usually fixed so only one or two vehicles can leave the on-ramp. Usually 3 to 6 seconds are used. In order to determine the access rate, the duration of the red phase has to be obtained by the RM algorithm. RM is effective only when increased traffic demand is present. During night time and other very low traffic demand periods it is usually turned off. In such periods, the traffic light generates only an unnecessary delay when a vehicle wants to enter mainstream traffic.

Effectiveness of RM is measured by its influence on the level of service (LoS) of the controlled part of the urban highway. LoS is defined as a group of qualitative measures that characterize operational conditions within traffic flow and their perception by motorists and drivers [3]. Basic measure of service quality for RM is travel time (TT). TT is a simple measure that describes the time that one vehicle needs to travel through the observed highway part. The observed highway part is usually divided on several segments during the modeling process. TT is measured in minutes and computed using equation (1):

$$TT = T \sum_{i=1}^{N} 60 \frac{L_i}{v_i}, \tag{1}$$

where $v_i(k)$ denotes the traffic density on the highway segment *i*, L_i is the length of segment *i*, *N* is the total number of segments, and *T* is the simulation step in seconds. An unusual high value of TT is a clear sign for the LoS quality drop for the examined highway. Apart from TT, the average speed on the mainstream will be used in this paper as an additional LoS measure for the evaluation of the obtained simulation results.

2.1 The ALINEA algorithm

The ALINEA algorithm is a local strategy for RM [2]. Local strategies include RM algorithms that take into account only the traffic condition on a particular on-ramp and its nearby highway segment. The traffic condition on other nearby on-ramps is not taken into account so unwanted interaction between adjacent on-ramps can occur. ALINEA is the most often used standard local RM algorithm. This is because of the ALINEA's optimal ratio between simplicity and efficiency. Core concept is to keep the downstream occupancy of the on-ramp at a specified level by adjusting the metering rate (amount of vehicles allowed to enter mainstream). Specified level of downstream occupancy is called the occupancy set-point *O*. Its value is slightly lower or equal to the occupancy at the maximum downstream capacity [2]. The resulting metering rate can be obtained by the following equation:

$$r(k) = r(k-1) + K_R[O - O_{out}(k)], \quad (2)$$

where *r(k)* is the current metering rate, *r(k-1)* is the metering rate from the previous iteration, K_R is the regulating parameter, and O_{out}*(k-1)* is the measured downstream occupancy from the previous iteration. Recommended value for K_R is 70 [veh/h]. ALINEA has numerous enhanced versions and is used as part of many other local and coordinated RM approaches. Basic working principle of the ALINEA algorithm is shown in Fig. 2.

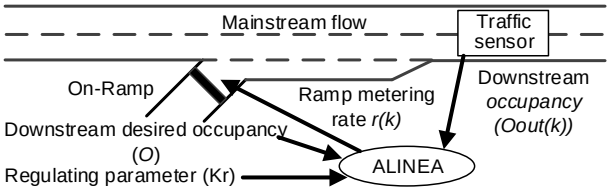

Figure 2 - Scheme of the basic working principle of ALINEA

2.2 Cooperation between on-ramps

A cooperative control system is defined as a set of control entities that share information and/or tasks to accomplish a common, though perhaps not singular, objective. Cooperation in RM is achieved by exploiting adjacent on-ramp's queueing capacities in order to perform effective mitigation of congestion related to a particular area with several close on-ramps. As mentioned, in such a highway network configuration there exists the risk that mainstream congestion originating from an on-ramp can cause severe congestion that includes one or more upstream on-ramps. Such upstream congestion propagation closes also the access of mainstream vehicles to upstream off-ramps enlarging the congestion problem.

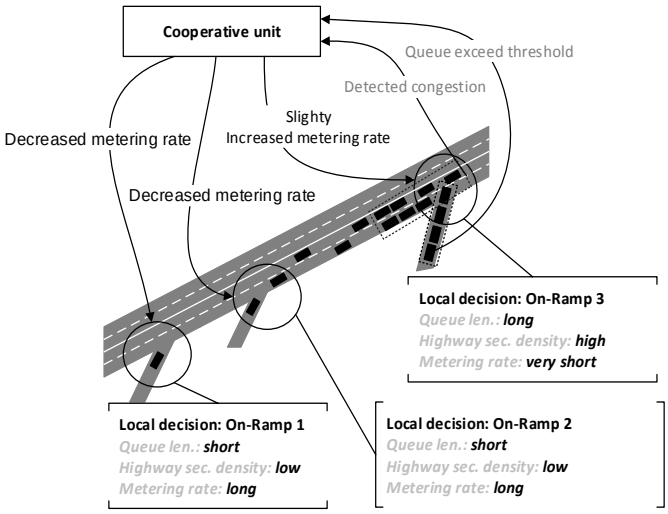

Figure 3 - Basic functionality of cooperative RM algorithms

Cooperation between on-ramps demands that several local traffic responsive metering algorithms communicate with a central cooperative unit. The central unit has an override possibility, i.e. it can alter the local metering rate for each on-ramp. Cooperative algorithm in the centralized operational unit uses a control logic, which exploits the queuing capacity of upstream on-ramps, to reduce the queue length on the congested one. In order to compute and adjust the values of metering rates computed by local RM algorithms, the cooperative algorithm uses the overall highway traffic information and mentioned control logic. Basic

working principle of cooperation between several on-ramps can be seen in Fig. 3 that presents a part of a highway with three on-ramps. In the area near the third on-ramp congestion started to build-up. The high level cooperative unit obtains this information and changes the RM rate of the upstream on-ramps to decrease the number of vehicles entering the mainstream. In such a way a time period of decreased traffic demand can be created enabling the congestion to resolve or to prevent further congestion build-up.

3. CHARACTERISTICS OF THE VISSIM SIMULATOR

In order to test traffic control algorithms accurately, an appropriate simulation model of the corresponding transport network has to be used. To build a model for the simulation of a road transport network, one has to gather data about the roads (number of lanes, road segment lengths, crossroad configuration, etc.) and vehicles travelling through the road network (origin-destination matrices, percentage of cars and trucks, characteristics of driver behavior, etc.). The accuracy and validity of a simulation model mostly depends on the quality of gathered traffic data and behavior of vehicles in the simulated traffic network. In this paper, the VISSIM simulation tool was used. It is a simulation tool for modeling of urban traffic networks on a microscopic level. Unlike other simulation tools, which use a constant vehicle speed and deterministic logic of pursuing, VISSIM uses a psychophysical model of driver behavior developed by Rainer Wiedemann in 1974 [7]. The basic concept of this model is that the driver of a faster moving vehicle starts to decelerate as he reaches his individual perception threshold to a slower moving vehicle. Since he cannot exactly determine the speed of that vehicle, his speed will fall below that vehicle's speed until he starts to slightly accelerate again after reaching another perception threshold.

VISSIM simulates the traffic flow by moving driver-vehicle units through a road network. The units depend on corresponding vehicle and driver characteristics. Every specific vehicle has a driver assigned with his own specific behavior. So, to each driver-vehicle unit the following attributes are assigned: (i) technical specifications of the vehicle (vehicle length, maximum speed, accelerating power, actual speed and acceleration/deceleration); (ii) behavior of the driver-vehicle unit (psychophysical perception thresholds of the driver, driver's memory, acceleration based on current speed and driver's desired speed); and (iii) interdependence of driver-vehicle units (reference to vehicles in front and trailing vehicles on own and adjacent lanes, reference to next traffic signal).

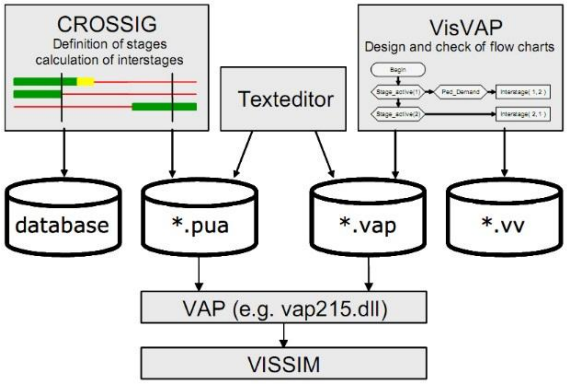

Figure 4 – Components of the VisVAP module [8]

For the development and simulation testing of traffic control algorithms, the add-on module for the VISSIM simulation tool VisVAP (Vehicle Actuated Programming) was used. VisVAP enables the use of object-oriented programming. The logic of the traffic control algorithm is implemented using flowcharts. The layout of the flowcharts and its components is given in Fig. 4. According to Fig. 4, it is evident that it is necessary to create an ASCII database with the extension "pua" that contains information on the number of signal groups, intergreen matrices, definition of signal plans, etc. The next step is the creation of an algorithm in the VisVAP module and after that an ASCII file with the extension "vap" is generated. This file is then loaded into the VISSIM simulation tool. The connection between the "vap" program control and VISSIM are detectors and traffic lights placed in the simulated road network. Using measurements from detectors, the signal plans for traffic lights on a specific crossroad or an on-ramp can be managed in a closed control loop.

4. SIMULATION FRAMEWORK

To create a simulation framework, two main components have to be implemented. First component is a model of the road transport network including corresponding detectors, traffic lights and traffic data. In this paper, an urban highway model has been implemented. The second component is the control logic, which is in this paper an algorithm for RM, with cooperative properties. In continuation this two components are described with more details.

4. 1 Urban highway model

The implemented urban highway model consists of a mainstream part and two on-ramps that feed the mainstream flow as shown in Fig. 5. Mainstream includes a fast and a slow lane, both 5067 m long. On-ramps have only one lane, the first is 710 m and second 713 m long. For simulation purposes, both mainstream lanes have differently defined vehicle speeds and driver characteristics. The fast lane is mostly occupied with cars and faster drivers, and the slow lane with more heavy vehicles and slower drivers. With differently defined vehicle speed and driver behavior, it was possible to make the simulation as realistic as possible. Mainstream is separated in three segments to enable a detailed simulation results analysis. Figure 5 also shows the detector locations that are used for collecting traffic data. Every detector is placed on an optimal position where it can gather relevant traffic data. Traffic volume used in this simulation consists of 98% personal vehicles. Other 2% are heavy vehicles (trucks, busses), which have a lower defined vehicle speed to match the real world situation. Simulation results showed that heavy vehicles had no significant effects.

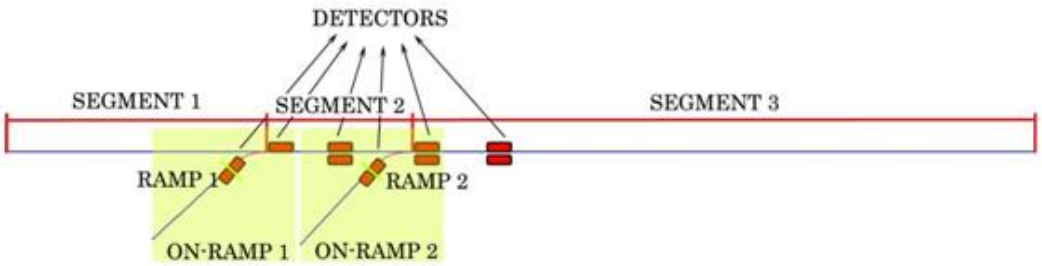

Figure 5 – Simulated road network

4. 2 Control logic for cooperative ramp metering

Used VISVAP module has a specific work logic. Every iteration of the simulation executes the control logic presented with the flowchart in Fig. 6 [9].

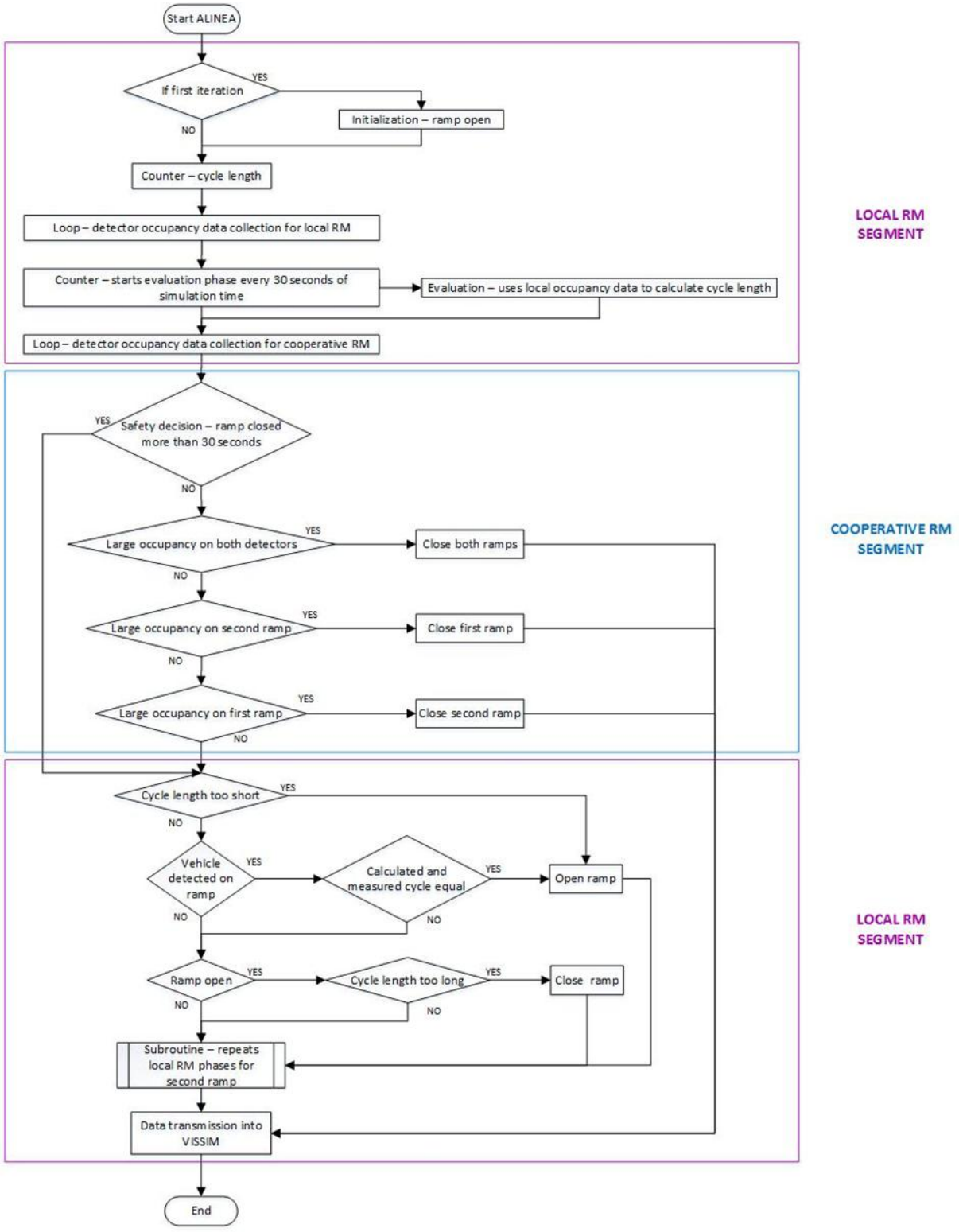

Figure 6 – Control logic framework for the ALINEA based cooperative RM

Only the first iteration uses the initialization phase to set all on-ramps to open. Initialization phase is used to prevent unnecessary waiting on ramps. First counter measures the traffic light cycle length while on-ramps are opened or closed. Every iteration increases this counter by 1. Second counter is used for the traffic light cycle evaluation phase that starts every 30 seconds. This process of evaluation uses local RM data only. First loop collects information about detector occupancy for both lanes. Data collection is carried out in every iteration and collected data are used for local RM. These data are used to obtain the cycle length according to equation 2. The algorithm compares both, calculated and measured cycle length to open or close the on-ramps depending on their mutual ratio.

As the next flowchart segment comes the second loop that collects detector occupancy data for cooperative RM. Cooperative RM has priority over local RM and therefore the algorithm can skip the local RM segment when the cooperative segment is active. This is also the beginning of the cooperative algorithm part. First there is a safety decision that prevents that the on-ramp is closed for too long. Main goal is not to exceed the maximum wait time calculated for real-time traffic flow. Right after the safety decision, the algorithm starts to check conditions regarding the occupancy of both detectors on the mainstream. If both mainstream detectors are largely occupied, the algorithm closes both on-ramps. If only the first detector is largely occupied, the algorithm closes the second on-ramp to prevent the creation of a bottleneck on the mainstream. The same logic is used when only the second detector detects large occupancy. Only this time the algorithm closes the first on-ramp. The cooperative RM segment of the flowchart ends with this condition.

Last segment starts with the cycle length decision. If the cycle length is too short, the on-ramp is opened and the algorithm starts the subroutine phase. However, if the cycle length is not too short the algorithm checks for vehicle presence on the on-ramp. If there is a vehicle detected, and the calculated and measured cycle are equal, the algorithm opens the on-ramp and immediately starts the subroutine phase. Otherwise, the algorithm starts the third decision branch where the on-ramp closes if it is currently open and the cycle length is too long. After that the subroutine phase is invoked. Mentioned subroutine phase repeats the whole local RM segment for the second on-ramp. Last step of the algorithm sends values of every variable into the VISSIM simulation module so it can compute the next iteration of the simulation.

5. SIMULATION RESULTS

The proposed framework was tested using the above described simulation model and control logic. Three different scenario with the same traffic demand data were used to evaluate the influence of local and cooperative RM. Obtained results where compared according to average speed and travel time on the mainstream. Used traffic data and results are described with more details in continuation.

5. 1 Traffic data and simulation scenarios

To obtain realistic simulation results of the implemented local and cooperative RM algorithm, the simulation model used traffic flow characteristics, which contain low and high traffic demand, as presented in Fig. 7. Traffic flow on the mainstream is changing like in real world situations while traffic volume for both on-ramps was set to constant values to simulate a rush hour situation. During rush hours there is a common situation that the on-ramps have long queues of vehicles giving constant inflow to the mainstream. Simulation time was set to 1 hour and mainstream traffic flow changed every 5 minutes. Mainstream flow starts with a

value of 2000 veh/h, after 30 minutes it reaches its peak of 7000 veh/h and starts to decrease. Traffic flow for the first on-ramp was set to 1500 veh/h and for the second to 1100 veh/h.

To test the implemented framework, simulations of the same urban highway model where conducted using three different scenarios. First scenario represents a traffic situation without RM applied. In this scenario, vehicles from the on-ramps have to merge with the mainstream without any help from a traffic control system. The second scenario uses local RM to alleviate the congestion on the highway by limiting vehicle inflow from the on-ramps. In the third scenario, communication between the two on-ramps was enabled to test the cooperative part of the implemented RM algorithm.

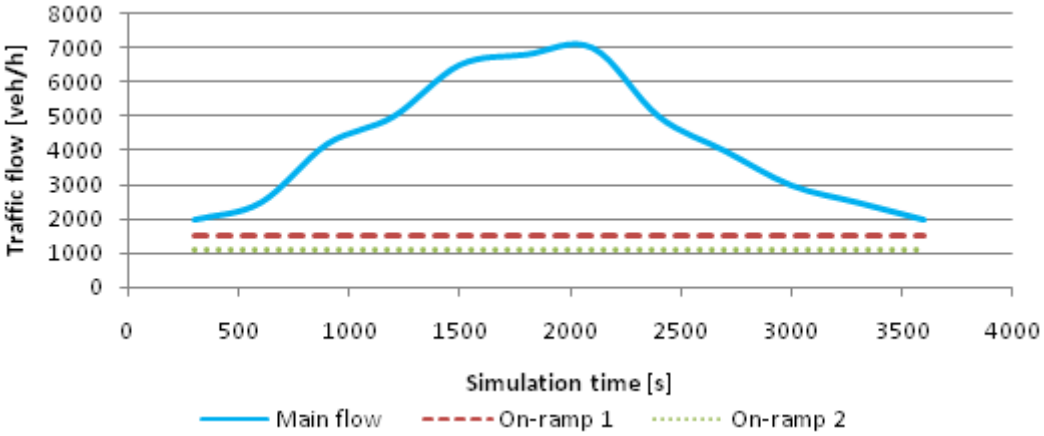

Figure 7 – Traffic flow characteristics for the mainstream and on-ramps

5.2 Obtained results and discussion

As denoted in Fig. 5 the modeled highway section is divided into segments. This enables better evaluation of simulation results using measurement data from the detectors in the simulation model and other data gathered by VISSIM. For example, average traffic flow speed can be gathered and analyzed for every lane separately. In Figs. 8 to 10 the average speed on the corresponding segments of the highway is given for the slow (right) lane. Same characteristics can be obtained for the fast (left) lane [9] but are not presented here due to page limitation. From these figures it can be noticed that application of RM increases the average speed on the first two segments. Thereby, cooperative RM shows a significant larger speed increase and a shorter duration of the congestion on the highway. Congestion starts later and resolves faster on the first two segments. This property can be detected by observing the moment when the speed begins to decrease significantly and the moment when the speed begins to return to its starting value. The third segment is located after the area where congestion happens so RM does not affect the average speed on this segment significantly. In this segment vehicles accelerate after they have left the congestion area and this behavior is the same for all scenarios.

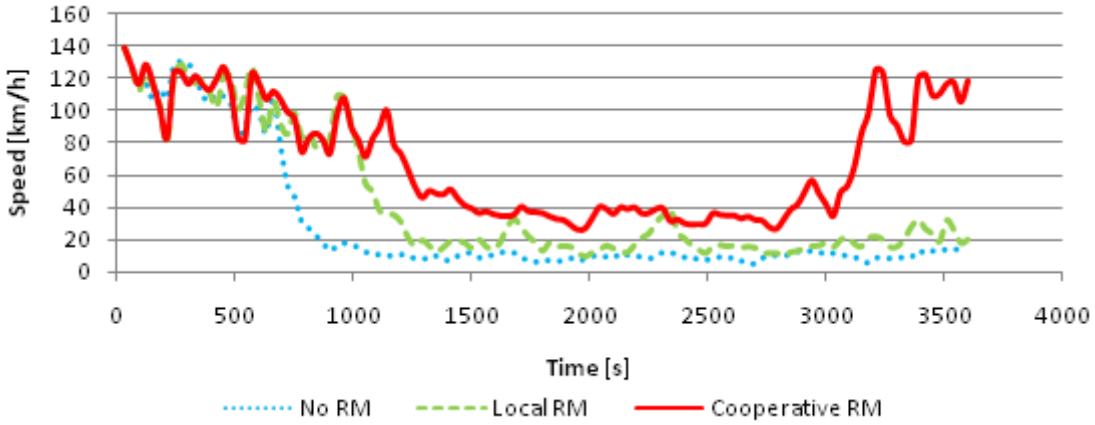

Figure 8 – Slow lane speed for the first segment

In Table 1 the average vehicle speed values are given for both lanes. It can be denoted that congestion significantly reduces the average speed on booth lanes. The speed drop is more profound on the slow lane that accepts the vehicles from the on-ramps. According to the results given in Table 1, one can conclude that RM can increase the average speed on the mainstream. This effect is even more pronounced in the case of cooperative RM. Similar result can be observed in Table 2 where average travel times for the mainstream for all three scenarios are given. The effect of smaller speed decrease and shorter congestion duration also significantly reduces travel time when cooperative RM is applied.

