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- Provide international dissemination of knowledge and contributions to the science and practice in the field of traffic and transportation
- Promote and exchange information and knowledge in the transportation research arena and its application
- Explore the new trends in development and invention related to the efficiency, reliability, safety and economically and ecologically sustainable transportation.

TTTP provides conditions and positive environment for the new idea promotion, exchange research results and achievements accomplished by the scientific community from academia and transportation industry.

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EDITOR'S WORD

Dear Readers,

In front of you, after a long preparation, there is the first issue of the internationally reviewed scientific journal "Traffic and Transport Theory and Practice - TTTP." The Pan-European University APEIRON, Faculty of Traffic and Transportation Engineering is publisher of the Journal. For the time being the Journal will be published twice a year: in April and October.

The Journal is published in an electronic, open access, and printed edition. Our desire is that readers can access it easily and cheaply. In addition to traditional technical, engineering issues visible in the publishing information, we publish papers from all scientific fields that gravitate toward traffic and transportation. We believe that reviews of the basic activity by other professionals would be also significant in the future. We will also nurture works that are created in collaboration with students, trying to involve them in scientific work.

For easier availability the Journal is published in English – the language essential in every mode of transportation. Therefore, this first issue brings eleven papers that bring different themes, ranging from traffic safety, transportation costs, financing public transportation, traffic flow characteristics, and intelligent transportation systems to air quality and environmental protection. Those papers aim at improving communication in English since we are all aware of misunderstandings and poor communication. The number of authors is very high, twenty-eight of those from, Croatia, Serbia and Bosnia and Herzegovina who gave contribution to this first issue. Our intention is to continue that way.

We hope that the papers published will prompt you to cooperation.

Sincerely
Mirsad Kulovic,
Editor-in-Chief

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ORIGINAL SCIENTIFIC PAPER

Illustration of Typical Situations of Fatal Traffic Accidents Involving Cyclists Within the Territory of the City of Belgrade

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Abstract: This paper analysed traffic accidents involving cyclists that occurred within the territory of the City of Belgrade, based on traffic technical forensics case files, over the period from 2009 to 2013. Within the analysed sample, identified and illustrated are typical situations in which there are fatal injuries of cyclists in traffic.

Key words: road safety, traffic accidents, safety of cyclists, belgrade, typical situations.

INTRODUCTION

With significant increase of the use of motor vehicles and their contribution to serious environmental, economic and health problems led to increased interest in promotion of cycling as an alternative mode of transport, which has been greatly expanding of late. Increased popularity of the bicycle is also influenced by the fact that this mode of transport is very cheap, and poor economic conditions and increasing price of fuel stimulates the lower income population to use the bicycle more often (1).

Increased use of the bicycle resulted in cyclists' safety in traffic becoming a more prominent problem. Cyclists are the most vulnerable participants in traffic, and that vulnerability is from one side attributed to insufficient protection compared to other participants in the traffic (lack of adequate and suitable traffic infrastructure, busy existing traffic infrastructure, improper education, etc.), and from the other side to specific characteristics of cyclists behaviour (2).

The size of the problem in cycling traffic is illustrated by the fact that during 2013 there were 1633 traffic accidents involving cyclists in the Republic of Serbia, which is 8.5% of the total number of traffic accidents. Percentage of killed cyclists was 9.1% of the total number of fatalities in traffic accidents, while the percentage of injured cyclists was 8.5% of the total number of injuries in traffic accidents (3).

Various researches conducted in the Republic of Serbia (2) show that cyclists over the age of 60 are the most vulnerable and make 43.5% of the fatalities. As much as 30.4% of the killed cyclists died during low (night) visibility (most of the accidents happened from 19:00 to 20:00 hours – 57.1%), while 43.5% traffic accidents with fatalities happened on local roads and streets.

Lately, increasing number of researches deals with the issue of vulnerability of cyclists in traffic. In order to manage the state of traffic safety, the first step is to establish the current state of play, which can be only performed if we observe both phenomenological and etiological aspects. Occurrence of fatal injuries of cyclists in traffic are established through phenomenological analysis, while the real causes of fatal injuries and specifics of traffic accidents involving cyclists are established through etiological analysis. In this way, and in order to improve the safety of cyclists in traffic, it is possible to define measures that correspond both to occurrences and specific causes of traffic accidents involving cyclists (4).

Bearing this in mind, as well as the importance of this issue, this paper analysed traffic accidents involving cyclists based on traffic technical forensics case files, over the period from 2009 to 2013 , where within the analysed sample, identified and illustrated are typical situations in which there are injuries of cyclists in traffic in the City of Belgrade.

ILLUSTRATION OF TYPICAL SITUATIONS WITH INJURIES OF CYCLISTS

The paper illustrates typical situations where injuries of cyclists occur in traffic in the City of Belgrade, based on forensic expert evaluation of traffic accidents involving cyclists, which were a subject of the Traffic Forensic Technical Committee of the Institute of the Faculty of Traffic in Belgrade over a five-year time period, from 2009 to 2013.

Based on the results of this analysis, which points out characteristics and mechanisms how traffic accidents with killed cyclists occurred, it is possible, in the best possible way, to define measures to avoid traffic accidents involving cyclists and by that increase the level of safety of this vulnerable category of participants in traffic.

Typical situation 1:
Other vehicle catching up with the cyclists

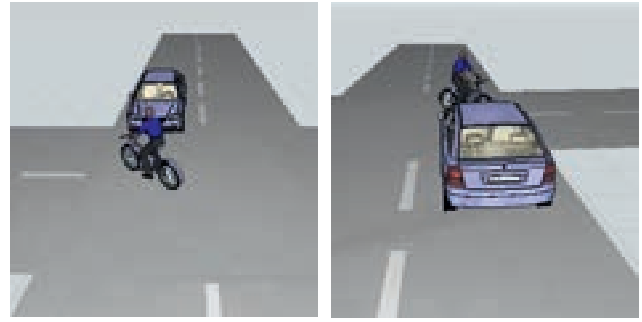
Circumstances: The most frequent case of fatal injuries of cyclists in traffic in the City of Belgrade is the case when another vehicle catches up with the bicycle. In most cases this situation occurs in conditions of low (night) visibility, i.e. on roads with poor lighting when the driver of a motor vehicle did not see the cyclist on time.

Picture 1. Illustration of a typical situation 1

Problem: In the situation above (Picture No. 1) the cyclist is moving along the right side of the road, in 83.3% cases, in low visibility (night) conditions riding an unlit bicycle. For drivers an unlit cyclist presents a sudden and unexpected obstacle on the road. That is why Article 81, Item 5 of the Law on Road Traffic Safety prescribes in detail the manner of marking cyclists during night and low visibility conditions on the road. By disobeying the traffic rules, the cyclist endangers himself, but also others because the driver is unable to see him on time, and therefore is unable to react sooner and avoid the accident. The main problems in this situation that led to the accident are most frequently disrespecting the traffic rules prescribed by the Law on Road Traffic Safety by cyclists and driver spotting the cyclist too late. Considering the situation, the possibility to avoid the accident is very small.

Typical situation 2: The cyclists is turning left across the trajectory of the incoming vehicle

Circumstances: Second most frequent case of fatal injuries of cyclists in traffic in the City of Belgrade is the case when the cyclist driving through a junction turns left across the trajectory of an incoming vehicle, coming from the opposite direction.



Picture 2. Illustration of a typical situation 2

Problem: In the situation shown in Picture No. 2, the cyclist is moving along the central line on the road and turns left in the junction across the trajectory of the incoming motor vehicle. The main problem in this situation is denying the right of way to the motor vehicle coming from the opposite direction. The cyclist could, by simply observing the road before making the turn see if the turn can be done safely and give up on the turn and give way to the incoming vehicle and avoid the dangerous situation and the traffic accident. By reckless behaviour the cyclist endangers himself and others. In this situation there is no low visibility at the site of the accidents, i.e. the accidents happened in conditions of daytime visibility.

Typical situation 3: Hitting the cyclist at the pedestrian crossing during a turn across the cycling track

Circumstances: In this situation (Picture No. 3) the driver of the motor vehicle during a right turn at a junction cuts across the cycling track and knocks down the cyclist who was riding on the pedestrian crossing, i.e. the cycling track crossing over the road.

Picture 3. Illustration of a typical situation 3

Problem: The main problems that lead to the accident are most commonly insufficient attention of the driver to other participants in traffic, i.e. disobeying the rules by the driver who does not stop at the cycling track on the road in order to give way to the cyclist, poor visibility of the cyclists due to physical characteristics, as well as insufficient attention to the forward area of his movement.

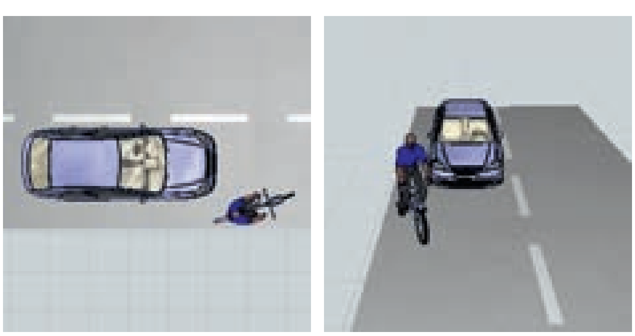
The Article 99 of the Law on Road Traffic Safety prescribes that if the traffic on the pedestrian crossing is not regulated by traffic lights or police officers, the driver must adjust the speed of the vehicle so that in any situation he spots or might have a reason to foresee he could safely stop the vehicle in front the pedestrian crossing and give way to the pedestrian who has already stepped or is stepping on the pedestrian crossing or demonstrates intention that he would step onto the pedestrian crossing. On the other hand, this Law prescribes that if the traffic at the pedestrian crossing is regulated by traffic lights or a police officer, the driver must, if by any such signal is allowed to drive over such crossing, give way to the pedestrian who has already stepped on the crossing or demonstrates intention to step on the crossing if that pedestrian was given permission to cross by a traffic sign or by a police officer. This article of the Law on Road Traffic Safety refers also to the crossing of cyclists across the road at the pedestrian crossing, i.e. cycling track crossing over the road.

Presence of a pedestrian crossing, i.e. cycling track crossing over the road can to some extent give confidence to a cyclist, i.e. the cyclist in such situation can behave more freely and carelessly due to the fact that he is located on a pedestrian crossing, i.e. a cycling track crossing.

In this situation there is no low visibility at the site of the accidents, i.e. the accidents happened in conditions of daytime visibility.

Typical situation 4: Collisions during parallel driving

Circumstances: Fourth most frequent case with fatal injuries of cyclists in traffic within the territory of the City of Belgrade is the case when a cyclist makes a sudden parallel turn to the left in front of or near an incoming vehicle.



Picture 4. Illustration of a typical situation 4

Problem: In the situation shown in Picture No. 4, the cyclist moves along the right hand side of the road, and then makes a sudden turn to the left in front and close to the incoming vehicle, without first making sure whether it is possible to make a safe turn, i.e. without previously informing other participants in traffic on his intentions. With his reckless behaviour the cyclist endangers himself because the driver has no special reason to expect a sudden change of direction by the cyclist, and with that the driver in this suddenly occurred dangerous situation does not have enough time to react adequately and avoid the danger and traffic accident.

The main problem in this situation that leads to the accident is reckless behaviour of the cyclist, i.e. the cyclist failing to look back and observe the traffic, to indicate his intention to turn, to monitor and recognize the danger on the road on time and respond adequately (e.g. open car doors, potholes, works on the road, etc.). We cannot exclude that there is a possibility that the cyclist cannot hear the motor vehicle closing in due to use of headphones.

In this situation there is no low visibility at the site of the accidents, i.e. the accidents happened in conditions of daytime visibility.

Typical situation 5: Illegal or irregular overtaking and driving around when there is a cyclist coming from the opposite direction

Circumstance: Fifth most frequent case with fatal injuries of cyclists in traffic in the City of Belgrade is the case when the driver of a motor vehicle overtakes another motor vehicle and then there is a conflict with a cyclist coming from the opposite direction.

Picture 5. Illustration of a typical situation 5

Problem: This is the situation (Picture No. 5) in which the driver of a motor vehicle overtakes another motor vehicle and then there is a conflict with a cyclist coming from the opposite direction. Considering the fact that this is illegal or irregular overtaking, which very often involves speeding, a frequent cause of the most serious traffic accidents, Article 55 of the Law on Road Traffic Safety defines when it is allowed to overtake or go around with certain places and situations where it is forbidden to do such activities. In both cases the accident happened in the low (night) visibility conditions so we cannot rule out that the driver of the motor vehicle could not see the cyclists, if the cyclist was riding an unlit bicycle. The main problems leading to an accident are disobeying the traffic rules prescribed in the Law on Road Traffic Safety by drivers of motor vehicles, who in this way endanger themselves and others, as well as the inability of the driver of the motor vehicle to see the cyclist.

CONCLUSION

Increased use of the bicycle resulted in cyclist safety in traffic becoming a more prominent problem. Cyclists are a vulnerable group of participants in traffic. Although traffic accidents involving cyclist are a small percentage of the total number of traffic accidents, when comparing the total number of vehicles and cyclists in traffic this percentage is very prominent and the consequences of such traffic accidents are often very severe.

The aim of this paper was to point out the dangers from disobeying the regulations by cyclists, especially dangerous situations in traffic that can result in case there are no lights on the bicycle in low (night) visibility, as well as when a cyclists turns left in front or near the incoming vehicle.

With the illustration and analysis of typical situations with fatal injuries of cyclists, the safety of this vulnerable category of participants in traffic can be influenced by using standard and systematic measures. By using preventive, educational, technical, regulatory, but also repressive measures we can provide safer and more secure traffic, which will directly decrease the number of traffic accidents and their severity.

Implementing measures to improve safety of cyclists, i.e. participants in traffic would initiate continuing research on a sample of findings and opinions, based on which it would be possible to monitor the implemented measures, but also taking preventive measures in order to improve the safety of cyclists in Belgrade.

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ORIGINAL SCIENTIFIC PAPER

The Influence of Meteorological Parameters and Traffic Flows on the Concentration of Ozone (O_3) in Urban Areas in Brcko

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Abstract: Meteorological parameters and traffic flows have a direct impact on air quality in large urban areas, and hence on the quality of life in them. A large number of done surveys confirmed the great dependence of the concentration of ground-level ozone (O_3) upon meteorological parameters and the size, structure and imbalances of traffic flows. As part of the research conducted in the period from November 5th to December 8th 2014 in Brcko in Muderis Ibrahimbegic St concentrations of ground-level ozone (O_3) were measured, meteorological parameters (temperature, humidity, wind speed and intensity of solar radiation) and characteristics of traffic flow of road motor vehicles. The maximum concentrations of ground-level ozone (O_3) in the measurement period was 106.54μg/m³, while the minimum concentration was 4.794μg/m³. By analyzing the results of measurements the high coefficient of correlation between wind speed, air temperature and humidity was established. The correlation coefficient between the traffic flows on the one hand and the concentration of ground-level ozone (O_3), on the other hand is very low and does not exceed the value of 0.301. A negative correlation coefficient between traffic flows and concentrations of ground-level ozone (O_3) is also observed in the certain time of the day.

Keywords: Ozone (O_3), meteorological parameters, traffic flow.

INTRODUCTION

Ozone (O_3) is a blue, reactive, explosive gas that occurs in both the upper and the lower parts of the atmosphere. In the stratosphere it is located about 90% of total ozone (O_3), which is located in the atmosphere. While in the upper atmosphere-the stratosphere, the presence of high concentration ozone (O_3) is preferable, because of its protective role, the presence of ozone (O_3), especially high concentrations in the terrestrial parts of the atmosphere-troposphere, is undesirable.

In many countries, the transport sector has been identified as a major source of ground-level ozone (O_3). The emergence of ground-level ozone (O_3) is related to the photochemical reaction between nitrogen oxides (NOx) and volatile organic compounds (VOC) in the presence of light. (*1*) The concentration of ground-level ozone (O_3) is determined by chemical reactions between the precursors of ozone (O_3), which originate from natural and anthropogenic sources, advection caused by the horizontal air flow and vertical movement of air masses .

Establishing relations between pollutants generated in the process of traffic and meteorological parameters (temperature, intensity of solar radiation, relative humidity, wind direction and speed, etc.) is related to the improvement of information on the state of ambient air quality. Air temperature and ozone (O_3) have a positive correlation coefficient and with increasing temperature comes the increase of the concentration of ground-level ozone (O_3). (*2*) The increase in the intensity of solar radiation leads to increased concentrations of ground-level ozone (O_3). High relative humidity, wet and rainy weather are connected with a low concentration of ozone (O_3) due to reduced efficiency and increased photochemical ozone deposition on water droplets. Relative humidity is negatively correlated with temperature, which is considered one of the primary indicators of ground-level ozone (O_3). (*3*) Between the concentration of ozone (O_3) and wind speed there is a negative correlation coefficient. Large wind speed allows transport of ozone (O_3). (*4*)

Increased concentrations of ozone (O_3) have a negative impact on human health, flora and construction. Inhalation of ozone (O_3) causes serious irritation and headaches. Ozone (O_3) irritates the eyes, the upper respiratory tract and lungs. Inhalation of ozone (O_3) can sometimes cause the formation of pulmonary edema fluid which accumulates in the tissues of the lungs. (*5*) In addition, increased concentrations of ozone (O_3) can decrease the lung capacity and weaken the immune system. The impact of ground-level ozone (O_3) on vegetation is manifested by the changes on the leaf of plants, which leads to faster aging and reducing the process of photosynthesis. (*6*) Ozone (O_3) has a strong influence on the metals, transforming them into corresponding oxides and organic products which are destroyable. (*7*) In addition, ozone (O_3) is a gas that can lead to an increase in air temperature by keeping the infrared radiation emitted from the Earth's surface. (*3*)

The main objective of the work is the ground-level ozone (O_3) concentration establishment (O_3) as a function of traffic and meteorological parameters. The starting point in determining the above depends on the gathering and analysis of data on the characteristics of the traffic flow (intensity, structure and weather unevenness) and basic meteorological parameters (temperature, humidity, atmospheric pressure, wind speed and wind direction, solar radiation). The significance of the work lies in its originality of the issues presented in the given area. Researches related to the determination of dependence between the concentration of ground-level ozone (O_3) and meteorological parameters and traffic flows on the territory of the Brcko District have never been done until now.

MATERIALS AND METHODS

Description Area

Brcko District is located in the north-eastern, lowland part of Bosnia and Herzegovina. In the southwest it borders with Srebrenik municipality in the southeast with municipalities Lopare and Čelić, in the west with the municipality of Gradacac, in the east with the municipality of Bijeljina and the northwest with the municipality of Orašje. The northern border of Brcko District of Bosnia and Herzegovina with the Republic of Croatia is the River Sava. The administrative center of the District is the town itself (44°53'0''N, 18°49'0''E), located in the northern part of the district on the right bank of the River Sava area which includes 183km^2. The town lies at the confluence of the River Brka, at an altitude of 96m, and it is a very important transit center. Brcko connects the western and eastern part of the Republic of Srpska, and moreover represents an important link between Bosnia and Herzegovina and Croatia, that is the European

Figure 1. Traffic position of Brcko District of BiH

Union. Figure 1 is represents traffic position of Brcko District. According to preliminary results of the Census of Population, households and residences in BiH in 2013, the total population on the territory of the Brcko District is 93028, while in the city there are 43859 inhabitants.

Brcko is a single-center organized so that almost all the administrative, commercial and other major attractions are concentrated in the city center, which has developed along the River Sava. Road network is irregular and it generally has a profile which doesn't allow building highly capacitive roads. The position of the border crossing with the Republic of Croatia and the customs terminal, which is located near the city center, as well as ports and railways which are located in the wider central zone, greatly complicate the traffic situation. In the framework of the existing road network in Brcko, traffic is mainly in two-ways. One-way traffic is taking place in 14 streets with total length of 2.78km. There are two main roads in Brcko M-14.1 with 31.75km length and M-1.8 with 5.3km length. The main road M-14.1 goes through the town in length of 9km. Also, two regional roads pass through the town R-460 with 23.2km length and R-458 with 13.6km length. Both regional road pass through the town, R-460 with 3.3km length, and the regional road R-458 with 3.6km length. The total length of the street network is about 85km. In 2014 in Brcko a total of 39982 road motor vehicles were registered. Out of the total number of registered vehicles, passenger cars were 82.82%, trucks 8.49%, motorcycles 2.47%, while other vehicles (mopeds, machinery, tractors, tricycles, motorcycles) were 6.22%. The vehicle fleet age of the Brcko District is extremely unfavorable. The fleet in 2014 prevailed vehicles older than 10 years and such vehicles were 29.21%. After this group of vehicles come vehicles whose age is more than 25 years, or vehicles aged between 26 and 35 years and these vehicles were a total of 24.19%. Vehicles age to 10 years, or between 0 and 5 years and vehicles from 6 to 10 years were only 9.23% of the fleet of the Brcko District. Out of the total number of registered vehicles, nearly 2/3 of the vehicles, or 64.66% of them had powertrains using diesel fuel, 31.69% use gasoline, while only 3.65% of the vehicles have generators using gasoline and LPG. The most recent engines, which meet Euro 5 and Euro 6 standards were located in 4.33% of vehicles, while the largest number of vehicles owned conventional engines 41.94%. Vehicles with catalyst formed the fleet structure of Brcko District with 51.14%, while vehicles without catalyst formed 48.86% of the vehicles. (*8*)

Location sampling has been selected in accordance with the source of emissions, safety, access, availability of electricity, visibility of the site in relation to the environment, safety of the public, the possibilities of determining sampling points for different pollutants at the same location and the requirements of spatial planning. Measuring the concentrations of ground-level ozone (O_3) and traffic counting were done within the Fifth Primary

School (44°52›24.8››N, 18°47›26.3››E) which is positioned in the residential area of the city, intended solely for individual housing, near the transit road connecting the eastern and western part of the Republic of Serbia. Figure 2 shows the micro location of sampling pollutants.

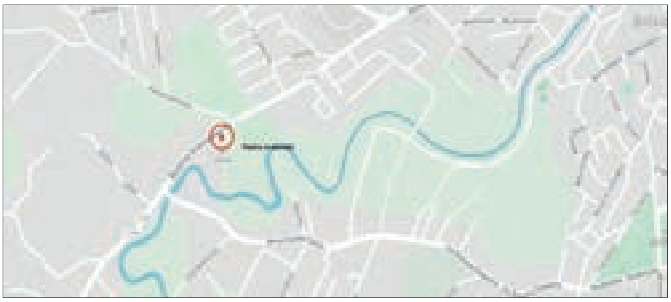

Figure 2. Micro location sampling of pollutants

Collection of ambient air quality and traffic data

Measuring the concentrations of pollutants in ambient air and traffic counting were done in the period from November 5th (from 6 pm) until December 8th 2014 (to 10am), the 784-hour interval. Data about measured concentrations of pollutants and meteorological parameters are automatically recorded in digital form. The values control is subsequently performed and also the validation of measured pollutants parameters. Measuring the concentrations of ground-level ozone (O_3) is performed using ambient O_3 monitor APOA-370. The principles of operation of the analyzer is in accordance with the requirements of the EU Directive 2008/50/EU on ambient air quality and cleaner air for Europe as well as with the requirements of Directive 2004/108 /EC. (*9*) Measurement of concentrations using APOA-370 is based on the principle of non-dispersive ultraviolet absorption, which is prescribed by the international standard ISO 13964. The measuring range of devices is 0 to 0.1/0.2/0.5/1.00ppm. For the concentration of 0.2ppm or less, the sensitivity is 0.5ppb, and for the concentration of>0.2ppm, the sensitivity is 0.5%(2σ). Data about the intensity, structure and timing of uneven traffic flow were obtained after visual process of digital camera. The flows of passenger vehicles (PV), light vehicles (LV), medium heavy vehicles (MHV), heavy vehicles (HV), car trains (CT) and buses (BUS) were recorded.

RESULTS

By Regulations on limit and target values for air quality, information and alert thresholds Brcko defined threshold value of ozone (O_3), which is 120μg/m³ for the sampling period of 8 hours, and a limit value for the protection of ecosystems is 18000μg/m³ for the period of 5 years. Within the Regulations the threshold of information is defined 180μg/m³ or alert threshold of 240**μg/m**³ for the sampling period of 1hour. (*10*) The ratio of measured concentrations of ground-level ozone (O_3) and limit values, threshold information and alert threshold is presented in Figure 3a and 3b.

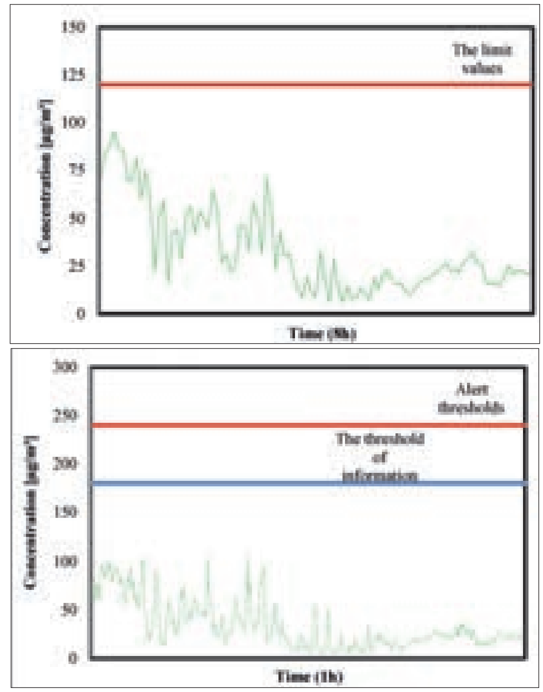

Figure 3A and 3B. The ratio of measured concentrations of ground-level ozone (O_3), the limit values, the threshold of information and alert thresholds

Measuring the concentrations of ground-level ozone (O_3) and meteorological parameters of traffic flows were done in a time series of 784 hours over a period from November 5th (06.00pm) to December 8th 2014 (10.00am). Results of measuring the concentrations of ozone (O_3) and meteorological parameters are shown in Table 1.