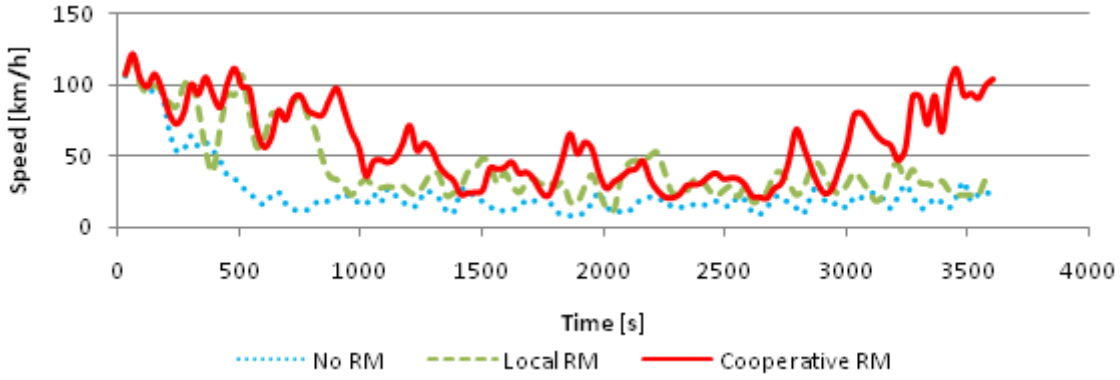

Figure 9 – Slow lane speed for the second segment

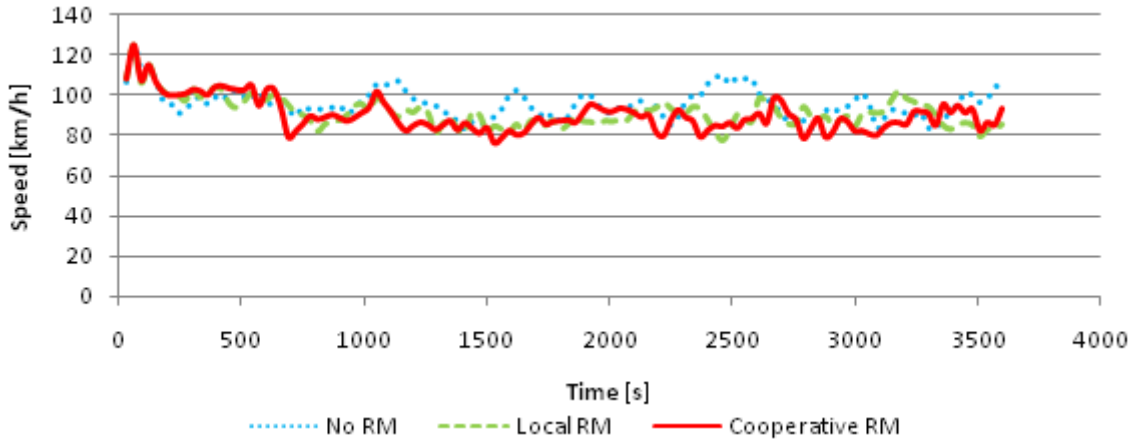

Figure 10 – Slow lane speed for the third segment

Table 1 - Average vehicle speed on the slow lane in km/h

Scenario	Segment 1		Segment 2		Segment 3	
	Slow lane	Fast lane	Slow lane	Fast lane	Slow lane	Fast lane
No RM	30.32	42.66	25.06	40.86	96.42	98.82
Local RM	44.00	53.74	43.66	53.45	91.24	93.46
Cooperative RM	69.11	72.54	59.44	67.01	90.26	92.14

Table 2. Average travel time on the highway

Scenario	Main flow
No RM	436.35 s
Local RM	380.86 s
Cooperative RM	263.59 s

6. CONCLUSION

In this paper a framework for simulation of cooperative RM for the microscopic simulator VISSIM is proposed and implemented. The framework consist of a road network model with corresponding detectors and traffic lights, traffic data for simulation and a control logic implemented in the VisVAP module. By adapting the traffic light signal plan and using only two phases (red and green) the simulation of RM is enabled. To test the framework a simulation model of an urban highway with two on-ramps has been created. Three simulation scenarios were defined and obtained results were compared according to average speed and travel time. Obtained results verify that the proposed framework can simulate RM systems and enable a deeper analysis of the implemented traffic control system prior its application on a real world system.

Future work on this topic will include augmentation of the framework with a module that enables implementation of advanced traffic control algorithms in the programming language C#. Additionally, variable speed limit control will be added into cooperation with the RM control system.

Acknowledgment

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ANALYSIS OF THE APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN PRODUCT PROMOTION AND SALES

ABSTRACT

Recent development of information and communication technologies increases the possibility of efficiency promotion and sale of products on the market. Web 2.0. technology based on HTML5 language allows customizing content for all currently available mobile devices that enables it. The above mentioned technology allows also, through its benefits, more effective overview of the content on the Internet browsers what makes the products and services more competitive. The paper is showing shaping the company's business model for the promotion and sale of dairy products. Based on the defined business model, the possibility of using information and communication technologies for business improvement is analyzed. Also, an example of the application of information and communication technologies in a defined business model is shown.

KEY WORDS

Web 2.0.; HTML5; e-bussiness; B2C; B2B

1. INTRODUCTION

Current development of information and communication technologies are assumption of more efficient development of all economic and social activities. Innovation originating in scientific knowledge, research and development is characterized as a high technological level, and dynamic market of electronic communications which are telecommunications basic determinant.

The application of information and communication technologies in the sales and promotion of products with a focus on products of the dairy industry will be investigated and described in this paper. It will also be described the application of a business model on the example of a company that specializes in sales of dairy products (primarily cheese). The aim of the research is to determine the effectiveness of the application of information and communication technologies in a defined business model.

The actuality of research is evident through a series of previous works published in this field. The study [1] shows the application of information and communication technologies in

enhancing the quality of life of blind and visually impaired persons. The paper provides guidance in the development and adaptation of web pages for the specified user group. The paper [2] explored the possibilities of online sales promotion and it sets theoretical model of relationship between sales promotion and encouragement of online and time and energy spent on the website searching. The level of risk of B2C model, security purchases through the e-business and the way in which companies can reach a competitive advantage in the market are presented within research [3].

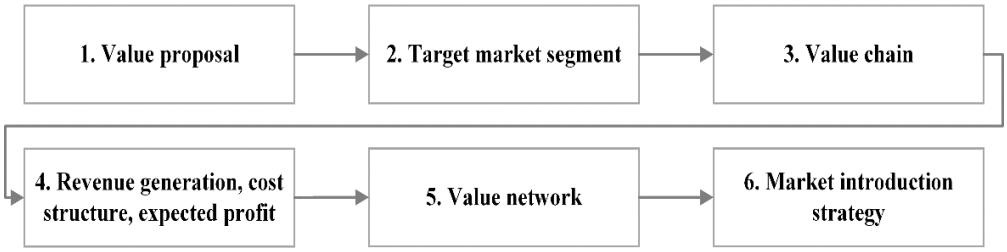

Figure 1 - Design of business model

Method of forming a business model according to Henry Chesbrough and Richard Rosenbloom, shown in Figure 1, is suitable for technological innovation witch are described through six basic steps [4]:

- Definition of the product or service and its value to the consumer,
- Target market for that product or service is intended, with the estimated size of the market and target market share,
- A description of the value chain necessary for the product or service, with the main elements of costs,
- A description of the structure of costs and potential revenue and profit of the product or service,
- The necessary arrangements with suppliers, partners and complementary to market participants and
- Draft strategy for the introduction of products or services on the market, as well as the actions necessary to achieve the desired position, with their estimated costs.

The final step is defined strategy ways of introducing products or services on the market [4], [5]. A business plan is a reflection of the business model in time and defines the way the company wants to make a profit.

In this paper, will be shown an example of the possibility of application of modern technologies to improve the functionality of the company's business for the promotion and sale of dairy products.

The goal of business model is to provide efficient access to products as well as help in choosing them by means of e-business.

2. METHODOLOGY OF RESEARCH

By analyzing the functionality and characteristics of current web technologies for the promotion and sale of dairy products, architecture information and communication system will be recommended. The proposed architecture will be based on Web 2.0 technology and uses all the advantages of HTML 5 programming language. The analysis comparing the

capabilities of native and mobile web applications in Table 1 shows the advantages and drawbacks of different versions.

Table 1 - Advantages and drawbacks of developing web technologies

Methods of web application development		
Characteristics	**Native applicative solutions**	**Web solution based on HTML5 language**
Cost	High initial cost and ongoing investment.	Modest initial investment.
Portability	Separate version required for each operating system.	Easy creation of cross platform versions.
Maintenance	Complex to maintain and slow to roll out changes.	Relatively simple to maintain with instant updates. Easy
Speed of Delivery	Starts from scratch, slow to develop, and requires a lot of testing.	Starts from scratch or optimized from desktop solution. Moderate time to develop; requires a lot of testing.
Performance	Runs locally with quick loading and fluid interaction.	Internet reliance results in slower load and response.
User Experience	Made for mobile: smooth, fast, and intuitive to use.	UI performance is slower and normally optimized from desktop, so less satisfying.
Integrated Device Features	Integrates with all device features and other apps.	Very limited device integration. from
Push Notifications	Cost-free notifications can be sent directly to users' devices in real time.	Not possible.
Offline Features	Best support for offline features, native data storage.	Limited offline support.
Future Proof	Native apps can take advantage of device innovation instantly.	Slow or impossible to adopt device innovation.
Cost	High initial cost and ongoing investment.	Modest initial investment.

Source: [4]

The development of e-business based on HTML5 technology can make products and services more accessible to users. Different types of mobile devices and the supported operating systems can make native applications more efficient in promotion and sales of dairy products.

In the research the analysis of the effectiveness of business models using HTML 5 technology will also be presented.

3. ANALYSIS OF THE APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE PROMOTION AND SALE OF DAIRY PRODUCTS

One of the key parameters of the decision on the introduction of modern information and communication technologies in the distribution process is the dispersion of the distribution area. In this study, analysis was carried out for the territory of Bosnia and Herzegovina, which has an extremely unfavorable dispersion of business objects that are found in many smaller towns. Among these towns is a significant geographical distance, but also extremely inadequate infrastructure routes, making it difficult and significantly more expensive distributive role in this market.

During the introduction of information and communication technologies in the distribution process is necessary to pay attention to the current institutional, infrastructural and other specifics because it is impossible to apply the positive achievements from other locations.

Thus, the fundamental suggestions for all decision-making regarding the application of information and communication technologies monitor progress and constantly studying the results of research in other markets. Finally the introduction and maintenance of such systems is, due to high costs of implementation, development and further improvement of technology, still necessary to put in the relative ratio together with other parameters such as the amount of salaries, cost of maintenance of information systems, the projected savings etc. An important paragraph in the introduction of information and communication is adequate readiness, particularly in infrastructure and human resources, since the implementation of the software without the appropriate standards in storage and logistical capacity or with a lack of expert knowledge responsible personnel makes little sense [4].

3.1 Analysis of the current business model

Key segments of the business model is to allow the user evaluation of products or services depending on user needs. The user will select a particular product or service if [5]:

- Thus achieves greater benefits (example - a better quality of service),
- Achieves the same benefits, but at a lower cost and
- Remains loyal.

The product or services are differentiated if the user perceives a higher and / or a new benefit in the use of that product or service. Differentiation can be achieved in the following ways:

- The introduction of new products and services,
- Improving of existing or adding new features product or service,
- Highlighting the reputation of the trademark,
- Building a wide network of users,
- The timing of entering the market,
- Segmentation of markets and selecting target markets and
- The establishment of support services and maintenance.

Because the business is conducted in the time of development of modern technologies, innovations are an important prerequisite for business success, and survival in the market. As the possibility of the application of modern technology in today's business is introduction of online orders and sales of certain items (dairy products).The market is divided into segments within which individual user groups have homogenous needs and between them there is no overlap of needs. Most often are analyzed the needs of the market segment. Sometimes the products or services which is being developed for the entire market is adjusted to the needs of a particular market segment [5][6]. An example of segmentation of the market in terms of users is shown in Figure 2.

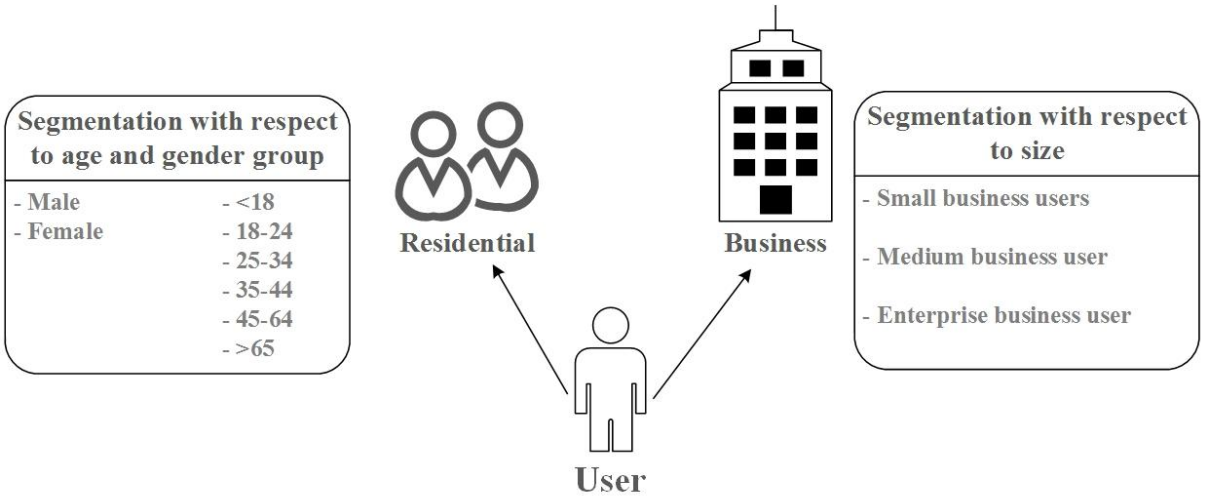

Figure 2 - Example of market segmentation

For an innovative product or service it is necessary to determine the relationship to existing products or services on the market.

New product or service may be independent of existing products or services. If they are dependent on each other can be a substitute or complement of another product or service [5].

3.2 The value chain of information and communication technology

Basic value chain of information and communication technologies includes elements shown in Figure 3 [5]. When developing a business model for a new product or service (promotion and distribution of dairy products), the company may include all or only certain elements of the displayed value chain. Defined in this way, the value chain is called the internal value chain.

Figure 3 - The elements of the value chain

According to the above image elements of the value chain include:

- **Content** - offer of dairy products from different manufacturers that are offered to users of the e-business,
- **Services / applications** - a unique interactive interface based on the principles of e-business,
- **Server** - service models based on the concept of cloud computing,
- **Network** - a network infrastructure that includes all the relevant factors of the system,
- **The customer premises equipment** - a mobile terminal devices and computer equipment for access to services and
- **User** - all interest groups.

New product or service should be evaluated in terms of the existing value chain in order to define possibilities of expanding the application of new services or products.

4. THE APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES FOR IMPROVING BUSINESS EFFICIENCY

The introduction of information and communication technologies in businesses, particularly those with activities in the field of production and distribution of dairy products, brings many benefits and offers a lot of advantages:

- Increase the speed and accuracy of logistics operations,
- Reduction efforts of employees,
- Improving control of operating,
- Improve capacity utilization storage and equipment,
- Reduction of needed inventory in stock,
- Reducing the cost of storage and
- Reduction of paperwork.

The objective of the business model, shown in this study, is to allow easier access to the products and the provision of information by using e-business model. Through Web access, users can find information about suppliers, as well as the full range of products. It gives customers the ability to order online, payment can be made via the electronic enrollment data from the credit card customer, until the entire purchase process ends with the delivery of the product in the shortest possible time, with the majority of the activities carried out automatically, without human intervention.

4. 1 Web 2.0. technology

During the development of e-business of company it is necessary to observe the rapid growth of the use of mobile devices. According to a study [7] 80% of users access the Internet has a smart mobile device, as shown in Figure 4. In order to maintain the competitiveness of the company in the market and increase the number of users and customers is a key step is the development of support for the e-business and through various platforms for mobile terminal devices.

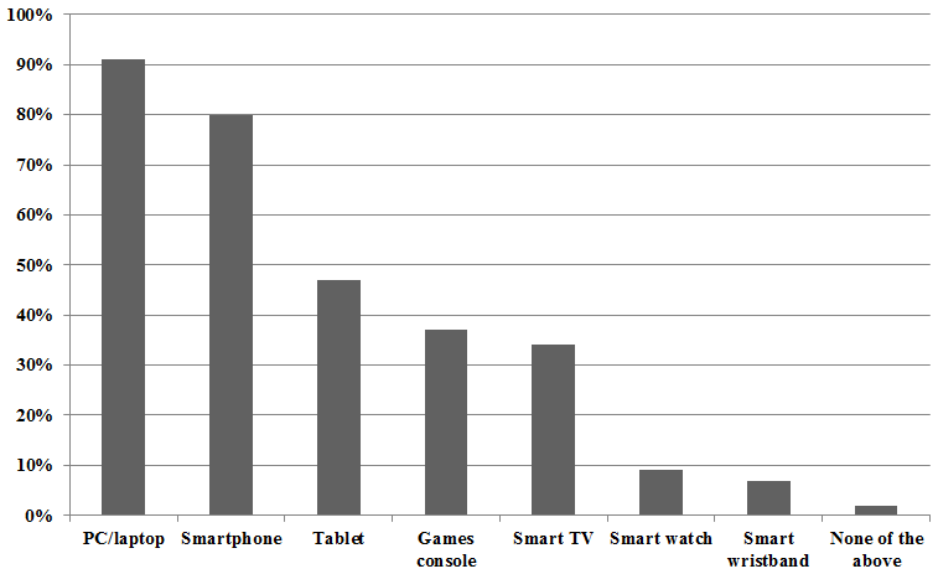

Figure 4 - The used terminal devices of users with internet access [7]

During the development of e-business support for multiple mobile platforms is essential to use advantage of HTML 5 language that enables responsive design available for multiple device types (desktop, smartphone and tablet).

Customizable or responsive website design does not require making a number of different models for different devices and device platforms. Adjustments to various devices (screen size) is needed, which does not include the added expense of all the different devices, but the cost depends on how your page is demanding (complexity, variety of content and capabilities required) detail is shown in Figure 5.

Figure 5 - Adjusting content to customer equipment

Everything you see on the monitor of desktop computer or laptop is also visible on your cell phone or tablet, but adapted to their screen size. The content of information affects the efficiency of search engine optimization - SEO module that also allows the objectives of the company and the market, all with the goal of more efficient promotion of products.

Web solutions based on HTML5 language are independent of the platform and are developed by traditional Web programming, which makes them more affordable for business.

4. 2 The model of e-business distribution and marketing products

More efficient distribution and promotion of dairy products is possible by using Web 2.0. technology. As one of the e-business model in this paper is a web interface based on Web 2.0. technology. Figure 6 shows the graphical appearance of a web model for the distribution and promotion of dairy products for Bosnia and Herzegovina (LiSIR).

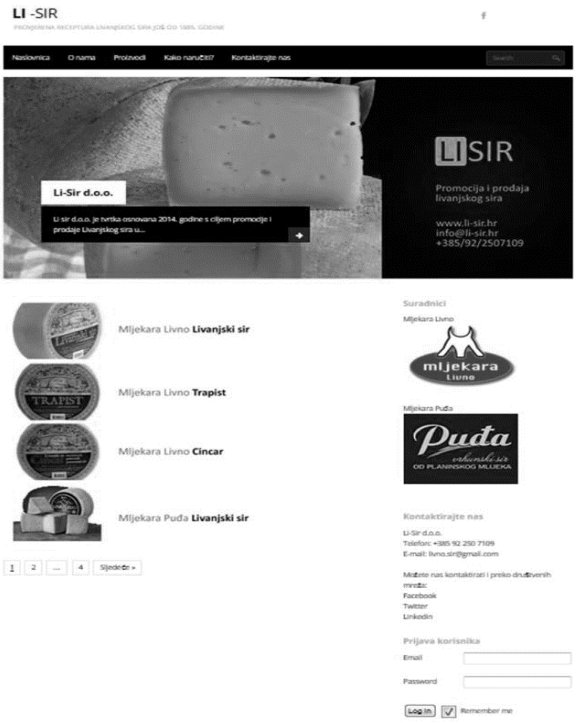

Figure 6 - Web 2.0. interface company for distribution and promotion of dairy products

Website is divided into five main segments: Home, About Us, Products, How to order and Contacts. The site is developed by HTML5 technology, PHP 5 programming language and CSS3 elements for graphical planning, and for the database MySQL server is used.

On the home page there are basic information about the company, news and current affairs in their business. Also can be found the registration form for all clients who wish to be registered users, and product's order form.

A large number of users of social networks is enough reason to create company profiles for the purpose of advertising. Therefore, in order to promote company created profiles, currently, the most frequent social networks Facebook, LinkedIn and Twitter.

New and innovative forms of promotion are key to attendance of the company's website which also has a positive effect on sales of the product. Native or organic promotion is one of such forms which includes native promotional formats designed for targeted platforms that take advantage of the ways to use them. An example of such forms of promotion is reflected in the use of "sponsored announcement" on the Facebook platform. Insurance company Standard Life is applying this form of promotion on the Facebook social network has achieved a 100% increase in attendance sites compared to standard ways of promotion [8].

Cancellation of purchase represents a significant problem in terms of loss of income. According to a study [9] 70% of all online purchases canceled for the following reasons, shown in Figure 7:

- Unexpected delivery costs,
- The need to create a new account,
- Conducting research,
- Safety issues related to payment,
- Unclear checkout and
- Difficulty of finding coupon code.

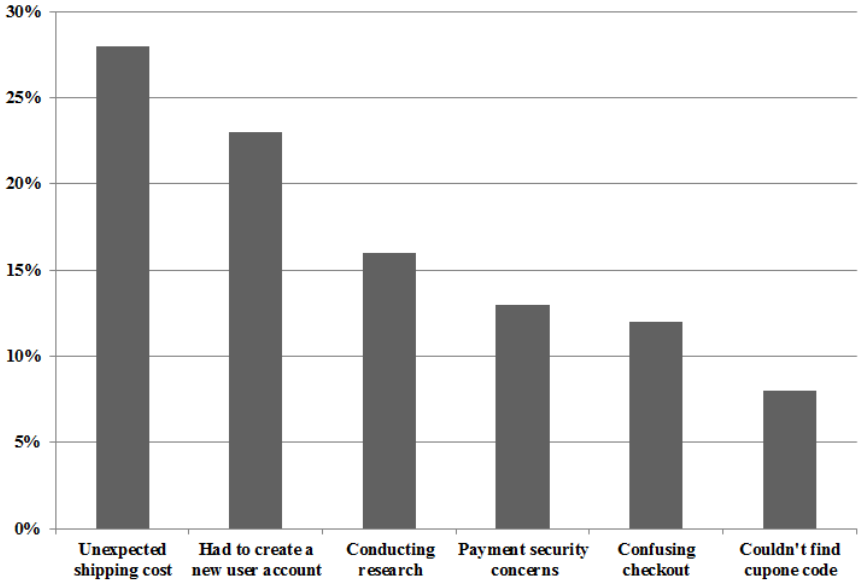

Figure 7 - Reasons for cancellation of the online purchase [9]

These problems can be avoided or reduced access which includes the use of carefully selected methods. Some of these methods are [9]:

- Application of interactive tools such supports in deciding whether to buy,
- Improving the functionality of search and
- Providing policy of purchase and assessment of total cost as early as possible in the process of buying a product.

In addition to these methods can be applied to the following:

- Provide opportunities for registration without the need to create a new account using the application possibilities of already existing accounts created on one of the more representative online platform (eg. Google, Facebook, LinkedIn)
- Special attention should be paid to safety issues, as a key factor of e-business. The required level of security system should be achieved by implementing multi-layer security model using the following mechanisms:
  - Encrypting the entire client-server communication
  - The implementation of two-factor authentication
  - The implementation of internationally recognized standards and recommendations of information security such as ISO / IEC 27001, 27002, COBIT, TM Forum, etc.
  - Connect the platform to implement online payment with a high level of information security implemented (for example. PayPal)
- Development of an intuitive interface to effortlessly use the Web or mobile applications

According to the above, it is necessary to consider many factors and manage them carefully in order to reduce the number of canceled purchase of products in order to achieve higher efficiency of online sales.

5. ARCHITECTURE OF THE SYSTEM BASED ON COMPUTING IN THE CLOUD

For described solution, architecture of the system based on computing in the cloud is proposed. Information provided by the interactive interface is created from all interest groups and suppliers of dairy products (Figure 8). Social networks are an important part in the process

of promoting new products so their integration is also a necessity. Attractive ads on portals social networks can create more effective online sales.

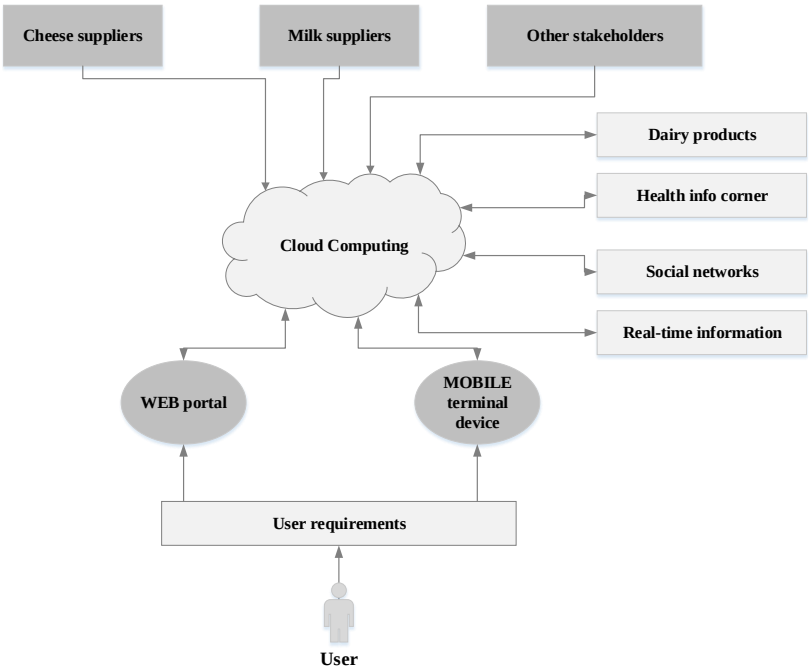

Figure 8 - Architecture LiSir system for the distribution and promotion of dairy of products

CC platform can be described through five basic characteristics, three models of services and three different implementation models [10]. Five basic characteristics are described as follows:

- *On-demand self-service*. A consumer has unilateral provision of computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service's provider.
- *Broad network access*. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., smartphones, tablets, laptops, and workstations).
- *Resource pooling*. The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or data centre). Examples of resources include storage, processing, memory, and network bandwidth.
- *Rapid elasticity.* Capabilities can be rapidly and elastically provisioned, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.
- *Measured Service.* Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

The most significant possibility in case of *CC* platform are the models of delivering the service. The mentioned models allow delivery of the defined aspect of computing as service. According to the mentioned literature three basic architectures of service delivery are defined: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). The mentioned service models have the following definitions [11]:

- *Software as a Service (SaaS*). The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a Web browser (e.g., Web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- *Platform as a Service (PaaS).* The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or -acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations.
- *Infrastructure as a Service (IaaS).* The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

CC platform can be implemented in three basic scenarios of service delivery [11]:

- *Private cloud.* The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.
- *Public cloud.* The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.
- *Hybrid cloud.* The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

By applying the concept of cloud computing the user is allowed the accurate and updated information regardless of the access technology use. Service Provider unique concept of promotion and distribution of products has no additional investment in the development of solutions dependent on specific devices. Described HTML5 technology by its responsive design allows that in the most efficient way.

6. CONCLUSION

New technologies are an important variable in economic growth. Investments in Internet technology and new business models allows the inclusion of companies in the Internet economy and create opportunities for development and growth of the business beyond the physical market. This is especially important for companies and economies that operate in the markets of limited size.

This paper has tried to answer the question of whether is possible this way of sale of dairy products, which are necessary investments in order to improve e-business and is it possible to follow the trends set by the major world markets. When the perception of people that shop online is changed it can save time and money, without having to think about risk of purchase on the internet.

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NEW DIFFUSION MODEL BASED ON THE TECHNOLOGICAL AVAILABILITY OF TELECOMMUNICATION NETWORK

ABSTRACT

Development and implementation of new telecommunication services require appropriate network support. Due to huge initial amount of capital expenditure costs network operators are faced with necessity to gradually building up their infrastructure. In this paper, we propose new forecasting model based on the Bass diffusion model with variable market potential that depends on the technological availability of telecommunication network infrastructure. The proposed model investigates the interaction between degree of infrastructure availability and diffusion speed. The model performances are illustrated by numerical example.

KEY WORDS

Bass model; forecasting; market potential; network infrastructure availability.

1. INTRODUCTION

The rapidly changing telecommunication environment and increasingly intensive competition indicate that operators must innovate in both their services and marketing strategies if they intend to continue prosperity. There are many factors why the forecasting results are necessary for decision-making. Particularly, the ability to accurately forecast the demand for new services is crucial when operators decide to allocate their network resources and development plans for services and productions. The decision to adopt some new telecommunication service may require considerable time and cognitive effort. However, in most cases potential users do not have sufficient knowledge to evaluate the advantage implied by a new service or technology compared to investment's risks. In addition, it is hard to acquire availability of new service for all users in the short term. The most telecommunication services have trouble in the first part of their life cycle, due to a limited knowledge about their features or even about their existence, prevent users to adopt them. The "word of mouth" communication has proven to be an increasingly powerful mean for the spread of information about a new service facilitating the way of communication, for example through the Internet, exchanging opinions, experiences and advices on new services or technology [1].

In order to forecast the adoption of new telecommunication service, diffusion theory is widely applied. The Bass diffusion model [2] is frequently applied in modelling and forecasting

diffusion processes in marketing research and other disciplines. It has been used to forecast sales of new services/technologies and it was proposed to deal with the problem of initial users. This modelling approach assumes that potential users become aware of an innovation by means of external events, for instance, marketing efforts. Bass introduced the idea of dividing the innovation adoption rate into two factors, one endogenous, usually called "imitation factor", and the other exogenous, and commonly referred to as the "innovation factor".

One of the main assumptions of the Bass model relates to the size of the market potential, whose value is determined at the time of introducing the new service and remains constant along the whole diffusion process. Building upon the Bass diffusion model, we proposed the new model with variable market potential that depends on the technological availability of network infrastructure. It is assumed that the availability of telecommunication network infrastructure is increased during the time according to the network investment. Those investments make influence to the market potential by creating conditions for more users to adopt some new service. By applying such modification of basic Bass model more accurate forecast could be obtained.

The rest of the paper is structured as follows. Section 2 describes the basic principle of diffusion theory. Section 3 proposes a modification of basic Bass model with the variable market potential based on the network infrastructure availability. Section 4 presents numerical example with different network availability parameters to test the performance of the proposed model. Finally, the contributions of this paper are summarized in Section 5.

2. DIFFUSION THEORY

The purpose of diffusion models in marketing is to estimate new service demand after provider's basic business decisions are made. In situation when manager's aim is to forecast demand before actual launch of the service, marketing research methods are used for determining the parameters of diffusion model. Diffusion models in marketing theory are first concerned with the possibility of estimation of new service diffusion rate. As they are based on different assumptions and on heterogeneous parameters, that is reflected in the complexity of their mathematical form.

According to diffusion theory, a new service's demand growth at any time largely depends on the strength of "word of mouth" from its previous adopters. Similarly, a service's sales growth should then depend on the extent to which it receives good "word of mouth" from its own previous adopters. An edited volume by Mahajan, Muller, and Wind [3] covers in depth various topics in diffusion models, such as estimation and applications. The paper [4] provides an excellent overview of the Bass model, its extensions and some directions for further research.

Historically, the deployment of new telecommunications services during the life cycle has taken years of effort and huge initial amount of capital expenditure. Development and implementation of new telecommunication services require appropriate network support. Thus, being able to predict the market acceptance before taking the business risk is critically important. Figure 1 represents a basic customer choice model.

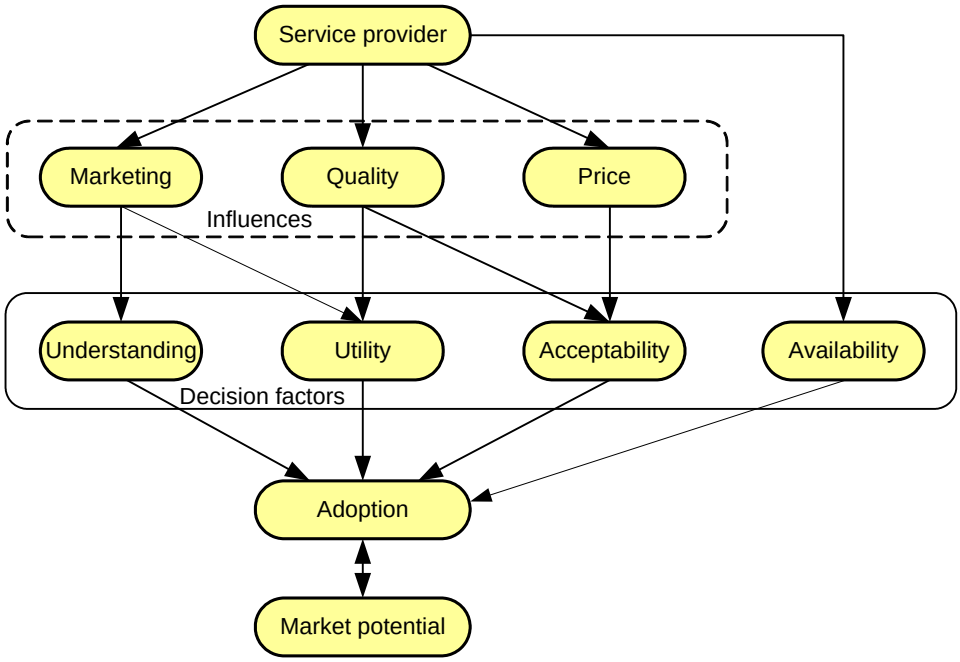

Figure 1 - A basic user choice model for telecommunication market

Three main service characteristics (understanding, utility and acceptability) made influence to the user's valuation of the new service and final decision about adoption. Understanding of new service may be affected by changing the actions of marketing. On the other hand the understanding of the service, greatly affect users who have already accepted a new service. Service utility is a factor that should include the actual need of users for the service, the importance of their work or daily life, the benefits that can be achieved by new service etc. The utility is affected by changing the quality of service and marketing functions controlled by the service provider [5]. The acceptability of the new service is affected by price and quality, which is controlled by the service provider, also. However, the availability of new telecommunication service is directly correlated with the development degree of network infrastructure.

Usually, the telecommunication network infrastructure develops gradually and has taken years of effort and large amounts of investment. Therefore, in addition to these well known three main service characteristics as decisions factors, we made extension of basic user choice model with the availability as the fourth service characteristics.

There are number of external influences such as culture, changes in price and quality equipment, competitive on the market, and so on. Despite the focus of these models on policy, they may also be used in forecasting, in part because of the transparent inadequacies of statistical methods [3].

The mathematical structure of the Bass model is derived from a hazard function corresponding to the conditional probability that an adoption will occur at time *t* given that it has not occurred yet. If $f(t)$ is the density function of time to adoption and $F(t)$ is the cumulative function of adopters at *t*, the basic hazard function underlying the Bass model is [2]:

$$\frac{f(t)}{1-F(t)} = p + q \cdot F(t) \tag{1}$$

From the differential equation (1) with the initial condition $F(0)=0$, it could be found the solution of purchase cumulative distribution function $F(t)$, cumulative demand forecast, i.e. forecasted number of users $Y(t)$, and non-cumulative adoptions $S(t)$ as follows:

$$F(t)=\int_0^t f(u)du=\frac{1-e^{-(p+q)t}}{1+\left(\frac{q}{p}e^{-(p+q)t}\right)}, \tag{2}$$

$$Y(t)=m_T F(t)=m_T\frac{1-e^{-(p+q)t}}{1+\left(\frac{q}{p}e^{-(p+q)t}\right)}, \tag{3}$$

$$S(t)=m_T f(t)=p\,m_T+(q-p)Y_{t-1}-\frac{q}{m_T}Y_{t-1}^2. \tag{4}$$

This model has three key parameters: the parameter of innovation or external influence, p, the parameter of imitation or internal influence, q, and the market potential, m_T. Parameter q reflects the influence of those users who have already adopted the new service/technology (i.e. "word of mouth" communication from previous adopters), while p captures the influence that is independent from the number of adopters (i.e. external communication). The sale at time t is $S(t)$, where m_T refers to the market potential for the new service/technology that could be reached at time T. These three parameters could be estimated using cumulative sales data. The size of the market potential, m_T, is probably the most critical element in forecasting matters and a reliable estimation of it should be necessary [6].

Bass model could be used to predict the timing and magnitude of the sales peak, and the shape of the diffusion curve. However, the most applications of the Bass model are used to make plans and decisions before the service/technology has been introduced to the market. Usually, no sales data exists with which to estimate p or q. Manager does not have an intuitive estimation of p and q. In such a case, Bass parameters could be evaluated in two manners.

One way is to use analogies with other similar services or diffusion process. The second way is analytical using comparative procedure with some other countries where a service/technology already exists, using ordinary least squares (OLS) multiple regression by equations (5–7):

$$s(t)=a+bY_{t-1}-cY_{t-1}^2, \tag{5}$$

where a, b and c are the coefficients that have to be calculated based on the regression analysis. For estimated value of market potential, m,

$$m=\frac{-b-\sqrt{b^2-4ac}}{2c} \tag{6}$$

the Bass model parameters of innovation p and imitation q, could be obtained by following equations:

$$p=\frac{a}{m} \quad \text{and} \quad q=-mc \tag{7}$$

If data sales do not exist, the market potential has to be estimated by taking into account different impact factors such as economy and social development of a particular area, the

presence of competitive services/technologies, the infrastructure investment strategies, etc. [7].

3. DIFFUSION PROCESS WITH VARIABLE MARKET POTENTIAL

One of the characterising assumptions of the Bass model relates to the size of the market potential, *m*, whose value is determined at the time of introducing the new service/technology remains constant along the whole diffusion process. The issue of a variable market potential is not new to the diffusion literature, see [8][9].

The market potential value has direct impact on diffusion process of a new service, in other words on parameters *p* and *q*. From a mathematical point of view there are different assumptions governing the shape of *m*(*t*). Almost, it is exogenously determined as a function of observed variables. Usually, market potential is likely to change with the influences of socio–economic factors, such as prices, number of households with special facilities, number of competitors, number of retailers, threshold probabilities, etc. Beside those values, the function of market potential in telecommunication, most of all, depends on the technological availability of the network infrastructure during the time. Therefore, gradually developing of telecommunication infrastructure made impact to the market potential and have to be included in the model throughout the network availability factor, $C(t,k)$, as follows:

$$C(t,k)=\frac{1}{1+e^{-kt}},\quad t=0,1,\ldots,T;\quad k\geq 0 \tag{8}$$

where *k* is the parameter related to the rate of network infrastructure up building.
Therefore, the market potential varies during the time as follows:

$$m(t)=m_T C(t,k) \tag{9}$$

where m_T is the market potential at time *T*.

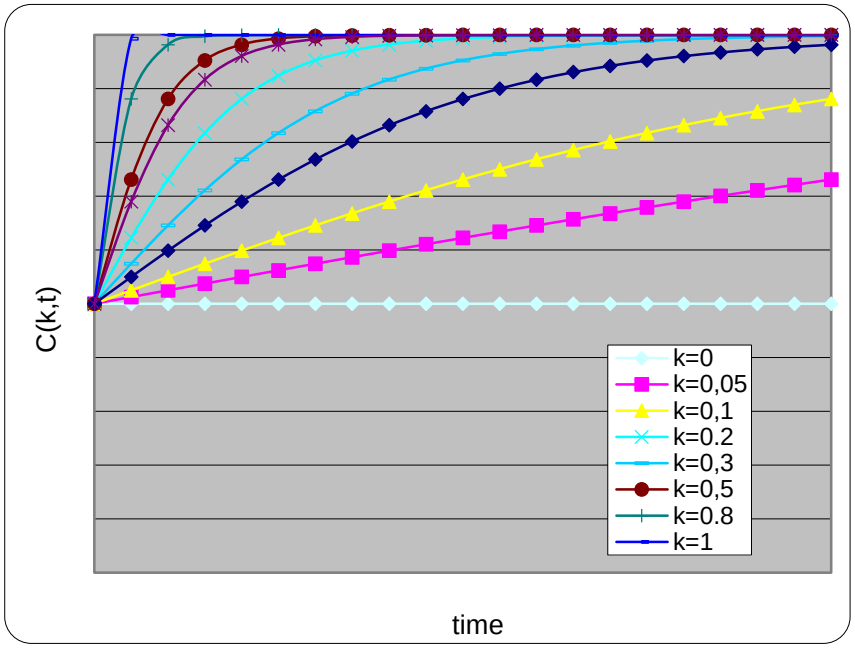

Figure 2 - The network availability factor

Figure 2 illustrates variations of the network availability factor, $C(t,k)$, during the time, for different values of parameter *k*. This parameter reflects the gradual building of telecommunication network infrastructure to support a new service.

It is assumed by equation (8) that 50% of total network infrastructure is available in the time of new service starting. It could be seen that for larger values of parameter *k*, the market potential, m_T, is reached earlier. If this parameter get large enough then the market potential becomes nearly constant.

The proportion of adoptions *Y(t)* provided by equation (3), describes the dynamics of the diffusion process, in terms of adoption parameters, *p* and *q*. We also can refer to the absolute scale representation that is to the number of adoptions, Y (t), just multiplying equation (3) by the market potential mT acting as a scale parameter. Since we defined the variable market potential, *m*(*t*), by equation (9) its structure has to be incorporated into the Bass diffusion model:

$$\begin{aligned} Y(t) &= m(t)\,F(t) = \\ &= m_T C(t,k)\frac{1-e^{-(p+q)t}}{1+\left(\frac{q}{p}e^{-(p+q)t}\right)} = \\ &= \frac{m_T}{1+e^{-kt}}\frac{1-e^{-(p+q)t}}{1+\left(\frac{q}{p}e^{-(p+q)t}\right)} \end{aligned} \tag{10}$$

The diffusion curve depends on the estimated values of parameters *p*, *q* and m_T.

4. NUMERICAL EXAMPLE

The major property of the proposed model is that it considers logistic growth of market potential depending on the technological availability of network infrastructure. The long-term forecasted cumulative number of users for different network availability parameter *k* is illustrated by Figure 3. Forecasting is performed for entire new service life-cycle, starting with service launching, through the rapid growth phase, up to the service saturation level. The proposed model attempts to forecast how many users will eventually adopt the new service or technology and when they will adopt it. The question of when is very important, because answers to this question guide the operator in its deployment of network resources and minimization of the business risk.

This model could be convenient to apply for services or technologies deployment where necessary new network infrastructure is needed, such as: IPTV, Fiber-To-The-x, cable TV, cellular networks, etc.

Initially, in order to forecast the total number of users we have to estimate the required Bass diffusion parameters values. For this purpose we used the values of Bass diffusion parameters (*p*=0.0014 and *q*=0.11). The low value of the innovation parameter is obtained as a result of the weak advertising efforts and slightly higher price than the competitive services. By introducing parameter of network infrastructure availability, we could more precisely forecast diffusion speed. We present this effect using five levels of the network availability parameter, *k*. Depending on these values the slopes of the curves are different and the market saturation is reached faster or slower. The value of this parameter is determined based on the planed network investment strategy.

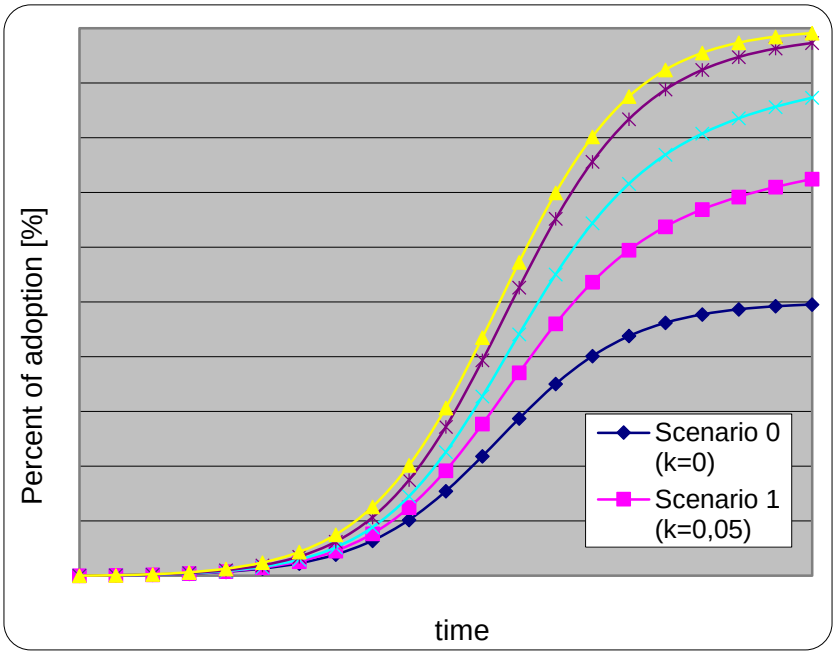

Figure 3 - The forecasted number of users for with different network availability parameter

By Figure 3, it is possible to analyse the impact that the network infrastructure availability has on the new service adoption process. The basic Bass diffusion model considers the fact that all potential users have the possibility to adopt a new service. However, the gradual building of the telecommunication network infrastructure to support a new service takes time. Beside, some operators can afford more investments than others.

5. CONCLUSION

Telecom service providers need to progress quickly and effectively to compensate the reduction of traditional revenue and meet users demand for new services/technologies. Wide-ranging market research have to determine which future services will be the most profitable, how to use efficiently the existing network infrastructure and where to make the key investments necessary for long-term success. This paper proposes a modified diffusion model for new service adoption with the variable market potential that depends on the network availability. This modification has to provide more accurate forecast compared with the basic Bass model, which assumes fixed market potential. It is particularly suitable for new telecommunication services or technologies. Additionally, paper analyzes the several possible scenarios of new service adoption process in the market based on the estimated diffusion parameters and network infrastructure availability.