Table 1. Results of Measuring The Concentration of Ground-Level Ozone (O_3) And Meteorological Parameters

	Time (h)	Maximum	Minimum	The medium value	The standard deviation
Concentration (μg/m³)	784	106.54	4.794	33.587	24.117
Wind speed (m/s)	784	3.611	0.146	1.154	0.655
Temperature(°C)	784	22.84	-2.139	7.33	5.027
Humidity (%)	784	99.85	42.85	92.29	10.713
Sunlight (W/m²)	784	409.9	5.195	42.741	72.068

The maximum measured concentration of ground-level ozone (O_3) was 106.54 (μg/m³) and measured on November 14th in the time period from 01.00pm to 02.00pm. At the time when the maximum concentration was measured, wind speed was 1.06m s, the air temperature 14.06°C, humidity 84.41%, while the intensity of sunlight was 155.80W/m². Minimum measured concentrations of ground-level ozone (O_3) was measured on November 23th from 07.00 to 08.00am and it was 4.794 (µg/m^3). During that period, the calm weather prevailed, with winds of 0.61m/s, the low temperature of -2.09°C, humidity of 99.54% and low intensity sunlight of 8.15W/m^2. The medium value of measured concentrations of ground-level ozone (O_3) is 33.587µg/m^3, while the standard deviation was 24.117µg/m^3. The approximate three-dimensional function of distribution of the concentration of ozone (O_3) in day function of the week and hour of the day is shown in Picture 4. The convex feature of graphic functions with maximum concentrations of ozone (O_3) is located around the coordinates on Thursday in the daily interval from 12.00 to 06.00pm.

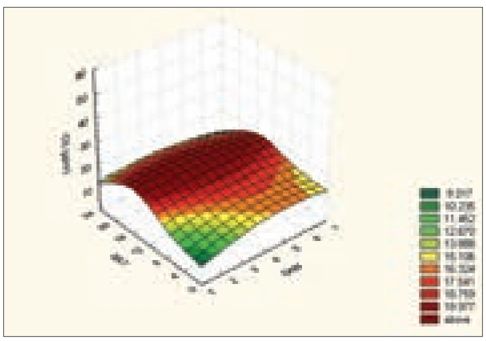

Figure 4. The approximate three-dimensional function of distribution of the concentration of ozone (O_3) in day function of the week and particular hour of the day

Analysis of variance of medium concentrations by a factor of the day of the week highlights the concentration of ozone (O_3) on Thursdays with a significant maximum of 38.33µg/m^3. The value of medium concentrations of ozone (O_3) on Thursdays is significantly higher than the minimum value on Tuesdays (30.35µg/m^3), but the same it does not apply in the remaining days. Between the value of concentrations of ozone (O_3), which are measured every other day, there were no significant differences. Analysis of variance of average concentrations of ozone (O_3) by a factor of hour in the day indicates the existence of two complementary periods. Period with a high concentration starts at 12.00pm and ends at 6.00pm, the value in this period is over 40µg/m^3 with a maximum value in the period from 03.00pm to 04.00pm with a value of 47.58µg/m^3. In the period from 06.00pm to 12.00pm concentration value does not exceed 40µg/m^3, and the minimum was established in the early morning hours in the interval from 08.00am to 09.00am and has a value of 25.96 µg/m^3. In these periods there are no significant differences in the intensity, and between these periods there are marked differences. Dependence of the concentration of ground-level ozone (O_3) as a function of meteorological parameters is shown in Figures 5A-5D.

Concentrations of ground-level ozone (O_3) is a high correlation coefficient or coefficient of determination of wind speed, temperature and air humidity. The correlation coefficient between the concentration of ground-level ozone (O_3) and specified meteorological parameters ranges in the interval $0.46<r<0.91$. The intensity of solar radiation and concentrations of ground-level ozone (O_3) are in a weak dependence and in this case the correlation coefficient is $r<0.29$. Concentrations of ground-level ozone (O_3) at the beginning of the measurements are considerably higher than at the end of the measurements, which is visible from Figure 3a and 3b. In addition, at the beginning of the measurements were significantly greater fluctuations in the concentrations than at the end, which is caused primarily by larger fluctuations in temperature. In contrast to the foregoing, the percentage differences in the concentration of ground-level ozone (O_3) are significantly higher at the end of the measurement, than at the beginning.

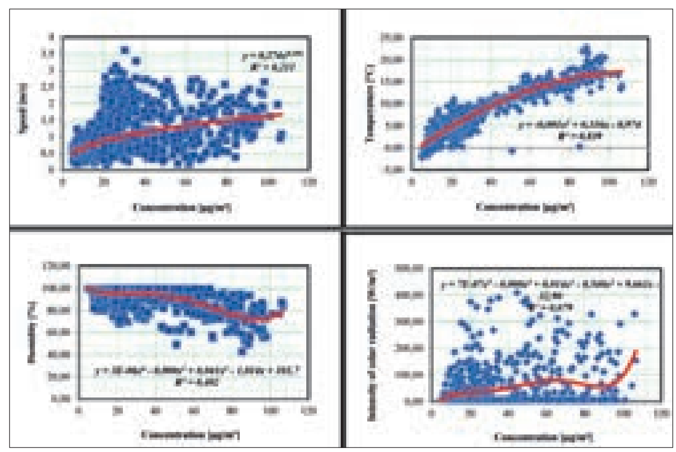

Figure 5A – 5D. Dependence of the concentrations of ground-level ozone (O_3) as a function of meteorological parameters

Results in recording traffic flows (PV, LV, MHV, HV, CT and BUS) indicate significant disparities of all traffic flows at the days of the week and hours of the day. Results measurement of traffic flow are presented in Table 2.

Table 2. Results of Measurement of Traffic Flow Characteristics

	Time (h)	Maximum	Minimum	The average number of vehicles	Standard deviation
PV	784	962	7	406.83	302.672
LV	784	27	0	5.662	6.149
MHV	784	21	0	2.512	3.078
HV	784	28	0	5.977	6.739
CT	784	54	0	12.205	10.337
BUS	784	18	0	5.343	3.991

From the analysis of variance of medium values of PV flows by a factor of the day of the week indicates the maximum value flows of PV on Fridays which is 451.90PV/day and on Sundays with a minimum value of 297.33PV/day. For LV traffic flows by the analysis of variance by a factor of the day of the week the maximum is established on Thursdays (7.12LV/day) and minimum on Sundays from 1.925LV/day, a maximum of MHV on Thursdays is 3.28MHV/day, a minimum on Sundays from 0.558MHV/day, for HV the maximum on Tuesdays is 7.558HV/day , and the minimum with PV, LV, MHV on Sundays is 1.35HV/day. The analysis of variance by a factor of the day of the week established for CT flows and BUS, minimum is on Sundays and for CT 4.308PCT/day, respectively BUS is 3.983BUS/day while the maximum for CT and BUS on Wednesdays is 15.525CT/day or 6.317BUS/day . Maximum values of concentrations of ground- level ozone (O_3) occurs at the end of the working week (Thursday and Friday), while the minimum values are measured at the end of the week (Sunday).

By the analysis of variance on the average number of PV by a factor of hours of the day is the maximum established in 11.00am and is 794.3PV/h, and a minimum of 24.84PV/h at 03.00am. For LV flows from the analysis of variance the maximum is visible at 07.00 pm (13.03LV/h) and a minimum at 11.00pm (0.03LV/h), a maximum of MHV is at 11.00pm (6.218MHV/h), and the minimum is at 02.00am (0.121MHV/h), a maximum of HV at 01.00pm (15.40HV/h) and a minimum at 01.00am (0.121HV/h). The maximum values for the CT and BUS flows are at 01.00pm 27.15CT/h, respectively 11.43BUS/h, while the CT minimum at 03.00am is 1.909CT/h, and BUS flows at 04.00am 0.505BUS/ h. To establish the correlation between the time series of the intensity of the traffic flow of vehicles (PV, LV, MHV, HV, CT and BUS) and time series of concentrations of ground-level ozone (O_3), the coefficients of linear correlation are calculated between the intensity of flows for each hour phase shift from + 1h. Time series of concentrations of ground-level ozone (O_3) have been moved in stages. Table 3 provides an overview of the calculated coefficients of linear correlation of PV, LV, MHV, HV, CT and BUS flows and total flows.

Table 3. Summary of The Linear Correlation Coefficient For Flows PV, LV, MHV, HV, CT And BUS And Total Flows

Coefficient	Maximum (sati)	Minimum (sati)
PV	0.250 (21)	-0.237 (10)
LV	0.253 (20)	-0.130 (8)
MHV	0.301 (21)	-0.018 (8)
HV	0.249 (21)	-0.188 (8)
CT	0.249 (23)	-0.121(11)
BUS	0.134 (21)	-0.143 (10)
Σ	0.253.(21)	-0.231 (10)

The maximum values of the correlation coefficient for PV flow was established at 09.00pm (r_{max}=0.250), while the minimum was established on 10.00pm (r_{min}=-0.237) for LV flow maximum is at 08.00pm (r_{max}=0.253), and the minimum at 08.00am (r_{min}=-0.130), for MHV flow maximum is at 09.00pm (r_{max}=0.301) and a minimum at 08.00am (r_{min}=-0.018), for HV flows maximum is established at 09.00pm (r_{max}=0.249), and minimum at 08.00am (r_{min}=-0188), for CT flow maximum is established at 11.00pm (r_{max}=0.249), and the minimum at 11.00am (r_{min}=-0121) and for BUS flow maximum is established at 9.00pm (r_{max}=0.134), and the minimum at 10.00am (r_{min}=-0.143). For total traffic flow, maximum is identified at 09.00pm (r_{max}=0.253), and the minimum at 10.00am (r_{min}=-0.231).

DISCUSSION

The measured values of the concentration of ground-level ozone (O_3) are extremely high, but there are within the permissible limits. The time at which the measurement was done was characterized by large fluctuations in temperature ($-2.139 < t < 22.84$°C), cold weather with an average temperature of 7.33°C and the low intensity of solar radiation (mean 42.741W/m^2) and high relative humidity (mean 92.29%). Because the formation of ground-level ozone (O_3) is related to the photochemical reaction between nitrogen oxides (NOx) and volatile organic compounds (VOC) in the presence of light, the intensity of solar radiation during the entire study period was very low, with a maximum value of 409.90W/m^2. In addition to low solar radiation, the period of intense solar radiation in the period when the measurement was performed is very short. High concentrations of ozone (O_3) occur at extremely windy weather, wind occurs when there are areas of low pressure and low pressure causes the cyclone (movement of air masses in the zone of low pressure). From the analysis of variance of the average concentrations of ground-level ozone (O_3) and traffic flows (PV, LV, MHV, HV, CT, BUS) it is evident that the maximum average values occur at the end of the week, roughly on Thursdays or Fridays, while the minimum value for flows occur on Sundays, for ground-level ozone (O_3) on Mondays and Tuesdays. Analysis of variance average concentrations of ground-level ozone (O_3) and traffic flows (PV, LV, MHV, HV, CT, BUS) by a factor of hour in a day show becoming two distinct periods - the period of minimum and maximum values. The maximum values of average concentrations of ground-level ozone (O_3) appear in the afternoon (maximum value measured in the period between 03.00pm and 04.00pm), while the medium maximum intensity flows for most vehicles is around noon. Minimum values of average concentrations of ground-level ozone (O_3) was established in the early morning hours in the interval from 08.00 to 09.00am and has a value of 25.96μg/m^3, while the minimum average values of traffic flows occur in the early morning, roughly around 04.00am. This ratio clearly indicates the dependence of the concentration of ground-level ozone (O_3) on traffic flows. The correlation coefficient between the traffic flow of vehicles and the concentration of ground-level ozone (O_3) is very small, and the emergence of negative correlation coefficient is visible.

Given the proven variation of the traffic flows during the months, where November and December are months with extremely low intensity of traffic flows, it is expected that the increase of the correlation coefficient will happen in the months with high intensity flows (July and August). If we take into account the fact that these months are extremely warm, July at the hottest month with average temperatures of 21°C, the concentration of ground-level ozone (O_3) could exceed the authorization of values. In order to create a complete picture of the concentration of ground-level ozone (O_3) in Brcko and the influence of traffic and meteorological parameters on the concentration of the same, it is necessary to do further research in this area. Within the research great attention should be paid, in addition to ozone (O_3) and other pollutants created during the traffic flow, especially volatile organic compounds (VOCs) and nitrogen oxides (NOx). In addition, future researches should be done in a rather long period of time, so time periods with higher air temperature or intensity of solar radiation and lower relative humidity and higher intensity of traffic flows were covered with them. Simultaneously with the above mentioned research, it would be necessary to implement a control research. Control research should include measuring the concentration of ground-level ozone (O_3) and meteorological parameters in a rural part of Brcko, in a location that is not near the road or where there are no local traffic impact. By comparing the results obtained from research in urban and rural areas a complete picture of the impact of meteorological parameters and traffic flows on the concentration of ground-level ozone (O_3) in the urban area of the town of Brcko would be created.

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ORIGINAL SCIENTIFIC PAPER

Accident Costs in Regard to the Length Of Motorway – Croatian Experience

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Abstract: The basic objective of this research is to explore the contribution of development of motorway networks to minimization of accident costs. Results of the study are based on Croatian experience. The possibility of a statistically negative correlation between gradation in the total motorway length and traffic accident costs will be investigated through observation of variations in the total length of motorway and the number and type of accidents that occured. Different scientific methods were applied in the research, including the method of induction and deduction, the method of abstraction and the method of correlation and regression analysis. The resulting knowlegde may be of help to traffic authorities, both on micro and macro levels.

Key words: road traffic, motorways, accidents, costs.

INTRODUCTION

Traffic accidents are a major issue in transport policies around the world. For example, traffic accidents reap more than 30 000 fatalities per year in the European Union. It is estimated that for each death on European roads, there are 4 permanently disabling injuries, such as damage to the brain or spinal cord, 8 serious injuries and 50 minor injuries [10]. The number of non-fatal accidents is much higher. There is an estimate of 1,2 million road traffic deaths per year on world roads, and about 50 million injured [9], most of them in developing countries. Over the past few decades, there has been a decrease in the number of traffic accident casualties, in spite of the substantial increase in the transport volume [1]. Similar trends can be perceived in Croatia as well. Road fatalities in EU in 2012 have fallen by 63,1% since 1991, in Croatia by 51,49 %. Accidents involving personal injury have fallen by 25% in EU since 1991, in Croatia by 27,2% since 2001. Perhaps this relative increase in road safety is due to implementation of a broad range of safety enhancing measures in vehicles and infrastructure, and to better traffic behaviour. Safety problems and the occurrence of accidents are a feature of transport, in particular of road transport. In European rail, air and water transport accidents in general occur less frequently than in road transport.

These accidents have an enormous cost. Since 2000, the length of motorway network in Croatia has increased three times. Accordingly, the fundamental premise of this study is that the enhancement of Croatian roads measured in length of motorway network has contributed to reduced number of traffic accidents, their consequences and costs. Consequently, the task of this study is to determine the exact contribution of additional length of motorways to reduction of road accident costs in Croatia. This approach, however, by no means seeks to either diminish or jeopardize the Law on Road Traffic Safety (2008) or the Croatian National Programme for Road Safety 2011-2020. (NN, 59/11).

The application of the method of abstraction, and an emphasis on road quality as the main factor in reduction of road accident costs, acknowledges the necessity of including these effects in discussion about total transport costs, or construction costs of modern motorways.

PROBLEM AND STATISTICAL DATA

Table 1, based on Greene et al. [4], provides a schematic outline of different types of cost involved in transport.

Table 1. Structure of transport costs

		Fauna and flora
		Energy
	Environmental costs	Noise
External costs		Pollution of air, water and soil
		Landscape
		Vibration
	Congestion	
	Accidents	

	Use of space	
Total costs		
	Infrastructure costs	
		Fuel
		Maintenance
Internal costs		Repairs
	Private costs	Insurance
		Taxes
		Depreciation

Source: Based on Greene et al [4]

Transport authorities on micro and macro levels are obliged to be acquainted with transport costs. However, not only do they need to have an insight in the amount of costs, but also in the cost function, which shows that costs vary in relation to various parameters [6]. More developed transport systems tend to have lower transport costs since they are more reliable, safer and able to cope with high frequency traffic.

The total external costs of transport in the EU plus Norway and Switzerland in 2008 amount to more than € 500 billion, or 4% of the total GDP. About 77% of the costs are caused by passenger transport and 23% by freight. Road transport modes have by far the largest share in these costs (93%). This can be explained by the large share of road transport in the overall transport output, as well as higher average external costs per passenger-km or tonne-km [3]. Accident costs, comprising both fatal and non-fatal damage costs, form an important part of external transport costs. In 2004, the estimated annual costs of traffic injuries both direct and indirect in the EU-15 countries exceeded 180 billion € [8]. Real costs in terms of deaths, injuries and social and economic consequences far exceed these estimates. According to the lowest estimates of insurance experts and economic analysts, due to traffic accidents, Croatia suffers a direct loss of social values in the amount of at least two percent of GDP, while indirect losses are manifold. The EU Directive 2008/96/EC on road safety requires Member States to carry out the calculation of average social accident costs ($a+b+c$). The costs ($a+b+c$) cover all social costs of the accident, with a representing the cost of death or injury to the exposed individual and b representing the cost for relatives and friends of the exposed individual. Parameter c represents the costs for the rest of society. This includes various direct and indirect economic costs and is assumed to be in the order of 10% of value of safety *per se* (i.e., of the value of life for a fatality).

Traffic accidents cost greatly, it is a cost which depends on the numbers of fatalities and injuries, and there is also a monetary value which can be placed on human life and injury. Assessing this value is a controversial and sensitive issue. The EU Directive 2008/96/EC on road safety requires Member States to carry out the calculation of average social accident costs (cf. table 2).

Table 2: Average social transport costs, at market prices (PPP) in € 2010.

Country	Fatality	Severe injury	Slight injury
Austria	2395000	327000	25800
Belgium	2178000	330400	21300
Bulgaria	984000	127900	9800
Croatia	**1333000**	**173300**	**13300**
Cyprus	1234000	163100	11900
Czech Republic	1446000	194300	14100
Denmark	2364000	292600	22900
Estonia	1163000	155800	11200
Finland	2213000	294300	22000
France	2070000	289200	21600
Germany	2220000	307100	24800
Greece	1518000	198400	15100
Hungary	1225000	164400	11900
Ireland	2412000	305600	23300
Italy	1916000	246200	18800
Latvia	1034000	140000	10000
Lithuania	1061000	144900	10500
Luxemburg	3223000	517700	31200
Malta	2122000	269500	20100
Netherlands	2388000	316400	25500
Poland	1168000	156700	11300
Portugal	1505000	201100	13800
Romania	1048000	136200	10400
Slovakia	1593000	219700	15700
Slovenia	1989000	258300	18900
Spain	1913000	237600	17900
Sweden	2240000	328700	23500
Great Britain	2170000	280300	22200

Source: [5]

As seen in Table 2, there is a significant difference in average social accident costs between countries. These costs in Croatia are considerably lower than the EU average (cf. Table 3).

Tablica 3. Descriptive statistics for social transport costs in EU-28

Variable	Descriptive Statistics (Spreadsheet1)					
	Mean	Std.Dev	Minimum	Maximum	N	No.cases Missing
Fatality	1790179	572413,2	984000,0	3223000	28	0
Severy injury	242025	87028,9	127900,0	517700	28	0
Slight injury	17814	5968,3	9800,0	31200	28	0

The immanent approach to development of road networks consists of phase one - investment in the length of the road network up to a certain, optimal level of development, followed by phase two – investment in the quality of the road network. Improvement in quality of the road network through increase of 1) the percentage of length of motorways in the total length of road network, 2) the length of motorways per 1000 km^2, 3) the length of motorways per 1 million inhabitants, considerably affect traffic safety and thus reduce external transport costs, notably accident costs. To prove this hypothesis in scientific terms and to investigate and elaborate on Croatian experience in the period between 2000 and 2012, the following statistical data were used as a starting point (cf. Table 4).

Table 4. Number and type of traffic accidents and the length of motorways in Croatia from 2000 to 2012

Year	Number of recorded accidents	Fatality	Severe injury	Slight injury	Length of motorways, km
2000.	73387	655	4497	19004	411
2001.	81911	647	4604	17489	429
2002.	86611	627	4481	19442	455
2003.	92102	701	4878	21275	554
2004.	76540	608	4395	19876	742
2005.	58132	597	4178	17595	792
2006.	58283	614	4308	18828	877
2007.	61020	619	4544	20548	959
2008.	53496	664	4029	18366	1043
2009.	50388	548	3905	18018	1097
2010.	44394	426	3182	15151	1126
2011.	42443	418	3409	14656	1254
2012.	37065	393	3049	12961	1254

Source: prepared by the author from [2]

This 12-year period was chosen specifically because Croatian transport policy since 1999 has been exclusively focused on infrastructure [7]. Namely, the length of motorways in 2012 increased 3,28 times compared to 1999, while in the same period, the number of traffic accidents was almost two times lower.

RESEARCH RESULTS AND DISCUSSION

Using statistical data from Table 4, Pearson's coefficient of correlation has been calculated to determine if there is a correlation between the number and type of accidents and the length of motorways (cf. Table 5).

Table 5. Correlation between the number and type of accidents and the length of motorways

Variable	Correlations (Spreadsheet"!) Marked correlations are significant at p < ,05000 N=13 (Casewise deletion of missing data)						
	Means	Std.Dev.	Number of accidents	Fatality	Severe injury	Slight injury	Length of motorways
Number of accidents	62751,69	17778,98	1,000000	0,802452	0,887263	0,772191	-0,924861
Fatality	578,23	101,52	0,802452	1,000000	0,942845	0,895606	-0,770742
Severe injury	4112,23	574,57	0,887263	0,942845	1,000000	0,918631	-0,831244
Slight injury	17939,15	2410,26	0,772191	0,895606	0,918631	1,000000	-0,643926
Length of motorways	845,62	308,47	-0,924861	-0,770742	-0,831244	-0,643926	1,000000

As seen in Table 5, it is clear that there is a statistically significant negative correlation between the length of motorways measured in kilometres and the number of accidents ($r=-0,92$; $p < 0,05$), between the length of motorways and the number of fatal accidents ($r=-0,77$; $p < 0,05$), between the length of motorways and the number of severe injury accidents ($r=-0,83$; $p < 0,05$), between the length of motorways and the number of slight injury accidents ($r=-0,64$; $p < 0,05$).

The method of correlation analysis indisputably established a strong negative correlation between the number and type of traffic accidents and the length of motorways measured by number of constructed kilometres, so what follows is an investigation of connection between social accident costs and the length of motorways. In order to do that, and to set an appropriate econometric model for Croatia, accident costs were derived from average data for certain types of accidents from Table 2, ie average cost of accidents resulting in fatalities was 1,333,000 €, average cost for serious injuries 173,000 € and for minor injuries 13,000 € (cf. Table 6).

Table 6. Annual losses due to road traffic accidents in Croatia

Year	Fatality	Severe injury	Slight injury	Total Average social accident costs	Length of motorways, km
2000.	873115000	779330100	252753200	1905198300	411
2001.	862451000	797873200	232603700	1892927900	429
2002.	835791000	776557300	258578600	1870926900	455
2003.	934433000	845357400	282957500	2062747900	554
2004.	810464000	761653500	264350800	1836468300	742
2005.	795801000	724047400	234013500	1753861900	792
2006.	818462000	746576400	250412400	1815450800	877
2007.	825127000	787475200	273288400	1885890600	959
2008.	885112000	698225700	244267800	1827605500	1043
2009.	730484000	676736500	239639400	1646859900	1097
2010.	567858000	551440600	201508300	1320806900	1126
2011.	557194000	590779700	194924800	1342898500	1254
2012.	523869000	528391700	172381300	1224642000	1254

Source: Author's calculation

When total average accident costs in this period are considered, significant oscillations with prominent tendency of decrease could be observed (M=1,72 billion €; SD=0,261 billion €; min= 1,22 billion €, max=2,06 billion €). After conducting correlation analysis (cf. Table 5), we decided on a one-dimensional model of linear regression in the following form:

$$Y = a + bX + u \qquad (1)$$

Where:
X – independent variable – length of motorways (LM),
Y – dependent variable – average social accident costs (SAC),
u – deviation from the functional relation,
a, b – parameters.

In assessing the value of parameters in function (1) the method of regression analysis was applied, while the numerical computation was performed by *Statistica* software (cf. Table 7).