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REVERSE LOGISTICS ACTIVITIES IN WASTE MANAGEMENT

ABSTRACT

The purpose of the waste management is to ensure a safe and technically appropriate waste processing without endangering the environment and to obtain materials quality for the benefit of possible reuse. The basic requirements of a good waste management system include organizational and technological concepts adapted to the requirements of involved parties and legislation, appropriate processes, accurate documentation, up to date records with regard to the amounts and detailed specifications, appropriate storage, all in primer focus for reducing the amounts directed to landfills. One of the main goals of reverse logistics is to provide processing for return, accompanied with proper reverse logistics activities where some of the benefits are reducing costs, reuse, minimizing amounts directed to landfills, etc.

This paper deals with the question of current organizational issues of waste management and usage of reverse logistics activities while processing waste.

KEY WORDS

Waste management; reverse logistics activities; green supply chain; sustainability.

1. INTRODUCTION

In today's market, designing a green supply chain cannot be specified on one of the points in the chain and it includes ecological approach through different aspects of "consumers meeting goods." To achieve improvements, green logistics must be a collection of organized and integrated activities in the whole supply chain, focused on creation of sustainable and upgradable green network in everyday life. Also, greening environment with reverse logistics activities that are set of approaches with aim to reduce amounts directed to landfills directly can be also observed and implemented in waste management systems and often are already significant foundation and part of a developed waste management system.

To define and organize right set of reverse logistics activities is a challenge on individual basis. Regarding waste management, different countries have even inside their regions different organization of waste collecting, with different raw materials as output of waste recycling. Different organization, results in different amounts that are reused, recycled and directed to landfills which will be presented in the paper.

2. GREEN LOGISTICS CONCEPT

Green logistics is a concept whose beginning is marked by the publishing of the first scientific article on the topic of the impact of logistics on the environment in 1950, while further research on this topic is dating back to the next decade. Today, the term of green logistics refers to all activities related to reducing the negative impact of logistics on the environment, where research is usually divided into several areas as reducing the impact of transport on the environment, reverse logistics, city logistics, logistics in corporate environmental strategies and management of green supply chains.

Over the decades, supply chains went through changes, starting from the level of a competitive market, globalization, service response, up to a demanding customer. Today the green supply chain requires an environmentally friendly product, which will ensure the appropriate disposal of reusable materials, parts or complete product. [1]

According to the most accepted definition made by Brundtland Commission, sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". [2] Sustainable development can be achieved by implementation of green logistics activities and strategies consisted of all activities related to the eco-efficient management of the forward and reverse flows. [3]

Operations within the supply chain, because of its complexity, result in different effects on the environment, which includes air pollution, noise, accidents, vibration etc. When measuring the impact of logistics on the environment there are usually two different aspects taken in consideration, the primary and the secondary. The primary aspect includes pollution directly related to freight transport, storage and manipulation. The secondary aspect arises indirectly from logistics operations and is visible in various forms which include the construction of infrastructure due to globalization and market needs. [4]

3. REVERSE LOGISTICS

Reverse logistics is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.

The issues of reverse logistics are still considered an area that is essential to research, with a final objective to optimize the entire supply chain. The difference between developed and developing reverse logistics systems implies the level of organization, uniformed procedures, implementation and organization of reverse logistics channels and activities, and continuous analysis. [5]

Typical reverse logistics activities are processes a company uses to collect used, damaged, unwanted or outdated products, as well as packaging and shipping materials from the end user or the reseller. [6]

Main reverse logistics activities include:

- **Refurbish-** most of the structure of the product is untouched, the product gets its "as new„ condition by some cosmetic changes such as minor repairs, new paints, cleaning, removal of stains, scratches, etc.
- **Recondition** – product overhaul, but not manufacturing process. The basic structure remains the same, but the worn out or failed parts are removed or replaced with new ones.
- **Repair** – Replacement of faulty or failed parts to make the product usable again

- **Disassembly** – Removal of parts from used products without damaging the parts. These parts are later reused or recycled, the rest of the product being either recycled or disposed.
- **Reuse** – use the product again without any alterations (includes transport packaging)
- **Recycle** – collection of used and faulty products so they can be used again, either in the same form or in a different form.
- **Disposal** – directing to landfill after only non-salvageable material is left.
- **Recovery** – is the operation of waste management that includes certain activities of reverse logistics with which raw materials and energy is obtained for the purpose of economic and environmental benefit.
- **Remanufacturing –** similar to refurbishing, but requiring more extensive work; often requires completely disassembling the product.
- **Resell –** when a returned product may be sold again as new [6] [7]

One of the issues in the field of reverse logistics are existing recycling programs insufficiently introduced to the everyday consumers. Consumers are interested in participation and actually very concerned in environmental problems but also often do not understand the needs, challenges and importance of reverse logistics. [8]

4. WASTE MANAGEMENT ORGANIZATION – COMPARATIVE ANALYSIS

Conceptual differences of waste management, including usage of reverse logistics activities, will be compared through **Croatian, German, Austrian and Norwegian** waste management.

4.1. Waste management organization in Republic of Croatia

The principle of the waste management in Croatia is defined by different laws. The Law on Sustainable Waste Management regulates measures for reducing or preventing the harmful effects of waste on human health and the environment, it regulates waste management with the aim to use valuable waste properties. It applies in the order of priority as waste prevention, preparation for reuse, recycling, other methods of recovery, energy recovery and waste disposal. [9]

Each local government is obligated to adopt the Waste Management Plan for local government, and has to submit an annual report on the implementation. [10] The framework for the new plan for Waste Management Strategy, are the existing legislation and guidelines of the European Union. The Strategy includes an evaluation of the current situation in waste management, strategic and quantitative goals and measures to achieve these objectives, guidelines, investment estimates and sources of funding.

Coverage of population and municipalities by organized municipal waste collection increased from 86 % in 2004 to 96 % in 2010, which fulfilled the quantitative target for 2015 (90 %) set by the Strategy. [11]

Since the year 2011 all municipalities and cities have organized (on certain level) collection and disposal of municipal waste. In 2012 a total of 1,670,005 tons of municipal waste was produced. As Croatia has 4 253 000 inhabitants, it is about 390 kg per capita, i.e. the daily amount of waste per capita is 1.1 kg. In 2012, the separate collection took in 382 078 tons of municipal waste and 23% of which was directly sent to the waste recovery 247 026 tons including 3 018 tons of mixed municipal waste was sent to mechanical and biological treatment plants in Varaždin County. The national rate of municipal waste sent for recovery

was 15%, and the remaining amount of waste is temporarily stored or forwarded to landfills where they separate usable components and forward it to recovery. Many local governments still have not implemented separate collection of useful wastes from total municipal waste. The following table shows data on separate waste collection in 2012 by county. [12]

Table 1 - Municipal waste management in counties in 2012

County	The total amount of municipal waste (t)	Delivered to the landfill (t)	The share of municipal waste sent to landfills (%)	Directly referred for recovery (t)	The share of municipal waste is addressed for recovery (%)
Zagrebačka	76 258	72 046	94,5	3 548	4,7
Krapinsko-zagorska	28 050	25 841	92,1	1 834	6,5
Sisačko-moslovačka	55 514	54 295	97,8	1 204	2,2
Karlovačka	45 572	44 276	97,2	1 281	2,8
Varaždinska	35 406	28 279	79,9	4 775	13,5
Koprivničko-križevačka	19 844	18 113	91,3	1 687	8,5
Bjelovarsko-bilogorska	30 560	29 493	96,5	1 067	3,5
Primorsko-goranska	119 301	73 032	61,2	17 219	14,4
Ličko-senjska	23 117	21 565	93,3	1 550	6,7
Virovitičko-podravska	26 326	24 554	93,3	1 771	6,7
Požeško-slavonska	13 686	13 176	96,3	504	3,7
Brodsko-posavska	43 501	40 258	92,5	3 219	7,4
Zadarska	86 954	85 446	98,3	1 476	1,7
Osječko-baranjska	80 388	76 486	95,1	3 891	4,8
Šibensko-kninska	50 976	49 358	96,8	1 618	3,2
Vukovarsko-srijemska	41 193	40 387	98,0	806	2,0
Splitsko-dalmatinska	205 092	202 854	98,9	2 238	1,1
Istarska	107 627	99 754	92,7	7 300	6,8
Dubrovačko-neretvanska	67 955	63 424	93,3	4 532	6,7
Međimurska	18 081	11 810	65,3	6 072	33,6
Zagreb	295 293	270 084	91,5	25 152	8,5
additionally identified the amount	199 314	35 867	18,0	154 284	77,3
in total:	1 670 005	1 380 397	82,7	247 026	14,8

Source: The Municipal Waste Report for 2012

According to the data it can be concluded that the highest rate of municipal waste sent for recovery was recorded in the Međimurska County and it amounted to 33.6%, Primorsko-goranska County to 14.4% and Varaždin County to 13.5%. The smallest amount collected was in Splitsko-dalmatinska County. This can be seen in the following graphs. [12]

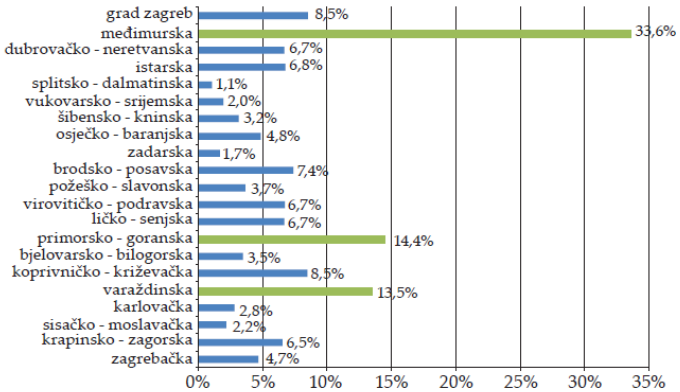

Figure 1 - Percentage municipal waste sent for recovery in 2012, by counties
Source: The Municipal Waste Report for 2012

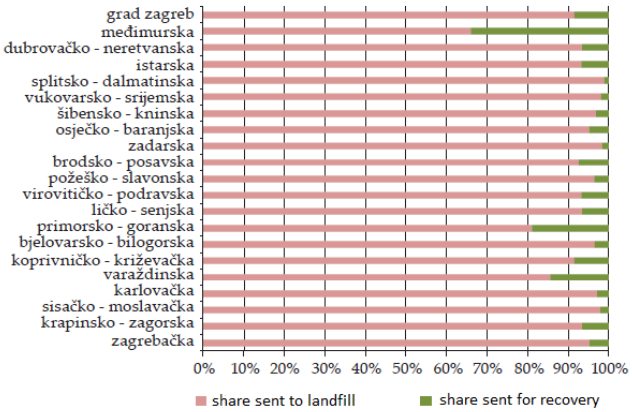

Figure 2 - Municipal waste management in 2012, by counties
Source: The Municipal Waste Report for 2012

The costs of waste management are mostly calculated according to the criteria of amount and properties of waste, applying the "polluter pays" principle. For municipal waste from households may apply other calculation criteria in accordance with the regulation governing utility. [10]

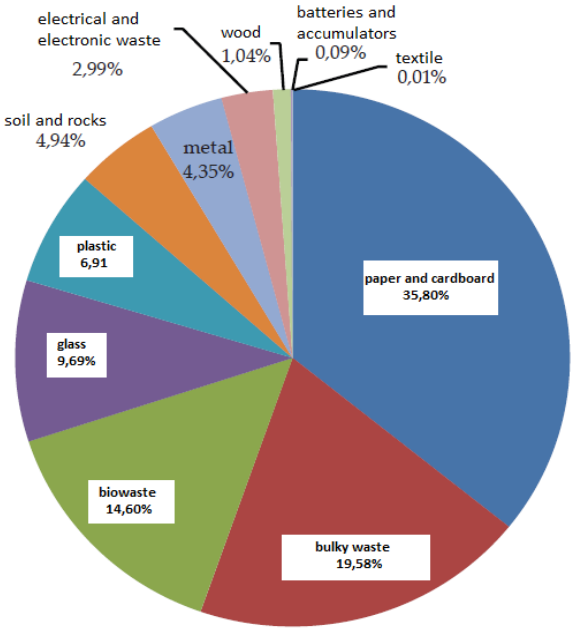

Figure 3 - Separately collected municipal waste in 2012
Source: The Municipal Waste Report for 2012

Of the total collected municipal waste for the year 2012 amounted to 382 078 tons, most of the waste sent to recovery was paper, metal and glass. The percentage of recycling of household and similar waste (paper, glass, plastic, and metal) for Croatia in the year 2012 amounted to 26.2%, or slightly more than half of the amount suggested by The Law on Sustainable Waste Management. Through the city/municipal recycling yards in the year 2012, according to reported data, past a total amount of 10 332 tons of municipal waste, most of it being paper, paperboard and bulky waste. [12]

4.2. Waste management organization in Norway

Norway is divided into five main regions, which are subdivided into 19 administrative regions or counties and 431 municipalities. A**c**cording to the data from 2013 with approximate population of 5 million. Waste management regards within the region Oslo and Akershus (which includes the capital city), Hedmark and Oppland region (located north of Oslo), Trøndelag region (located in the central Norway) and Nord Norge (the northern part of Norway). [13]

In accordance with the Norwegian law, waste management is the obligation on the municipal level, and it refers to the waste management of households, although throughout the agreements, municipal agencies may provide certain services related to waste management and business subjects. Regulation Act 2004 changed the responsibility of municipalities in relation to waste management, where before the application of the new legislation, municipalities were responsible for household and company waste. After 2004, municipalities are legally responsible only for the waste management of households, while the schools, restaurants, industry, etc., have the obligation to dispose of their own waste by themselves.

The waste management is financed 100% by the citizens as a non-profit service. The applied model is based on the "PAYT - pay as you throw" principle, and the customer has to pay based on the size of the container, with a starting price of 400 euro per year for 140 l waste per week. Use of the location for separate collection of certain categories of waste is free of charge.

All incomes and expenses are directed and expended from the municipal funds intended for waste management (Waste fund). Although there are features to make bigger profits, with the occasional deficit, it's mostly levelled, and operates as non-profit.

Households finance waste collection services by paying monthly fee, which for example in Oslo in 2011 accounted to 111 million dollars of municipal income (of which 7 million was the income from the sale of metals, paper, components, etc.), while expense, including the costs of storage, transportation and other activities for waste management accounted for 93.5 million dollars.

Waste management in Norway is focused on incineration and recycling, which based on the data from 2010 are in the ratio: 50% or 1 154 000 tons of waste that goes into the incinerator, 42% or 967 000 tons of waste that focuses on recycling, 6% or 137 000 tons directed to landfill. [13]

4.3. Waste management organization in Germany

In Germany, the responsibility for waste management and environmental protection is divided between the national government, federal states and local governments. Ministry of Environmental Protection defines priorities, proposes laws and cares for strategic planning, information and public relations, and also defines the conditions that the facilities for processing and disposal have to meet. Each of the 16 federal states brings its act on waste management and to develop its own waste management plan (germ. Abfallwirtschaftsplan) for their own waste. The Act on waste management is built on the national law and contains the regulations through which the draft of the concept of the regional waste management and regulations on conditions of waste disposal are defined. There is no planning waste management at the national level, but each develops its waste management plan for its area. [14]

Each local government determines the frequency of waste collection and transportation. The same is obliged to promote the ways of preventing waste and recycling, and makes decisions about the planning, construction and operation of facilities for waste disposal.

National Act for the management and disposal of waste in Germany is the Law on recycling and waste management which regulates the area related to waste management.[15] This act was passed in 1994, and in accordance with the European Directive on Waste (2008/98 / EC) amendments were made in 2012. With it five-steps of waste management were defined: prevention of waste, preparation for reuse, recycling, energy recovery and disposal.

Germany was among the first countries in the EU which has already started in 1990 to introduce the policy of limiting the amount of waste directed to landfills. These measures include the separation of packaging waste, bio waste and paper. The result was that by 2001, Germany has recycled approximately 48% of municipal waste; about 25% was directed to landfills, and about 22% was incinerated. In 2010, the level of recycling has increased to 62%, and about 37% of waste was incinerated. With that the amount of waste directed to landfills was reduced to minimum. [14] The reason for the drastic reduction in the amount of waste directed to landfills is a ban on disposal of untreated waste to landfill (since 1 June 2005), which resulted in an increase of the recycled waste and recovery.

Germany was the first EU country that in 1991 introduced the responsibility of the manufacturers with the Law regarding packaging waste, which is also one of the reasons that have contributed to today's results. [14] According to the principle of producer responsibility, each producer is responsible for the proper handling of their waste and is obliged to deliver their waste to an authorized person. Exceptionally, manufacturers of waste may recover or process their own waste but they must have a permit for waste management. That principle in Germany is valid only for a certain types of waste, primarily for the packaging, and then for electrical and electronic waste, batteries, vehicles and waste oils.

The third reason of the present results of the waste Management in Germany is the focus on separate waste collection. This system of separate waste collection is based on the primary selection through the system more containers. The procedure begins with the separation of waste at homes, where residents perform primary selection and sorting of waste by type. The aim of introducing the system of more cans was to increase the recycling of plastic, paper, metals and bio waste from households.

The highest recycling rate in Germany was from 2005 to 2008, a total of 64%, while in 2010, the recycling rate was 62%. In 2002 Germany has already fulfilled the requirement set by the EU.[1]

The German system of municipal waste management consists of about a thousand municipal and private companies that do the work of collecting, recycling and disposal. It is a wide range of companies - from small businesses with one employee to large concerns. In the overall structure the public utilities accounted for 35%, while the remaining 65% is the private sector.

Since each municipality adapts its own plan for their own waste management, there are differences in waste management between the provinces. These differences are most common in the types of waste that is collected separately, which leads to a different number of buckets in the household in which the waste is disposed. Furthermore, as each local government (municipalities and towns) is responsible for issuing regulations that apply to the disposal of waste from households, are defined and different ways of charging for waste collection.

[1] According to the Directive on Waste (2008/98 / EC) the goal is to recycle at least 50% of the total municipal waste in each Member State by 2020.

4.4. Waste management organization in Austria

The total cost of waste management in Austria amounted to 1.100.000.000 €, while municipal waste accounts to three quarters of the total cost. Collection and disposal of waste is financed through municipal fees, while fees are obligations of property owners. The level of compensation is determined by the number and volume of garbage cans and the time of their discharge. The average Austrian household pays € 250 every year for the collection, recycling and processing waste from households. [16] Municipalities are authorized to collect fees in order to cover the costs of collection and processing of waste. Municipalities are not limited to legal regulations and are free to define charges.

According to the Austrian Ministry of Environment in 2009 households and other entities have generated 3 895 000 tons of waste. Approximately 2 233 800 tons or about 57% of the total amount is collected for recycling or special treatment through separate collection. [17]

In the period from 2001 to 2010, the overall rate of waste recycling in Austria amounted to 55-63%, of which 22-30% is related to the recycling of materials (including metal, glass, plastic, paper and cardboard), while composting and other biological treatment together account for 33-39%. According to data from 2009, 555 000 tons of waste were treated in facilities within Austria, of which 321 000 tons makes bio-waste, 222 000 tons (waste of high caloric value) is sorted and sent for incineration, and the remaining 12 000 tons of metals are recycled. [18]

Table 2 presents the structure of collected waste from households in tones and the data related to the amount of categories of waste collected per inhabitant.

Table 2 - Household waste by type of waste per capita for 2009

Division	t	kg/ population
Other waste	1.402.100	168
Bulky waste	259.100	31
Waste materials collected separately	1.386.000	166
Biowaste collected separately	752.100	90
Hazardous waste collected separately	95 700	11
In total	3 895 000	466

Source: Bundes-Abfallwirtschaftsplan 2011

According to data from 2010 Austria has 182 plants for sorting and processing plants with a total capacity of at least 2.9 million tons of which is shown in Table 3 below. [19]

Table 3 - Sorting and processing facilities in 2010

Country	Number of facilities	Minimal capacity t/g
Burgenlad	3	30.000
Kärnten	11	35.000
Niederösterreich	27	130.500
Oberösterreich	42	534.600
Salzburg	21	184.000
Steiermark	26	1.236.700
Tirol	11	72.000
Vorarlberg	10	220.400
Wien	31	455.500
AUSTRIJA	182	>2.898.700

Source: Bundes-Abfallwirtschaftsplan 2011, BAND 1

According to data from 2010 in Austria has a total of 48 plants for the recycling of waste from households and other facilities, with a capacity of at least 1.2 million tons. [19]

The facilities are designed for recycling:

- Old paper, cardboard - 14 facilities
- Waste glass - 6 facilities
- Iron and Metal - 9 facilities
- Plastic waste- 15 facilities
- Wood waste - 4 facilities.

5. IMPLEMENTING OPTIMAL STRATEGY FOR WASTE MANAGEMENT USING REVERSE LOGISTICS ACTIVITIES

Provided examples of good practices regarding waste management organization in EU countries, highlighted the necessity for a change in organization of waste management in Croatia. Although some Croatian counties have higher recovery level than others, they all seek for better solutions in organization for the aim of reducing the amounts directed to landfills.

Some EU countries even import waste to recover it that is managed by developed infrastructure with huge capacities for waste processing, while amounts recovered in Croatia are on low level. Figure 4 presents amounts of recycled waste in described waste management organizations where Croatia is compared with Germany, Norway and Austria and where total recycling in Croatia level is low and was around 4 % in 2010.

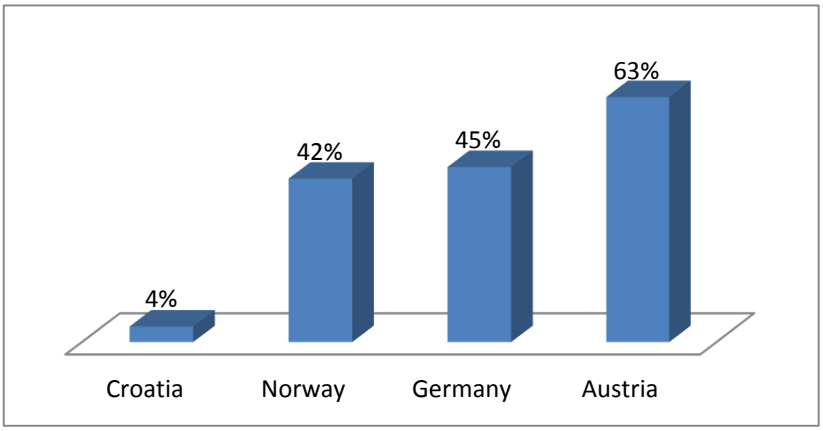

Figure 4 - The recycling waste in Austria, Croatia, Norway and Germany from 2010
Source: According to data from the MSW Austria, Croatia, Norway and Germany

The more or less successful approaches described by these EU countries do not present exactly same model, but different approaches that are continuously developed and continuously improved by implementing methods to recycle more and direct to landfills less.

The organization of waste management that is not strategic and individually developed will provide some kind of activity but not in a way that will result in a maximal added value of each material (waste), in every case. Activities that should be used can continuously evolve based on possibilities, or materials that are entering processing plants, which is also concept in reverse logistics, just with a difference regarding the return which is in this case product or transport packaging. Also, except modelling only activities governments should recognize importance of a final consumer that is in this case producer of waste.

Approach for designing the appropriate waste management organization, construction of significant reverse logistics activities, modeling them basing on the consumer profiling, expected amounts and waste categories, regarding materials, is crucial. To develop an optimal model for waste management even continuous education should be organized where

consumers should find reuse, recycle and recover as a way of life, to be in accordance to positive approach of sustainable development and to be willing to be part of it.

As today's distribution logistic cannot be separated from tendency for greening and from a significance of final consumer in the chain, also waste management cannot function without this significant part of it, in a form of a final consumer. This final consumer can provide sorting that is pre-function of all reverse logistic activities.