Table 7. Regression analysis

N=13	Regression Summary for Dependent Variable: Social accident costs (Sp R= ,79479278 R2= ,63169556 Adjusted R2= ,59821334 F(1,11)=18,867 p<,00117 Std.Error of estimate: 1657E5					
	Beta	Std.Err. of Beta	B	Std.Err. of B	t(11)	p-level
Intercept			2,291433E+09	138911147	16,49567	0,000000
Length of motorways	-0,794793	0,182981	-6,733688E+05	155027	-4,34357	0,001168

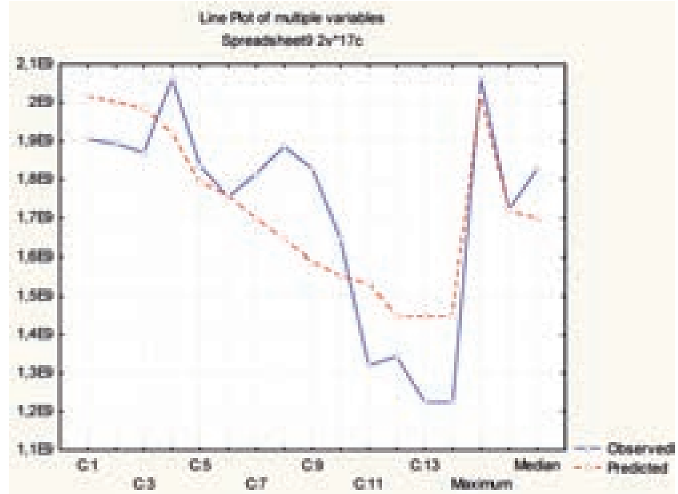
Regression analysis of the correlation between average social accident costs and the length of motorways gives the following model of simple linear regression:

$$\mathbf{SAC = 2\,291\,432\,984{,}6 - 673\,368{,}\,8 \quad LM} \qquad (2)$$

Results of regression analysis (cf. Table 7) indicate that there is a statistically significant correlation between total average social accident costs and the length of motorways ($R=0{,}79$; $F(1{,}11=18{,}867$; $p<0{,}01$). Correlation between the total average social accident costs and the length of motorways is negative, indicating that the decrease in social accident costs is linked with an increase in the length of motorways. An increase in the length of motorways of 1 km leads to decrease in social accident costs about 673 368,8 € in the first year ($B=-673368{,}8$; $SE=155{,}027$; $p<0{,}01$). Decrease in social accident costs with 79% of variance can be explained by the length of motorways.

Chart 3 shows a comparison between the actual and model predicted values of the dependent variable. Chart 3 also shows a satisfactory adaptation of the model to the real data.

Chart 1. Comparison between the econometric model and the real data for the total social accident costs in Croatia from 2000 to 2012.



CONCLUSION

Problems of safety and the occurrence of accidents is a feature of traffic, particularly of road traffic. One of consequences of these accidents is an immense cost, a cost which depends on the numbers of fatalities and injuries and the monetary value which can be placed on human life or injury. Economic damages from road traffic accidents are estimated in hundreds of millions of euros, noting that more developed transport systems tend to have lower transport costs. This study has proven the statistically significant negative correlation between social accident costs and the length of motorway network in Croatia over the last decade. The conducted regression analysis has confirmed that a newly constructed kilometer of a motorway results in decrease of social accident costs in the amount of 673 688 €.

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REVIEW PAPER

Estimation of External Costs of Transport in Canton Sarajevo for 2014

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Abstract: The main aim of this paper is to raise awareness of the necessity to estimate the external costs of transport, and in particular in urban area of Canton Sarajevo. It does not provide full extent of the costs as it focuses only on two components, air pollution and accidents. It focuses on the concise methodology for estimation of external expenses of air pollution from road and air transport and road traffic accidents, using official statistical data for modeling emissions (COPERT 4, Copert Street Level, IPPC Tier 3A methodology) and for accounting road traffic accidents. Statistical significance of correlation between traffic flow and measured concentration of pollutant at Otoka location is determined by Pearson's correlation coefficient. Air pollution and traffic accidents are monetized according to the Synapse Energy Economics cost estimation of metric ton of CO2, and Nicholas School of the Environment, Duke University, for other pollutants, while estimation methodology for both air pollution and traffic accidents is done in line with Handbook on External Costs of Transport, European Commission.

Key words: air pollution, external expenses, traffic accidents.

INTRODUCTION

Transport is a backbone of any economic growth. However, most forms of transport have significant side effects that rise to various resource costs that can be expressed in monetary terms, which is understandable to all. Costs of delays, productivity losses due to injuries and deaths cause by traffic accidents, health costs caused by air pollution, abatement costs due to climate impacts of transport, are few of many social and environmental pressures. In the event of imposition of costs to a society as a result of certain activity, economists use the term of an external cost. The external costs of transport are generally not borne by transport users alone but by the entire society and environment as well.

The main aim of this paper is to raise awareness of the necessity to estimate the external costs of transport, and in particular in urban area. It does not provide full extent of the costs as it focuses only on two components, air pollution and accidents. Sarajevo Canton has been exposed to persistent and immense air quality deterioration from 2006 to date, resulting with such an extreme air pollution that led the local authorities to close schools for a certain period in December 2015. At the time the measures and activities of local representatives had no positive effect, and no strategic approach, and particularly for the traffic and transport, no clue whatsoever.

METHODOLOGY

Statistical correlation significance between road transport intensity and measured concentration of pollutants in the air was calculated according to the data provided by traffic counters and automatic meteorology station at Otoka location, municipality Novi Grad. The data was collected on hourly, daily, monthly and annual basis. Road traffic counter data was taken from official report Directorate for roads in Sarajevo Canton. Automatic meteorology station is under the authority of Cantonal Public health Institute.

Hourly reading is particularly important as the road traffic intensity fluctuates significantly by the hour. Concentration of air pollutants readings and speed of wind (as very significant ambient factor) are averaged throughout a year for every hour of 24 hour scale, and then compared to traffic data.

The methodology used in this paper is based upon Handbook on External Costs of Transport of the European Commission – DG Mobility and Transport.

As it is focused on air pollution and traffic accidents, official statistics data has been a foundation for modeling air pollution[1,2], while local monetizing data has been supplemented by figures and estimates provided by relevant international and local authorities respectively [3,4,5,6,7]. Emission of pollutants in Sarajevo Canton for the year 2014 from road transport is estimated in a model in COPERT 4, Copert Street Level (CSL), and previous research of the author [8].

RESULTS

Statistical correlation between road transport intensity and air pollutants at Otoka

Air pollutant concentration data collected was put in database and statistically analyzed. Statistical correlation was tested by Pearson's correlation coefficient, Table 1. It has been determined that the correlation between road transport intensity and measured concentration of pollutants in the air is significant and correlation is higher for winter months than in summer months.

Table 1. Pearsons coefficient- correlation between road transport intensity and measured concentration of pollutants

Pearson Correlation Coefficient	
January	June
X Values	*X Values*
∑ = 987109	∑ = 1040321
Mean = 31842.226	Mean = 34677.367
$\sum[X - M_x]^2 = SS_x$ = 643521847.419	$\sum[X - M_x]^2 = SS_x$ = 630079848.967
Y Values	*Y Values*
∑ = 17082.2	∑ = 11210.8
Mean = 551.039	Mean = 373.693
$\sum[Y - M_y]^2 = SS_y$ = 637472.834	$\sum[Y - M_y]^2 = SS_y$ = 238836.379
X and Y Combined	*X and Y Combined*
N = 31	*N* = 30
$\sum[X - M_x][Y - M_y]$ = 11000286.329	$\sum[X - M_x][Y - M_y]$ = 5637538.773
R Calculation	*R Calculation*
$r = \sum[[X - M_y][Y - M_x]] / \sqrt{[[SS_x][SS_y]]}$	$r = \sum[[X - M_y][Y - M_x]] / \sqrt{[[SS_x][SS_y]]}$
r = 11000286.329 / √[[643521847.419][637472.834]] = 0.5431	r = 5637538.773 / √[[630079848.967][238836.379]] = 0.4596
Meta Numerics [cross-check]	*Meta Numerics [cross-check]*
r = 0.5431	r = 0.4596

Figure 2, providing average hourly readings throughout a year show that emission are significantly correlated with road transport intensity at the location. However, average hourly values of the wind speed determine that it poses a significant factor in air pollution measured concentration. The Figure 2 shows numerically determined influence the wind speed has on air pollution levels at the location, under non-fluctuant road traffic intensity. One may conclude the spatial obstacles to the wind flow, positioned without proper land-use modeling examination, may significantly increase air pollutant concentration at a location. It is particularly important where the urban canyons are predominant in spatial distribution.

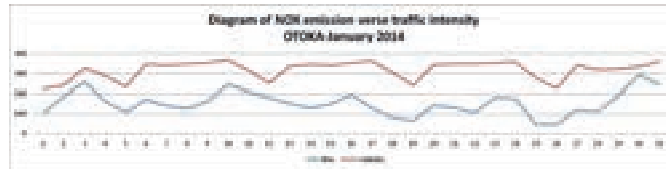

Figure 1. January 2014 – Daily NOx emission verse traffic intensity [vehicles x 100], author

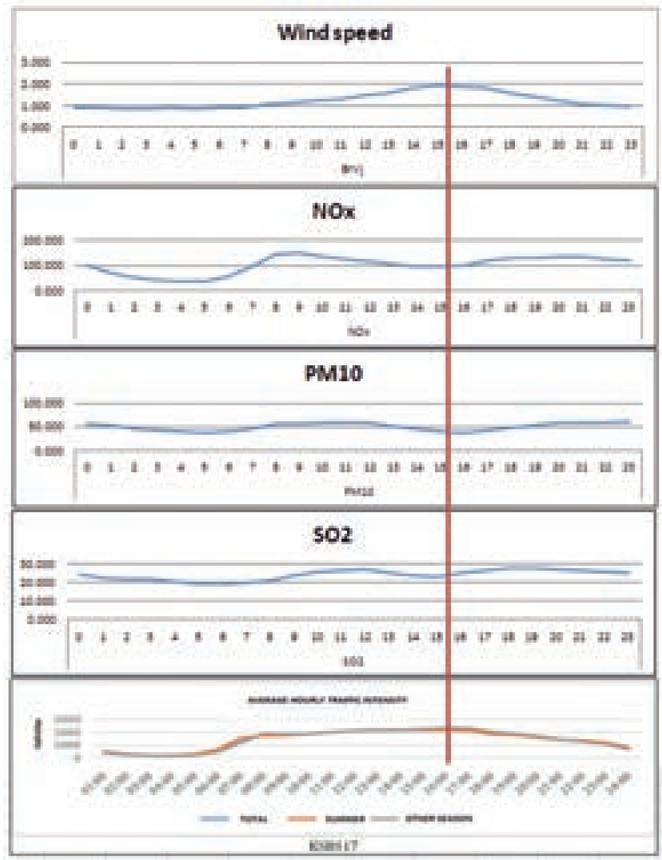

Figure 2. Hourly readings of air pollutants, wind, and traffic, author

Road traffic intensity has statistically significant influence on air pollution levels, and air flow velocity has significant influence on concentration of air pollutants at the observed location.

Emission of pollutants from road transport in Canton Sarajevo

Previous research of the author [8] determined the quantity of the emission of pollutants from road and air traffic in Canton Sarajevo. Table 2, has shown that incoming traffic from outside Sarajevo significantly increase local fleet's emission and these values have been taken into monetizing the emission of pollutants.

Table 2. Road traffic emission for year 2014, author

POLLUTANT	CO	CO2	NOx
Average speed [km/h]	23.24	23.24	23.24
Total road mileage with vehicles counted [km]	77.27	77.27	77.27
Total road mileage in Canton Sarajevo [km]	212.00	212.00	212.00
Copert street level - Estimated emission [t]	1249.58	239308.52	826.08
COPERT 4 estimated value [urban only]	850.2173638	184202.9802	763.730143
Ration of incoming traffic from outside Sarajevo	32%	23%	8%

Definition of a carbon price and estimated value of social cost of road and air transport

Transport is an integral and an essential part of any form of entrepreneurship, and is therefore to be incorporated into any policy of carbon-pricing.

In the environmental science research there are a number of the terms refereeing to the "carbon price" or "CO2 price" used in various contexts, whereas in the environmentally conscious economics, pricing emissions is labeled as "internalizing an externality", or the external (not paid by the polluting entity) cost of pollution damages that is assigned a market price, making it internal to the enterprise. Synapse Energy Economics, provides definition of terms and elaborates pertaining use.

Carbon allowances, allowances are certificates that give their holder the right to emit a unit of a particular pollutant. A fixed number of carbon allowances may be issued by local authority (in developed countries, not in BiH) or put on the market for trade in a way. The price that enterprises are to pay for the allowances increases their operational price tag of business, thus giving an advantage to those with "greener" operations.

Carbon tax, in the similar way internalizes the externality of carbon emission, but instead of selling or giving away rights to pollute, it creates an obligation for firms to pay a fee for each unit of carbon that they emit. They represent an opportunity cost of emissions to the holder, and becoming an incentive for emission reduction. Of course, with bureaucratic apparatus finances acquired in this way may not be used to reduce for mitigation but rather to fill the gaps in the overloaded budgets.

Effective price of carbon are referred to as the notional, hypothetical, or voluntary price that may be looked into at legal entity level, such as enterprise or local government institution.

Marginal abatement cost, and perhaps with some similarities Average policy cost as looks more into benefits, of carbon refers to an estimate of the expected cost of reducing emissions of a pollutant. Estimation of a marginal abatement cost looks into all of the possible solutions to controlling emissions, being technologies or poli-

Table 3. Social cost of pollutants, Source: Drew T. Shindell, The social cost of atmospheric release, Nicholas School of the Environment, Duke University, USA

Valuation; discount rate	CO_2	CH_4	N_2O	HFC-134a	BC	SO_2	CO	OC	NO_x	NH_3
Climate[a]; 5 %	10	490	2800	19,000	13,000	-900	42	-1800	-56	-240
Climate[a]; 3 %	32	910	9200	36,000	20,000	-1400	90	-2800	-220	-380
Climate[a]; 1.4 %	67	1400	19,000	56,000	30,000	-2100	160	-4200	-400	-560
Regional climate, aerosols; 5 %	0	0	0	0	19,000	3000	0	6100	90	820
Regional climate, aerosols; 3 %	0	0	0	0	26,000	4400	0	8700	350	1200
Regional climate, aerosols; 1.4 %	0	0	0	0	34,000	5900	0	12,000	600	1600
Additional climate- health1[b]; 5 %	16	1600	8300	62,000	110,000	4500	140	9000	7	1200
Additional climate- health1[b]; 3 %	45	2800	24,000	110,000	150,000	5700	260	11,000	30	1500
Additional climate- health1[b]; 1.4%	87	4000	47,000	160,000	190,000	6900	430	14,000	50	1900
Composition-hcalth; 5%	0	550	0	0	62,000	33,000	200	51,000	67,000	22,000
Composition-hcalth; 3%	0	670	0	0	62,000	33,000	240	51,000	67,000	22,000
Composition-hcalth; 1.4%	0	740	0	0	62,000	33,000	250	51,000	67,000	22,000
Median total; 5 %	27	2700	12,000	85,000	210,000	40,000	410	64,000	67,000	24,000
Median total; 3 %	84	4600	37,000	160,000	270,000	42,000	630	68,000	67,000	25,000
Median total; 1.4 %	150	6000	62,000	210,000	310,000	43,000	820	71,000	67,000	25,000
Median total; declining rate	110	4700	47,000	160,000	280,000	42,000	730	69,000	67,000	25,000

cies, listed by their cost per unit of pollution reduction. Starting from the least expensive option, going down the scale one identifies financially most feasible (at a market price) way to reduce emissions to the designated target, and in that way identifying the "marginal" cost of targeted level of pollution reduction.

Table 4. Revised Social Cost of CO2, 2010 – 2050 [in 2007 dollars per metric ton of CO2] Interagency Working Group on Social Cost of Carbon, United States Government, upon Executive Order 12866

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

Figure 3, Table 3 and Table 4 show the estimated value of social cost per metric ton of CO_2. It is evident that the social cost shall rise significantly in coming years [9] and therefore immediate mitigation action is required. These damages are addressing decreased agricultural

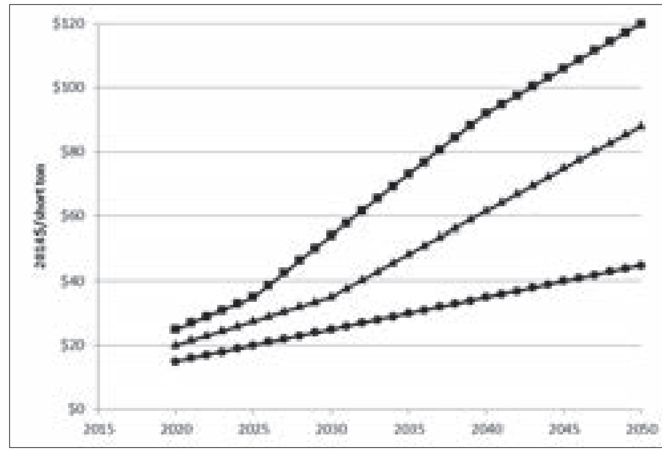

Figure 3. Synapse Energy Economics, Inc. 2015 Carbon Dioxide Price Forecast

yields, harm to human health and lower worker productivity, all related to climate change. For calculation purposes the value of 37 US$/35EUR per metric ton of CO_2 is considered, in line with US Environmental Protection Agency [10]. It has to be noted that there are recent studies at Emmett Interdisciplinary Program in Environment and Resources in Stanford's School of Earth Sciences suggest that this cost is as high as 220 US$ [11].

Therefore, estimated road transport emission of 239308 t CO2 accounts for social cost in the amount of approximately 8,6 million EUR. Air transport contributes with the estimated emission of 12632 t CO2, thus accounts for social cost in the amount of approximately 0,5 million EUR.

Air and road transport cause social cost of roughly estimated value of 9 million EUR for the year 2014.

Table 5. Number of traffic accidents in Federation B&H in 2014, Federal Ministry of Interior

Area	Traffic accidents			Killed			Grave injuries			Minor injuries		
	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
Kanton Sarajevo	9.877	10.536	**10.974**	21	24	**19**	170	165	**180**	876	1.001	**1.003**
SBK	2.731	2.944	**3.094**	19	17	**19**	147	117	**120**	392	445	**477**
BPK	74	94	**81**	2	0	**2**	2	7	**10**	20	30	**27**
Posavski kanton	252	253	**247**	3	3	**3**	25	24	**23**	58	82	**60**
ZHK	528	608	**740**	10	5	**7**	32	32	**40**	340	357	**420**
HI IK	1.860	1.944	**1.995**	18	25	**25**	105	119	**127**	702	747	**911**
USK	2.463	2.691	**2.247**	22	23	**23**	129	130	**123**	641	746	**813**
Tuzlanski kanton	3.418	2.840	**2.720**	36	38	**33**	216	187	**194**	1.405	1.383	**1.455**
ZDK	4.027	4.126	**4.411**	27	28	**24**	131	182	**165**	600	664	**697**
Kanton 10	728	645	**701**	8	13	6	37	49	**40**	146	143	**145**
FEDERACIJA BiH	25.958	26.681	**27.210**	159	176	**161**	994	1.012	**1.022**	5.180	5.598	**5.856**

However, there is a need to include other pollutants into the calculations. A recent study [12] suggests that other pollutants have much higher social and environmental cost, as shown in Table 3. NOx is estimated at 300 US$ per metric ton for environmental, plus additional 50US$ for health related issues. CO is estimated at 260 US$ for health related issues. SOx is estimated at 6,900 US$, while CH4 is estimated at 6000 US$. Therefore the costs should include:

- for CO
  - Air transport – 10,500 EUR
  - Road transport – 320,000 EUR
- for NOx
  - Air transport – 14,500 EUR
  - Road transport – 275,000 EUR
- for SOx
  - Air transport – 22,000 EUR
  - Road transport – 331,200 EUR
- for CH4
  - Road transport – 225,000 EUR

It comes to additional 1,2 million EUR, and therefore the total cost of air pollution from air and road transport is around 10 million EUR. It has to be noted there are other cost that are to be taken into consideration, but the main aim of this paper is to raise awareness that shall hopefully result in more detailed approach in spatial and transport in urban area.

Estimation of social cost of traffic accidents

There are many issues regarding the socio-economic aspects of traffic accidents and consequent injuries [3,4,5]. The accuracy of official road accident statistics, long-term impacts of an injury, and social disparities are only few of many. The burden of traffic accidents is borne not only by those directly affected in traffic accidents but also by their families. The European Federation of Road Traffic Victims proposes the creation of free assistance centers for victims, where they would receive professional assistance and advice in dealing with legal issues, medical issues and psychology.

Socio-economic losses resulting from the traffic accident in the Federation B&H have been calculated using the gross output or Human Capital methodology, comprised of administrative expenses, property damage, medical treatment costs, lost output and human costs. According to the estimation the traffic accidents are estimated as follows:

- fatal injuries – 190,100 EUR
- severe injuries – 90,180 EUR
- minor injuries 16,490 EUR

However, in Republic of Srpska these estimations, done in cooperation with Swedish National Road Consulting AB – SweRoad, are quite different.

- fatal injuries – 317.317 EUR
- severe injuries – 34.094 EUR
- minor injuries 1.666 EUR

While there are many methodologies, this paper uses the figures, used by the official authorities of Federation B&H [5], responsible for transport management, provided by the Federal Ministry of Interior is shown in Table 3.

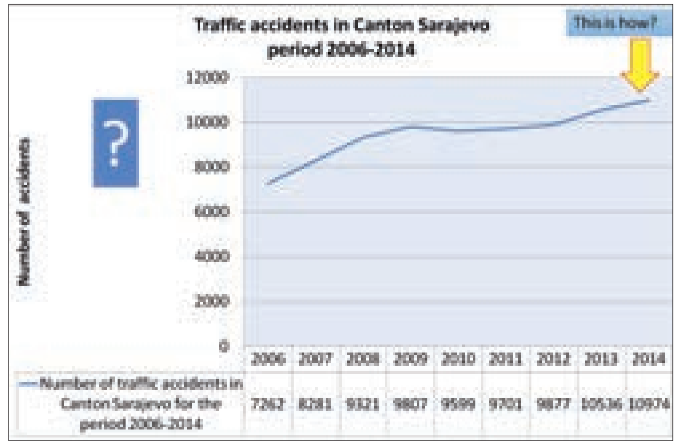

Figure 5. Number of traffic accident in Canton Sarajevo for the period 2006-2014, Federal Ministry of Interior

Figure 5 shows that there is a steady increase of number of traffic accidents in Canton Sarajevo. Comparing the year 2014 to 2006 the number of traffic accidents has increased by 51%.

Using the cost values of traffic accidents provided above, in line with the numbers provided in Table 4, the cost of traffic accidents in Sarajevo Canton for 2014 is estimated as follows:

- fatal injuries – 190,100 EUR x 19 = 3,611,900 EUR
- severe injuries – 34.094 EUR x 180 = 6,136,920 EUR
- minor injuries 1.666 EUR x 1003 = 1,670,998 EUR
- It totals to the sum of 11,419,800 EUR.

In 2013, an amount of 367,909,320 EUR was a result of financial transactions from sale of fuel and lubricants. Out of that sum it is roughly estimated that 47,027,262 EUR is the tax collected for the local authorities, which is to be used for highways, water, environmental protection etc.

CONCLUSION

External costs of traffic are significant and are to be carefully studied. So far, little or no attention was paid to the monetization of air pollution from road and air transport in Canton Sarajevo. As evident, the cost of air pollution is similar to the cost of traffic accidents. Nonetheless, along with traffic accidents these costs are growing and posing significant burden to the local government and its institutions, while the finances wasted through inadequate traffic solutions could be used for rectification of the most chronic issues detriment to the sustainability of transport system in the Canton.

These are public transport of passengers, traffic flow and congestion, and spatial planning.

The burden of air pollution and traffic accidents is borne not only by those directly involved in traffic but also by their families, elderly and children. A strategic approach should take all these chronic issues into consideration, and then incorporate it in transport and land-use models of the city, open to public for debate, thus providing effective guidelines for addressing the issues. Furthermore, there is a necessity for the creation of free assistance centers for victims of traffic accidents, where they would receive professional assistance and advice in dealing with legal issues, medical issues and psychology.

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PRELIMINARY COMMUNICATION

Financing Public Transportation of Passengers

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Abstract: Public transportation of passengers has very important role in the life and functioning of urban areas. Public transportation of passengers stimulates effective economic activities, improves the life standard and increases the mobility of the population. Such system is difficult for financing. The revenue that the system brings is not sufficient to compensate for the operational costs. This research presents the possible ways of financing the system of public transit. There are various experiences in financing the public transit in European cities, but this problem has been also identified in the cities all over the world. The system of public transit in the Republic of Serbia has recently started to implement activities related to the improvement in the quality of work and services, as well as rationalization of the system in all aspects of business and operation, improvement of organization and maintenance at all levels, and increase in the efficiency and reputation.

Key words: financing, public transportation of passengers (or public transit).

INTRODUCTION

Public transportation of passengers has a vital role and unique position in urban areas. The service of public transit contributes to the better life standard of certain area, by providing personal mobility. On a macro level, public transportation of passengers stimulates effective economic activities, promotes equal social conditions and creates humane oriented urban environment. Thus, public transit is important matter of public policy and effective tool for achieving public goals.

High quality of public transit can provide various economic, social and environmental benefits. This includes direct user benefits, as well as different indirect and external benefits. Residents of communities with high quality transit are less prone to use motor vehicles in public transport and they spend less on transport. This can support economic development. As a result, the improvements in the public transportation services are important component of strategic plans and political decisions, and they also improve the life in cities.

In order to achieve their goals, public transportation of passengers must compete with private cars and other means of transport in the cities. Different means of transportation widely differ in financial structure, including user costs and price, as well as government funding. Financing public transportation of passengers is very complex in its nature and depends on the polity of the country.

The revenue from the transit fares represents payments from direct users of public transit and that is the main source of income. One of the main goals of every public transit company is to improve business and to increase the revenue from the transit fares in relation to the overall business income. If the operation ratio is bigger than one, the company has operating profit and no other resources are necessary. However, since 1960 the operation ratio in public transit companies has been ranging between 30-90% in many countries. In order to acquire the necessary resources for maintenance, as well as for capital investment in public transit, the state leadership at all levels (local, regional or republic) must provide the resources from their budgets, or develop new mechanisms for collecting revenues. [1]

This research deals with resources in the system of public transit, as well as with possible models of financing. Also, this research presents the mechanisms which represent the sources of income. The examples of government funding from some countries in the world are given, as well as the examples of some European cities and examples and experiences from Serbia.

SOURCES OF INCOME IN THE SYSTEMS OF PUBLIC TRANSIT

There are various private and public resources for financing the systems of public transit, which can be grouped in three categories. This research defines them respectively, starting from the direct payments from the users to special funds and resources from state budgets. [1]

a. Revenues from the direct payments from service users:

The main resources in the system of public transit are resources from direct payments from service users, such as fares, tickets and different charges and fees. These revenues can sometimes cover only for one part of the operating costs, which is the case with the most of the public transit systems.

b. Special state funds:

The state leadership at all levels (local, regional or republic) sometimes uses resources from special funds for financing certain public services. If the system user is taxpayer and if the collected revenue is used for financing, maintaining and functioning of the system, than this is called tax on use.

a. Government budget resources:

Many public systems, objects and services are available without direct charges (tickets, reception costs, etc.) Their construction and maintenance is completely financed by the state from its budget. Some other services are available at prices that are not regular market prices and users do not pay the full amount for the service. In this case, the state compensates the difference between the prices. Such services are partially or completely financed from the city budgets, or by the local government, republic or a union (European Union). [2]

Considering the given data, public transportation of passengers belongs to the category of systems that are financed by the combination of revenues from the users of the system, special funds and budget resources. Potential resources for the income of the public transit systems are:

a) Primary, the income from the main activity, i.e. the income from selling the tickets in the system of public urban and suburban transit. These incomes include tickets bought in the vehicle, tickets bought outside the vehicle, different types of season tickets, etc. This income is an operative income in the system of public transit and it can cover only for one part of the system functioning expenses. Depending on the system, the income is 30-60% of the system functioning expenses.

b) Secondary, the income from subsidies of the city budget, local government, republic or European Union. In order for the public transit system to function in the scope and content that fulfills the needs of contemporary life (reliability, availability, comfort, speed, time of service, etc.) the founder or owner of the market must be prepared for the cost of the service, as well as for the fact that the market price is acceptable for a small number of users. Thus, the incomes from subsidies of budgets are intended to compensate the expenses for some categories of users and make the system of public transit available for them. On the other hand, these incomes are used for capital investments in the system of public transit. These investments are: infrastructure construction, procurement of rolling stock, works on the network lines, maintenance of the stations, turntables, etc. These investments cannot be financed from the main activity incomes because they represent the interests of the founder or market owner.

c) The income from other sources: taxes on parking fees, taxes for using cars in the city areas, etc. In some cases, earmarked taxes are gathered from the resources of indirect users of public transit system. This is the case when special taxes are collected from the population or companies that are located along the lines of public transit, near the stations and turntables, or around the metro stations. This is the case because their owners have direct or indirect benefits from the location of such objects. These incomes are used for functioning expenses or capital investments in the system of public transit. The idea of such taxes that are paid by residents of city areas goes in two directions. In the first direction, they have impact on reducing the usage of cars in favor of the public transit systems, because they are less competitive. In another direction, the resources gathered in this way are used to increase the quality of the system and to reduce the budget financing. A good example of such resource is a policy of giving a part of the state lottery income for the compensation of fares for senior citizens in the USA. [1]

THE REASONS FOR FINANCING THE SYSTEMS OF PUBLIC TRANSIT

In cities, local authorities have the main role or full responsibility in maintaining public objects such as streets, pedestrian zones, parks, historical objects, etc. Authorities also finance public services such as safety and security, health, clean and nice environment in the cities. They are also included in the financing of transit systems. The main reasons and explanations for the usage of public resources in financing the systems of public transit are summed up here: [1]

a. Public transit is a service that provides mobility for the population of all ages and categories of people (residents, visitors, invalids and others). Systems of public transit have different positive influences and results which are qualitative in great deal and they are not plausible for measuring in monetary units.
b. By its nature and function, public transit together with its infrastructure, represents a public object.
c. With its high capacity and reliable services, public transit enables the development of numerous urban activities.
d. The railway system of public transit with its side objects and structures, represents the basic urban infrastructure, together with streets, water, sewerage and other municipal systems.
e. Transit networks in the system of public transit, especially railway systems, can contribute to the urban development by decreasing the potential for uncontrolled city expansions.

f. Public transit serves the city centers and suburban areas and it is oriented towards people. Thus, it improves life in the cities, which is not possible in the cities that are dependent on cars.
g. Public transit also helps to avoid great potential expenses. For example, people who travel by cars will face traffic jams, negative environmental influences and lack of parking spaces.
h. The height of charges is limited by the fact that the ticket price must be competitive with marginal costs of driving a car.
i. If the charging systems would increase the incomes of public transit, numerous users of public transit could start using cars instead of public transit. This would cause the increase in social and ecological expenses.
j. Since the benefits from the public transit is not only for those who use it, it is logical that the system is not financed only from the pockets of its users, but also throughout different taxes and from the state budget.
k. The most of transit systems demand central and coordinate control over certain objects and operations. Thus, even though the majority of vehicles (as well as planes and ships) is private property, they operate over the public places, such as highways, streets, airports, terminals, etc.
l. All transit systems (land, air or water traffic), especially those which deal with transport of passengers are very important for state economy and life standard. Financing the transit systems stimulates the development and mobility of population, and this is the reason why financing the transit systems is one of the most important economic and social policies.

In certain capital investment cases such as constructions of metro systems, it was usual from the start for local authorities to take part in financing such projects partially or completely. Streets, underground tunnels and metro lines should be treated as objects with the same function, and that is the function of public object. Thus, authorities should finance constructions of metros, railways and other types of infrastructure for transit in the same way as construction of the streets.

Since 1930s and 1940s, the increase in competition of private vehicles and other means of transport has started. The transition of transit systems from private to public ownership has influenced the authorities to finance transit systems in greater deal. Thus, all governments accepted to finance transit systems, especially those involving transport of passengers, from the state budget in different ways and amounts, in order to achieve social goals.

Unlike the private companies, all public services financed from the state budgets, including the public transportation companies, have complex mechanisms of financing and rigorous measures for operational efficiency.

POTENTIAL MECHANISMS FOR FINANCING PUBLIC TRANSPORTATION OF PASSENGERS

Local and state authorities have developed numerous options for financing public transportation of passengers. Characteristics of the public transit system in the area of realization, as well as local policy and economic conditions, influence tax options for financing public transportation of passengers. Financial mechanisms can be classified in several groups, according to the types of their sources. This chapter offers eighteen types of potential mechanisms for financing public transportation of passengers: [1], [2]

a. Fare increases – in order to increase the income;
b. Discounted bulk transit passes – it is given to a certain number of passengers or bigger group;
c. Property taxes – increase of property taxes because of the attractiveness of the location under the influence of public transit;
d. Regional sales taxes – special type of sales taxes;
e. Fuel taxes – additional taxes for fuel;
f. Vehicle levy – additional fee for registering vehicles in the region;
g. Utility levy – a special transit levy to all utility accounts in the region;
h. Employee levy – a levy paid by employers located in a transit service area, because of the positive impact of the public transit nearness;
i. Road tolls – fees for driving on a particular road, bridge, or in a particular area;
j. Vehicle-km tax – a form of road pricing that charges motorists per kilometer travelled;
k. Parking sales taxes – a special tax on parking transactions in certain area;
l. Parking levy – a special property tax on non-residential parking spaces throughout the region;
m. Expanded parking pricing – parking price is determined by the location, as well as the duration of the parking time;
n. Development cost charges or transportation impact fees – a fee on new development to help fund infrastructure costs, and allow existing development fees to be used for public transit infrastructure investments;
o. Land value capture – a special property tax imposed in areas with high quality public transit;
p. Station rents – revenues from public-private developments on publically-owned land in or near transit stations;
q. Station air rights – a tax for using the space above the transit station;
r. Advertising – additional advertising on vehicles and stations.

THE STRUCTURE OF INCOMES IN PUBLIC TRANSIT SYSTEM IN THE CHOSEN EUROPEAN CITIES

Considering the structure of incomes in public transit systems in different European cities can help us understand how economic situation influences financing the public transportation of passengers.

On average, the main activity income covers for 50% of the operating costs in European cities, with significant differences between the cities (ex. 30% in Paris and Warsaw, but 60% in Vienna). Local and regional authorities usually compensate for the lack of resources and differences between revenues and expenses of the system functioning. In Italy, regional authorities finance about 90% of lacking resources, while local authorities finance about 10%. In Spain, local and regional authorities finance more than 80% of the resources in the largest cities, while the rest is provided by the national government. [3], [4]

In Poland, local authorities finance 100% of the resources and differences between main activity incomes and costs of the system functioning.

Generally, public transportation of passengers is financed from the local, regional or state budget. However, in some cities, the required amount or a part of it is provided by certain taxes, fees or charges. Employee levy in France is collected by the local government and covers for 38% of the costs for the system functioning in Paris. Road tolls income in Oslo represents 8% of the costs of the system functioning.

In Italy, regional authorities get most of the incomes from fuel taxes, and it is used to finance public services under its authority, including public transit. National government is usually uninvolved in financing public transit. In many countries (such as Germany, Italy, Poland, countries of Scandinavia except for Norway), not even a capital city gets resources from the national government for the public transit. If the national government finances the public transit, this financing is usually very small (for example, it is 2% of the costs for the system functioning in Paris, or 9% in Madrid). In these cities, financing from the national government comes from the state budget. In Paris, employers must compensate for at least 50% of the price tickets for the employed. This income represents about 11% of the costs for the system functioning.

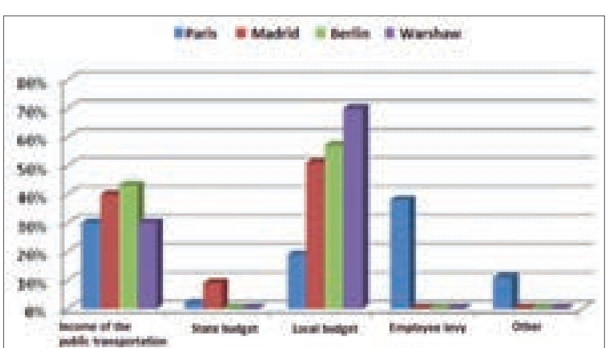

Figure 1. The structure of incomes in public transit system in the chosen European cities.

ANALYSIS OF INCOMES IN THE PUBLIC TRANSIT IN THE REPUBLIC OF SERBIA

Recently, the system of public transit in the Republic of Serbia has been conducting significant activities such as: improvement of the system work and services quality, rationalization of the system in all aspects of business and functioning, improvement of organization and maintenance at all levels, increase of efficiency, improvement of reputation, etc.

After systematically implemented activities related to improvement of regulations, network lines, organization structure and management processes, conditions for significant improvement of economic efficiency of the system are created.

Activities related to improvement of cost and economic efficiency of the system should be managed at all levels, but that demands detailed analysis of incomes and expenses of the system, as well as planning and operating relations between the processes in function of acquisition and distribution of incomes. The final goal of these activities should be viability of the system for all key participants in it (local authorities, operators and users). Incomes and expenses of the public transit system are influenced by many factors (quality and structure of the rolling stock, type and price of operating power, price of spare parts, level of the salaries of employees, prices of transport services, organization and maintenance, etc.) which directly influence on the achieved financial results.

In order to get real and reliable information for this research, the analyzed incomes are taken from available annual business reports for period from 2009 to 2012. Besides key indicators, the reports show management based on the data from financial reports. The data from these reports is grouped and presented according to the needs of this research. As an example, three cities with their characteristics are shown in the tables below:

Table 1. Basic city information

No.	City	Number of operators (public + private)	Number of lines City + Suburbia	Network length City + Suburbia (km)	Number of vehicles in use
1	NIŠ	1+4	15+36=51	122,5+599,04=721,54	77+31=108
2	SUBOTICA	1	10+11=21	88+264=352	30+42=72
3	PANČEVO	1	7+11=18	98,0+107,5=205,5	15+52=68

Table 2. Transit system information

No.	City	Number of residents City	Number of residents City + Suburbia	Area (km^2)	Average population density (resident/ km^2)
1	NIŠ	183.164	260.237	597	435
2	SUBOTICA	105.681	148.124	1007	147
3	PANČEVO	76.203	123.414	148	512

Table 3. Realized incomes in the transit system in the Republic of Serbia for the period from 2008 to 2011

Income - City	2008		2009		2010		2011	
Proper income NIŠ	726.251.264	76%	778.249.270	77%	886.355.395	82%	942.192.500	84%
Participation of the owner of the market NIŠ	232.571.748	24%	226.283.539	23%	190.596.624	18%	180.917.737	16%
Total revenue NIŠ	958.823.012	100%	1.004.532.809	100%	1.076.952.019	100%	1.123.110.237	100%
Proper income SU	547,881.000	96%	479.112.000	95%	521.514.000	95%	531.677.000	89%
Participation of the owner SU	20.650.000	4%	23.137.000	5%	26.892.000	5%	66.752.000	11%
Total revenue SU	568.531.000	100%	502.249.000	100%	548.406.000	100%	598.429.000	100%
Proper income PA	361.773.017	67%	361.604.637	61%	348.573.003	57%	403.437.792	59%
Participation of the owner PA	175.274.104	33%	227.267.326	39%	260.975.412	43%	277.474.478	41%
Total revenue PA	537.047.121	100%	588.871.963	100%	609.548.415	100%	680.912.238	100%

The data about realized incomes in the system of public transit are copied directly from the business reports in the years that are included in the analysis.

According to structure, total revenue consists of incomes from transportation service sales (ticket sales, bus stop services, subsidies, etc.), financial incomes (interest and exchange gains) and other incomes (recovered bad debts, waste material sales, charged damages, etc.). Total revenues and their structure is presented in the table below, with amounts in local currency (dinar).

Total revenue in the given period, according to analyzed years, was always on the level of realized total costs (expenses) in the public transit system. When compared to costs, the amount of incomes practically shows that the system spends as much as it earns.

In the following section, the relation between realized incomes from the participation of the owner and realized transportation work is analyzed. That represents the revenue from the participation of the owner by the unit of realized transportation work in the public transit system. The presented revenue practically shows ineffectiveness of the transit market.

The following table shows the incomes from the participation of the owner in the Republic of Serbia by unit, compared to four selected criterions (realized transportation work (vehicle per km), inventory number of vehicle, number of passengers and number of employed).

For good managing in the system of public transit, it is necessary to register and balance all categories of revenues and expenses according to subsystems. This should be done in a way suitable for analysis of business in the transit companies with similar systems, because the existing way of registering is not offering this in the previously mentioned reports. The analysis of the incomes by unit from the participation of the owner leads to conclusion that those in Nis have falling trend which is positive, and that they are equal to the unit values in Subotica for the year 2011. In this period, Subotica got

Table 4. The incomes from the participation of the owner in the transit system in the Republic of Serbia for the period from 2008 to 2011

No.	Participation of the owner - City	2008	2009	2010	2011
PTR 1.	dinars / veh km NIŠ	26,93	26,20	22,71	21.81
PTR 1.	dinars / veh km SUBOTICA	6,65	7,65	8,88	22,33
PTR 1.	dinars / veh km PANČEVO	31,76	41,18	47,52	49,75
PTR 2.	dinars / passenger NIŠ	11	10	8	7
PTR 2.	dinars / passenger SUBOTICA	2	3	3	8
PTR 2.	dinars / passenger PANČEVO	26	33	36	38
PTR 3.	dinars / inventory vehicle NIŠ	1.875.579	1..824.867	1.537.070	1.459.014
PTR 3.	dinars / inventory vehicle SUBOTICA	254.938	285.642	336.150	834.400
PTR 3.	dinars / inventory vehicle	2.218.660	2.840.841	3.262.192	3.468.361
PTR 4.	dinars / employed NIŠ	312.597	304.145	256.178	243.169
PTR 4.	dinars / employed SUBOTICA	55.214	6.2196	72.290	188.034
PTR 4.	dinars / employed PANČEVO	351.956	438.740	510.715	550.545

bigger subsidy (148% higher) compared to the previous business year. The highest subsidies are in Pancevo, having positive growth which indicates bad management and urgent actions for the necessary improvement.

Since the income in the system depends directly on the service price policy (ticket prices) and structure of the tickets, it is very important to carefully form the structure of the tickets and their values. Otherwise, disproportion can appear between the parameters of the production of transportation service and realized incomes (considering that inadequate prices of transportation service can cause decrease in the number of transported passengers).

The following tables show social and commercial discounts according to valid pricing policy in use.

Table 5. Values of social discounts for certain user groups

No.	City/user category	Employed	College students and high school students	Elementary school students	Retired persons and invalids
1	NIŠ	0%	30%	40%	30%
2	SUBOTICA	0%	36,15%	36.15%	61,15%
3	PANČEVO	0%	45-60%	45-60%	0%

Due to the analysis of pricing policy in these three cities, it was difficult to make comparison, considering the differences in the approach.

Table 6. Values of commercial discounts for certain user groups

No.	City/user category	Employed	College students and high school students	Elementary school students	Retired persons and invalids
1	NIŠ	43,75%	43,75%	43,75%	43,75%
2	SUBOTICA	23,85%	23,85%	23,85%	23,85%
3	PANČEVO	40%	0%	0%	0%

Due to the analysis of pricing policy in these three cities, it was difficult to make comparison, considering the differences in the approach. Analysis shows that in Nis and Subotica ticket prices for certain user groups depend on mobility per month of the characteristic groups, number of zones, percentage of commercial discount and percentage of discount approved for certain user groups. The difference between these two cities is mobility per month, which is 64 rides in Nis and 104 rides in Subotica. In Pancevo, tariff and ticket systems are not projected in accordance with transportation needs and requests. There are significant deviations in the rights of usage and ticket prices for the same length of rides on different lines in the city and suburban transit. Lack of coordination in tariff zones is inadequate for short-distance travelers who pay the same price as travelers who travel almost 14 kilometers (which is almost three times longer than middle ride length for city lines). This violates one of the most important principles in public transit: equality for all users of the system.

CONCLUSION

Improvement of public transit services is an important component of transportation plans for improvement of the transit system in a specific area. High quality of transit services can provide different economic, social and ecological advantages, including direct benefits of revenue increase from the activity. The implementation of plans for improvement often demands additional resources. These resources often exceed the possibilities of local and city budgets, sometimes even state budgets, so they have to be financed from various funds which are in domain of higher levels of governing.

This research offers eighteen options for financing, including some that are already in use as well as others that are considered innovative.

The research does not discover any new options for financing, which would be very profitable and easy for implementation. Every existing option for financing has flaws and limits. The point is that different options for financing should be used to help financing the local part in the functioning, to improve public transit and ensure stability, as well as to distribute expenses in the wide area which the system covers. Even the residents who do not use public transit have benefits from the system. Those benefits are: decreasing traffic jams, increasing public security and health, enabling better options for mobility of the residents and regional economic development. All these lead to better quality of life and environment.

Further research in this field should analyze every new option for financing better. It is necessary to maximize benefits and minimize problems which such option brings. Certainly, the potential lays in accessibility, preservation of the environment, alternative types of transportation, which leads to sustainable public transit.

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PRELIMINARY COMMUNICATION

Modelling of the Interdependence Between Speed and Traffic Flow Density. A Neuro – Fuzzy Logic Approach

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Abstract. The speed-traffic flow density interdependence diagram has a number of variations, starting with the theoretical model, through various empirical models that were developed and models based on actual research done on traffic flow. The functional interdependence is obtained using the Sugeno fuzzy logic system, where representative values proposed in HCM 2010 have been adopted as parameters of output association functions. Subsequently the neural network is trained based on actual traffic flow data, which by adjusting the association function of the fuzzy logic system yields an output form of the basic traffic flow diagram. It was noticed that this hybrid expert system produces better output results by applying the "subtractive clustering" method on data that are used for training a neural network. Finally, the model was tested on several input data groups, and the interdependence between speed and traffic flow density is shown in graphical form.

Keyword. Basic traffic flow diagram, traffic flow theory, neural networks, fuzzy logic, subtractive clustering, hybrid expert systems.

INTRODUCTION

Earlier attempts to estimate the road capacity led to the establishment of the first relations between speed and flow, thus several papers on this topic were published in the 1920- and 1930-ies, most of them in Britain, Germany and the USA. It is difficult to determine which paper was the first to be published, but according to references, that honor would go to Schaar [15]. A wider preview of theoretical curves, which were considered at the time, and also some more contemporary approaches are set out in papers [4, 6, 7, 8, 9, 14, 21], while the paper [1] contains basic theoretical principles regarding the relation between speed and traffic flow density.

Theoretical interdependence between speed and traffic flow density in automatic traffic flow control conditions on highways is another among a series of problems regarding the interdependence of the basic traffic flow parameters [2]. The driver's decisions are replaced by a computer-based control system which carries out the optimization of the traffic flow.

The use of a queuing system, which is based on traffic counting and measuring traffic behavior as a function of relevant limitations, is another model that was used to illustrate the interdependence between speed and traffic flow density [22]. The road was divided into segments of equal length, where each segment is considered a service station where vehicles enter (λ) and are queued (μ) and served according to the parameters of the queuing system. The output result is shown in the form of analytically obtained curves of the traffic flow diagram.

The result of fixed- and floating point Langevin equations for traffic flow is a set of relations which can be linked to the basic traffic flow diagram [11].

The new model of the basic traffic flow diagram as a function of homogenous states, which was confirmed by research conducted on German highways, is one of the most important papers in the recent history of traffic flow theory studies [24]. According to the model, the basic traffic flow diagram can entirely be defined using the following five key parameters: desired speed, sequence distance between vehicles in the flow, average traffic flow speed, average forced flow sequence distance and forced flow vehicle density.

Figure 1. [24] shows a diagram of interdependence between speed and traffic flow density on German highway A43, for a saturated state of flow. The author has determined that the form of the curve shown in the figure is identical for highways and other categories of motorways.

The basic diagram of traffic flow has its specific properties in big urban areas. The paper [5] contains experimental results concerning this interdependence, which were obtained using a combination of detectors in the network and a vehicle fleet equipped with sensors.

The authors of this paper propose a model based on fuzzy logic, where the Sugeno fuzzy logic system is used, implemented in the programming language "MATLAB" [18, 19]. As guiding output (reference) values for the design of the system we took the ones proposed in HCM 2010[20].

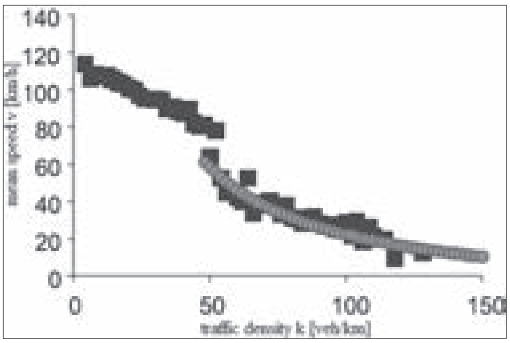

Figure 1. Form of speed-density interdependence for forced flows on German highway A43

The second part of the paper will be about neuro - fuzzy logic. The third part of the paper is dedicated to the basics of subtractive clustering. In the fourth part of the paper, the proposed model will be presented. This model is based on a neuro-fuzzy logic system and also on subtractive clustering of data used for training a neural network. The data for the training of the neural network have been taken from the paper [24]. That data has been obtained from measurements carried out on German highways. In the last part of the paper, the model will be tested on a group of input data sets (values of traffic flow speed), where as a result values of traffic flow density and a corresponding curve of this interdependence will be obtained. The data sets that are used to test the model, are independent from the data used to train the neural network and have been obtained on Serbian highways. It is, of course, possible to test the model with available data sets from any highway in the world. The model was designed in the programming language MATLAB.

NEURO - FUZZY LOGIC

In real life, one cannot answer all questions with just yes or no. For example, is there really a strict line of distinction between tall and short people, or can we say that a person is absolutely good or absolutely bad. The answer to these questions is certainly negative.

According to the classical set theory one can belong to the set of tall people or not, which means that elements of a set can absolutely belong, or absolutely not belong to that set. If we, for example, have a classical Fibonacci set A = {1,1,2,3,5,8,13,21...}, a set element {8} belongs to the Fibonacci se with a probability of 100 %.

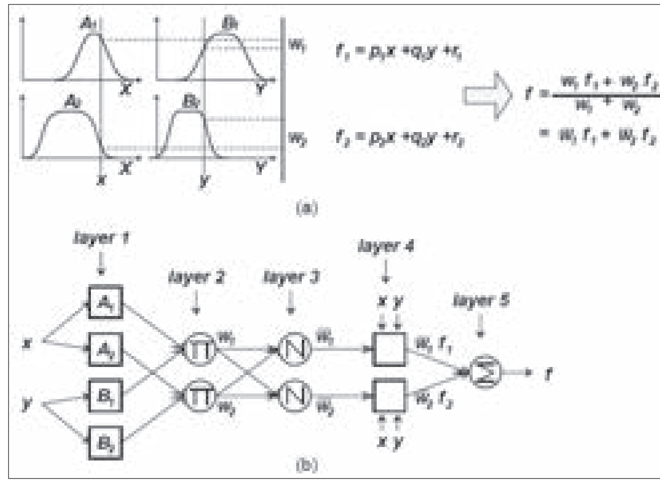

Figure 2. (a) First-order Sugeno fuzzy model; (b) Corresponding ANFIS architecture

Inspired by this way of thinking, in 1965 Zadeh [28] proposed a modified set theory (fuzzy sets) where the association to a set can be expressed through different percentages, and not only through absolutely belongs to (1) or absolutely does not belong to (0). Therefore, according to this modified set theory, one can belong to the set of tall people with 70 %, and belong to the set of short people with 30 %. Take, for example, a fuzzy logic system of the Sugeno type containing two rules, where the output functions are given in linear form [16, 17].