6. CONCLUSION

Strategy of designing a green supply chains is to raise the level of environmental conscience, as a matter of thinking and as a marketing strategy on competitive global market. This strategy is a result of the need for a perfectly closed green supply chain. Reverse logistics is a part of green logistics that suggests movement of goods from destination to origin to enable reprocessing, remanufacturing, repairing, reusing, recycling, disassembling or disposing. As forward logistics processes include an organization of warehouse processes based on market and optimization requirements, reverse logistics warehouse requirements depend on organization of evaluation and specific processes for each returned product.

In Croatia a large number of counties doesn`t have satisfying level of waste management organization, but some as, Međimurska, Primorsko-goranska and Varaždinska, have organized separate waste collection. Level of organization still is behind Germany, Norway and Austria. The total recycling in Croatia level is low and was around 4 % in 2010. According to Eurostat data, the level of organic recycling is very low, only 1 % or 13 000 tons in 2010 and 12 487 tons in 2009. The material recycling is also low and was only 3 % or 53 000 tons in 2010.

Germany had a high starting level of recycling of MSW in 2001, and the total recycling continued to increase steadily in the period from 2001 to 2008 from 48 % to 64 %. However, in the last two years total recycling has decreased to 62 %. The reported German amounts of generated MSW decreased 11 % from 2002 to 2006. Nevertheless, the total and consistent increase of MSW recycling covers different trends for material recycling and organic recycling. The amount of material recycling increased during the period from 17.5 million tons (34 %) in 2001 to 21.3 million tons (45 %) in 2010.

The total material recycling in Norway has increased from 37 % to 42 % between 2004 and 2010, peaking in 2008 with 44 %. The total increase of recycling is first of all linked to organic recycling which has increased from 12 % in 2004 to 16 % in 2010, or in absolute amounts from 220 000 tons to 358 000 tons. Material recycling has only increased from 25 % to 27 % in the same period equivalent to an increase from 475 000 tons to 609 000 tons. In other words, there is room for improving both material and organic recycling.

In Austria, the overall performance in terms of MSW recycling has remained consistent at a high level over the last decade. The Households and similar establishments generated approx. 3 895 000 tons of waste in 2009. Of this amount, the waste management system collected about 1 402 100 tons of residual waste and some 259 100 tons of bulky waste. Some 2 233 800 tons or about 57 % of the total amount accumulated was collected for recycling or special treatment through separate collection. [20]

Waste management in Republic of Croatia is still on not satisfying level and needs to be reorganized in accordance to laws and strategic approach which cannot be taken from other countries as a certainly successful model. It needs to be developed on foundations regarding current state and possibility of implementation of certain activities that will be also met by final consumers. All chosen activities should be constructed in a way that will reduce waste directed to landfills and to high the level of recovered waste. Policy needs to be developed in

accordance to consumers that are significant factor in reverse logistics activities, where can provide sorting that is crucial for quality of waste that is the material which will be processed to be used again.

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INVENTORY OPTIMIZATION BY 3-D PRINTING

ABSTRACT

Inventory optimization is critical in order to keep costs under control within the supply chain. Supplies of spare parts produce significant logistics costs for storage, delivery/shipping and transport of those spare parts. 3-D printers provide new possibilities for inventory management. In focus of possibilities are „near-sourcing", creating the production closer to consumption and production strategy „make to order". Over a long period, reduced costs of stocks transport and warehouse management could justify the investment in 3-D printers. If implemented in spare part industry, 3-D printers will for sure make big influence on supply chains activities and whole 3PL industry.

KEY WORDS

Inventory management; 3-D printing; supply chain; optimization.

1. INTRODUCTION

Logistic costs are important part of supply chain activities planning. As inventory (stock) exist throughout each phases and cycles of supply chain, costs of inventory have great share in total supply chain logistic costs. Main goal in logistic industry is to decrease total logistic costs. In that sense, inventory management in different industries is focusing on ways how to optimize inventories and decrease its costs.

Supplies of spare parts produce significant logistics costs for storage, delivery/shipping and transport of those spare parts. Also, when speaking about spare parts, as they are part of system integrity, its availability when and where needed in right quantity model service level to customer.

By new technology development such as 3-D printing, new ideas appears in spare parts industry, especially for those parts produced by plastic and smaller by dimension. Technologically, 3-D printer works by inflicting layers of material like plastic, ceramics or metal powders using computer simulations. With that, production of smaller product series are cheaper and simply. Every printed product is original and hardware/software can have acceptable price for printing smaller series and for mass production. For justification of use the 3-D printers in inventory management, it's important to make a systematic analysis of inventory and consider the possibility of implementing planning business strategy „near sourcing" or „make to order". In inventory analysis the most important analyse is ABC analyse

which can give answers which items in inventory is most important in respective business (industry).

This paper gives presents possibilities of 3-D printing in reducing logistic costs.

2. FEATURES OF ABC ANALYSIS APPLICATION

Inventory optimization is critical in order to keep costs under control within the supply chain. Yet, in order to get the most from management efforts, it is efficient to focus on items that cost most to the business [1].

In supply chain, ABC analysis is an inventory categorization method which consists in dividing items into three categories: A, B and C. Category A represent the most valuable items while category C represents the least valuable ones. This method aims to draw manager's attention on the critical few (A-items) and not on the trivial many (C-items).

The ABC analysis is based on Pareto principle. The Pareto principle states that 80% of the overall consumption value is based on only 20% of total items. In other words, demand is not evenly distributed between items. Items that are best selling items vastly outperform the rest. Graphical illustration of the ABC analysis is shown on figure 1.

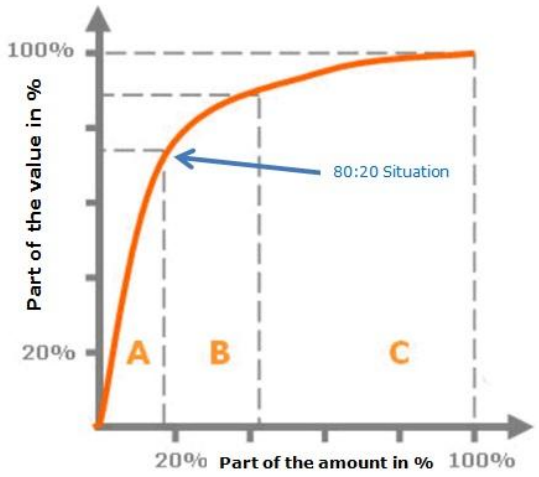

Figure 1 - Graphical illustration of the ABC analysis
Source: [2]

The ABC approach states that, when reviewing inventory, a company should rate items from A to C, basing its ratings on the following rules [1]:

- A-items are goods which annual consumption value is the highest. The top 70-80% of the annual consumption value of the company typically accounts for only 10-20% of total inventory items. That type of goods should have tight inventory control, more secured storage areas and better sales forecasts. Reorders should be frequent, with weekly or even daily reorder. Avoiding stock-outs on A-items is a priority.
- •B-items are the interclass items, with a medium consumption value. Those 15-25% of annual consumption value typically accounts for 30% of total inventory items. An important aspect of class B is the monitoring of potential evolution toward class A or, in the contrary, toward the class C.
- C-items are, on the contrary, items with the lowest consumption value. The lower 5% of the annual consumption value typically accounts for 50% of total inventory items. A typically inventory policy for C-items consist of having only 1 unit on hand, and of

reordering only when an actual purchase is made. This approach leads to stock-out situation after each purchase which can be an acceptable situation, as the C-items present both low demand and higher risk of excessive inventory costs.

For C-items, the question is not so much how many units do we store, but rather do we even keep this item in store. The possibility to use 3-D printers [3], is precisely in this category of items.

3. ADVANTAGES OF IMPLEMENTING NEAR-SOURCING

Near-sourcing is a term used to describe a business strategically placing some of all of its operations, close to where its end-products are sold. [4]For example, a car manufacturer in the United States might decide to near-source operations to Mexico, rather than outsource offshore to China. What is inherent to the decision is finding the closest location possible to the product market that offers some or all of the aforementioned advantages, while avoiding some of the rising costs in the supply chain.

The hidden costs in the supply chain - which are often overlooked - where are referring to, include lost gross margins and the cost of excess inventory write-downs [5]. As supply chains in global sourcing are complex, consist of multi echelon and have long distance between origins and consumer destination, hidden costs are the largest costs. Due to this hidden costs near-sourcing has significant advantages with respect to global sourcing.

When the product isn't there for the consumer to purchase, a company will face a gross margin loss which ranges from 40% - 60% of the shelf price [5]. Besides, when there's an oversupply of products that consumers don't want, a company will face the cost of excess inventory write-downs which comes down to 10% - 20% of sales [5]. Moreover, a company will face the expense of flushing defective inventory from the supply chain. This type of hidden cost is related to the time, which is lost to identify the cause of a quality problem, correcting it, and resetting production. Costs are incurred by removing the defective inventory and by producing additional goods to meet back order and current demand [5].

Another example of influence of near-sourcing is port of Rotterdam who functioning as a gateway to Europe. Before, goods were being produced in Asia, afterwards, being shipped (mainly in containers) to Rotterdam, and at the end distributed to many countries in Europe (the hinterland). Now, there's an emerging trend that goods are being produced in CEE, Turkey or Northern Africa instead of Asia, because of the rising wages and other costs related to a lengthy supply chain. As a result, one can imagine that when goods are produced in CEE instead of Asia, it might happen that they won't reach the port of Rotterdam any longer, since it's unnecessary to ship the goods from Asia to Rotterdam anymore. Since, now, products are produced in CEE, they can reach the final markets by rail, road, and feeder as well.

4. THE INTERFACE BETWEEN 3-D PRINTERS AND OPTIMIZATION OF STOCKS

3-D printers provide new possibilities for inventory management. Creating the production closer to consumption and produce on „make to order" basis is in focus of possibilities when discuses about 3-D printing. Precisely those 3-D printers can make the completely „near-sourcing", so the certain types of smaller plastic parts can be printed/produced in retail places.

For analysts of Deloitte, two main reasons motivate manufacturers and suppliers to take the plunge [6],[7]. 3D printing enables manufacturers to innovate. Printing of geometries

impossible to produce with the means of traditional production, reduction of weight with raster structures, new features like the integration of the wiring in the structures or composed of multiple materials parts production, 3-D printing will allow these industrialists to differentiate and win market shares for those who will master the first 3-D printing.

The transformation of the Supply Chain is the great driver which will push the auto industry to convert to 3-D printing. Additive manufacturing techniques will allow industrialists to move from tooling in an increasing number of cases. As well as printing 3-D should allow them to limit the loss of materials related to manufacturing processes. By limiting the losses of materials, manufacturers can expect an optimization of the production costs. In addition, the relative simplicity of using 3-D printing to consider new organizations of decentralised productions, with restricted stocks, 3-D production sites to the nearest market.

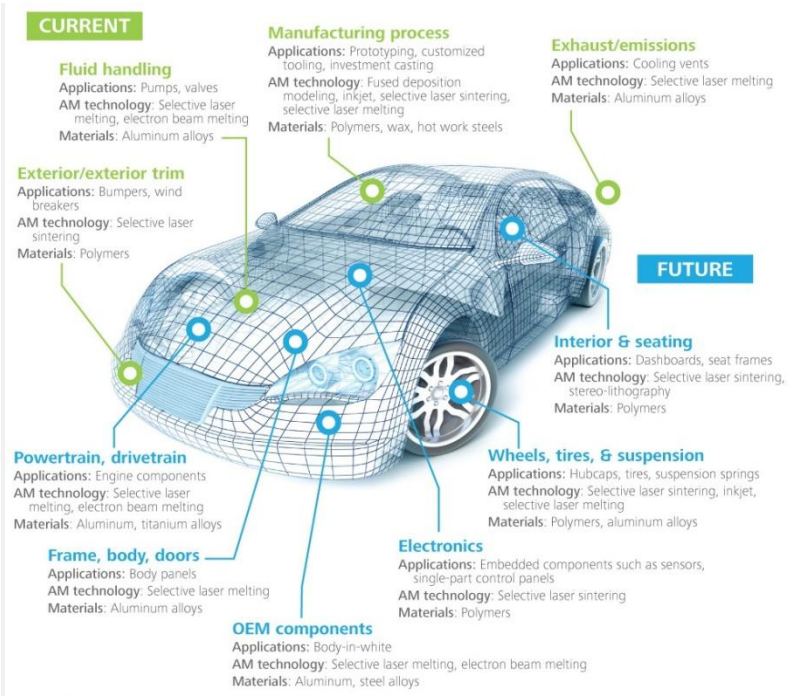

Figure 2 - The fields of application of 3-D in the car
Source: [6]

When deciding to print near-sourcing or to distribute it from some location in network, costs are crucial. For printing, hardware and software are needed. Needed components has its price and represent some cost. Systematic analysis of stocks in distribution network can show in which cases is good to make investment in 3D printer with their hardware and software, and organization of „near-sourcing“, opposite the delivery of goods from afar production places.

As mentioned in the title no. 2, the ABC analysis will indicate which products have such performance and belonging activity ratio justifying the planning of „near-sourcing „with 3-D printers.

Section of procurement at the time of receiving order will be able, using 3-D printers, to pull programs from on-line library to print the product and fulfil the order in a short time. With this approach, supplies of certain products and the warehouse space requirement are directly reduced. Opposite to that, there is a cost for purchase of 3-D printers with belonging materials and costs of using the program which prints the products.

Over a long period, reduced costs of stocks, transport and warehouse management could justify the investment in 3-D printers. If implemented in spare part industry, 3-D printers will for sure make big influence on supply chains activities and whole 3PL industry.

5. CONCLUSION

Increasing trend in using the 3-D printers is constant and that's caused with his unquestionable advantages. Using the 3-D printers directly effects on inventory management and logistics costs for more reasons:

- Certain products can be printed by certain order, so there is no reason to have that product in stock or occupy the warehouse space.
- Certain products can be printed directly at the retail location.
- Except inventory management and warehouse management, there is impact on the amount of goods for transport in distribution network which reduces the logistics costs.

Activities and processes of providing logistic services, using 3-D printers implies different approach and sets new challenges for logistics operator.

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INVENTORY MANAGEMENT SIMULATION MODEL AT SELF SERVICE WHOLESALER

ABSTRACT

This paper presents inventory management analysis at one of self-service wholesalers in Republic of Croatia. For the purpose of lost sale analysis, inventory system simulation model is being developed and simulated using Arena 14.0. Model consists of two active members: self-service wholesaler and key customer. Simulation model is based on (s, Q) inventory model. This model focuses on reducing lost sales by changing order quantity and reorder point. Past demand of key customer has been analyzed, and five different scenarios were developed.

KEY WORDS

Inventory management; self-service wholesaler; ARENA simulation modelling; lost sale

1. INTRODUCTION

For every company each customer is very important. That is why different analysis of lost customer and lost sale are made. In each industry sector there are different reasons for lost sale or lost customer, so the aspects of analysis differ. In commercial enterprises, industry lost sale analysis relies mostly on stock (inventory) availability. Inventory management includes process of inventory control, order quantities, cycle times of orders and shortage. Different models of inventory management are developed and followed.

Wholesalers are important part of supply chain, since they ensure availability of stock on retail market. In this paper self-service or cash and carry wholesaler inventory management problem is observed. Cash and carry wholesale represents a type of operation within the wholesale sector. Its main features are summarized by the following definitions: Cash and carry is a form of trade in which goods are sold from a wholesale warehouse operated either on a self-service basis, or on the basis of samples (with the customer selecting from specimen articles using a manual or computerized ordering system but not serving himself) or a combination of the two. Customers (retailers, professional users, caterers, institutional buyers, etc.) settle the invoice on the spot in cash, and carry the goods away themselves. There are significant differences between "classical" sales at the wholesale stage and the cash and carry wholesaler: namely a cash and carry customer arranges the transport of the goods themselves and pay for the goods in cash [1].

In that kind of wholesale key customers are very important since they secure significant gain of sale [2]. Among other reasons, key customers can be lost when wholesaler is not having

inventory they need, especially in observed kind of wholesalers. That is why in this paper key customer is in focus when planning inventory.

In this paper a simulation based model on (s,Q) inventory system is proposed. The continuous review (s,Q) inventory control policies is one of the inventory control policies, where a replenishment order quantity is placed whenever the inventory position (on hand stock minus back orders plus on order quantities) reaches the reorder level (s). This replenishment order quantity is calculated as Economic Order Quantity (EOQ) [3].

In their research authors [4] use (s,S) inventory model, which is similar to (s,Q) model.

The model was constructed using Arena™ (a product of Rockwell Software/Systems Modeling Corporation).

2. METHODOLOGY DESCRIPTION

From one self-service wholesaler of consumer goods in Croatia past purchase data for three years are taken. From that data key customers are identified. One key customer is taken for further analysis. Past purchase data of chosen key customer is analyzed and ABC and XYZ inventory method analysis is made.

As there was large amount of different items in assortment (14520 items) purchased in different period of time, items are grouped in category by applying ABC/XYZ cross analysis. Items in group A are those with 65% in total purchase by key customer, or 977 different items with the higher sale rate. Items group in B are those with 30% in total purchase by key customer, or 7090 different items with the higher sale rate. Items in group C are those with 5% in total purchase by key customer, or 6453 different items with the higher sale rate. There are 2801 items in group X, 4046 in group Y and 7673 items is group Z.

With the ABC/XYZ cross analysis 789 items are identified as AX items that make 59% of key customer total purchase (demand).

Lost sale of this 789 items (AX) will be in focus of this research as well as focus in simulation experiments. The goal is to make this category lost sale as close to value of 0%, with the respect of holding cost.

The total costs of ownership (TCO) were also analyzed. TCO consist of order cost, acquisition cost, cost of research for procurement and suppliers, transportation costs, quality control cost, cost of lost sale, holding cost, costs of financial resources availability and etc. [5, 6].

As the goal of this research was to try to influence on cost of lost sale, only costs that participate in cost of lost sale was analyzed. Total cost in further analysis was sum of cost of lost sale, holding cost, order cost, and interest cost.

Lost sale cost is calculated by multiplication quantity of products in lost sale with its price [5]. Taken price value is average price value in respected group after ABC analysis. Total order cost is calculated by multiplication total numbers of orders and one order cost [5]. Costs of financial resources availability is calculated based on average quantity of items on stock. These costs represent the cost of loaning money on market. Company use bank loan with different interest rate for financing stock. This creates 5-6% on average the cost of availability of financial enough money. The cost of holding inventory is also calculated based on the value of the average amount of inventory in stock [5].

For each category demand distribution is made, and is used to present key customer future demand data as shown in table 1. Demand distribution is calculated and tested by use of ARENA Input Analyzer.

Table 1 - Key customer demand distribution

Category code	Demand distribution	Article category
1	EXPO(9) *NORM(1.05,0.1)	AX
2	GAMM(34.6, 0.09)	AY
3	WEIB(0.024, 0.23)	AZ
4	EXPO(10)*TRIA(0,1,1.3)	BX
5	GAMM(28, 0.089) * TRIA(1,1.1,1.2)	BY
6	WEIB(0.195, 0.295)	BZ
7	EXPO(8.3)*TRIA(0,1,1.3)	CX
8	WEIB(0.0247, 0.215)	CY
9	WEIB(0.034, 0.24)	CZ

Model is developed based on key customer behavior, and for the inventory replenishment (s, Q) inventory model is used. Five different scenarios of inventory replenishment are observed and simulated. Replenishment is based on reorder point level (s) and quantity of ordered goods (Q). Scenarios data are show in table 2.

Model is created in three levels; top level, first and second level. Figure 1 shows top level model in ARENA. Process trigger is customer arrival or customer on-line order.

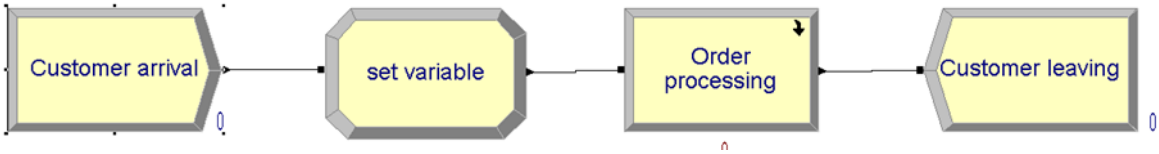


Figure 1 - Top level Model in ARENA

When simulated following rules apply:

- Process is triggered by customer arrival.
- Customer demand follows stated distribution for each group category (table 1)
- When inventory level on hand satisfied customer demand, sales data for each category is recorded and new state of inventory level is checked weather it is lower than reorder point.
- When inventory level on hand unsatisfied customer total demand, unsatisfied demand is recorded as lost sales. Lost sale record trigger new order for the missing items up to forecasted demand for next month. Lead time is set on one week, so the next time customer demand can be satisfied.

When entity “customer” gets in block named “Order processing” shown in figure 1, submodule of first level is triggered (Figure 2). On this level, customer takes items from each category (shown in table 1) following demand distribution.

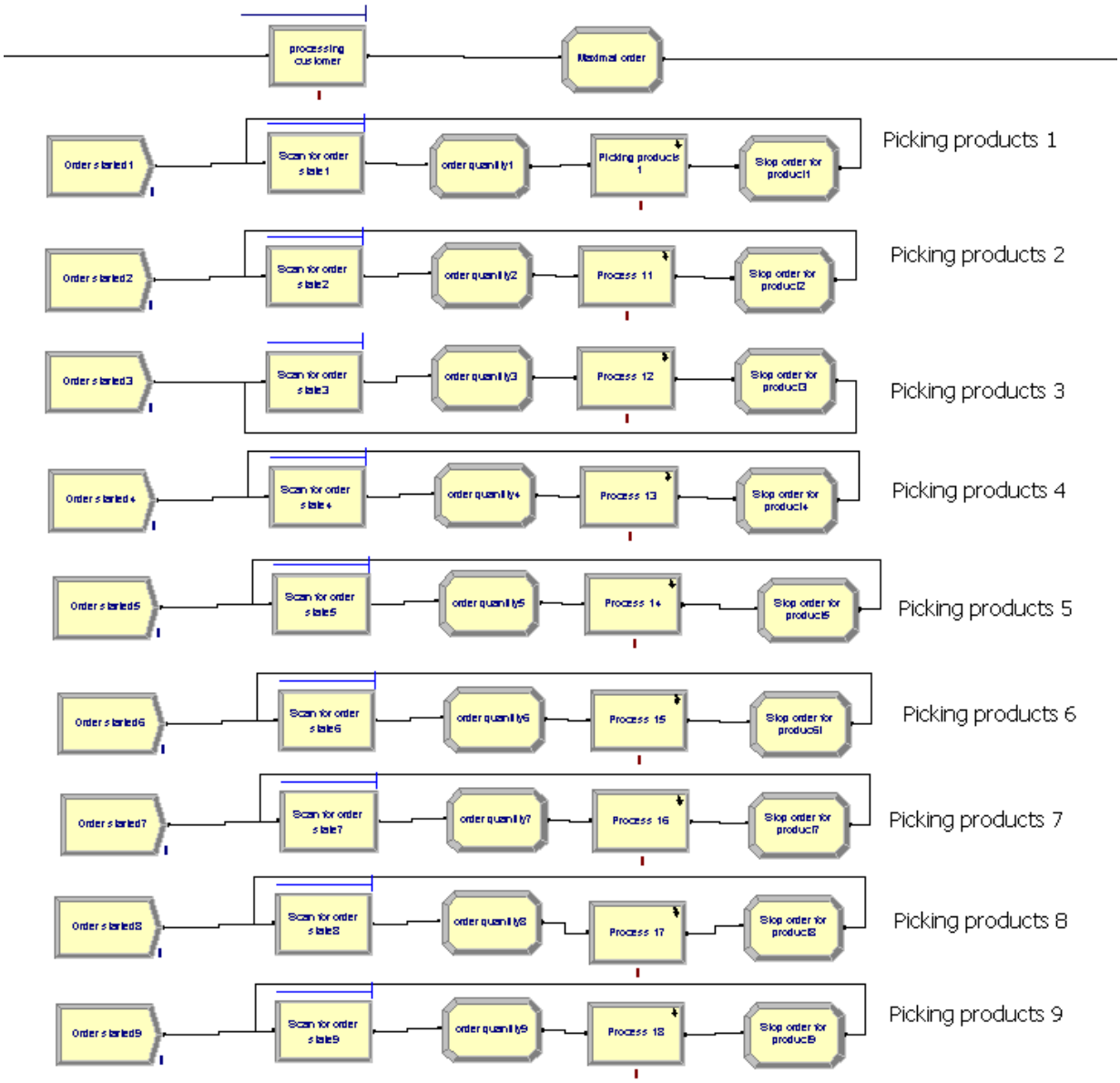


Figure 2 - First level Model in ARENA

When finished, customer gets out from block “order processing “ and third level of model is triggered to record lost sale. In figure 3 submodule of second level is shown. This part of model records inventory level changes during picking process and make checks against reorder point.