Rule 1: IF X is A_1 AND Y is B_1 THEN $f_1 = p_1x+q_1y+r_1$
Rule 2: IF X is A_1 AND Y is $B2$ THEN $f_1 = p_1x+q_1y+r_1$

Figure 2. [16, 17] (a) graphically illustrates the mechanism of fuzzy conclusion in order to obtain output function f based on input values [x, y]. Weight factors ω_1 and ω_2 are usually derived from level of belonging in the premise, whereas the output function f is the weighted average of each of the rules in the THEN part. To improve the Sugeno fuzzy model, i.e. to improve its performance, the fuzzy model has been put into the frame of a neural network. As a result we have the ANFIS architecture shown in figure 2. (b), where the role of each network layer is explained in detail. All the network nodes in the same layer execute a function of the same type. O_i^j marks the outputs of the i-th node in the j-th layer.

Layer 1. Each nod in this layer generates one linguistic variable association function (low, medium, etc.). For example, the i-th node generates a bell-shaped association function which can be mathematically expressed in the following way:

$$O_i^1 = \mu A_i(x) = \frac{1}{1+\left|\frac{x-c_i}{a_i}\right|^{2b_i}} \qquad (1)$$

Where x is the input value for node i; A_i is the linguistic variable association function relating to the node, $\{a_i, b_i, c_i\}$ is a group of parameters for the change of association function shape and refers to the rules premise (part IF).

Layer 2. Each node in this layer calculates weight coefficients through multiplication, which can be expressed in the following way:

$$O_i^2 = \omega_i = \mu A_i(x) \cdot \mu B_i(y), \; i = 1,2 \tag{2}$$

Layer 3. Node i in this layer calculates the ratio of the weight coefficient of i-th rule and the sum of all weight factors. This ratio can be expressed as follows:

$$O_i^3 = \overline{\omega_i} = \frac{\omega_i}{\omega_1 + \omega_2}, \; i = 1,2 \tag{3}$$

Layer 4. Node i in this layer calculates the participation of the i-th rule in the total system output. This can be mathematically described as follows:

$$O_i^4 = \overline{\omega_i} \cdot f_i = \overline{\omega_i} \cdot (p_i x + q_i y + r_i) \tag{4}$$

Where $\overline{\omega_i}$ is the output from the third network layer, i $\{p_i, q_i, r_i\}$ is a group of parameters which refers to the rule consequence (part THEN).

Layer 5. A single node in this layer calculates the total output as a sum of each rule's contributions:

$$O_i^5 = \sum_i \overline{\omega_i} \cdot f_i = \frac{\sum_i \omega_i f_i}{\sum_i \omega_i} \tag{5}$$

Structure of an adaptive network, shown in figure 2. (b) is functionally equivalent to the fuzzy system shown in figure 2. (a). This leads to the conclusion that the output function from the neuro - fuzzy system is linearly dependent on the parameters from the consequences of fuzzy rules:

$$\begin{aligned} f &= \overline{\omega_1} \cdot f_1 + \overline{\omega_2} \cdot f_2 = (\overline{\omega_1} \cdot x) \cdot p_1 + \\ &+ (\overline{\omega_1} \cdot y) \cdot q_1 + (\overline{\omega_1}) \cdot r_1 + (\overline{\omega_2} \cdot x) \cdot p_2 + \\ &+ (\overline{\omega_2} \cdot y) \cdot q_2 + (\overline{\omega_2}) \cdot r_2 \end{aligned} \tag{6}$$

Backpropagation is used as an algorithm for training, which calculates the error (derives the square error taking into consideration the output function of each of the nodes) recursively, starting with the output layer and then back to the input layer. Further improvements of fuzzy hybrid systems can be found in [25].

SUBTRACTIVE CLUSTERING

Grouping numeric data is a base for many types of classification and system modelling algorithms. The purpose of grouping is to identify the subgroup of data of the same nature from a big group of data, in order to give a summary of system behavior.

Data clustering, also known as cluster analysis, groups an unallocated data set into homogenous clusters based on similar properties. Several varieties of clustering are proposed, like fuzzy clustering, hierarchical clustering or subtractive clustering, etc.

A simple cluster center determination method estimates the center of the cluster based on lowering and lifting the objective function with a "greedy" algorithm [26]. However, this method is efficient for a small group of data, but in case of a large group of data, the algorithm becomes unusable. To reduce the complexity on a large group of data, the subtractive clustering method is proposed, which will be described in the following text [3].

Fuzzy clustering is a "monitored" algorithm because it is necessary to determine the number of clusters in advance. If it is not possible to determine the number of clusters in advance, a "non-monitored" algorithm is used. Subtractive clustering is based on the measurement of data density in relation to the data space characteristics. Thus, the idea is to find the maximum data density in the data area over which the cluster analysis is carried out. Data with the largest number of neighbors is selected as the cluster center. The objective function has the following form [10]:

$$M(x_i) = \sum_{j=1}^{n} e^{-\alpha \left\| x_i - x_j \right\|^2} \tag{7}$$

Where α is a positive constant, and $\left\| x_i - x_j \right\|^2$ is the square of distance between x_i and x_j.

If M_1^* is the maximum found value of the objective function, and x_i^* is the data for which the maximum objective function value was found (this data will be selected as the first cluster center), the following modified objective function for the determination of the next cluster is proposed:

$$\hat{M}^{j}(x_i) = \hat{M}^{j-1}(x_i) - M_{j-1}^* \sum_{j=1}^{n} e^{-\beta \left\| x_i - x_{j-1}^* \right\|^2} \tag{8}$$

Where x_{j-1}^* is the newly determined centroid, and β is a positive constant. This method is, among others, also used to define the initial number of clusters in fuzzy clustering.

Contrary to the classic (sharp) classification of data, fuzzy clustering offers the possibility to assign a data not only to one, but multiple, cluster groups, so that each data belongs to one of the clusters with a certain level of association. Each cluster group is represented by a prototype, which consists of the cluster center and probably of an additional information regarding the size and shape of a cluster. The level of association which determines which data will be associated to the cluster, is obtained from the distance of the data from the cluster center in relation to the size and shape of the information.

Further improvements of the subtractive clustering method can be found in [12, 13, 23]. It is also possible to use the well-known entropy equation as an objective function, under the approach that data with a minimum entropy value becomes the candidate for the next cluster center [27].

APPLICATION OF ANFIS ON A V-G TRAFFIC FLOW DIAGRAM

The idea of this paper regarding the use of fuzzy logic is to propose values related to the traffic flow density from input data (traffic flow speed values). The justification of such an approach lies in the fact that flow density is a parameter that is hard to measure or calculate. Based on this assumption, an input to the Sugeno-type fuzzy logic system is formed, while guiding reference output values are adopted based on the values recommended in HCM 2010. Figure 3. shows fuzzy set used with this model.

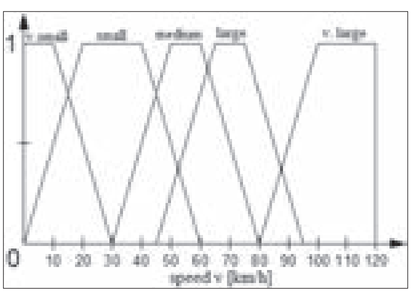

Figure 3. Fuzzy sets as an input value of a Sugeno fuzzy logic system

Before forming an ANFIS model it is necessary to define the initial structure of the Sugeno-type FIS model. That can be achieved using the technique of network division or the data clustering technique. In the first case, the author has applied the technique of network division, whereas in the second case data clustering was used, where in the following text speed-flow density dependence curves will be shown, which represent an output for each of the mentioned cases.

Models based on fuzzy logic consist of fuzzification, forming of a base of "if – then" rules, and as a final step, the selection of the output variable value, and of defuzzification. The fuzzy rules base together with the output variable association function values, presented in the form of constants, are shown in the following table 1. Output functions can be linear or constant. In this paper, the output functions are assumed to be constant. Figure 4. shows a curve which illustrates the dependence between speed and flow density. FIS was tested on 212 input data which represent traffic flow speed values on Serbian highways. This table shows fuzzy logic system output results without the use of neural network.

Table 1. Base of FIS model fuzzy rules

No.	and V(km/h) is	THEN g (veh./km) is		Weight fact.
1.	very small	mf_1	100	1
2.	small	mf_2	70	1
3.	medium	mf_3	60	1
4.	large	mf_4	30	1
5.	very large	mf_5	10	1

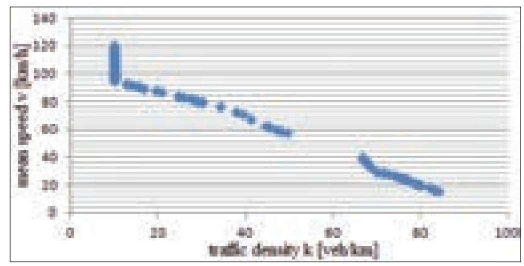

Figure 4. Speed-flow density curve as an output from FIS

The data for the training of the neural network have been taken from the paper [24]. That data has been obtained from measurements carried out on German highways. Data for the learning of the neural network consisted of 411 data pairs (speed and flow density values). A combination of the backpropagation algorithm and the minimum square method was used as an algorithm for network learning. Other parameters of the applied ANFIS model are:

- Number of linear parameters: 5
- Number of nonlinear parameters: 20
- Total number of parameters: 25
- Number of fuzzy rules: 5
- Number of epochs: 800

The dependence of the average test error on the number of epochs is shown in figure 5., while figure 6. shows the association functions of the input variable of a corresponding ANFIS model, which are automatically adjusted based on the neural network test. The base ANFIS model fuzzy rules model is shown in table 2., where output parameter values have been changed.

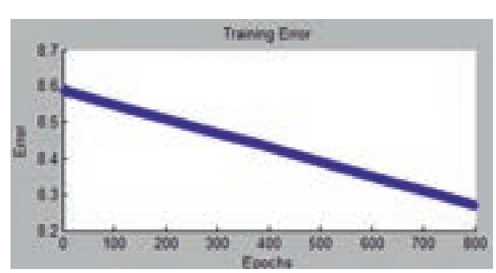

Figure 5. Average test error-number of epochs curve

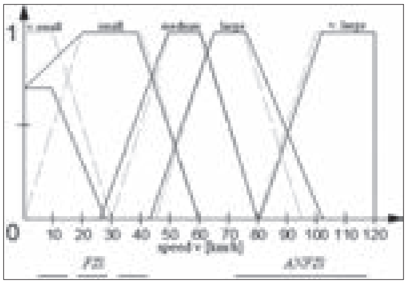

Figure 6. Adjusted ANFIS model association functions

Table 2. Base of ANFIS model fuzzy rules

No.	and V(km/h) is	THEN g (veh./km) is		Weight fact.
1.	very small	mf_1	97,13	1
2.	small	mf_2	55,79	1
3.	medium	mf_3	53,51	1
4.	large	mf_4	32,22	1
5.	very large	mf_5	19,96	1

Figure 7. shows the speed-traffic flow density curve as an output from a hybrid system. The ANFIS model was tested for the same input data as the FIS model (identical flow speed values).

The final system enhancement measure is the clustering of input data, where the association functions will change one more time (their second change). The principles of data clustering and an application method are more detailed described in the third chapter of this paper.

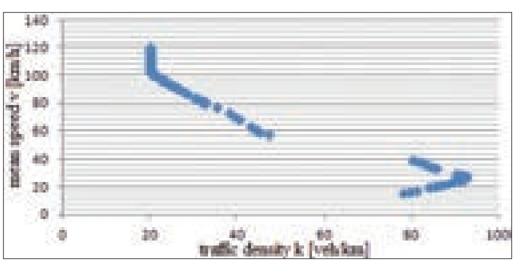

Figure 7. Speed-flow density curve as an output from ANFIS

After the input data clustering is completed using the subtractive clustering method, a significant change in the form of the association function (figure 8) occurred, fuzzy rules, where the output parameters finally take a linear form (table 3). Average test error-Number of epochs curve is shown on figure 9., whereas the speed-traffic curve is shown on figure 10.

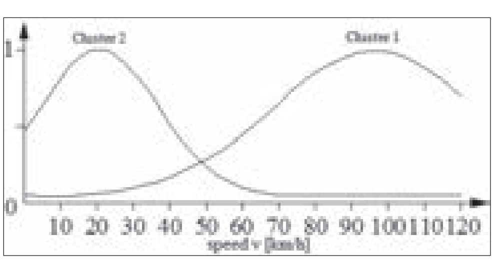

Figure 8. ANFIS model association function after completed clustering

Table 3. The fuzzy rules base after clustering

No.	and V(km/h) is	THEN g (veh./km) is		Weight fact.
1.	input cluster 1	output cluster 1	[-0.422; 65.26]	1
2.	input cluster 2	output cluster 2	[-0.5451; 101.3]	1

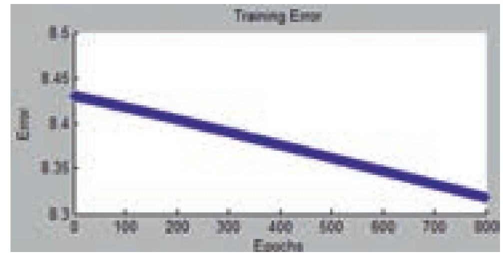

Figure 9. Average test error-number of epochs curve after clustering

Other parameters of the applied ANFIS model with data clustering are:

- Number of linear parameters: 4
- Number of nonlinear parameters: 4
- Total number of parameters: 8
- Number of fuzzy rules: 2
- Number of epochs: 800

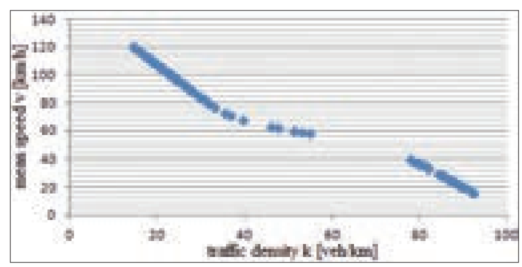

Figure 10. Speed-flow density curve as an output from ANFIS with data clustering

It should be noted that the data used for learning of the neural network were different from the ones the models were tested with. Therefore, clustering was carried out on the data used for learning of the neural network (411 pairs), and the models were tested o independent data (212 traffic flow speed values). Figure 10. illustrates an output from the proposed model and shows the speed-traffic flow density curve.

DISCUSSION OF THE RESULTS

The speed-traffic flow shown in figure 4. represents a set of output solutions which is obtained by applying FIS not including a neural network as part of a hybrid system. It is an approximate density value that was obtained using the fuzzy rule base and parametrical values which were adopted as input to the FIS.

The curve in figure 7., in the part where speed is lower than 20 km/h, i.e. under conditions of oversaturated (forced) traffic flow, shows the differences in regard to theoretical models, and also in regard to the model obtained from a Sugeno fuzzy logic system. It should be noted again that the ANFIS model was trained based on actual data obtained on German highways. The previously mentioned paper [24] is one of the most significant in the recent history of traffic flow theory studies. One of the conclusions which the author has come to in that paper, is that the sequence distance is not a function of speed, which explains the paradox shown in the above figure.

The curve shown in figure 10. was obtained by data clustering and is similar to the one shown in figure 1. Although the curve in figure 7., which is an output from the ANFIS model without clustering, has its specific properties, the speed-traffic flow density curve shown in figure 10. is adopted as an output result from the entire model. As can be seen, this model shows that the zone of saturated flow emerges for speeds of 40 km/h to 50 km/h, which are expected values regarding high level motorways for which this model gives an approximation.

CONCLUSION AND DIRECTIONS OF FUTURE RESEARCH

The approximation of a continuous, nonlinear function specified through an input/output ta set is a widely present problem. Because of the good results it showed, ANFIS is more often used as a neuro-fuzzy tool for the solution of the mentioned problem.

Using FIS on a system for which input/output data (which should be used for modeling) already exists, is realized by using ANFIS, because it is not always possible to see how association functions should look like, just by simple observation of input/output data. The use of a neuro-adaptive learning technique secures that the selected association functions and their parameters best fit the input/output data.

Although it is a less known and not very often used technique, neuro-fuzzy conclusion may also be used for forecasting, for basic approach and/or for checking results obtained by standard forecasting methods.

Applying ANFIS to the basic traffic flow diagram has yielded the model shown in this paper and it can be used for approximation of traffic flow density, being the parameter which is most difficult to determine. The interdependence was obtained using data which was collected on German highways, so that this model is best to use for the approximation of density on highest level motorways.

The logic used in this paper can also be used on the q-V traffic flow diagram, in which case flow would be an input value. Of course it would be necessary to also train the model on data from low category motorways or urban areas, and compare the differences that this model is able to offer. Especially interesting for further research would be to study the behavior of the basic traffic flow diagram in case of bottlenecks or objects on the road (tunnels, bridges, etc.) when the model proposed in this paper is applied to these cases.

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PROFESSIONAL PAPER

Safety of Cyclists in Belgade

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Abstract: This paper analyses traffic accidents involving cyclists that occurred within the territory of the city of Belgrade over the period of five years from 2009. to 2013. year, as well as survey of attitudes and behaviour of cyclists and use of protective equipment. Based on observed statistical data, subjective and objective risk, we defined a proposal of measures to improve the safety of this vulnerable category of traffic participants.

Key words: road safety, traffic accidents, safety of cyclists, Belgrade.

INTRODUCTION

Cities have largely become unsuitable for riding a bicycle. This is due to increasing intensity and speed of motor vehicles and traffic infrastructure that has for years been built exclusively for motor vehicles. The issue of pedestrian safety has so far been resolved by separating pedestrians from the rest of the traffic and by improving pedestrian crossings. Cyclists have mostly been left out in this process [1].

Safety is an important factor that influences the development of bicycle traffic. If there is no suitable infrastructure and if there are no conditions improving their safety, cyclists can be endangered in traffic, first and foremost by a large number of motor vehicles. Due to large difference in mass and speed they feel unprotected if they move on the same surface as motor vehicles. Safety of cyclists in a city is a basic precondition for expanding cycling traffic and its promotion as an everyday mode of transport. Cycling traffic in a city can be a replacement for car travel. Experience in numerous European cities have shown that by improving cycling traffic conditions the number of cyclists and bicycle travel is significantly increased [2].

Danger for cyclists in traffic, along with insufficient protection compared to other participants in the traffic (lack of adequate and suitable traffic infrastructure, busy existing traffic infrastructure, improper education, etc.), can also be observed from the aspect of specific behaviour of cyclists themselves. Because of their heterogeneous structure in terms of age, physical and mental capabilities to participate in traffic, level of traffic culture and the fact that by engaging in traffic, regardless of their traffic education, they become equal participants in traffic with others, most of all with motor vehicles, the cyclists are more exposed to risk of fatal or severe injuries in traffic accidents [3]. Also, there are no medical requirements for cyclists or tests of their traffic training, i.e. whether they are familiar with necessary traffic regulations and signs, or whether they have the necessary skill to ride the bicycle [4]. Bearing all this in mind, cyclists, as a vulnerable category of participants in traffic need to be given special attention, considering their specific movement and need to provide adequate and suitable infrastructure.

Cyclists in Belgrade face a number of difficulties. First, there is no adequate infrastructure that would answer the needs of cyclists and make cycling a safe and attractive activity. Second issue is the lack of respect and tolerance of drivers, as well as pedestrians who do not obey the traffic rules and endanger themselves as well as the other participants in traffic.

The subject of research includes the problem of endangered cyclist's safety with concrete examples and possibility to improve the safety of cyclists in Belgrade by implementing protection measures for cyclists. The research involved field visits, records of locations, photographs of locations and "problems" for safety of cyclists. The subject of research also is the analysis of traffic accidents with cyclists that occurred within the territory of the City of Belgrade over the period of five years from 2009. to 2013. year, as well as survey of attitudes and behaviour of cyclists and use of protective equipment.

The aim of the research is to, based on results of survey on attitudes and behaviour of cyclists on traffic safety and based on results of analysis of traffic accidents, reach the most accurate data that would be used to accurately define problems in traffic safety of cyclists within the territory of the city of Belgrade.

RESEARCH METHODOLOGY

Cyclist's safety in traffic within the territory of Belgrade has been analysed from several aspects by using three different research methods. The aim of using different research methods is to get more reliable results from different aspects in order to better recognize the problems of cyclists' vulnerability in traffic and define measures for improving the safety of this vulnerable category of traffic participants.

The first method used in this research is a statistical method of analysis of traffic accidents with cyclists that occurred within the territory of the City of Belgrade in the five-year period from 2009. to 2013. year. During data processing the following characteristics of the traffic accidents were reviewed, i.e. the traffic accidents were analysed according to: total number and consequences, time characteristics (monthly distribution, daily distribution, hourly distribution over a day, hourly distribution over a week and hourly distribution over a month), types, causes and place they occurred. The aim of using this research method is to perform a statistical analysis of traffic accidents which will be a basis for taking management measures to decrease the frequency and consequences of traffic accidents involving cyclists. Although the analysis of traffic accidents is a retroactive approach to analysing the problem of traffic safety, it represents an important analysis, because in order to probably establish adequate measures for preventing traffic accidents it is first necessary to view and analyse samples and circumstances under which those accidents occur.

The second method is survey research of attitudes and behaviour of cyclists within the territory of the city of Belgrade as well as the use of protective equipment. The survey was conducted from 1 to 22 August, 2014. year from 8 am to 7 pm at ten locations within the territory of the city of Belgrade, on a sample of total 320 cyclists. The respondents were members of Belgrade cycling clubs, professional cyclists, but also amateurs who cycle every day for recreational or some other purposes. The survey form had 15 questions, 10 of them of closed type, while 5 were of open type. The concept of the survey form was such that it led respondents to give concrete answers, based on which one can get quality perception of their view of the issue of cycling traffic in the city of Belgrade. A special attention was given to the set of questions referring to the safety of cyclists and where they were expected to point out concrete problems (situations) in traffic, and point out direct locations or parts of the road for which the surveyed cyclists thought to be "dangerous". The survey was divided into two parts. In the first part of the survey there were questions dedicated to overview of general data on the surveyed cyclists, such as gender, age, how many years had they been riding the bicycle, during which part of the day, for what purpose, which streets they usually ride through and how much time a day they spend cycling. In the second part, the questions were predominantly aimed at over viewing the safety of surveyed cyclists in traffic. In the second part the cyclists were asked to point out the most significant risks in traffic, and to rank them. During the development of questions a special attention was given to the attempt to acquire data on concrete types of risks and their location in the road network. In order to give a simple overview of the location with increased risks for cyclists, the survey form had a map of Belgrade where the surveyed cyclist would mark the locations with increased risk. A database was prepared in order to analyse and process the survey. The aim of this survey was to observe the attitude and knowledge of cyclists, as well as determining subjectively dangerous and unsafe behaviour in traffic.

The third method was field research, i.e. visiting the location of subjectively and objectively increased danger for cyclists in traffic, which had been identified in previous parts of the research. The conclusions related for the analysis of traffic accidents involving cyclists and conclusions related to the analysis of cyclists attitude were used as a basis for choosing the locations. The behaviour of cyclists and drivers of motor vehicles was observed on these subjectively and objectively "dangerous" locations in order to determine the problems in road safety.

The limitations of this research were related to the readiness of the surveyed cyclists to cooperate in the survey as well as the accuracy and completeness of data on traffic accidents that occurred within the territory of the City of Belgrade. The analysis is based on available data from the Common Information System of the Interior Ministry of the Republic of Serbia, so the quality and availability of data determines the quality of research.

RESULTS OF RESEARCH

Based on the statistical analysis of traffic accidents involving cyclists, conducted survey as well as field research, done for this paper, there was an analysis of the current state of cyclist safety in traffic within the territory of the city of Belgrade.

Analysis of traffic accidents involving cyclists

In the time period from 2009. to 2013. year there were 931 traffic accidents involving cyclists within the territory of the city of Belgrade. From the total number of traffic accidents that occurred most of them were with injured persons (696 TAs – 75%), then the traffic accidents with material damages (208 TAs – 22%) and traffic accidents with fatalities (27 TAs – 3%).

The largest number of traffic accidents with fatalities was recorded in 2009 (10 TAs), followed by 2013 (7 TAs), while the largest number of accidents with injured persons was recorded in 2012 (151 TAs). The number of traffic accidents with injuries and the number of traffic accidents with fatalities "varies" from year to year and there is no trend.

By analysing the data on time distribution of traffic accidents according to months of the year, we can conclude that the months with the largest number of accidents are August (150 TAs) and June (133 TAs), while the least number of accidents happened in January and February (18 TAs each). The largest number of traffic accidents with fatalities was recorded in the months of August (5 TAs), May, July and December (4 TAs each), while the largest number of traffic accidents with injuries were recorded in August (123 TAs). Increased number of traffic accidents with fatalities in the months of May, July and August can be related to the weather conditions which are more favourable for large number of cyclists in traffic.

By analysing the distribution of the total number of traffic accidents over days of the week, the largest number happened on Fridays (152 TAs) and Saturdays (151 TAs). If we look at traffic accidents with fatalities, the days with largest number of such accidents are Tuesdays (7 TAs), Mondays and Wednesdays (5 TAs each), while the largest number of traffic accidents with injuries happened on Saturdays (124 TAs).The analysis of the number of traffic accidents with fatalities, injuries and material damages indicates that, while defining preventive measures, but repressive policy as well, we need to give a special attention to Mondays, Tuesdays and Wednesday.