If even after picking process inventory level is lower than reorder point, replenishment process is started. Quantity of items that will be ordered in replenishment process, as well as reorder point is variable.

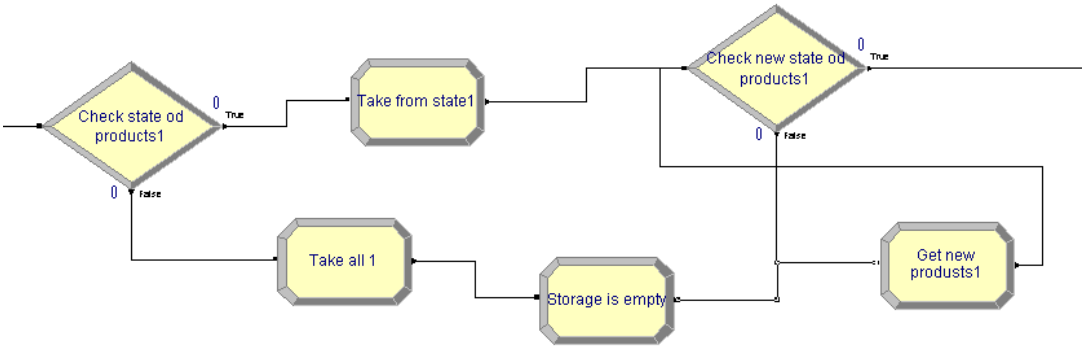


Figure 3 - Second level Model in ARENA

3. SIMULATION EXPERIMETNS AND DISSCUSION OF RESULTS

After model creation, parameterizations of blocks were done. Inventory level of each group is monitored and recorded simultaneously. By the use of Virtual Process Analyzer in ARENA, simulation experiments with different input data were done.

In order to minimize lost sale and optimize quantity that have to be order after each purchase, five different scenarios were developed and simulated. Parameterization data for blocks that control parameter reorder point (s) and order quantity (Q) for each scenario is shown in table 2, and its modification is explained further in text.

Table 2 - Simulated scenarios

Category code	Total number of items	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
		(s)	(Q)	(s)	(Q)	(s)	(Q)	(s)	(Q)	(s)	(Q)
1,4,7	19626	18	60	18	685	26	685	36	411	64	236
2,5,8	16711	30	100	30	369	45	369	46	295	48	295
3,6,9	14601	20	170	20	270	30	270	33	270	33	270

First Scenario consists of data for s and Q parameter as they are set by the business policy at respective wholesaler. Results of simulation for Scenario 1 are shown in table 3. For every other scenario modifications in s and Q parameters are made in order to minimize lost sale of category AX, BX and CX (1,4 and 7).

In Scenario 2 economic order quantity (EOQ) is calculated. Reorder point is taken to be the same as in Scenario 1. Order by EOQ model increase inventory holding cost and decrease lost sale for 56%. Simulation experiment results for Scenario 2 are shown in table 4.

In order to reach lost sale on category 1,4 and 7 in Scenario 3 reorder point is modified, while Q is kept same as was in Scenario 2. As there was 44% of lost sale left to be decreased, reorder point was modified as follows:

- The share of each category in lost sales was calculated
- That share was added to total percentage left to decrease lost sale on 0%

So reorder point for category 1, 4 and 7 was increase for 0,72%, category 2,5 and 8 for 5,9%, and category 3,6 and 9 for 7,4%. Simulation experiment results for Scenario 3 are shown in table 5.

As for most important category of items, results in Scenario 3 shows that lost sale reached 0% which means that main goal of this research is achieved.

Table 3 - Simulation experiment results for Scenario 1

Category code	Lost sale	No. Order	Average Storage	Lost Sale Cost	Holding Cost	Order Cost	Costs of financial resources availability	Interest Cost
1,4,7	124	576	146	55728,1	9657,6	11520	64384,02	3541,12
2,5,8	265	98	235	12215,01	1688,98	1960	11259,86	619,29
3,6,9	587	26	328	8095,76	718,48	520	4789,85	263,44
Total	976	700	709	76038,87	12065,06	14000	80433,73	4423,86
							Total cost	106527,79

Table 4 - Simulation experiment results for Scenario 2

Category code	Lost sale	No. Order	Average Storage	Lost Sale Cost	Holding Cost	Order Cost	Costs of financial resources availability	Interest Cost
1,4,7	80	52	1085	31089,53	71749,61	1040	478330,72	26308,19
2,5,8	197	27	656	9187,81	4832,49	540	32216,57	1771,91
3,6,9	133	20	541	2390,66	1175,3	400	7835,35	430,94
Total	411	99	2282	42668,01	77757,4	1980	518382,64	28511,05
							Total cost	150916,45

Table 5 - Simulation experiment results for Scenario 3

Category code	Lost sale	No. Order	Average Storage	Lost Sale Cost	Holding Cost	Order Cost	Costs of financial resources availability	Interest Cost
1,4,7	0	53	1192	0	80045,32	1060	533635,44	29349,95
2,5,8	87	28	705	2823,35	5175,34	560	34502,27	1897,62
3,6,9	146	20	581	2556,18	1255,8	400	8371,98	460,46
Total	232	101	2478	5379,53	86476,46	2020	576509,7	31708,03
							Total cost	125584,02

Scenario 4 was made in order to decrease holding costs but keeping lost sale on minimum. For the most important category (1, 4 and 7), as they generate the most profit, reorder point is increased for 40% in regard to value in scenario 3. Also, as total holding costs increase for 40% when quantity change from 60 (Scenario 1) to 685 (Scenario 2, and 3), quantity (Q) in Scenario 4 was decreased for 40%. For category 2, 5 and 8 quantity was decrease for 20% and reorder point increase for 3% as this is equal to lost sale in Scenario 3. For category 3, 6 and 9 quantity is kept the same, but reorder point was increased for 8% in regard to Scenario 3. Simulation experiments results for Scenario 4 are shown in table 6.

Results of Scenario 4 shows significantly decrease of total costs, but holding costs are still high, and lost sale for category 2,5,8 and 3,6,9 increased.

Table 6: Simulation experiment results for Scenario 4

Category code	Lost sale	No. Order	Average Storage	Lost Sale Cost	Holding Cost	Order Cost	Costs of financial resources availability	Interest Cost
1,4,7	0	88	758	0	51102,73	1760	340684,87	18737,67
2,5,8	97	35	586	3175,18	4308,01	700	28720,05	1579,6
3,6,9	221	20	577	3784,37	1240,65	400	8271,01	454,91
Total	318	143	1921	6959,55	56651,39	2860	377675,93	20772,18
							Total cost	87243,12

In Scenario 5 goal was to keep lost sale for 1,4 and 7 category on 0%, lower total holding cost and decrease lost sale for 2,5,8 and 3,6,9 category. Modification in Scenario 5 was made as follows:

- For quantity (Q) average value of values in Scenario 1 and 4 is taken
- Reorder point (s) for category 1,4 and 7 is reduced proportionally to Q for the same category
- Reorder point (s) for others category is increased proportionally to the share of each category in total lost sale (in regard to previous scenario). So for 2,5 and 8 category increase is 3% and for 3,6 and 9 category is 12%

Simulation experiment results for Scenario 5 are shown in table 7.

Table 7 - Simulation experiment results for Scenario 5

Category code	Lost sale	No. Order	Average Storage	Lost Sale Cost	Holding cost	Order Cost	Costs of financial resources availability	Interest Cost
1,4,7	0	152	584	0	38809,7	3040	258731,62	14230,24
2,5,8	97	35	587	3175,18	4329,72	700	28864,80	1897,62
3,6,9	154	20	594	2697,07	1275,92	400	8506,11	460,46
Total	252	200	1765	5872,24	44415,38	4140	296102,52	16588,32
							Total cost	71009,36

Simulation experiment results for Scenario 5 shows additional savings on holding costs, also reducing the total cost, but did not have a positive effect on reducing the lost sale for 2,5,8 and 3,6,9 category.

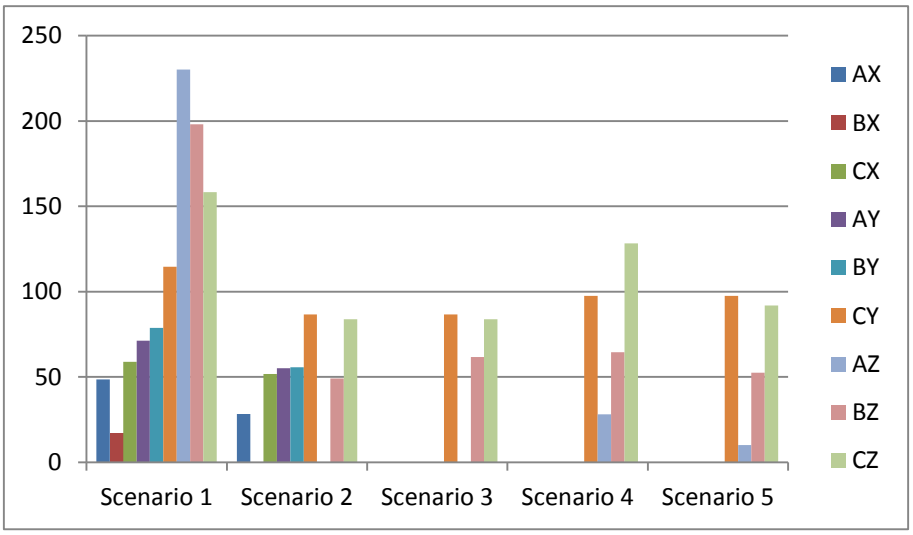


Diagram 1 - Quantity of items in lost sale by category

Lost sale cost is proportional to quantity of demanded items which were unavailable when key customer asks for it. Diagram 1 shows quantity of unavailable items by each category in all scenarios.

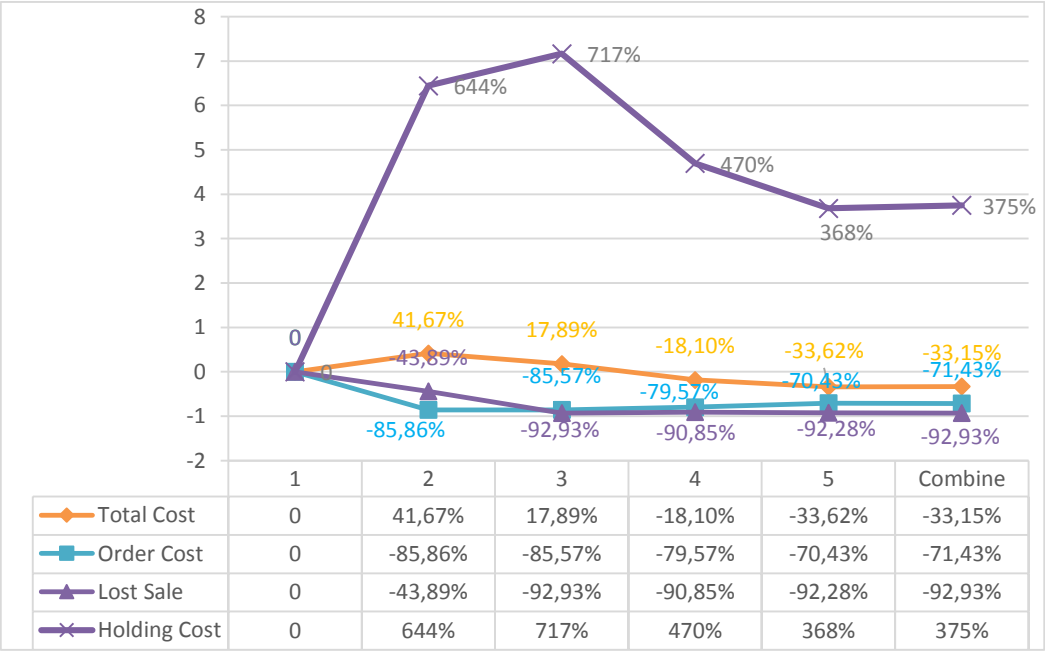
Main goal was to decrease lost sale for AX category for the respective key customer on 0% of lost sale. As can be seen from diagram 1 the best results are achieved in Scenario 3, 4 and 5. Simulation experiments results show that in order to minimize lost sale and holding cost is possible to have different reorder point and order quantity by category group.

Analysing outcomes of Scenario 3, 4 and 5 first by criteria of lost sale and then by holding cost, for category 1,4,7 Scenario 5 gives best results. Compering settled criteria for category 2,5,8 and 3,6,9 among Scenario 3, 4, and 5, Scenario 3 gives best results. As its shown in table 8, tailored inventory management by category groups (different s and Q for each category) results with decrease of lost sale for 93%, and decrease of total cost for 33% (see diagram 2). This is also the best solution for respective key customer.

Table 8 - Simulation experiment results for Scenario 3 and 5

	Lost sale	No. Order	Average Storage	Lost Sale Cost	Holding cost	Order Cost	Costs of financial resources availability	Interest Cost
1,4,7 (S 5)	0	152	584	0	38809,74	3040,00	258731,62	14230,24
2,5,8 (S 3)	87	28	705	2823,35	5175,34	560,00	34502,27	1897,62
3,6,9 (S 3)	146	20	581	2556,18	1255,80	400,00	8371,98	460,46
Total	233	200	1870	5379,53	45240,88	4000,00	301605,88	16588,32
							Total cost	71208,73

Costs differences in scenarios against basic value from Scenario 1 are shown in diagram 2. As can be seen from diagram 2, holding cost in all scenarios increase, but total cost is decreased, especially in Scenario 4 for 18,1%, and Scenario 5 for 32,6%.



	1	2	3	4	5	Combine
Total Cost	0	41,67%	17,89%	-18,10%	-33,62%	-33,15%
Order Cost	0	-85,86%	-85,57%	-79,57%	-70,43%	-71,43%
Lost Sale	0	-43,89%	-92,93%	-90,85%	-92,28%	-92,93%
Holding Cost	0	644%	717%	470%	368%	375%

Diagram 2 - Results of all five scenarios

4. CONCLUSION

Simulation results presented in this paper as well as presented methodology show that it is possible to apply customized inventory models concerning key customers. For every company key customers are very important, and losing key customer can influence company income. The main goal of this research was to present ways how customized inventory management can contribute in decreasing lost sale and make key customer satisfied.

Presented customized inventory model is based on history sales data by key customer. From that data it is possible to forecast future key customer demand and adjust order quantity of items as well as reorder point.

For that purpose of five different scenarios has been made with the aim of reducing the lost costs of AX category (or category group 1,4,7) for the key costumer. These scenarios are simulated in ARENA software tool, and the obtained results show that the best solution of established model is achieved with Scenario 5, 4, and 3. We show that combination by category groups different parameters of reorder point and order quantity can result with high decrease of total cost as well as decrease in lost sale cost.

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REVIEW OF AIRCRAFT FUEL EFFICIENCY MEASURES

ABSTRACT

Economic factors regarding fuel, and regulations on aircraft emissions put pressure on airlines to develop a more sustainable system. Special programmes, known as fuel efficiency programmes, have been developed in order to reduce airline fuel consumption. This article describes the legislative requirements that indirectly define the scope of such programmes and also presents the most commonly used measures to reduce fuel consumption. In the end, a brief overview of new measures, that are yet to be perfected, will also be given.

KEY WORDS

Fuel efficiency; fuel consumption; aircraft gas emissions; emissions trading scheme

1. INTRODUCTION

Today's variable fuel prices present an ever so important factor in airline management. According to IATA (International Air Transport Association) Economic Briefing from February 2010, fuel makes up about 25% to 35% of airline operating costs [1]. To battle the growing prices, most airlines have developed and implemented their own fuel efficiency programmes. Fuel efficiency programmes have a goal to reduce fuel consumption in the airline's fleet by finding means for better and more efficient fuel use. Although the primary goal of the airlines is to reduce their operating costs, this goal also has a benefit of reducing greenhouse gas emissions because the emissions are directly related to fuel combustion.

2. EU ETS AND IATA FUEL CAMPAIGN

There are no regulations that directly regulate airline's fuel efficiency. Most of the fuel efficiency programmes are based on recommendations from aircraft and engine manufacturers and from airline's previous experience. Theoretically, this means that airlines are not obliged to develop such programmes. Apart from the fuel prices incentive mentioned in the introduction, airlines are also incited to develop and implement fuel efficiency programmes by regulations on greenhouse gas emissions.

In 2003, the European Union established an Emissions Trading Scheme also known as EU ETS. The basic concept of the Scheme is to put a limit on overall emissions for different industry sectors. The limit is then reduced each year by a certain amount. Companies who are subject to EU ETS regulations can buy and sell emission allowances as needed [2]. Those companies who emit less emissions than was predicted sell their allowances to those who emit more than their limit. This ensures that companies are stimulated to reduce their emissions. The regulations regarding EU ETS was subsequently amended several times. It was first amended in 2004 to link

the Kyoto protocol mechanisms with the Scheme. Then, in 2008 to include aviation in the emissions trading scheme, and in 2009 to improve the Scheme and extend its applicability. The Scheme became operational in 2012 and applies to flights within the EU, plus Iceland, Liechtenstein and Norway to both EU and non-EU airlines alike. Originally, the Scheme was supposed to apply to flights to and from non-European countries as well, but this decision was dropped in 2013 when ICAO (International Civil Aviation Organization) Assembly announced plans to develop a global market-based mechanism to address international aviation emissions. ICAO's mechanism is to be developed by 2016 and to be implemented by 2020 and will be similar to EU ETS in terms of emissions trading. This means that, in the meantime, European airlines are at a disadvantage compared to airlines that fly to and from non-European countries because EU ETS presents an additional expense for the airlines.

IATA has launched its own campaign for achieving more sustainable air transport. The campaign is not restricted to just improving fuel efficiency of the airlines. Instead, IATA focuses on a range of different areas to reduce the industry's fuel requirements, such as better airspace design, better air traffic procedures and management, route optimization, improved traffic flows, efficient operating procedures and more efficient fuel. Members of IATA have voluntarily adopted a fuel efficiency goal to reduce fuel consumption and CO_2 emissions per revenue tonne kilometre by at least 25% by 2020 compared to 2005 levels [3]. In order to help airlines with their fuel efficiency programmes, IATA established the so-called Green Teams – specialized teams that perform fuel efficiency audits of both IATA member and non-member airlines on request. Green Teams generate a FEGA (Fuel Efficiency Gap Analysis) report which calls attention to inefficiencies in airline operations and also recommends solutions for them. The report covers flight planning, dispatch and operational control, flight operations, maintenance and engineering, ground operations, and in-flight commercial activities, although additional areas might be included. According to IATA, implementing the recommendations could provide savings of about 1% to 15% of the airline annual fuel budget [4].

3. EXISTING MEASURES FOR IMPROVING FUEL EFFICIENCY

There are many different ways an airline can conserve fuel and use it more efficiently. Basically the measures can be divided into five different areas, similar to those previously mentioned:

- Flight planning, dispatch and operational control
- Ground operations
- Maintenance and engineering
- Taxi and flight operations
- In-flight commercial activities

3. 1 Flight Planning, Dispatch And Operational Control

Good flight planning is essential to reducing the amount of fuel an aircraft needs for a particular flight. Fuel carried on an aircraft can be divided into taxi fuel, trip fuel, contingency fuel, alternate fuel, final reserve fuel, minimum additional fuel and extra fuel. Minimum additional fuel is only required if other amounts of fuel won't be sufficient to allow the aircraft to hold at 1500 feet above aerodrome elevation in standard conditions for 15 minutes and make a successful approach and landing [5]. All the aforementioned fuel amounts are precisely defined, except the extra fuel. Extra fuel is an optional amount of fuel to be carried, and the decision on whether to carry it or not rests with the commander of the aircraft. The

commander can decide to load extra fuel onto the aircraft if he or she thinks it will be needed, for example because of expected weather conditions. If a flight can be meticulously planned then the amount of fuel needed can be precisely known. This would eliminate the need to carry extra fuel. Although extra fuel may not be actually used during the flight, the additional weight it imposes has a negative effect on overall fuel consumption. A heavier aircraft burns fuel at a higher rate than a lighter aircraft and consequently produces more gas emissions. Considering the fact that extra fuel can amount to several hundreds of kilograms per flight it is evident how improvements in this area can provide significant savings.

Precise flight planning can also provide savings regarding other mentioned fuel amounts, such as contingency fuel. Contingency fuel is defined as the greater of two of the following quantities: Fuel required for holding at aircraft's specified holding speed at 1500 feet above aerodrome level or 5% of the planned trip fuel. There are other methods of defining contingency fuel that can be used instead of the latter requirement. These, however, require airworthiness approval and/or fuel consumption monitoring. If an airline can obtain an approval for these methods it could save on fuel as is evident in Figure 1.

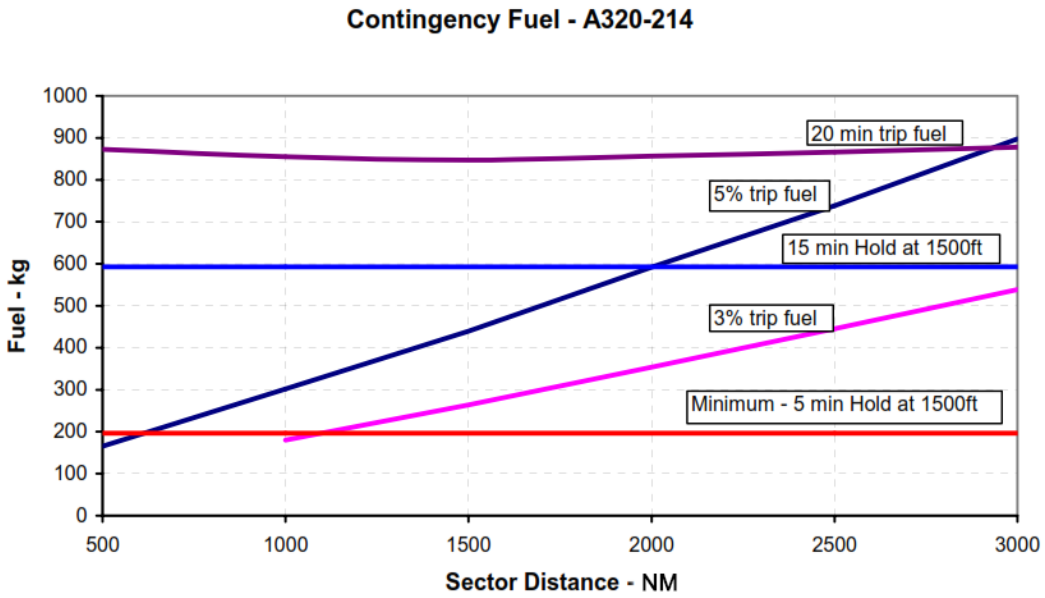

Figure 1 - Amount of contingency fuel needed for a sector length in respect of different Contingency Fuel definitions for an Airbus A320 [6]

For example, defining contingency fuel as 3% instead of 5% of trip fuel for a 2000 NM sector could save 250 kg of fuel per flight for an Airbus A320.