Based on the distribution of traffic accidents according to hours of the day we can conclude that the number of traffic accidents is rising from 5:01 am to 5:00 pm (546 TAs), after which the number is decreasing. The number of fatalities is especially significant in the time intervals from 5:01 pm to 6:00 pm and from 9:01 pm to 10:00 am (4 TAs each), and the time intervals from 2:01 pm to 3:00 pm (3 TAs), while the number of TAs with injuries reaches its maximum from 6:01 pm to 7:00 pm with 60 TAs, and then the time intervals from 3:01 pm to 4:00 pm (56 TAs) and 4:01 pm to 5:00 pm (55 TAs).

When we analyse traffic accidents according to consequences and hours during the week, we can see that the largest number of traffic accidents with fatalities happened on Tuesday (7 TAs) between 5:01 pm and 6:00 pm (2 TAs), as well as in the following time periods: 1:01-2:00 pm, 2:01-3:00 pm, 6:01-7:00 pm, 7:01-8:00 pm and 9:01-10:00 pm (one TA each), while the largest number with injuries happened on Saturday (124 TAs) in the following time periods: 4:01-5:00 pm (14 TAs), 2:01-3:00 pm, 3:01-4:00 pm, as well as 5:01-6:00 pm (12 TAs each).

By analysing the total number of traffic accidents according to consequences and hours during the month we can see that the largest number of traffic accidents with fatalities happened in August (5 TAs) in the following time periods: 1:01-2:00 pm, 4:01-5:00 pm, 5:01-6:00 pm, 9:01-10:00 pm and 10:01-11:00 pm (one TA each), as well as the largest number of TAs with injuries (123 TAs) in the following time intervals: 4:01-5:00 pm (13 TAs), 8:01-9-00 pm (12 TAs), as well as in the time periods from 2:01-3:00 pm and 6:01-7:00 pm (10 TAs).

Traffic accidents involving cyclists with the territory of the city of Belgrade in most cases occur in straight line streets – without any narrowing (614 TAs), in junctions regulated by traffic signs (122 TAs), in junctions regulated by traffic lights (65 TAs), as well as in straight roads with narrowing at the location of the traffic accident (46 TAs). The largest number of traffic accidents with fatalities (21 TAs), with injuries (456 TAs) and traffic accidents with material damages (137 TAs) occurred on a straigth road, without any narrowing.

The most frequent types of traffic accidents involving cyclists that occurred within the territory of the city of Belgrade in the time period from 2009. to 2013. year were "side crashes" (225 TAs), then "same direction driving crashes" (150 TAs), as well as "opposite direction driving crashes" (90 TAs). The largest number of traffic accidents with fatalities (9 TAs) and traffic accidents with material damages (62 TAs) happened with "collision of vehicles going in the same direction", while the largest number of traffic accidents with injuries (160 TAs) happened with "a side collision".

The most frequent cause of traffic accidents involving cyclists within the territory of the city of Belgrade is "other speed unsuitable to the conditions of the road and visibility" (129 TAs), then "performing other activities with the vehicle" (95 TAs), as well as "change of position or traffic lane" (90 TAs). When analysing the causes of traffic accidents we need to bear in mind that the data were taken from the database on traffic accidents from the Ministry of Interior Affairs. The named causes represent circumstances under which a traffic accident occurred. Although inaccurate and incomplete sample analysis, i.e. circumstances under which a traffic accident occurred, can point out problems in the traffic safety system. The most frequent cause of traffic accidents with fatalities (7 TAs) and traffic accidents with injuries (94 TAs) is the "other speed unsuitable to the conditions of the road or visibility", while the most frequent cause of traffic accidents with material damages (45 TAs) is "unsuitable speed considering the distance between vehicles".

By analysing the traffic accidents according to the location they happened, we noted that the largest number of traffic accidents involving cyclists happened on the following locations, i.e. streets:

- Ada Ciganlija (29 TAs with injured persons)
- Radnicka (17 TAs with injured persons)

- Zrenjaninski Put (10 TAs with injured persons)
- Obrenovacki Drum (7 TAs with injured persons)
- Blvd Vojvode Misica (6 TAs with injured persons)
- Blvd Mihajla Pupina (6 TAs with injured persons)
- Blvd kralja Aleksandra, the section from the junction with Zarka Zrenjanin street to the junction with the Gospodar Vucic street (1 TA with fatality and 4 TAs with injuries);
- Blvd Oslobodjenja (5 TAs with injured persons);
- Savski Nasip (1 Ta with fatalities and 2 TAs with injuries);
- Prvomajska (3 TAs with injured persons)
- Usce (3 TAs with injured persons)
- Dr Ivana Ribara (3 TAs with injured persons);
- Blvd Mira (3 TAs with injured persons);
- Mirijevski Venac (3 TAs with injured persons);
- Pancevacki Put (3 TAs with injured persons);
- Glavna (1 TA with fatalities).

Based on the area division of traffic accidents we can conclude that the largest number of traffic accidents happened at, or near Ada Ciganlija, as well as within the territory of the Municipality Novi Beograd. Basically, Ada Ciganlija is one of the leading places for recreation in the city of Belgrade, and as such attracts large number of cyclists, while the largest number of cycling tracks, about 46 kilometres, is located in the Municipality Novi Beograd.

The junctions with the most traffic accidents involving cyclists are:

- Gandijeva – Jurija Gagarina (4 TAs with injured persons);
- Roundabout at the Novi Beograd municipal building (3 TAs with injuries);
- Dr Ivana Ribara – Jurija Gagarina (3 TAs with injured persons);
- Blvd Oslobodjenja – Crnotravarska (3 TAs with injured persons);
- Partizanske Avijacije – Dragise Brasovana (2 TAs with injured person persons);
- Omladinskih Brigada – Jurija Gagarina (2 TAs with injured persons);
- Radnicka - Pastroviceva (2 TAs with injured persons);
- Kneza Milosa – Nemanjina (2 TAs with injured persons).

Results of cyclists survey

Out of total of 320 people who participated in the survey, 80% (256) were male, while 20% (64) were female. Most of them were from age 25 to 35 (42.81%), then age 35 to 45 (23.13%), from age 18 to 25 (16.25%), over 50 (10.31%) and from age 45 to 50 (6.88%), while there were 0.63% those under 18.

The third question was an open type and the respondents had the opportunity to name more than one term when are they riding their bicycles during the day. The surveyed people stated that 50.31% of them ride the bicycle from 5:00 to 6:00 pm, 40.31% of them from 6:00 to 7:00 pm, and 34.69% from 8:00 to 9:00 am. The results of this analysis indicated that the cyclists participate in traffic in rush hours, i.e. that the bicycle is used as a transport vehicle to work/home/school, but also for recreational purposes later in the day. All of this data indicates that the cyclist, during rush hour, move through same corridors as pedestrians and motor vehicles, and that a special attention needs to be given to dividing these flows and decrease, i.e. channelling of the intersections.

The results of the fourth question indicated that most of the respondents in Belgrade use the bicycle for recreational activities (62.81%), followed by for going to work (42.50%), as well as for going shopping (16.25%). When analysing the answers provided in the survey we can see that very few of the people use the bicycle for riding to school/university (10.31%). Cycling has many advantages that these categories of young people can use if some conditions are met.

On the fifth question 25.8% of the surveyed people responded that they had been using the bicycle up to 5 years, then 17.31% of them from 5 to 10 years, 17.67% from 10 to 15, 13.43% of the surveyed people had been using the bicycle from 15 to 20 years, while 14.84% of them from 20 to 30 years. From the above we can conclude that one third of the surveyed people were cyclists with only few years of cycling experience. People who use the bicycle for over 20 years are 25.8% of the total number of surveyed cyclists.

In the sixth question the surveyed people were naming the streets they most use while cycling. Most of them (30.63%) stated that they use the streets in the Municipality of Novi Beograd, 17.5% said they use Blvd Kralja Aleksandra, while Street 10.63% of cyclists use Kralja Milana. By analysing the results of the survey we can conclude that most of the cyclists use streets with separate cycling tracks. This indicated that the cyclists feel safer and more comfortable on proper cycling tracks, which stresses the importance of adequate planning, design, construction and maintenance of cycling tracks. In this way we can manage the quality of cycling traffic, and with that the number of cyclists in the future.

For the seventh question, most of the surveyed cyclists said that that daily they cover from 10 to 20 km (30.74%), while 25% of them cover from 20 to 30 km, which is consistent with the distance necessary to get to and from work from the city suburbs. Around 11.82% of surveyed cyclists cover daily up to 10 km.This distance corresponds to shopping trips or trips to school/university. Daily distance from 30 to 50 km refers to answers given by professional cyclists (23.99%).

For the eighth question 39.32% of surveyed people stated that they ride the bicycle from 1 to 2 hours on average, while 23.73% of them spend 1 hour. In 18.31% of cases the respondents spend from 2 to 3 hours riding the bicycle, while the cyclists who ride from 3 to 5 hours represent 14.92% of the total number of the surveyed cyclists. The time riding a bicycle up to 1 hour corresponds to trips for shopping or to the market, while the average daily riding time from 1 to 2 hours corresponds to trips to work, possible to university, while the trips lasting from 2 to 3 and 3 to 5 hours can be interpreted as recreational rides.

In the ninth questions the respondents stated which participants in traffic act unsafely and in that way endanger the safety of cyclists. Also, the respondents graded different categories of traffic participants with risk levels on a scale from 1 to 5, which 5 was for "high risk". By analysing the results we can notice that the cyclists first recognized the drivers of personal cars as the biggest threat for their safety (69.88%), while the truck drivers are in the second place (69.25%), followed by bus drivers (90.55%) and parked cars (57.13%). Careless pedestrians are in the fifth place with 56.38%, while roller-skate and skateboard users are in the sixth with 31.69%.

By analysing the answers given by the respondents we can conclude that, along with the drivers of private cars, the truck drivers have also been identified as a significant potential threat. Truck drivers have difficulty spotting cyclists due to size of the vehicle and "dead" angles, especially in junctions and in cases when a truck is turning right. In these answers of the respondents there is fear from the size and mass of freight vehicles. This sense of vulnerability with cyclists is especially present on roads with heavy freight traffic where there are no cycling tracks for them to use.

In the tenth question the respondents stated what they believe is the greatest threat in traffic for cyclists' safety, and then they attributed levels of risk to those threats on the scale from 1 to 5, with 5 representing "high risk". The results from the tenth question indicate that the biggest threats for cyclists in the City of Belgrade are "unsuitable speed of motor vehicles" (75.63%), followed by "road conditions" (74%), "common lanes for cyclist and motor vehicles" (70.63%), and in the end "pedestrians walking on cyclist tracks" (66.13%) and "use of headphones and mobile phones while riding a bicycle" (64.06%). By analysing the answers of the surveyed cyclist we can conclude that they believe that, along with "unsuitable speed of motor vehicles", "poor road conditions" is the biggest threat for their safety in traffic. This problem is present on several cycling tracks and it is usually caused by vegetation (trees and bushes growing next to cycling tracks), i.e. trees that spread their roots under and over the track, which causes the tracks to get damaged and crack. Common lines for motor vehicles and cyclist also present a big problem for cyclists. Due to large difference in mass and speed the cyclists feel unprotected if they move over the same surface as motor vehicles.

Answers to the eleventh questions indicate that 46.25% of respondents use the protective helmet while riding the bicycle, while 0.98% of them use elbow and knee pads. As much as 46.91% of the respondents stated that they do not use any protective equipment when riding a bicycle, which is quite worrying. Other equipment is used by 5.86% of the respondents, and most of them stated that they use cycling gloves (50%), then goggles (18.18%) and high-visibility vest (13.64%), while 9.09% of the respondents use reflecting ribbons and cycling clothes.

In the twelfth question the respondents named unsafe places, i.e. sections of the road where they do not feel safe as participants in traffic. The respondents singled out Pancevacki Bridge (16.88%) as a section where they do not feel safe, followed by Brankov Bridge (12.34%), Slavija roundabout (10.39%), Despota Stefana Blvd (9.74%), Kralja Aleksandar Blvd (7.79%), Kneza Miloša (6.49%), Zrenjaninski put (5.84%), as well as Jurija Gagarina and Kralja Milana (5.19% each).

The answers to the thirteenth question indicated that the respondents believe that the "non-existing cycling infrastructure" is the biggest problem to the safety of cyclists in traffic (53.09%), i.e. on locations mentioned in the previous, twelfth question. Along with "non-existing cycling infrastructure", the respondents also indicated that "behaviour of other participants in traffic" (41.98%), "damaged road" (40.74%), "unsuitable speed of motor vehicles" (27.16%) and "narrow streets" (22.22%) are significant problem for the safety of cyclist safety in traffic.

One of the most frequent answers on the fourteenth questions, to solve the issues at "dangerous locations" according to the surveyed cyclists was to build cycling tracks (28.83%). In the second place is the proposition to set up suitable traffic signals for other participants in traffic to warn/inform them on the presence of cyclists (14.11%), while 12.88% of the respondents agreed with the proposition to mark additional cycling lanes.

In the fifteenths questions the respondents were giving suggestions on how to improve the safety of cyclists in traffic within the territory of the city of Belgrade. As the most important suggestion they stated mandatory evaluation of cyclists needs in the traffic planning process (83.44%). As the second suggestion the surveyed cyclists stated the construction of additional cycling tracks (79.06%). Along with building new cycling tracks, a large number of respondents stated that additional cycling lanes need to be marked (76.88%), as well as that is necessary to conduct an increased traffic control (49.06%).

Results of field research

The field research involved visiting the location of subjectively and objectively increased danger for cyclists in traffic, which had been identified in previous parts of the research. The conclusions related for the analysis of traffic accidents involving cyclists and conclusions related to the analysis of cyclists attitude were used as a basis for choosing the locations. The behaviour of cyclists and drivers of motor vehicles was observed on these subjectively and objectively "dangerous" locations in order to determine the problems in traffic safety.

There are 68 kilometres of cycling tracks over the territory of the city of Belgrade. Most of them are in the territory of the New Belgrade Municipality, with the total length of 46 kilometres. The track going from the "Dorcol" Marina to the Sava Lake is 7.5 kilometres long, while the track around the Sava Lake is 8 kilometres long. Over the Bridge over Ada there is a cycling track 1.5 kilometres long.

Within the analysis of the problems cyclist face every day many examples of illegal parking of vehicles on cycling tracks were noted (Figure 1). Drivers park their cars on cycling tracks not caring about the consequences of their actions, safety of their own vehicles and other participants in traffic and it is the reason why cyclist are often force to drive on the road in order to go around parked cars, and by that exposing themselves to danger. Considering the fact that the parking control is quite poor, the drivers use all surfaces they can reach.

On some locations in the City of Belgrade, due to non-existing of cycling tracks of the lack of their continuity, cyclists are forced to move to and ride on the road, and by that endangering both their own and other people's safety (Figure 2).

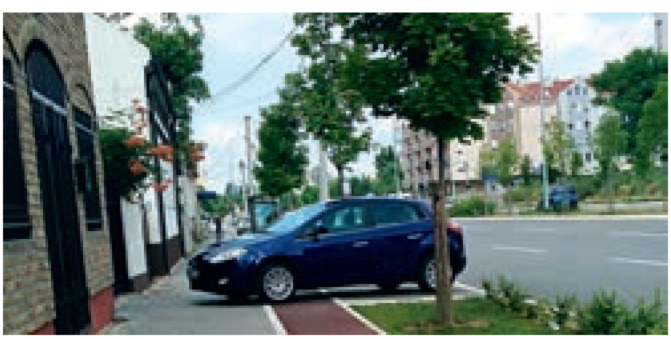

Figure 1. Example of illegal parking of vehicles on cycling tracks

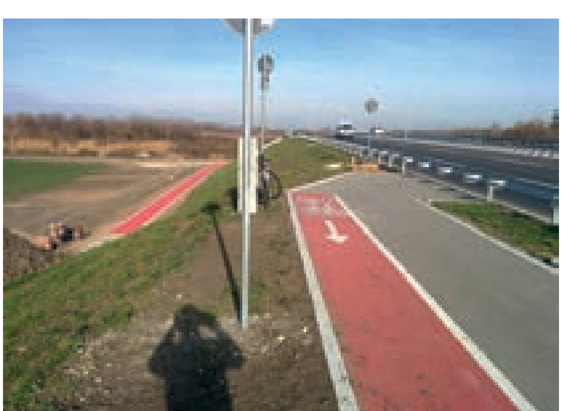

Figure 2. Example of lack of continuity of cycling tracks

Cycling tracks within the territory of the New Belgrade Municipality are organized together with pedestrian tracks, frequently leading to cycling tracks being used by pedestrians, therefore cyclists are most of the time forced to use the road. Conflicts between pedestrians and cyclists are not in themselves of fatal type. Due to their speeds in traffic, these conflicts are mostly distractions, and only in exceptional places there can be fatal consequences. Conflicts with pedestrians most frequently happen in places where infrastructures intersect (pedestrian crossings over cycling tracks next to public transportation stops, physically connected crossings over the road, locations where cycling surfaces are formed by using markings next to the pedestrian surfaces and on locations with mixed pedestrian and cyclist surfaces or areas).Sometimes not even the physically separated infrastructure guarantees that conflicts will be eliminated. Near markets pedestrians often walk on the cycling tracks ignoring the cyclists, and sellers place unsanctioned improvised stalls at the very edge of the cycling tracks (Figure. 3).

Figure 3. Examples of cycling track being occupied

Figure 4. Example of inadequate traffic infrastructure

Along with these problems, every day cyclists also face inadequately placed dumpsters, public transport stops, posts and other facilities that hinder cycling traffic (Figure 4). Based on everything mentioned, we can conclude that potential and current users are not adequately provided with cycling infrastructure.

PROPOSED MEASURES FOR IMPROVING CYCLIST SAFETY IN TRAFFIC

While analysing the current safety of cyclist in traffic, we determined the basic problems of this vulnerable category of traffic participants, and reasons why they have traffic accidents. It is necessary to take the following measures to protect the cyclists:

1. **Legal and other normative and regulative measures:**
   - Developing rulebooks or instructions for identifying locations of increased vulnerability of cyclists in traffic (based on available data, e.g. analyses of traffic accidents, analyses of conflicts, analyses of cyclists attitude, field research, etc.);
   - Developing rulebooks or instructions to define necessary visibility on locations that have been proclaimed highly unsafe for cyclists by an expert independent body.
   - Separately regulating obligations of public communal companies in the areas unsafe for cyclists in traffic, which refer to:
     - number and quality of public lighting fixtures:
     - clearing cycling track and lanes from snow, leaves, dust and mud;
     - control and penalties for illegally parked vehicles, locations and improvement of bus stops;
     - restrict licenses for advertising boards;
     - arranging plants who could influence visibility (for drivers and cyclists); visibility of vertical signals, etc.(periodical pruning of trees that could hinder visibility in junctions, visibility of cyclists);
     - setting up, maintenance and quality check of traffic signals;
     - separating from the existing and introducing new sources of financing for concrete measures to increase safety of cyclists in traffic at the most endangered locations;
     - forming a special section of the local authority that would oversee, direct and coordinate the work of utility services at the locations with increased danger for cyclists in traffic.
   - Discuss the possibility to introduce the rule of "opposite direction" in one-way streets (regulated with the sign "except for cyclists");
   - Formulate a legal concept for mixed pedestrian and cyclist surfaces. Current legislation regulates the existence of pedestrian area, but not joint mixed pedestrian - cycling surface or area;
   - Harmonize legal definitions (e.g. different definition of the cycling track in the Law on Road Traffic Safety and the Law on Public Roads);
   - Define the cycling protective equipment and bicycle equipment in the law;
   - Consider the possibility to introduce "cycling streets" (Belgian example). A cycling street is a street in which there is not enough room to build a cycling track, so the cyclists are given advantage over motor vehicle traffic. Motor vehicles are allowed to use the street, but they are not allowed to overtake cyclists. Speed in cycling streets must not be over 30 km/h.
2. **Construction measures**
   - Construction measures aimed at drivers in order to decrease the movement speed:
     - decreasing the width of road at the entry of the slow traffic zone, at the level of pedestrian crossings, cycling tracks crossings over the road and other locations with increased number of cyclists. In this way the drivers are "forced" to decrease their speed due to the narrowing of road, i.e. decreased profile of the road that was previously available to them;
     - use of physical obstacles for force drivers to change the direction of movement in the zones of slow traffic, zones of pedestrian crossings and other zones with increased number of cyclists. Using this solution forces the drivers to constantly change their trajectory, which requires them to decrease speed. In this way, beside clearly letting the drivers know they are in a special zone, their speed is decreased in a direct way;
     - upon entering the streets or parts of streets that are primarily intended for vulnerable participants in traffic, a "gate" effect can be used which would clearly let drivers know they are in zones with special traffic regime;
     - physical obstacles on the road are very successful and efficient construction measures. One of the cheapest and highly effective ways to physically decrease the speed of motor vehicles is installing speed ramps ("sleeping policemen"). By installing different models it is possible to give priority to some categories of traffic participants, e.g. cyclists, and to discourage others to drive fast. Also, installing rubber speed ramps slows down the motor vehicle traffic, and on the other side gives cyclists a better sense of safety;
     - raising cycling track crossing over the road by using a platform, so that drivers would be "forced" to decrease their speed. Placing platforms that require vehicles to slow down even more, warns the drivers that they are entering a zone with increased number of cyclists and that it is necessary to decrease their speed. The platform itself, as well as any other physical obstacle, forces drivers to decrease their speed.
   - Construction measures aimed at cyclists in order to prevent unsafe behaviour:
     - one of the construction measures to increase the safety of all participants in traffic, not only cyclists, can be a reconstruction of the road by

introducing a clear border between the surfaces intended for pedestrians, cyclists and motor vehicles. During the reconstruction of streets with higher intensity of cycling traffic, a special attention should be given to separating the motor vehicle and cycling traffic;
- construction grade separation junctions, underground passages and overhead crossings. Building gangways and underground passages provides safe movement of cyclists, avoiding conflict with other participants in traffic. It is necessary to provide for the construction of underground passages on locations where the layout of the terrain allows it, and it is also necessary to provide for the track continuity, as well as their regular maintenance. Grade separation crossings must be located in suitable places, maintained, clean and well-lit, in order to attract people to use it, not to discourage them;
- building a central island, in order to make it easier for cyclists to cross streets with four or more traffic lanes. A central pedestrian island provides for partial crossing of the road with multiple traffic lanes, which makes crossing the road significantly easier. A central island provides for additional safety for the cyclist while crossing the road, because it provides protection while crossing the road. By building central island speed of vehicles is decreased as the result of road getting narrower and presence of obstacle (the island) on the road;
- placing posts and flower pots prevents illegal parking on cycling tracks and it is another good and efficient construction solution intended to protect integrity of cycling tracks. By placing physical barriers their improper use by motor vehicles is directly prevented.

3. **Technical and regulatory measures**
   - Regulating the intersections between cycling streams with other traffic streams by painting and marking surfaces intended for movement of cyclists:
   - Separation of cycling tracks from the motor traffic by using rumble strips (in combination with dying the surfaces intended for cyclists) or rubber fenders;
   - Measures intended to discourage drivers of motor vehicles to use roads close to areas attractive to cyclists, which is achieved by artificially extending the road by using regime measures (chicanes, road narrowing, etc.), with the aim to maximally decrease the speed of vehicles, or give up using those roads in the attraction zones in order to arrive to desired destination.
4. **Preventive measures**
   - Educational measures (Educational measures are the corner stone of preventive actions aimed at all participants in traffic, children as well. A special attention within educational measures must be given to children. Children need to be adequately prepared for their safe participation in traffic as pedestrians, but also as cyclists. This was confirmed in practice in the countries with world's most developed cycling traffic. For example, in 97% of elementary schools in Amsterdam students go through certain cycling tests (theory), while in 66% of them there is also a practical test. In practice it was proven that children prepared to be cyclists (not only as pedestrians), are much more familiar with the rules and behaviour in motor traffic, which is logical and clear considering the fact that according to the standing Law on Traffic Safety a cyclists is treated as a driver, and the bicycle is treated as a vehicle);
   - Campaigns (Potential topics of campaigns aimed at promoting cycling and safety of cyclists in traffic within the territory of the city of Belgrade, could be: comprehensive promotion of cycling; promotion of using the bicycle to go to work, school, cultural events, etc.; promoting modern, socially and environmentally acceptable local mobility in towns at short distances up to 5 km; promotional campaign for big events; "Code of Conduct in cycling" – educational campaign aimed at the most frequent accidents that cyclists have with proposed measures to decrease the number of accidents; campaign to stimulate use of protective helmets (use data from research that the cycling helmet offers the protection for the head at speeds up to 20 km/h and decrease the risk of head injury by 42%, risk from brain injury 53%, and risk of face injury by 17%); campaign to increase the visibility of cyclists in traffic in conditions of low light or during the night; an awareness raising campaign for other participants in traffic on what is specific about cyclists and what is their "vulnerability".
5. **Measures to improve the road/street infrastructure**
   - Review (RSI) and evaluation (RSA) of traffic safety;
   - Depth analysis of traffic accidents with fatalities (cyclists);
   - Management of dangerous locations (black spots).
6. **Repressive measures**
7. **Measures for improving research of cyclist safety in traffic**
   - Organize international expert seminars on cycling traffic in order to exchange knowledge on this mode of transport;
   - Encourage private organizations and citizens action groups to cooperate with city authorities and find common solutions to increase participation and safety of cyclists in traffic within the territory of the city of Belgrade;

- In cooperation with the institutions of the Republic give contribution in making the National Strategy for Development of Cycling Traffic;
- Make a city strategy for developing cycling, in which a special attention would be given to infrastructure, cyclist safety and guide for financing. Write the strategy for a certain time period in accordance with the General Urban Plan and Detailed Regulatory Plan for the city of Belgrade. In the Strategy, define a long-term plan in the image of the city of Amsterdam, especially in terms of financing ("Long-term Cycling Plan 2012 - 2016", states measures and budgets needed to solve cycling issues. Amsterdam wants to invest around 200 million euro in cycling infrastructure by 2040, 170 million of that sum for bicycle parking because in short time it returns the investment through savings);
- Define the tools for selecting the type of cycling surfaces, especially while connecting the cycling infrastructure of suburban areas of the City of Belgrade with downtown.This should be done in the image of the City of Ottawa, who made a unique tool to choose a type of a cycling facility, following examples of good practice from all over the world and adjusted it according to their needs;
- Develop a plan to promote cycling within the territory of the city of Belgrade, based on the suitability of this city for the development of cycling;
- Develop a construction plan for bicycle parking containing design and their spatial distribution. When it comes to design and the manner on which these parking facilities are build, we need to follow the example of countries like the Netherlands or Denmark, and the spatial distribution and micro locations need to be determined in accordance with data on where cyclists move, their subjective need and their numbers.

CONCLUSION

In the future, the cycling traffic is definitely going to represent an important part of the traffic system in all countries where there is a possibility to develop it, as well as in those countries who aspire to continually improve their traffic system.

Belgrade, as a city in which travelling distances within it are such that the cycling traffic can meet the requirements, has all conditions for the development of this type of transport. A highly developed network of cycling tracks, with tendency of expanding it, as well as the city traffic policy supporting the development of cycling traffic create a suitable basis for further development of this environmentally acceptable and healthy mode of transport.

During the analysis of the problems that the cyclists are facing every day, it was established that on surfaces intended for cycling there are a lot of illegally placed facilities. Due to lack of continuity of cycling tracks, illegal parking, inadequately placed dumpsters, traffic signs, public transport stops and other facilities, cyclists move with difficulty and are forced to use the road intended exclusively for motor vehicles.

Such conditions in the cycling infrastructure requires a series of measures and activities aimed at improving the quality of traffic, with a special aim to decrease the number of traffic accidents and increase safety, not only of cyclists but all categories of participants in traffic. Solving the dominant problem, i.e. improving the existing infrastructure, would be a significant step towards improving the functionality and increasing safety of traffic.

The most important factor that requires least funds and is not achieved by technical or engineering measures is traffic education. What is necessary in order the most modern system to work is mutual respect of participants in traffic and mutual tolerance. Therefore, besides implementing technical solutions and regular maintenance of the system, it is necessary to education participants in traffic as well as propagating tolerance in traffic.

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PROFESSIONAL PAPER

The Effects of ITS Application in Speed Management on State Road From Mali Pozarevac to Kragujevac

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Abstract: The application of intelligent transport systems (hereinafter ITSs) on roads enables continuous monitoring of road users during a whole year with the aim to collect good-quality data based on which the more complex analyses could be done, such as monitoring of certain traffic safety indicators. Automatic traffic counters are one of the most commonly implemented ITSs for collecting traffic flow parameters that are relevant for traffic management on state roads in Republic of Serbia. This paper presents one of the possible ways to collect, analyze and present data on road users' speeds using automatic traffic counters, where certain traffic safety indicators are analyzed in terms of road users' compliance with the speed limit on the road section from Mali Pozarevac to Kragujevac. Based on the analyses of data downloaded from automatic traffic counters, it is observed that an extremely high percentage of vehicles drive at speed higher than the speed limit, indicating clearly to higher traffic accident risk, as well as to the need for a tendency to implement speed management on roads using ITS in the forthcoming period.

Key words: ITS, speed, automatic traffic counters, traffic safety, indicator.

INTRODUCTION

Nowadays most of developed countries tend to collect as much as possible information on road users that would be used in all stages of planning, designing, construction, exploitation and traffic safety management on roads, with the aim to establish safe and undisturbed movement of all road users. Higher design vehicle speeds and speed limits on roads have brought numerous positive effects and one of the most obvious among them is the travel time reduction, implying greater mobility of people. This progress in recent decades has significantly reduced travel time, leading to a large extent to the development of national economics and easier travel for road users from an origin to a destination on road network. However, besides the all mentioned advantages enabled by higher travel speed of road users, there are also negative effects caused by speed increasing.

Increased number of traffic accidents, caused by an inappropriate and irregular speed, the severity of traffic accident consequences, number of fatalities and injured persons, great material damage caused by high speed are only some of the reasons why each road user, especially a driver, before he/she takes the attitude to increase the speed in order to get to the destination earlier, should wonder what is the price. Moreover, if we note that higher speeds lead to increased environmental pollution, noise level and human health impact, it is clear that there is a reasonable need to limit vehicle speeds. Namely, besides the speed limits, the research and various studies show that the largest part of drivers still drive at speed higher than speed limit. As a consequence, speeding on roads is a big problem of public safety and health, although it is difficult to determine precisely a causal role of speed in traffic accidents.

According to the statistical data, in the last decade 51% to 55% of total fatalities in Republic of Serbia died because of an inappropriate and irregular speed and this fact makes this factor one of the leading factors of mortality in traffic accidents.[12]

Speed regulation is an ongoing operation, so the regular speed monitoring is essential. Engagement of permanent radar controls, consisting of police officers, requires enormous resources, both in terms of manpower and materials. Namely, in order to provide continuous vehicle speed monitoring, it is necessary to set up permanent measuring sites, i.e. to provide wide range of high technologies for traffic monitoring, inductive loops and other detectors that are reliable and cheaper solution than permanent presence of traffic police. The high technology application in Republic of Serbia is still in the development stage and it is necessary to choose the application of well-known and internationally accepted terms describing the use of these technologies. Automatic traffic counters belong to the group of intelligent transport systems and they are collective systems based on one-way communication with the traffic system users.

ITS is a system of measures and technologies used in transport system which integrates information and telecommunication technologies with the aim to increase traffic safety level and to provide more efficient traffic with less congestions, as well as to reduce the level of environmental pollution.[16]

The components of various ITS subsystems are used on roads, in vehicles and in broader physical and information environment. Broader information environment, in which some of ITS applications operate and on which some of them rely when communicating, consists of Earth satellite systems, GSM and GPRS networks, radio-communication space etc. Besides detection of number of vehicles per categories and traffic lanes, average time headway and traffic lane occupancy, automatic traffic counters can also be used as systems for automatic control of traffic regulation compliance in terms of speed limit on the particular site or road section. In this way it is possible to collect information on speeds of road users passing the road cross section where these devices are installed, which, on the one hand, enables speed analysis with regard to vehicle categories, while on the other hand automatic speed control leads to the significant decrease of speeds on observed dangerous road section and therefore to the reduction of traffic accidents and consequence severity. Nowadays traffic police do not have an adequately made plan of radar speed control based on certain indicators, while collecting and processing of these data would enable to determine accurately the site where the highest percentage of drivers drive at speed higher than speed limit, i.e. to locate a site where the presence of traffic police is mandatory in order to establish continuous monitoring of road traffic safety.

LITERATURE REVIEW

The speed is one of the key factors contributing to fatalities and injuries in traffic accidents across Europe. According to ICF Consulting study conducted in Europe, better application of speed limits on roads could save 5,800 fatalities and 185,000 injured persons in traffic accidents where the speed was a leading factor of the accident. First speed measuring in public traffic in Europe were recorded 150 years ago when speeding-relating public notices were delivered to the citizens of Hamburg and only in 1924 the allowed horse speed was established to be 18 km/h.

World Health Organization (WHO) recognizes the motor vehicle speed as one of the key factors related to injury severity in traffic accidents, so it impacts on traffic accident risk, as well as on consequences of a traffic accident. According to WHO, "excessive speed" is defined as driving at speed higher than the speed limit on given site, while "inappropriate speed" means the speed which is necessary to enable a driver to overcome road and traffic conditions.[20]

During 2011 it is conducted a research in Canada dealing with the improvement of speed limit efficiency in school and playground zones (Lina et al. 2011), where the road user speed is limited to 30 km/h. Based on the 30-minutes observation, the sample of 4,580 vehicle was collected. In this case, 85th percentile of speed was used for statistical analysis. The research was aimed to perceive the total percentage of vehicle exceeding 30 km/h and the percentage of vehicles exceeding the speed limit by 10 km/h. The results based on the sample showed that the average speed on all locations was 31.96 km/h, standard deviation was 6.61 km/h, while 85th percentile speed was 38.81 km/h. The research showed that it is very high and has value of 54.43% of vehicles driving at speed higher that speed limit, while the percentage of vehicles exceeding the speed limit by 10 km/h was only 10%.

Besides Canada, speed limit on highways and rural roads in Australia, in the Melbourne region, was increased from 100 km/h to 110 km/h in 1987. Just two years after, it was returned to 100 km/h. In relation to control region where speed limit remained unchanged, after increase of speed limit by 10 km/h in Melbourne the traffic accident rate per kilometre travelled increased for 24.6%, while after reduction of speed limit the traffic accident rate decreased for 19.3%.[9]

Something similar happened in New Zealand. In 1973 the Government of New Zealand reduce the speed limit on all rural roads from 55 mph to 50 mph (1 mph = 1.609 km/h), resulting in average speed reduction by 5 to 6 mph. In the time period when the speed limit reduction occurred, the percentage of injuries in traffic accident participants was decreased in relation to the period when speed limit of 55 mph was valid. In this way the number of fatalities was reduced by 27%, the number of seriously injured persons by 24%, while the percentage of drivers who sustained light injuries was reduced by 22%. The speed limit reduction on rural roads was in average from 4% to 15%.[3]

In USA (United States of America) the investigation of speed limit change effects, in relation to fatalities on rural roads in certain countries, has being conducted. The research has shown that in certain countries where the speed limit was changed from 65 to 70-75 mph the number of fatalities increased by 38% and 35%, respectively, in relation to the countries that did not change speed limit. Namely, in period 1987-1988 the speed limit was increased by 55 to 65 mph in 40 USA countries, resulting in average speed increasing by about 3 mph and the number of fatalities on these roads increased by 20-25%.[19]

There are numerous studies in which the likelihood of an accident occurrence, including injuries, was proportional to the square of speed and the likelihood of an accident with serious injuries was proportional to the cube of speed, while the likelihood of an accident with fatalities was proportional to the fourth order of speed.

Empirical evidence from certain studies on speed in different countries indicates that the average speed increase by 1 km/h increases the likelihood of injuries in an accident by about 3%, i.e. it increases the likelihood of fatality in a traffic accident by 4-5%. Speed reduction by 1 km/h reduces the likelihood of injuries in an accident by about 3%, while it decreases the likelihood of fatality in a traffic accident by 4-5%.

Also, based on the analysis of accidents on different road types in United Kingdom, it was concluded that every speed reduction by about 1 mph results in the reduction of traffic accident number up to 6%.[13]

The use of automatic traffic counters in Republic of Serbia is based on measuring certain traffic flow parameters on state roads, while this type of data collection on traffic flow is not in use at the local level, except Novi Sad. There are 24 automatic traffic counters in Novi Sad providing information that are also available at the web site of Public Enterprise for City Construction and Development of Novi Sad. The list of automatic traffic counters is automatically updated on every 15 minutes and then some of the collected parameters are presented in tabular form at the web site.[1]

SPEED AS A LEADING FACTOR OF TRAFFIC ACCIDENT OCCURRENCE

Spatial distribution of traffic accidents with fatalities of ABS indicates that road users are the most vulnerable at state roads of I and II order passing through the settlements that account for 34% of total number of fatalities in traffic accidents. An irregular and inappropriate road user speed is a leading and most commonly influential factor contributing to the number of casualties in these traffic accidents.

Data indicate that speed factor was identified in more than 50% of traffic accidents with fatalities.[11] Of course, these absolute indicators should not be taken with great confidence considering that some traffic accidents have been identified by the police as the accidents where the speed is the main influential factor even in the case when it is not, but it is related to the possible contribution in terms of traffic accident consequence severity.

In many developed countries traffic accident experts use in-depth traffic accident analysis in order to determine accurate share of speed as an influential factor of traffic accident occurrence, so the police do not provide information on traffic accident cause. Namely, in Republic of Serbia there are not accurate and in-detail analyses in which it is determined the number of fatalities and injured drivers caused by speed as a main factor contributing traffic accident occurrence.

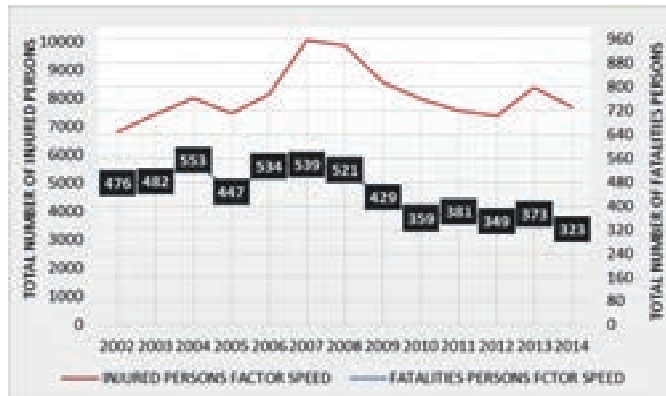


Figure 1. Speed as an influential factor by years[12]

RESEARCH METHODOLOGY

For the purpose of determination of certain traffic safety indicators in terms of road users' speed limit compliance on state road of IB order number 22, from Mali Pozarevac to Kragujevac, the detailed reports on recorded speeds of vehicles passing by installed automatic traffic counters on April 8, 2015 were used; i.e. the reports for time period from 0-24 h were taken from nine road sections on which automatic traffic counters were installed. Downloaded data were analyzed on the basis of data on speed limits provided by Ministry of Interior for location on which automatic traffic counters were installed. After downloading data from automatic traffic counters it was created a database in Microsoft Excel, which is used to calculate certain speed-related traffic safety indicators. Speed-related traffic safety indicators, analyzed on the road from Mali Pozarevac to Kragujevac, include:

- Average vehicle speed,
- 85th percentile of speed,
- Standard deviation of speed,
- % of vehicle exceeding the speed limit,
- % of vehicle exceeding the speed limit by more than 10 km/h,
- Average speed of vehicles exceeding the speed limit,
- Minimum and maximum speed.

One of the leading criteria when choosing road direction for which the research will be conducted was the position of automatic traffic counters on road and it had a great impact. The road direction from Mali Pozarevac to Kragujevac consists of thirteen road sections with length of 78.9 km in total, so it is mainly covered by automatic traffic counters. Automatic traffic counters were installed on nine road sections, collecting data during a whole year, while on 3.2 km long section, between Gornja Trnava and Vlakca, data interpolation based on the data taken from adjacent road section was used. On road section Mali Pozarevac – Mali Pozarevac (settlement), with total length of 0.7 km, traffic flow data were downloaded from highway tool booth, while they were not collected for road sections passing through the settlement. Bearing the above in mind, on sections passing through the settlement, section where data interpolation was used and on section where data were downloaded from highway toll booth, the data on road user' speeds were not collected, so this is also a limitation of the conducted research. Namely, if we take into account a total length of road sections for which data were not collected, it could be concluded that 90% of the road direction from Mladenovac to Kragujevac was covered by automatic traffic counters and this is a good sample for given road direction.

Bearing in mind the impact of "an inappropriate and irregular speed" on total number of fatalities in traffic accidents, the aim of this research was based on indication to the opportunities to continually monitoring certain traffic flow parameters, i.e. road users' speeds during a whole year. Based on the above, this paper presents one of the possible ways to collect, analyze and present data on road users' speeds using reports downloaded from automatic traffic counters where certain traffic safety indicators were analyzed in terms of speed limit compliance in traffic flow on road direction from Mali Pozarevac to Kragujevac.

Principle of automatic traffic counter operation

There are 396 automatic traffic counters of QLTC-10C series installed on state road network of Republic of Serbia that enable at every moment to collect, monitor and analyze traffic flow parameters per pre-defined time intervals during a whole year. One of the basic reports consists of recording the number of vehicles, vehicle travel direction, vehicle category according to the European norm EEC 1108/70 (motorcycle, passenger car, van, light duty vehicle, medium duty vehicle, heavy duty vehicle, heavy duty vehicle with trailer, truck tractor with semitrailer, bus, articulated bus and uncategorized vehicles), minimum and maximum vehicle speed in chosen time interval, vehicle classification into 16 speed classes, headways, lane occupancy and other relevant parameters for road traffic monitoring. The benefit of this report is reflected in the fact that the total number of vehicles driving at particular speed class could be calculated based on the report on the number of vehicles classified into certain speed class (classes: up to 10 km/h, 10-20 km/h, 20-30 km/h, ..., 140-150 km/h and higher than 150 km/h) for the period during a whole year.

Another type of report is very complex compared to the basic one. This kind of reporting is related to one day, i.e. 24 hours, where separate .txt files are created for each day. The structure of this report consists of recorded data: category of a vehicle passing over an inductive loop, ordinal number of vehicles per direction during a day, number of passed inductive loop depending on vehicle travel direction, vehicle speed (km/h) and recorded vehicle length (cm). This report could be used when it is necessary to conduct some more detailed research, as in the case of research conducted in this paper, i.e. when it is necessary to determine a speed of each vehicle passing certain cross section of the road or to define certain speed-related traffic safety indicators. These ITSs operate on the principle of distance-time and inductive loops installed into the carriageway.

The most commonly used detectors are inductive loops. An inductive loop consists of a coil, commonly copper wire, which is put into the grooved carriageway surface, sealed and connected to automatic traffic counters located beside the road. Considering that cables are located under the road surface, there is no fraying caused by the traffic. In the case where there is only one loop per direction, that counter construction could not record speeds, but only traffic volume, vehicle presence and lane occupancy. If there are several loops, as in traffic counters in our examples, it is also possible to record vehicle speed on the basis of distance travelled and real time provided by server.

Figure 2. The spatial layout of QLTC-10C automatic traffic counter[2]

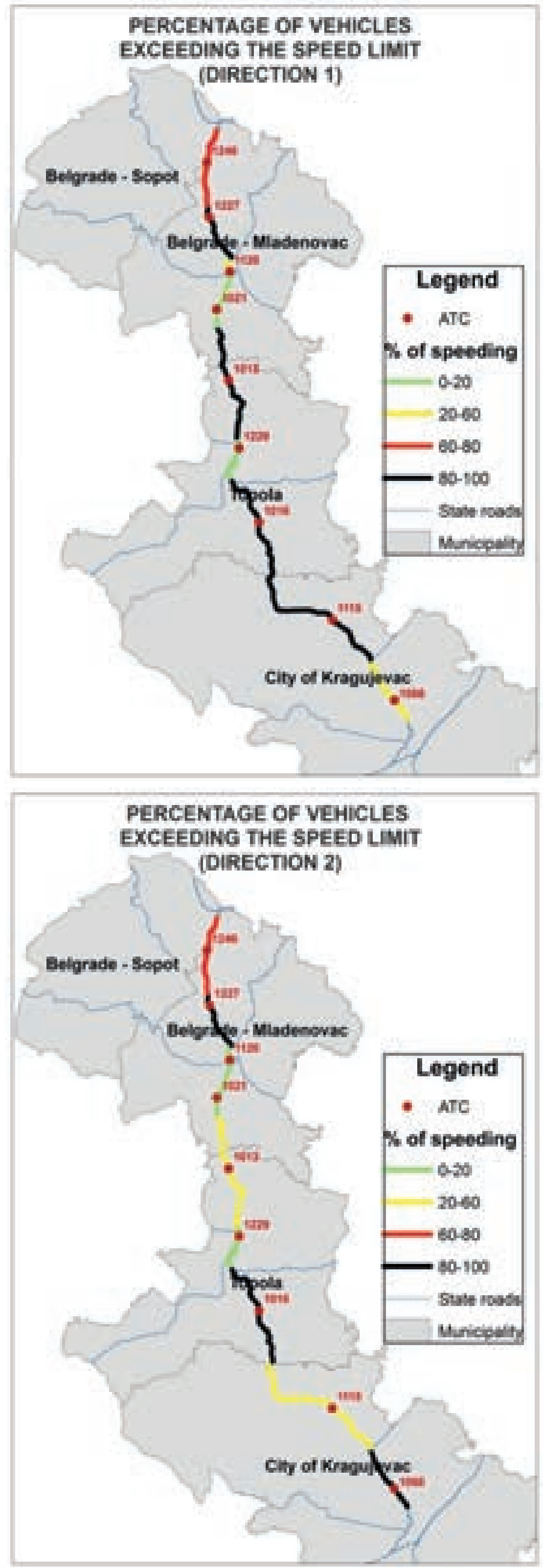
Vehicle detection is based on measuring inductance change of wire loop, i.e. vehicle is detected when it enters loop's magnetic field and when it leaves the loop. Storage capacity will depend on the traffic volume at certain location. If vehicle simultaneously covers all four loops in the carriageway (it drives on the middle of the road), QLTC-10C device has integrated intelligent software for detection and elimination of double counting.

It is preferred that they record the traffic during a whole year, as it is the case in traffic counters owned by Public Enterprise "Roads of Serbia". A server enables access to each of these counters and downloading some of the reports. Some of speed-related technical conditions recommended by device manufacturer are related to the percentage of errors which is 2% at speed of 50 km/h, while it is less than 3% at speed of 160 km/h. Time of sampling is 2 ms per cycle, while GSM module in these ITS devices could operate in the temperature range from -35 to 75 Celsius degrees.

RESEARCH RESULTS

When analyzing obtained results, the directions of observations defined in Tables 1 and 2 were adopted, i.e. direction 1 is a road direction from Mali Pozarevac to Kragujevac, while direction 2 is a road direction from Kragujevac to Mali Pozarevac. The research was conducted on nine road sections whereby recorded vehicle speeds for both directions were analyzed separately. The positions of automatic traffic counters are shown on the map as ACT. Based on the conducted research, the average vehicle speed on certain number of analyzed road sections is higher than the speed limit. The highest average speed compared to the speed limit was observed on the road section Topola 1 – Gornja Trnava, long 11.4 km, where the average speed is 35.54 km/h higher than the speed limit. On this road section even 85% of drivers drive at speed up to 92 km/h, while the percentage of vehicle exceeding the speed limit is 96.92% and it is the highest one in comparison with other given road sections in this direction and percentage of vehicle exceeding the speed limit by more than 10 km/h is 93.85%. Besides this road section, an extremely high percentage of vehicles exceeding the speed limit, 80-100%, was observed on road sections Vlasko Polje– Mladenovac 1 (95.16%), Medjuluzje – Krcevac (89.18%), as well as Vlakca – Cerovac (87.08%).

The listed road sections are designated by black colour on the map, which clearly indicates that these are road sections with higher traffic accident risk where an inappropriate and irregular speed could be one of the contributing factors. Maximum speed of 180 km/h was recorded on the road section Mali Pozarevac – Vlasko Polje, while minimum speed of 11 km/h was recorded on the road section Cerovac – Kragujevac 1. The lowest percentage of vehicles exceeding the speed limit on road sections in direction 1, 0-20%, are designated by green colour and they include road sections Mladenovac 2 – Medjuluzje (8.08%) and Krcevac – Topola (15.57%).