Trip fuel, which is the amount of fuel required for all phases of flight from take-off to landing at the destination airport, could be precisely planned by taking account of all the conditions a flight will be in on a particular day. An airline should obtain good quality data about weather conditions, air traffic conditions, such as expected re-routings, and aircraft performance data for efficient flight planning and dispatch.

Alternate fuel, which is the amount of fuel required to perform a successful missed approach at the destination airport, then to fly to an alternate airport and perform a successful approach and landing, can be minimized by choosing alternate airports which are nearer to the destination airport. However, flight planning must never sacrifice the safety of the aircraft and its occupants in order to obtain as much savings as possible.

3.2 Ground Operations

Fuel consumption is not only affected by the mass of the aircraft, but also by the way the useful load is distributed across the aircraft. Useful load is defined as the sum of traffic load (passengers, baggage and cargo) and the mass of usable fuel [7]. The distribution of the useful load affects the centre of gravity position. A more forward centre of gravity produces a nose-down pitching moment which is counteracted by reduced or negative lift on the horizontal stabilizer, depending on aircraft design. This means that the wings need to produce more lift which in turn produces more induced drag, thus increasing the fuel consumption. Therefore, it would be desirable to load the aircraft so that its centre of gravity could be as close as possible to the aft limit, without endangering safety, of course. Other than loading the aircraft in such a way, some aircraft manufacturers provide a trim tank transfer system on their aircraft that manages the centre of gravity position automatically throughout the flight by transferring fuel between different fuel tanks [6].

3.3 Maintenance and Engineering

Aircraft maintenance also affects fuel consumption and has a direct effect on flight planning as well. It is inevitable that aircraft will deteriorate with time and use. The deterioration affects both aerodynamic properties and aircraft performance. Some examples of the usual aerodynamic deterioration are incomplete retraction of moving surfaces, skin roughness, chipped paint, excessive door gaps and deformation due to damage by foreign objects [6]. Table 1 shows the increase of fuel consumption in kilograms for different types of Airbus aircraft due to aerodynamic deterioration.

Table 1. Increase of fuel consumption in kilograms due to aerodynamic deterioration for different types of Airbus aircraft [6]

Category	Condition	A300/310	A320 Family	A330/340
Misrigging	Slat 15mm	90	60	270
Absence of Seals	Flap (chordwise)	30	14	90
Missing Part (CDL)	Access Door	50	13	150
Mismatched Surface	Fwd Cargo Door 10mm step for 1m	20	11	80
Door seal leakage	Fwd Pax Door 5cm	2	1	5
Skin Roughness	1 m^2	21	13	105
Skin Dents	Single	2	1	2
Butt joint gaps	Unfilled	0.2	0.1	0.6
Butt Joint Gaps	Overfilled	3	2	7
External Patches	1 m^2 3mm high	6	3	16
Paint Peeling	1 m^2 leading edge slat	12	8	57
	Sector Distance	2000nm	1000nm	4000/6000nm

Basically, aerodynamic deterioration means unnecessary increase in drag which consequently increases fuel consumption. Although some of the surface deformations such as patches are necessary, proper maintenance of deteriorated surfaces can save fuel.

Aircraft engines degrade with time and use as well. Since the engines are the main consumer of fuel on board it is logical that proper engine maintenance will directly affect fuel

consumption. Airlines should implement an Aircraft Performance Monitoring (APM) programme to be able to track aircraft deterioration. APM data is of significant use in flight planning and dispatch, because flights can be planned more accurately using actual performance factors. Other than that, simple activities such as cleaning the aircraft and its engines can reduce mass and, ultimately, fuel consumption.

3.4 Taxi and Flight Operations

More fuel can be saved by flight crews by controlling and flying the aircraft efficiently in all phases of flight and during taxi. During taxi, fuel consumption can be significantly reduced by taxiing with one (for twin-engine aircraft) or two (for four-engine aircraft) engines off or on idle setting. Research conducted in this area shows a 26% decrease in both fuel consumption and gas emissions during taxi for single-engine taxi operations compared to all-engine taxi [8].

In order to fly an aircraft efficiently, crews should be familiar with the procedures described in the Flight Crew Operating Manual (FCOM) of their aircraft. During climb and descent, an optimal technique for the specific aircraft type should be followed. Procedures during climb such as derated climb and noise abatement increase fuel consumption. On the other hand, during descent a Continuous Descent Approach (CDA) procedure reduces fuel consumption as well as noise and gas emissions. Aircraft in cruise flight should be operated as close as possible to its optimum altitude to achieve the lowest fuel consumption. Optimum altitude depends on aircraft weight. The heavier the aircraft, the lower the optimum altitude. Since the mass of the aircraft decreases during flight due to fuel consumption, the optimum altitude increases. Due to air traffic management limitations, aircraft are not allowed to perform a continuous climb at optimum altitude. Long haul flights for that reason perform a step-climb procedure to reduce fuel consumption, while short-haul flights might conserve more fuel by climbing to a much lower altitude than optimum if the cruise phase is short enough. Optimum speed for minimum fuel consumption also exists but flying at that speed can prove to be very cost-ineffective.

Aircraft equipped with Flight Management Systems (FMS) automatically compute required flight parameters for a particular flight, based on input data. FMS obtains data from its own performance and navigation databases, aircraft sensors and other aircraft systems (such as flight control system, engine system and fuel system etc.), and from direct pilot input. One of the most important direct input data elements for fuel consumption is the Cost Index because it allows the airline to define the way the fuel is spent. Cost Index (CI) is a ratio of the time-related cost of an aircraft operation and the cost of fuel for that operation. A high cost index means an aircraft will fly faster and consume more fuel, while a low cost index means an aircraft will fly slower but will also save more fuel. Airlines usually determine specific cost indices for specific flights. Although the lowest cost index, zero, is the most fuel efficient it is very time inefficient as can be seen in Figure 2.

If an aircraft is required to enter holding it should, if possible, hold at the speed for minimum drag to reduce fuel consumption. Moreover, if the crew is informed of the holding ahead of time they should reduce the cruise speed to minimum drag speed and proceed to the holding fix. Such a procedure is known as a linear holding and can save fuel while reducing time spent in an actual holding pattern.

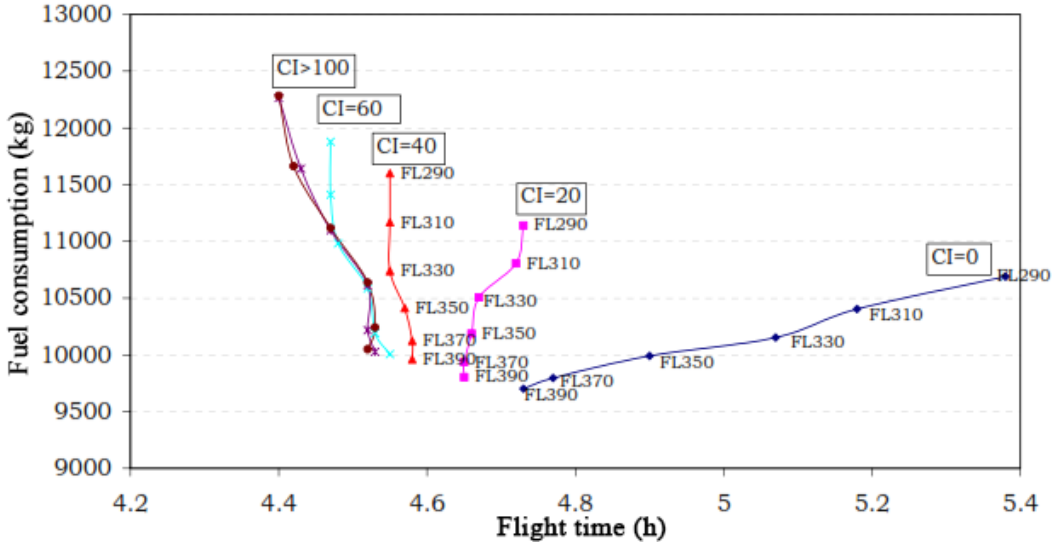

Figure 2. Airbus A319 fuel consumption versus time in respect of cost index (CI) and flight level [6]

For example, if the crew is informed that a holding of 10 minutes is expected for approach, 5 minutes before the aircraft reaches the holding fix, then the crew could reduce speed to minimum drag speed immediately – thus spending more time reaching the fix (for example 7 minutes) and spending less time in an actual holding pattern (8 minutes) [6]. It is important to note that linear holding is not a standard procedure and although this procedure could potentially save a lot of fuel, it is rarely possible to conduct it due to air traffic control restrictions. Crews should make proper arrangements with air traffic control prior to conducting linear holding.

Lastly, during approach crews should avoid putting the aircraft in the landing configuration too early, as this would increase drag and fuel consumption.

3.5 In-Flight Commercial Activities

Nowadays, most airlines offer in-flight entertainment, foods and beverages and duty free shops on board their aircraft. While this is important for passenger satisfaction it also increases fuel consumption because it adds additional mass to the aircraft. Less mass means less fuel consumption, therefore cutting back on the amount of commercial services can save fuel. An example of such a practice would be removing all or some of the magazines offered in each aircraft seat, completely removing the on-board duty free shops or reducing the amount of food and drinkable water to a minimum. A more elaborate way of saving fuel would be to remove all existing seat-based in-flight entertainment systems from the aircraft and instead provide a free wireless Internet connection. This would allow passengers to use their own devices on board while reducing the mass of the aircraft and thus reducing fuel consumption as well.

4. ALTERNATIVE FUEL EFFICIENCY MEASURES

When it comes to fuel efficiency the aviation industry is driven to develop new and better measures when the cost of oil gets too high as can be seen in Figure 3. Fuel prices were relatively low and stable from 1977 until 2003. During that period the fuel consumption rose steadily. A drop in fuel consumption in 2001 can be explained by the decrease in air travel after the terrorist

attacks in New York and Washington. Subsequent steep rise in fuel prices due to global economic crisis caused a stagnation in fuel consumption from 2004 to 2007 followed by a reduction until the end of available data, 2014. It can also be seen on a smaller scale that a rise in fuel price causes a stagnation or reduction in fuel consumption, for example in the years 1979 and 1990. Trend lines for fuel costs and fuel consumption reflect this trend on a larger scale. The periods of stagnation or reduction can be explained by development and implementation of improved fuel efficiency measures by airlines and aircraft manufacturers [9].

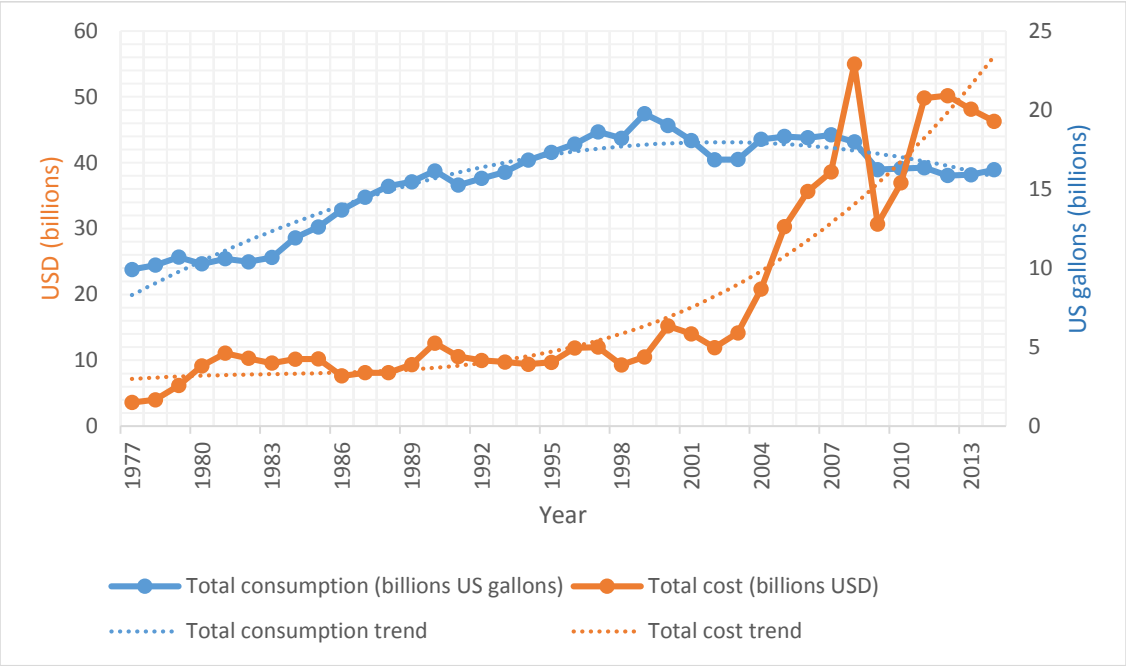

Figure 3. Total fuel consumption and total fuel expenses of all US airlines; data obtained from United States Department of Transportation

Fuel efficiency measure described in this article have already been greatly optimized and there is not much room to improve in those areas. This is why new, alternative efficiency measures are being developed. Some of the alternative fuel efficiency measures are alternative fuels, nano-technology coating and electric taxi. Alternative fuel efficiency measures should not be confused with alternate fuel which was defined previously in section 3.1. Alternative fuel efficiency measures described in this chapter are ways of reducing fuel consumption which have not yet been certified or are not yet widely recognized in the aviation industry.

Aviation biofuel is an alternative fuel used for aircraft. It has been approved for commercial use in 2011 and could provide significant reduction in greenhouse gas emissions since it is the only low-carbon fuel available for aviation. It is not yet widely used although IATA predicts that 6% of aviation fuels will be biofuels by 2020 [10].

Nano-technology coatings are polymers that bond to the aircraft's paint surface thus filling the gaps and crevices invisible to the eye and making the surface smoother. This reduces aerodynamic drag and reduces the build-up of debris on the aircraft. The weight of the coating is estimated to be just over 100 grams so it has the potential to reduce fuel consumption [11].

Electric taxi is a means of moving the aircraft on the ground without the use of main engines. The system consists of landing gear mounted electromotors powered by the APU (Auxiliary Power Unit). Although research in this area is scarce, it shows about 41% decrease

in fuel consumption and 29% to 48% reduction in greenhouse gas emissions compared to all-engine taxi [8]. Electric taxi systems are still pending certification for widespread commercial use.

5. CONCLUSION

There are many measures to improve airline fuel efficiency. Improving it not only helps the environment but is also very economical for the airlines. However, not every airline has to implement all the measures as this could be impracticable or might even prove uneconomical, depending on the type of their operations. The fact that there is a visible trend between fuel consumption and fuel prices is discouraging because it means that the primary goal of developing fuel efficiency programmes is of a financial nature. Luckily, systems such as EU ETS and the proposed future ICAO global market-based aviation emissions mechanism will put pressure on airlines and manufacturers to develop better and more sustainable aircraft, engines and fuel efficiency measures.

Further research regarding the alternative fuel efficiency measures is recommended because most of the existing measures, which are widely used today in aviation industry, have been thoroughly optimized to provide the largest possible fuel savings and there is little room for improvement. A global endeavour is needed in order to reduce greenhouse gas emissions, but while striving for the goal of fuel efficient and sustainable aviation, safety must never be put in question.

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MAIN FACTORS THAT DETERMINE PUBLIC TRANSPORTATION SERVICES IN THE URBAN AREAS

ABSTRACT

This article is focused on the factors that determine the public transportation services in the urban areas. The issue of the first part is the description of Czech legislation codifying the public transportation service including the obligations connected to public transportation contracts. It assumes short history overview of the public transportation services definition development as well as the connection to European legislation acts. The first chapter distinguish clearly public transportation services based on the public transportation contracts and commercial operation. The second part deals with the concrete factors determining the final state of public transportation services. It takes the main factors and introduces their impact and importance in more detailed way.

KEY WORDS

Public transportation services; urban public transport.

1. INTRODUCTION

The society is still developing, thus changes occur all the time, this leads to continuous change of peoples transport needs, the development brings new challenges for public transportation services securing. Longstanding monopolistic market bloke up in 1960s, when public transport secured only by companies as their own commercial activity became unprofitable, caused by the growth of car ownership. State authorities decided to subsidy the public transportation services as a social service in order to provide transport for those who weren't using cars. The other scenario was a gradual lapse when only few commercially viable routes and connections would be provided. Since this time the financial subsidy provided by competent authorities to carriers is rising up in order to provide acceptable level of public transportation services.

Competent authorities shall react efficiently when a change of certain factors, that determine the public transportation services, occurs. It is a closed spiral, public transportation services provided on needed level represent one of mobility headstones. The sufficient mobility is essential for the harmonic regional development. The mobility rise is the goal of Czech as well as European transport policy.

The aim of this paper is to show embodiment of public transportation services in Czech legislation and to show the factors from real life to the rigorous legislation point of view. The paper shows the most important factors creating the final state of public transportation services as well as the interaction of themselves each other. I focus on the factors important for the urban areas.

2. PUBLIC TRANSPORTATION SERVICES

Public transportation services came into focus mainly after the Velvet Revolution, when Czechoslovakia and later Czech and Slovak Republic reconquered the freedom and democracy. Eventough the public transportation services were operated during the whole era of communists reign in Czechoslovakia and their services were in ones point of view even more important than now, because car ownership was significantly lower, the service was given mainly by political decisions not considering real economic needs and costs. After the establishment of the Czech Republic, first legal codification was embodied in the Act no. 111/1994 Coll., on road transport. This act defined the base public transportation services level and the supplementary level. The base public transportation services level was later incorporated into the new Act no. 194/2010 Coll., on public transportation services, first part: Public transportation services, head I: General Enactments, § 2 Public transportation services. This paragraph defines public transportation services as following: public transportation service shall provide transportation in all weekdays primarily to schools and education institutions, to the employment places, to health care institutions providing primary health care and to satisfy cultural, recreational and social needs, including transport back, which is supposed to contribute to the sustainable development of region.

The supplementary public transportation level was understood as the public transportation services according to a municipality's needs exceeding the regional base public transportation level. Nearly all urban transport lines contracts were concluded as this supplementary level. The act included also the enactments that the municipality concludes the agreement with the carrier and subsidy the reasoned costs. The award to the carrier goes from the municipality's budget.

Public transport contracts are concluded between authorities competent in providing of public transportation services and public transport operators in situation, when needed level of public transportation services isn't able to be operated on a commercial basis. Public transportation obligation defined in the former enactments of road transport Act was compounded in three parts supplementing each other:

- The obligation of operation, that is the carriers obligation to provide the operation of public transport line smoothly and according to accepted timetable including the additional transportation services,
- the obligation of transport, that is the carriers obligation to carry the passengers for special price when fulfilling the conditions,
- the tariff obligation, that is the carriers obligation to carry the passengers or items for regulated price according to the price regulation amendments, regulated price is lower than the economical fare.

Public transportation services are now embodies in the special Act no. 194/2010 Coll., on public transportation services. Public transportation services definition is above in the first paragraph of the second chapter. Public transportation services are defined by the list of certain transport connections, institutions and services. The public transport needs when caused by a purpose defined in the act should be able to be covered by the public transportation services. Main purpose of public transportation services is the harmonic regional sustainable development, public transportation services are contributing to it as its essential part. Czech Republic is proud member of European Union, so transport policy and its issues are harmonized with the European transport policy as well as acquis communitaire. Czech Act no. 194/2010 Coll., on public transportation services is based on the Regulation (EC)

No 1370/2007 on public passenger transport services by rail and by road and it implements this Regulation in Czech legislation.

Public transportation services of interregional and international character are provided by the trains concluded by the Czech state using its Ministry of Transport. The main network of ministry-provided trains in supplemented by the trains and buses provided in the regions to ensure public transport services in regions areas. Although the public transport services provided by the Ministry of Transport and regions cover also a part of transport needs inside urban areas, most important are the public transportation connections provided by the municipality. The other public transportation services can be offered on a commercial basis, these are all long distance bus lines, one open access railway track between Prague and Ostrava and few other bus lines, where fully commercial services are viable.

Thus public transportation system declare the minimal public transportation services level, but the final public transportation services level can be upgraded by competent authorities. When deciding about public transportation services in urban areas more criteria is evaluated. The fulfillment of inhabitants' transport needs of a certain city usually overreaches the public transportation extent defined in the legislation. Municipal authorities shall respect social and environmental aspects of public transportation services, important aspect is also the capacity of transport infrastructure. The crucial point defining the public transportation is the financial situation of the municipal authority.

3. FINAL STATE OF PUBLIC TRANSPORTATION SERVICES

The decision about the extent of public transportation services must be based on the transport demand analysis. The transport demand determines the public transportation more than any other factor. Transport demand is almost exclusively derived demand, based on the knowledge about the urban area and functions of single city parts is possible to build a model of transport flows that are determined by the linkages among city parts. The transport flows, resp. traffic flows models as a base for urban public transportation planning are determining the technological conditions of urban public transportation system.

Bulíček and Mojžíš (2005) described the general overview of factors: "*Operational extent of regional public passenger transport is depended on character of solved region, especially on the number of inhabitants. Number of passengers is also able to be influenced by some other socio-economic characteristics like structure of industry, unemployment rate or average income of inhabitants in the region*." In addition to them, more detailed overview of factors specified for urban areas is provided by Drdla. According to Drdla (2005) urban public transport flows determining factors can be divided by seven groups:

1. demographical characteristics,
2. inner city structure,
3. relation between the urban area and its surrounding,
4. transport infrastructure,
5. leisure time activities and trends.

The quality of understanding to transport needs, that are the base to transport demand derivation, is one way of public transportation services evaluation, it is complex of social, political, demographical and economic factors to be understood and corresponding public transportation systems should be offered in return. The rate of importance of certain factors can be analyzed and measured by statistical tools and models, the author introduced the model of public transportation based on the hypothesis, that the quality of public

transportation services can be measured by the amount public transportation connection offered during one day (Trpišovský, Průša, 2014).

3.1 Demographical characteristics

Demographical characteristics of inhabitants describe the division of the inhabitant by the groups, which are creating functional parts of the city connected by transport infrastructure. Functional parts aren't usually the same as administrative parts of the city. Household counts should be observed in these city parts and then inhabitants' structure in these households with the focus on employment rate, salary levels and age characteristics. The amounts of children, teenagers, youths, men and women employed and seniors are needed.

Every inhabitant group has its own characteristics and its typical transport needs. Focus on the inhabitants' structure leads the planners to the detailed overview of transport needs in certain area.

3.2 Inner city structure

Inner city structure represents the layout of main functional areas – living, industry, agriculture, central parts, commercial zones, transport and leisure time & sport areas. When analyzing the layout not only the importance and mutual linkage, but also their immixture is important. Czech cities don't usually have monofunctional parts, more functions are connected to one city part. Based by the functional parts layout the workplaces layout is derived and its peak hours title on public transportation services. Workplaces character can lead to the rise of saddle hours transport needs in specific cases such as majority of workplaces in Tertiary.

Geographical conditions and natural restrictions lines, such as bays or rivers limit the transport connection possibilities, but on the other hand they create natural transport corridors (Vuchic, 2005).

3.3 Relation between the urban area and its surrounding

The city surroundings usually creates an attraction zone to the city, the attraction zone generates amount of passengers travelling to the central city. As the city transport system isn't isolated and the interaction and connectivity with outer transport system is needed. Outer areas generate other passengers travelling to the city and who are not only the public transportation services passengers, but also car riders using the transport infrastructure in the city.

3.4 Transport infrastructure

Transport infrastructure determines the final transport situation in the city. The road as well as the rail system of present time cities is given as the historical heritage and potential changes are very difficult, especially in the city centers.

Kotas (2007) mentioned that nearly in all European cities with historically given urbanistic history the transport system must be subordinated to the city needs. Only in new estates, typically in suburban areas, the road system may be as important as urbanistic study and it can be co-creating the city structure, but the architects must never forget that transport has to serve the city, not conversely.

Transport infrastructure has to be appropriate to the transport needs, this situation is only hypothetic and no real example can be introduced. Transport infrastructure construction has discrete character in time, but the transport demand has continuous character in time, its dynamic changes can lead to two possible situations:

- Transport infrastructure is appropriate to the transport needs in the city – ideal short time state, which will be changed soon by continuously changing transport demand.
- Transport infrastructure isn't appropriate to the transport needs. This situation can occur in two states:
  - Transport infrastructure is insufficient, traffic jams occur regularly.
  - Transport infrastructure is has higher capacity then transport needed, that can lead to the transport induction.

3.5 Leisure time activities and trends

Transport doesn't serve only for securing of the traffic to the job, school or necessary shopping, but also securing the traffic o free time activities, especially sport and culture. The share of this kind of connections is rising up constantly in recent years. Free time activity and the needs connected to them influence the public transportation services especially during weekends and specific times (summer holidays, winter holidays) and in specific regions.

Leisure time activities are subject to change by short and longtime social trends.

4. CONCLUSION

Deciding about the extent of public transportation services is very important case for every city, where urban transport is provided. The overview of key factors influencing transport services demand is presented in the paper. The list can never be final, every city is specific and has its own factors, it can vary a lot. The experience and knowledge is necessary for technologists planning the urban transport, the continuous optimization is essential in order to match the actual transport needs of passengers. The technologists must define factors correctly and find estimation of their influence on final transport demand.

The final decision about urban public transportation services is always based on the political and financial situation of the city, the funds aren't likely to be used for transportation. The share of public transportation services costs is quite high on the total amount of city costs. Higher effectivity of invested money is required to ensure efficient use of European funds.

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PREDICTION MODEL OF DYNAMICAL SYSTEM

ABSTRACT

This situation is well known to all of us. You're on your way, once out of the blue you are stuck in traffic. It's not a typical "rush hour" time and commonly traffic doesn't get like that. There should be an accident or some kind of serious incident up ahead. You bit by bit move forward, bumper to bumper, perpetually attempting to search out the flashing lights of ambulances and police cars the indications of a main road incident. Then instantly, traffic starts to maneuver forward once again. There is no indication of an accident, incident, or the other reason for the downswing in traffic. What happened? Traffic flow system may be a human-joined, changeable, open and sophisticated massive system. It is extremely nonlinear and unsure. Under certain scenario, chaos is found in it. The summary of studies on chaos in traffic flow suggests that study on chaos is of nice theoretical and helpful worth. In addition, the summary of techniques to identify chaos shows the constraint on current strategies and course and angle of study on recognition of chaos in traffic flow.

KEY WORDS

Traffic flow; congestion; simulation model; chaos theory

1. WHEN CATASTROPHE MEETS TRAFFIC CONGESTION

Let us analyze one probable real life situation. It is a sunny day as well as the streets contain no apparent hazards that will create issues with traffic. Traffic concerning this particular highway is rather thick, but it is flowing easily and continuously. One of the motorists, let us say a man inside a blue vehicle, decides that people in the lane are moving far too gradually for his taste. He quickly changes lanes so that they can reach a quicker moving lane. He does not correctly check his mirrors and reduces another driver within the lane beside him. This forces that driver to use his brakes in order to avoid being clipped from the large blue vehicle.

There is no impact, and the person at a blue vehicle proceeds. The motive force that had expected to use their brakes has slowed a little, leading to the motive force in it to use their brakes too. Consequently, the person in it must hit their brakes too. Human reaction moment what it's, each following time that somebody needs to hit their brakes, it might be progressively more sudden eventually leading motorists farther in the future having to slam on their own brakes and are available to some complete pause and avoid rear ending the individual before them.

Because of the dead stop at that lane, motorists start to change lanes to change position to among the other lanes, which are moving correctly. Because this happens, another similar lanes start to slow as individuals are merging over. Exactly the same process repeats itself inside the other lanes before the entire highway has slowed down to some crawl and finally an entire stop.

Once the traffic on the highway continues to be dense and continuous, this chain reaction could still travel back for miles and may go on for an unknown period. The person at a blues vehicle, who had been in hurry, most likely to rush home and browse over the internet, may be home now. He could be sitting on his chair, and watching TV while all other are caught inside the traffic jam because of his behavior.

An event similar to this may be known by many people to become a probable theory along with a probable reason for most of the traffic jams we all experience events like this every day.

The predicament is inside a theory of Chaos and Non Linear Dynamics. It is simply like the principles from the “domino effect” as well as the “butterfly effect”. The “butterfly effect” results in a conclusion when a butterfly flaps its wings, that small disruption within the chaotic motion from the atmosphere could create a chain reaction enhancing the result to what large atmospheric motion able to changing the elements in another place in the world. The “butterfly effect” shows the impracticality of creating forecasts for complex systems.

This sensitive attachment to initial conditions could be the essence from the Chaos Theory. Our situation may be loosely referred to when it comes to a “domino effect”, however the “domino effect” uses linear number of identical occasions. The “butterfly effect”, however, seems to suit our circumstances better because it demands the effect increases the problem upon each iteration. Within our demonstration of the traffic jam, the result was increased each time as motorists were forced to use breaks, more abrupt action creating a slowdown and eventual dead stop.

Vehicle accidents might have been induced by all this action and response, resulting in more traffic and events as emergency automobiles are rerouted towards the arena from the accident. Some motorists may take another exit than usual to avoid the traffic, resulting in elevated traffic and occurrences on side roads distributing the problem past the confines from the original highway. This could begin affecting traffic, people’s lives all around the city weight loss actions, and responses derive from the first traffic jam. Each reaction brought to another reaction creating a finish result that has been impossible to calculate.

It is feasible for both ideas involve some devote explaining a predicament for example ours. It is also probable that neither can precisely describe the succession of occasions. Most of the events might have happened without worrying about our “man in a blue car”. It is also entirely possible that if traffic had not been subsequent so carefully behind the people instructed to brake all of a sudden, the resulting traffic jam would not have occurred.

So the next occasion you are stuck in bumper to bumper traffic, it’s very likely that the person that triggered it is already at home watching TV when you stay in traffic nothing to do but to think about the finer points of nonlinear dynamics.

2. MODELS FOR TRAFFIC FLOW MODELING

Traffic procedures on roadways might be improved by field study and field experiments of real-life traffic flow. However, in addition to the scientific problem of recreating such experiments, costs and safety be a factor of dominant importance as well. Because of the

complexity of the traffic flow system, analytical methods may not provide the preferred results. Consequently, traffic flow (simulation-) models designed to characterize the actions of the complex traffic flow system have become an essential tool in traffic flow investigation and experimentation.

With respect to the type of model, the application area of these traffic flow models is extremely broad, e.g.:

- Evaluation of alternative treatments in (dynamic) traffic management.
- Design and testing of new transportation facilities (geometric designs).
- Operational flow models serving as a sub-module in other tools (model based traffic control and optimization, and dynamic traffic assignment).
- Training of traffic managers.

The description of discovered phenomena in traffic flow is nevertheless not self-evident. Common mathematical models aimed at describing this behavior using mathematical equations include the following methods (Papageorgiou, 1998):

- Purely deductive approaches whereby known accurate physical laws are applied.
- Purely inductive approaches where obtainable input/output data from real systems are utilized to fit generic mathematical structures (ARIMA models, polynomial approximations, neural networks).
- Intermediate methods, whereby first basic mathematical model-structures are produced first, after which a specific framework is fitted using real data.

Papageorgiou (1998) convincingly claims that it is improbable that traffic flow theory will achieve the descriptive precision achieved in other areas of science. The sole correct physical law in traffic flow theory may be the preservation of vehicles equation; all other model structures reveal either counter-intuitive idealizations or coarse approximations of empirical findings. Therefore, the challenge of traffic flow researchers is to search for useful theories of traffic flow, which may have sufficient illustrative power, where sufficiency depends on the application purpose of their concepts.

Accordingly, the discussed, traffic models are categorized based on the following:

- Scale of the independent variables (continuous, discrete, semi-discrete);
- Level of detail (submicroscopic, microscopic, mesoscopic, macroscopic);
- Representation of the processes (deterministic, stochastic);
- Operationalization (analytical, simulation);
- Scale of application (networks, stretches, links, and intersections).

Time series analysis of nonlinear dynamic system is a macroscopic traffic flow model, in order to recognize the importance of chaos theory in modeling traffic one needs to explore all of the aspects of traffic flow theory.

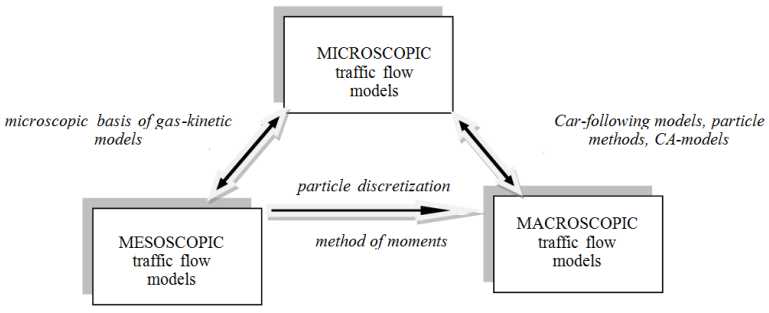

Figure1 - Relationship between microscopic, mesoscopic, and macroscopic flow models.

Concerning the relationship between microscopic and macroscopic traffic flow models, the work of Franklin (1961) and Del Castillo (1996) also needs to be pointed out. Franklin (1961) has evolved a microscopic model that catches macroscopic highlights of traffic flow, such as shockwaves, using a stimulus reaction car following model. In the same vein, Del Castillo (1996) suggests a car-following model, the three parameters of which can be determined directly from speed-density data. This car- following model displays comparable shockwave distribution behavior as the model of Franklin (1961).

2.1 Science behind Chaos theory

One of microscopic traffic flow models is also modeling with chaos theory. A substantial amount chaos theory has been publicized lately. The discoverer of chaos, Lorenz offers useful, entry-level dialogue. Casdagli et al. provide an effective overview of chaos theory and evaluation techniques. Hilborn provides a broad yet detailed study of chaos, while Argyris et al. present more mathematically sophisticated coverage. Abarbanel offers an excellent presentation of chaotic data analysis techniques. In the context of transportation, significantly less has been published.

Prigogine and Herman modeled traffic adding statistical mechanics with individual choice behavior and demonstrated it to exhibit a high degree of complexness. Disbro and Frame demonstrate how the theoretically derived, Gazis, Herman and Rothery traffic model is highly chaotic, no matter whether used on small systems. Van Zuylen et al. discussed the implications of human behavior, chaos and unpredictability for urban and transportation planning and forecasting. Safanov et al. showed that chaotic behavior in traffic can due to the delays in human reaction. And Weidlich demonstrated how random-utility-based models of relatively simple social behaviors produced chaotic behavior.

A number of authors have noticed the non-linear of even chaotic-like conduct of the traffic system (Bovy and Hoogendoorn (1998), Pozybill (1998)). Of these behaviors is the metastable or unstable behavior of traffic flow, meaning that in heavy traffic a critical disruption can be increased and develop into a traffic jam. Empirical experiments done by Forbes (1958), and Edie and Foote (1958,1960) have demonstrated that a disruption at the foot of an update advances from one vehicle to the next, while being increased until at some time a vehicle came to a total stop. This fluctuations effect explains that once the denseness crosses some crucial density, traffic flow becomes swiftly more congested with no obvious reasons. More empirical proof of this instability and start-stop wave development is available in amongst others Verweij (1985), Ferrari (1989), and Leutzbach (1991). Kerner and Rebhorn (1997) and Kerner (1999) show empirically that local jams can persist for many hours, while keeping their form and characteristic qualities. Quite simply, the stable complex structure of a traffic jam can and does exist on motorways*. These findings reveal that traffic flow has some chaotic-like properties, meaning that microscopic disturbances in the flow can lead to the on-set of local traffic jams persisting for many hours.

Microscopic simulation models are founded on the presumption how the behavior for each individual vehicle is a function of the traffic circumstances in its direct environment. Nevertheless, the (microscopic) behavior of humans in real-life traffic - not in contrived “car-following experiments” - is hard to see, measure and validate (cf. Daganzo (1994a)). Microscopic details of the simulation models have to be just right for the microscopic simulation to realistically describe and predict the stop-start waves in traffic flow. Thus, from

a model calibration perspective, the large number of sometimes-unobservable parameters plays a limiting role.

On the other hand, in macroscopic models, the amount of parameters is fairly small and, more importantly, comparably simple to observe and calculate. Calibration and validation of macroscopic models consequently requires less effort than calibration of microscopic or mesoscopic models. Furthermore, macroscopic models are considered to explain macroscopic characteristics of traffic flow better. In addition, microscopic simulation tools do not provide insight into the macroscopic mechanisms of traffic flow (e.g. shock wave behavior). However, macroscopic models provide such insights through mathematical evaluation and adjustment.

To be able to apply chaos tools, one must first comprehend chaos theory.

3. SHORT TERM PREDICTION OF TRAFFIC FLOW USING TIME SERIES ANALYSIS

Many studies concluded there exists evidence of nonlinear dependence in the short-term traffic flow dynamics and that chaotic time series model can successfully explain such nonlinear structures, one had better test if chaotic or stochastic phenomena exist in the traffic flow time series before applying chaos theory to the traffic flow dynamics explanation and prediction. Here are four tests that we employ: reconstruction of phase space, correlation dimension method, and Lyapunov exponent we just briefly outline their concepts without elaborating them in full extent.

3.1 Reconstruction of phase space

For any scalar time series xt, where t= 1,2,...,N, the phase space is usually reconstructed while using method of delays (Takens,1981).The fundamental idea in the approach to delays is that the development of any single variable of a system is based on the other variables with which it interacts. Information about the relevant variables is thus implicitly contained in the history of any single variable. On the basis of this an ‘‘equivalent’’ phase space can be reconstructed by assigning an element of the time series xt and its successive delays as coordinates of a new vector time series

$$Yt=Yt = \left\{ xt, x_{t+\tau}, x_{t+2\tau}, \ldots\ldots, x_{t+(m-1)\tau} \right\} \qquad (1)$$

Where τ is referred to as the delay time and for a digitized time series is a multiple of the sampling interval used, while m is termed the embedding dimension. The dimension m of the reconstructed phase space is considered as the sufficient dimension for recovering the object without distorting any of its topological properties, thus it may be different from the true dimension of the space where this object lies. Both the τ and m reconstruction parameters must be determined from the data.

3. 2 Correlation dimension method

Correlation dimension is a way of measuring the extent that the existence of a data point affects the positioning of the other point lying on the attractor. Among numerous methods available for differentiating between chaotic and stochastic systems, the correlation dimension technique is probably the most basic one. The method uses the correlation function (or integral) for differentiating between chaotic and stochastic behaviors. The idea of the correlation function is that an apparently irregular phenomenon as a result of deterministic dynamics will have a restricted number of degrees of freedom comparable to the smallest

number of first order differential equations that capture the most crucial features of the dynamics.

According to the embedding theorem, to characterize a dynamic system with an attractor dimension d, an m-dimensional phase space, $d \geq 2m + 1$ is required. However, Abarbanel suggested that m>d would be sufficient. For an m-dimensional phase space the correlation function C(r) is given by

$$C(r) = lim_{n\to\infty} \frac{2}{N(N-1)} \sum H(r - |Y_i - Y_j|) \quad (2)$$

Where H is the step function, with H(u) = 1 for u > 0, and H(u) = 0 for u $\geq$ 0, where $u = r - |Y_i. - Y_j|$, N is the number of point on the reconstructed attractor, r is the radius of the sphere centered on Yi or Yj. If the time series is characterized by an attractor, then for positive values of r the correlation function C(r) is related to the radius r by the following relation:

$$C(r) \propto ar^{D_2} \quad (3)$$

Where α is a constant; and D2 is the correlation exponent or the slope of the logC(r) versus $\log r$ plot given by:

$$D_2 = lim\, log_{r\to 0} \frac{logC(r)}{logr} \quad (4)$$

To see regardless of whether chaos exists, the correlation exponent (or local slope) values are plotted from the corresponding embedding dimension values. When the value of the correlation exponent is limited, low and non-integer, the system is believed to exhibit low-dimension chaos. The saturation value of the correlation exponent is described as the correlation dimension of the attractor. The closest integer above the saturation value offers the minimum number of phase spaces or variables essential to model the dynamics of the attractor.

3.3 Largest Lyapunov exponent

Rosenstein et al. suggested a method to determine the largest Lyapunov exponent from an observed times series. After reconstructing the phase space using appropriate values for τ and m, a point xn0 is chosen and all neighbor points x_n closer than a distance rare found as well as their average distance from that point is calculated. This is repeated for N number of points along the orbit so as to calculate an average quantity S known as the stretching factor:

$$S = \frac{1}{N} \sum_{n_0=1}^{N} \left(ln \frac{1}{|u_{x_{n0}}|} \sum |x_{n0} - x_n| \right) \quad (5)$$

Where$| u_{x0}|$ is the number of neighbors found around point x_{n0}. A plot of the stretching factor S versus the number of points N(or time t=NΔt) will yield a curve with a linear increase at the beginning, followed by an almost flat region. The first part of this curve represents the exponential increase of S as more points from the orbit are included, while the flat region signifies the saturation effect of exponential divergence due to the finite size of the attractor.

4. PREDICTION WITH ANALYSIS OF TIME SERIES OF NONLINEAR DYNAMIC SYSTEM

As mentioned formerly, though chaos is essentially deterministic, it is unpredictable beyond short intervals. This section addresses how short this interval will in theory be and just

how accurate predictions can be made within that period. The technique follows those discussed in Abarbanel, Casdagli et al., and McNames.

The period limit on precise predictions of a chaotic system is a function of the largest Lyapunov exponent [1]:

$$\Delta t_{\max} = \frac{l}{\lambda_{\max}} \tag{6}$$

To be chaotic, the largest Lyapunov exponent must surpass zero. If it surpasses one, the maximum length of an accurate forecast is less than the data series sampling frequency. Therefore, just for systems with Lyapunov exponents between zero and one are chaotic predictions of any practical use. If the exponent is much less than one, long, accurate forecasts are possible.

For forecast, one starts with the unfolded attractor in m-dimensional space and time lag τ. Given an initial vector y(t1), one selects the k nearest trajectories on the attractor, and then the k nearest points to y(t1), one on each trajectory. An average of these trajectories is used to find the next point on the predicted trajectory, y(t1 + m τ). The predicted point is then set as the new starting vector and the process is repeated.

This predictive technique provides the best model feasible within the context of chaos theory, which carefully exploits the fact that details are contained in the data and can be utilized for predictions.

5. CASE STUDY AND RESULTS

We use the traffic flow data from the system real time traffic counters. The sampling time interval is 15min. We have done some experiments and our method has shown goad performance. Here, we just randomly select one of them to show our results. The raw data from Mar. I to Mar. 21, 2013.

The raw data is shown in Fig. 3. The data of 20 days, as training set, are used to construct initial phase space. The residual data of 2 days, called testing set, are used to test the accuracy of the model proposed in this paper. Use chaotic neural network and BP neural network to make predictions on traffic flow time-sequence. Their results and real results are compared below:

Table 1 - Comparison of two prediction methods

	operation time	nb. of steps	average deviation	polarity
Conventional BP neural Network prediction	8.2456345	1560	0.0082542	0.87112
Chaos theory and BP neural network prediction	4.314568	712	0.0000451	0.9987

Table 1 shows us that prediction method based on chaos theory and BP neural network is slightly more precise, its simulation features are relatively better, calculation time is also relatively shorter, which makes it more apt for real-time control and guidance of traffic flow.

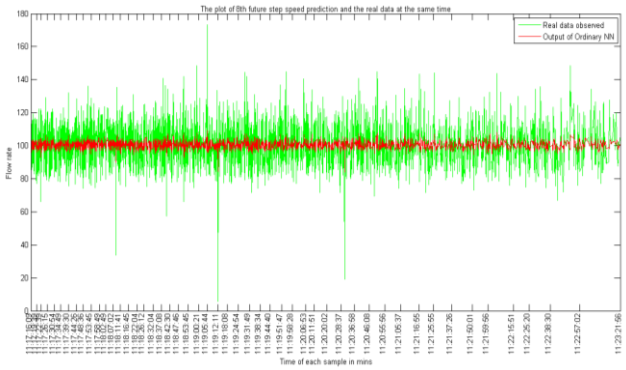

Figure 2 - Real data observed compared to chaotic neural network

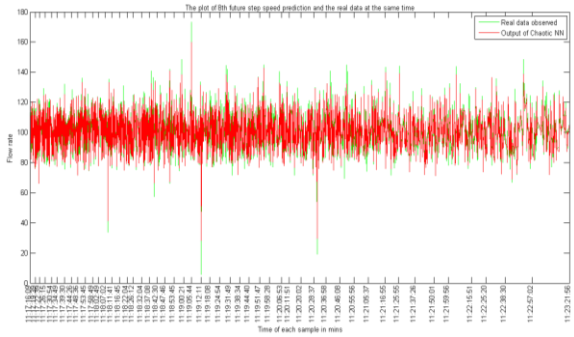

Figure 3 - Real data observed compared to modified chaotic neural network.

Prediction method based on chaos theory and BP neural network is slightly more precise, its simulation features are relatively better, calculation time is also relatively shorter, which makes it more optimal for real-time control and guidance of traffic flow.

6. CONCLUSION

While the article did not provide or develop a traditional model with equations, it extracts valuable information involving all system dynamics for general application. Chaos theory seems naturally applicable to transportation systems, yet little convincing real-world evidence exists.

Conclusions are of general importance, since simple dynamical models can exhibit extremely complicated behavior. It cannot be though there are circumstances of chaotic behavior in traffic flow that occur and a simulation of real world behavior.

The common character of' strategies to predict traffic flow is to ascertain the subjective model of the time series beforehand and also the calculation and prediction in line with it. However with exploitation of chaotic theory, we'd like to not establish the subjective model beforehand. We are able to predict the traffic flow in line with the target properties of the traffic flow time series. Thus we can avoid the subjectivity of the prediction and improve the exactitude and reliability. It’s been shown that a prognostication approach supported deterministic chaos is quite effective in predicting traffic flow.

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