Figuire 3. Percentage of vehicles exceeding the speed limit per directions

If we consider the road from Kragujevac to Mali Pozarevac, road sections where significant percentage of vehicles exceeding the speed limit (80-100%) are Kragujevac 1 – Cerovac (89.62%), Gornja Trnava – To-

Table 1. Research results

Road section	Section length (m)	The observed sample vehicles (8.4.2015.)	ID counters	Direction	Speed limit (km/h)	Average vehicle speed (km/h)	85th percentile of speed	Standard deviation of speed	exceeding the speed limit	exceeding the speed limit by more than 10 km/h	Average speed of vehicles exceeding the speed limit (km/h)	Minimum speed (km/h)	Maximum speed (km/h)
Mali Pozarevac - Mali Pozarevac (settlement)	0,7	No data - traffic flow data were downloaded from highway tool booth											
Mali Pozarevac (settlement) - Mali Pozarevac	0,7												
Mali Pozarevac (settlement) - Vlasko Polje	7,8	4 691	ATC 1246	direction 1	80	93,14	109,00	16,85	0,76	51,84%	99,58	21,00	180,00
Vlasko Polje - Mali Pozarevac (settlement)	7,8	4 719		direction 2	80	88,28	106,00	16,40	0,64	38,00%	97,01	28,00	172,00
Vlasko Polje - Mladenovac 1	6,0	5 968	ATC 1227	direction 1	50	66,47	77,00	11,21	0,95	70,29%	67,57	15,00	124,00
Mladenovac 1 - Vlasko Polje	6,0	5 996		direction 2	50	66,39	78,00	12,38	0,93	69,28%	67,97	15,00	150,00
Mladenovac 1 - Mladenovac 2	2,1	4 512	ATC 1120	direction 1	80	72,15	84,00	12,50	0,21	7,03%	90,27	19,00	138,00
Mladenovac 2 - Mladenovac 1	2,1	4 338		direction 2	80	70,48	82,00	12,12	0,17	4,56%	89,40	12,00	150,00
Mladenovac 2 - Medjuluzje	5,1	4 160	ATC 1021	direction 1	80	63,85	77,00	13,08	0,08	1,80%	88,12	12,00	120,00
Medjuluzje - Mladenovac 2	5,1	4 124		direction 2	80	63,80	75,00	13,73	0,08	2,62%	89,48	11,00	133,00
Medjuluzje - Krcevac	12,3	2 145	ATC 1013	direction 1	60	77,15	92,00	16,09	0,89	67,88%	80,41	15,00	151,00
Krcevac - Medjuluzje	12,3	2 100		direction 2	80	79,79	95,00	17,19	0,45	23,00%	94,02	11,00	164,00
Krcevac - Topola	4,6	3 347	ATC 1229	direction 1	80	68,37	82,00	13,64	0,16	4,30%	89,17	14,00	157,00
Topola - Krcevac	4,6	3 327		direction 2	80	68,54	82,00	13,98	0,16	5,11%	89,89	12,00	124,00
Topola - Topola 1	1,0	No data - road sections passing through the settlement											
Topola 1 - Topola	1,0												
Topola 1 - Gornja Trnava	11,4	1 885	ATC 1016	direction 1	40	75,54	92,00	16,47	0,97	93,85%	76,94	16,00	133,00
Gornja Trnava - Topola 1	11,4	1 895		direction 2	60	78,85	95,00	15,81	0,90	74,04%	82,06	17,00	144,00
Gornja Trnava - Vlakca	3,2	No data - interpolation based on the data taken from adjacent road section											
Vlakca - Gornja Trnava	3,2												
Vlakca - Cerovac	12,4	2 160	ATC 1115	direction 1	60	75,69	90,00	15,11	0,87	64,44%	79,17	14,00	133,00
Cerovac - Vlakca	12,4	2 100		direction 2	80	79,13	95,00	14,75	0,42	19,48%	92,67	18,00	150,00
Cerovac - Kragujevac 1	9,6	4 326	ATC 1066	direction 1	60	53,46	65,00	11,94	0,25	8,21%	68,43	11,00	109,00
Kragujevac 1 - Cerovac	9,6	4 324		direction 2	40	56,41	69,00	12,79	0,90	69,15%	58,98	12,00	100,00
Kragujevac 1 - Kragujevac 3	2,8	No data - road sections passing through the settlement											
Kragujevac 3 - Kragujevac 1	2,8												

pola 1 (89.97%), as well as Mladenovac 1 – Vlasko Polje (93.31%). The abovementioned road sections are designated by black colour on the map. Maximum speed of 172 km/h was recorded on the road section Vlasko Polje – Mali Pozarevac (settlement), while minimum speed of 11 km/h was recorded on two road sections: Medjuluzje–Mladenovac 2 and Krcevac – Medjuluzje. Road sections in direction 1 with the lowest percentage of vehicles exceeding the speed limit, 0-20%, are designated by green colour and they include road sections Mladenovac 2 – Mladenovac 1, Medjuluzje – Mladenovac 2 and Topola – Krcevac.

If we take into account common values in both directions, it could be concluded that the percentage of vehicle exceeding the speed limit on road section Vlasko Polje – Mladenovac 1 is between 80% and 100% for both directions. Slightly higher percentage of vehicles exceed the speed limit in direction towards Topola, while maximum speed recorded in direction Kragujevac – Mali Pozarevac was 150 km/h, which is two times higher than the speed limit on this road section. Also, the percentage of vehicles exceeding speed limit by 80% up to 100% in both directions also appears on road section Topola 1 – Gornja Trnava. Table 1 shows all research results.

DISCUSSION

The results of speed-related traffic safety indicator research clearly indicate that the highest percentage of drivers drive at speed higher than the speed limit. On six out of nine road sections, in both direction for given day, more than 40% of drivers exceeded speed limit and this is a very high value of traffic safety indicator, while on even five road sections this value is higher than 80% of drivers. Bearing in mind the speed limit on given road direction, on almost all road sections the average vehicle speed is higher than the speed limit. A worrisome fact is that maximum speed on all road sections of given road direction is almost two times higher than speed limit.

On this road section there are several different speed limits, i.e. 40, 50, 60 and 80 km/h. This fact and the fact about the settlement through which given road direction passes indicate that it spreads through the built-up areas. Namely, we should not forget a statement that pedestrian and other road user frequency is extremely high in settlements compared to the other road categories, implying that there is a very high risk of traffic accident occurrence in circumstances obtained based on the results. Besides the speed recorded by automatic traffic counters, there are also other traffic flow parameters that could be analyzed. Namely, this type of data collection for 24 hours during a whole year enables in-depth analysis of road users' speeds in all time periods. The operational accuracy of this type of ITSs provided by the manufacturer is 96% when it comes to classification accuracy, while it is 99.9% for vehicle detection accuracy. Maximum speed detectable by these devices is 260 km/h and the measuring error at speed of 50 km/h is less than 2%, while it is less than 3% at speed of 160 km/h. The most common errors may occur when measuring the speed of uncategorized vehicle and motorcycles.

Nowadays the schedule of traffic police patrols is based on the estimate of authorized police office when choosing locations for traffic control. Analysis of data downloaded from automatic traffic counters could lead to accurate percentage of speeding on state roads for particular time period, which could greatly help when choosing locations of radar controls and therefore there is reduced possibility for increase of traffic accident risk in circumstance of an irregular and inappropriate speed. In this way it could be achieved savings in time and available resources spent on police officer engagement in radar traffic control. Also, it enables to determine speed limit change possibilities on particular road sections based on 85th percentile of speed, as it is the case in other developed countries. One of the current limitations in application of these ITSs is low coverage of road network by automatic traffic counters, where the percentage of network coverage is about 40%.

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PROFESSIONAL PAPER

Management of High Risk Road Sections of Sarajevo - Romanija Region (Case Study)

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Abstract: Road traffic, as a part of the entire transport system, is an important factor of social growth and development, which is necessary to create conditions for its safe operation, bearing in mind that all the benefits of this phenomenon are still paying a high price of unnecessary human suffering. In a contemporary society, there is a large number of institutions that play a role in the functioning of the transport system, but they stand out as the holders of activities and measures to improve traffic safety. Given that the number of accidents in recent years has reached a worrying level, in the interest of society is to reduce the number of accidents, or to increase traffic safety, because the consequences that the society is submitting in the form of human casualties and material damage are large. The model for the absolute traffic safety does not exist, but a permanent analytical monitoring of the status of road safety, control and regulation of traffic and taking measures to eliminate the risk factors can greatly increase the level of traffic safety.

Keywords: traffic safety, road accident, high-risk road sections.

INTRODUCTION

Considering that the traffic safety system consists of a series of elements which are mutually interdependent and connected in their activities, the main task of the competent authorities is to make decisions about when and to which elements is necessary to direct activities, and therefore limited financial resources, in order to improve traffic safety and reduce the risk of accidents occurrence. Keeping in mind that the road, as one of these elements has a very important role in secure traffic, and requires a significant financial investment, it is necessary to identify high-risk road sections and establish the priorities for eliminating dangerous spots by detailed expert analysis of the road network. In the Republic of Srpska bylaws define procedures for determination of priorities for taking adequate measures to eliminate the defects on the road. The basis for the identification of high-risk road sections is an adequate database of road traffic accidents that would enable determination of real causes of accidents and their connection with deficiencies on the road. Related to previously stated, throug this paper it will be given an example of application of the bylaw, as well as guidelines for identification of defects on the roads of the Sarajevo-Romanija region, by the analysis of traffic accident data.

ROAD IN THE FUNCTION OF TRAFFIC SAFETY

The basis of the problem of traffic safety consists of four essential elements, namely: human, vehicle, road and environment. On the occurrence of accidents in traffic, in addition to these four elements, is affected by inadequately defined and harmonized regulations on traffic, insufficient funds for traffic regulation and ineffective control and supervision of traffic flow. However, it is important to find risk factors to which it is possible to affect in order to improve traffic safety. Therefore, it is necessary, inter alia, to take into account the road and all of its elements that can be direct or indirect cause of traffic accidents or which may in any way affect the outcome and consequences of accidents. Expert analysis of the parts of the road network on which action is needed in terms of improving traffic safety, as well as expert formulation of measures to control trading with increased risk of traffic accidents, it is necessary to, among other things, optimize the application of financial resources and to channel funds to those defects that really are risk factors on the roads.

Traffic accidents rarely occur as a consequence of exposure to a single element or cause. They are usually intertwined combination of different elements. Traffic accidents can occur due to the effect of subjective (human) and objective (vehicle, road and environment) elements. These elements do not act separately, but represent a structural unity, within which the strength of their influence is differed, so it is difficult to measure how each element works in this interaction. In order to take appropriate actions, it is necessary to consider the characteristics of these elements in the field of traffic safety.

The Road as an objective Element of Traffic Safety

The fact that the road affects the driver and vehicle and determines conditions under which the traffic is running and traffic accidents occur, cannot be ignored. Although there is an opinion that the mistakes or bad behavior of drivers, in almost all cases, are the only cause of road accidents, it should be borne in mind that the road is equally important segment in the system of traffic safety, and that the defects on the road can be a direct cause of traffic accidents. Road elements create the conditions in which, the danger caused by some other elements, turns into a traffic accident or affect the severity (result) of it.

The road may not be the main cause of traffic accident, but it can contribute to it in a way that: [1]

- road affects on the driver and the vehicle and determines the traffic conditions and the occurrence of traffic accidents,
- defects on the road may be the immediate cause of traffic accidents,
- road elements create the conditions that the danger caused by other elements, turns into a traffic accident and
- some elements of the road do not affect the occurrence of accidents, but may affect the severity of traffic accident when it occurs.

The driver's obligation is to adjust the speed of his vehicle and his behavior to the road conditions. However, one can not always adapt to road conditions, so it is sometimes necessary to adapt the roads to people. The road should be equipped with signs and communication system, in order to provide high quality and reliable information. Condition and quality of the roads are of extreme importance for the traffic safety, because it affects the behavior of the driver and the vehicle. The road should, first of all, provide safety, comfort and economy and then a high level of service. [2]

The Road Elements in the Function of Traffic Safety

Traffic accidents and critical situations usually occur in places where the situation on the road unexpectedly changes, where traffic flows intersect, merge and divide, where the pedestrians, cyclicts or animals unexpectedly appear, at pedestrian crossings etc. The road route significantly affects traffic safety, particularly the changes in road curve radius and road grade. Accidents concentrate on sections with much sharper corners relative to the previous direction or a slight curve, as well as on sections with the rise after a long straight section. Inadequate radiuses and gradients make drivers additionally tired, tensed, impatient and aggressive.

Number of traffic accidents increases with the number of intersections per kilometer of road. This is logical, because each intersection produces larger number conflicts and dangerous situations that can turn on into an accident. The risk of accidents is higher in intersections with more entrances with intense traffic (especially with more vehicles from side roads) and speeding at the intersection entrance. On the other hand, the intersections make drivers more tired, create the conditions for aggressiveness and other negative occurrences that increase the risk of traffic accidents between intersections. [3]

Wet and dirty roadways make steering and braking weaker. The changes in road condition is particularly dangerous. Most traffic accidents happen during the first rainfalls coming after a long dry period. After a long period of driving on a poor condition road, drivers adjust their behavior, thus the risk of traffic accidents decreases. Therefore, in winter conditions occurs lower number of accidents. On the other hand, the drivers drive slower, so the severity of accidents is lower. [1]

Alongside the road are often different obstacles (trees, concrete pillars, different objects, vegetation, etc.) that affect active and passive road safety. If these barriers obstruct visibility, it may contribute to the occurrence of traffic accidents. Common obstacles make drivers tied and occupate their attention and increase the risk of traffic accidents. On the other hand, obstacles affect the passive traffic safety. In the case of a collision with solid obstacles the severity of traffic accidents is being increased. However, the barriers may have a positive effect on accident severity. Nowadays, as a measure for speed reduction at intersections and other dangerous places are being set obstacles that reduce visibility and force drivers to reduce speed in dangerous areas. While this may increase the number of minor accidents, thus reducing the number of accidents with the gratest consequences. Therefore, these obstacles can adversely affect the active traffic safety (increasing the total number of accidents), but can be positive for passive safety (reducing the consequences of accidents).

According to some statistical data, 15-25% of road accidents occur due to bad road conditions. When analyzing the state of pavement on roads in the Republic of Srpska and its role in traffic safety, it can be said that our roads are "old" and that the surface is worn, and that investments in order to improve them are unsatisfactory, precisely because of limited financial funds. Poor condition of road surface results in deterioration of security elements during the occurence of dangerous situation, that can be reflected in the extension of stop time of the vehicle.

It is possible to identify risk factors or elements that may negatively affect the number, flow and consequences of traffic accidents, either alone or in interaction with other elements, such as:

- damage and potholes on the road,
- substrate with a low adhesion coefficient,
- insufficient horizontal and vertical visibility,

- inadequate road gradients,
- inadequate ruts or
- narrow roadway along road curves.

HIGH-RISK ROAD SECTIONS MANAGEMENT

Considering that the elimination of road defects requires an investment of substantial financial resources, there is a need for detailed analysis to identify a real risk factors and determine priorities for taking action. For subjects that manage the roads it is a difficult task to assess the safety infrastructure of some road sections independently of other components, in order to set priorities to improve the infrastructure. Because of that, a different methodologies defined by Directive 2008/96 [5] describe a method of analysis of the road network in terms of traffic safety and provide assistance to the relevant entities to identify high-risk sections and rank these according to priority treatment. In accordance with this, road safety inspection and expert analysis on a national level is being adjusted.

The Legislative Framework for Road Safety Inspection and Management of Dangerous Spots on Public Roads

Modern approach of increasing road safety involves the combined use of active and preventive methods, because the preventive methods can not eliminate all the defects on the road. However, prevention methods are much better, because the problem is being solved before the occurrence of accidents and casualties.

In the White Paper of 12 September 2001 "European transport policy for 2010", the European Commission has expressed the need for evaluating the impact on traffic safety and the implementation of road safety inspection, with the aim of defining and fixing conditions on high-risk sections within the EU. With its Directive of the European Parliament and of the Council of Europe no. 2006/0182 on safety management of road infrastructure, published in October 2008, the European Union made a clear decision about the measures and methodologies to increase road safety, where, among other things, road safety inspection (RSI) will be required for the European road network in the years that follow. [1]

According to this, through different legal documents is defined legislative framework for the road safety inspection in Republic of Srpska. The Law on Road Traffic Safety of the Republic of Srpska (Article 28 and 30) prescribes that, in order to improve the conditions for safe traffic, a system of mandatory independent inspection of existing public roads in terms of traffic safety (RSI) is being established. [6]

When it comes to managing dangerous spots on public roads in the Republic of Srpska, as one of the management segments of traffic safety, was adopted the document on Regulations which prescribes definitions, conditions and obligations on the identification of dangerous spots, the process of identification, determination of priorities and ways of elimination and evaluation of the proposed measures to eliminate dangerous spots.

Stakeholders in the Process of Road Safety Inspection and Management of Dangerous Spots

In the system of traffic safety there is a great number of entities directly or indirectly involved in traffic safety management system, and each of these entities has its own function, and bears a special responsibility in terms of increasing the level of safety and creating better conditions for safe traffic. The most important entities in analysis and verification of public roads safety and dangerous spots management are the Government, the Ministry of Transport and Communications, Traffic Inspectorate and Road management company, which in accordance with the above mentioned document on Regulations, has special responsibilities and obligations in road safety inspection and dangerous spots management on public roads.

Road management company implies a public company, concessionaire, other legal entity or competent authority of local community responsible for managing the roads in accordance with the law. Road management company, as one of the parties directly involved in the traffic safety system has a specific and particularly important role when it comes to traffic safety management and is required to annually perform the identification of dangerous spots on public roads by using data on road accidents and the average annual daily traffic. When drawing up a plan of repairation of dangerous spots, the company is obliged to firstly repair dangerous spots with the highest prioritiy and to perform an expert analysis of at least 20% of dangerous spots with the highest priority annually. [4]

Road management company is obliged to, in accordanse with the annual plan, perform expert analysis of dangerous spots and high-risk road sections, prepare projects for the repairing of dangerous spots and dangerous sections, and take other measures to improve traffic safety [4]. At least once a year road management company is required to report to the Ministry of Interior and the Ministry of Transport and Communications, delivering the information on identified dangerous spots, priority list for reparation, about performed expert analyzes and applied measures for reparation of dangerous spots. All subjects, including the road management company are obliged to continuously work on improvement of quality and availability of database on road accidents, which are the basis of monitoring traffic safety and road safety inspection.

The Procedures for Dangerous Spots Management on Public Roads

Dangerous spots management on a public road is the procedure of determining spots with distinctly increased risk in traffic, defining, implementing and monitoring the effects of measures aimed to reducing the risk of traffic accidents in these areas and procedures for management of dangerous spots regulated by Regulations document. Prior to presenting the dangerous spots management algorithm, it is necessary to clarify the terms "dangerous spot", "dangerous part of section" and "dangerous section."

Dangerous spot is a spot on the suburban public road up to 300 meters length where at least six traffic accidents with affection on human health and life happen during three year period, or an urban public road up to 100 meters lenght where at least four traffic accidents with affection on human health and life happen during the same period. Dangerous part of section is a part of suburban road up to 1500 meters length, which includes at least two dangerous spots, measured from the first dangerous spot. Dangerous section is a part of suburban road more than 1500 meters length with includes at least one dangerous spot per kilometer of road. [4]

During the dangerous spots management on a public road it is necessary to conduct the procedure through the following stages (Figure 1):

- Identification and ranking of dangerous spots;
- Analysis of dangerous spots and proposing measures;
- Implementation and monitoring of measures to eliminate the dangerous spots.

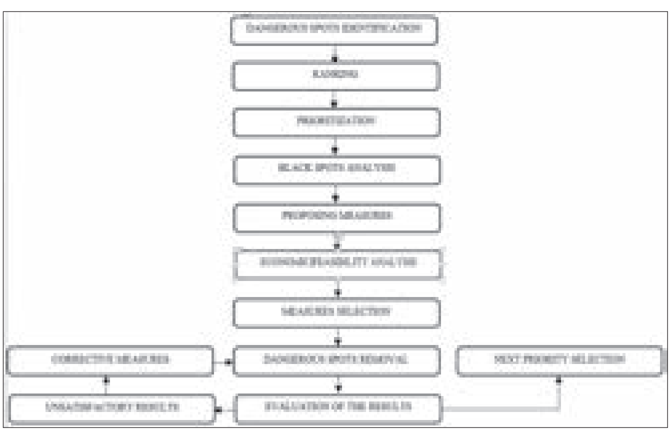

Figure 1. Simplified algorithm processes of dangerous spots management [4]

After identification, mapping of dangerous spots is being performed, as well as mapping the density of traffic accidents based on the data of location of traffic accidents. In those maps it is possible to include all available data such as flow, geographic characteristics of the terrain, objects, as well as other data describing the location of dangerous spots which may be of importance in determining risk factors. From the above definitions we can conclude what is the importance of having an adequate database on road accidents with precise data about exact spot of traffic accidents and their consequences.

Identification of Dangerous Spots on the Public Road

Identification of dangerous spots on public roads is one of the segments of traffic safety management and road safety inspection, aimed to identify high risk road parts, as well as taking measures to eliminate these risk factors. Considering that the major problem for the entities involved and responsible for traffic safety is reasonable and justified investment of funds to improve traffic safety, the identification and ranking of priroties on high-risk sections and dangerous spots provides proper aiming of these funds precisely where needed.

Given the fact that investment in roads as an element of traffic safety require significant financial resources, it is especially important to perform detailed expert analysis in order to identify the main defects on road infrastructure, which removal would increase the level of traffic safety [7].

Risk Assessment of the Traffic Accident Occurrence per Municipalities of Sarajevo – Romanija Region

Considering that solving the problem of traffic safety is not only the responsibility of entities on the national level, it is necessary to emphasize the role of the local authorities (municipalities) in undertaking activities aimed at creating safer traffic conditions. According to this, it is essential for the authorities in the local government to realize and recognize the risk of traffic accidents, actually that on the basis of reliable analysis results have a clear idea of where and how they can affect to reduce the risk of traffic accidents. For this purpose may be useful a risk assessment of traffic accidents occurrence per municipalities, which are based on exposure of traffic participants to a risk of traffic accidents occurrence. Related to this, as the most reliable and the most commonly used indicators for risk assessment in road traffic exist:

- The number of fatalities per 100,000 population (public risk);
- The number of fatalities per 10,000 registered vehicles (traffic risk);
- The number of fatalities per 100 million kilometers (dynamic traffic risk).

Public risk represents mortality rate (the annual number of fatalities) per 100,000 population and measure the risk of of each inhabitant to die in a traffic accident. Different areas can be compared according to this criterion only if their population is equally exposed to traffic. If there are a significant differences in the level of motorization (number of registered vehicles per 1,000 population) and the mobility of the population (number of trips and the mileage), then it isn't correct to compare areas (municipalities) only based on indicators of the public risk. So there are some other relative indicators of traffic safety that can be used, especially traffic risk.

Traffic risk represents mortality rate (the annual number of fatalities) per 10,000 registered vehicles and it takes into account the level of motorization. It is possible that two areas may have a similar level of motorisation, but the degree of use of vehicles is significantly different. Therefore it is necessary to take into account the mobility of the population during the assessing level of traffic safety. If mobility is significantly different, then the level of traffic safety can be evaluated using dynamic traffic risk.

Dynamic traffic risk represents the number of fatalities per 100 million kilometers. This indicator is the best measure of the risk of fatalities during the trips by car and the best indicator of traffic safety. However, there are a lot of problems related to the determination and application of dynamic traffic risk. The main problem is determination of the mileage in a certain period. Mileage can be measured directly (correctly determined kilometers of each vehicle during the regular technical inspection), calculated indirectly (the quantity of sold fuel, as well as average fuel efficiency), or evaluated through a pilot studies (determining the mileage of the representative samples of vehicles) and so on. Considering that there isn't developed methodology of determining the mileage in the Republic of Srpska, the risk assessment based on this parameter does not apply.

Below are presented the maps of public risk (Figure 2) and the traffic risk (Figure 3) for the individual municipalities of the Sarajevo-Romanija region, which are based on the number of fatalities, as well as registered vehicles in 2015, and the data of population per municipalities in recent years.

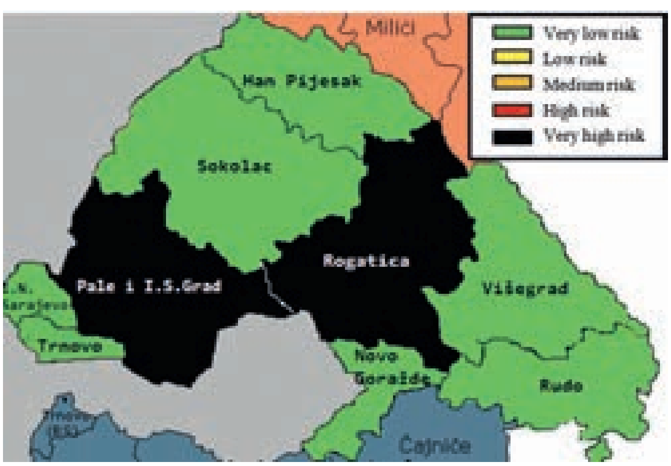

Figure 2. Public risk per municipalities of the Sarajevo-Romanija region

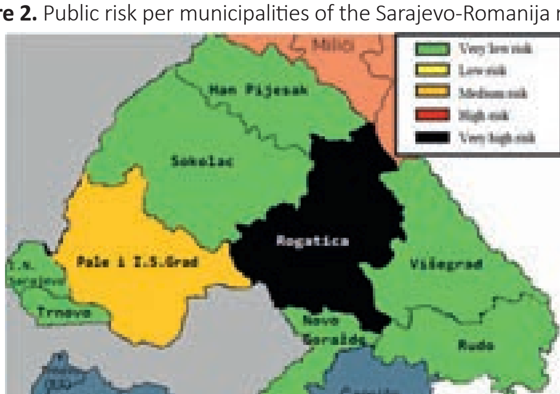

Figure 3. Traffic risk per municipalities of the Sarajevo-Romanija region

In the traffic safety assessment process of some specific location on the road (vertical or horizontal curve, bridge and others endangered places) it should be used parameters that take into account the intensity of traffic, such as number of accidents per 100,000 vehicles that pass through these sections, as well as the number of victims (fatalities and injured persons) to 100,000 vehicles that pass through these road section.

If we consider the traffic safety assessment on the crossroads, it is important to observe the geometry of crossroads and traffic regime at driveways (the crossroads similar in geometry and regime of traffic can be compared).

Prioritization of removing Dangerous Spots on Road Network of Sarajevo – Romanija Region

The implementation of certain measures aimed to improve traffic safety requires an investment of significant financial resources, so it is necessary to optimize their use and direct them where their application is justified. This ensures that the ratio of invested funds on one side, and savings caused by reducing the number traffic accidents and their consequences on the other side, would be as big as possible. Therefore, it is particularly important professional identification of parts of the road network on which action is needed in terms of traffic safety, what can be done based on the risk assessment on roads and detailed analysis of high risk sections and finding valid solutions for improvement.

Regulations define the procedures for prioritization of dangerous spots on public roads in the Republic of Srpska, and this requires data on the number, structure and consequences of traffic accidents, with emphasis on incidents which have resulted in dead and injured persons, as well as data on average annual daily traffic (AADT).

Prioritization of dangerous spots on a public road shall be based on the following indicators: [4]

1) The coefficient of severity of accidents (C_S), which is determined by:

$$Cs = 1 \cdot MI + 13 \cdot SI + 99 \cdot DI$$

where:
MI - the number of persons who have suffered minor injuries in reported road accidents,
SI - the number of persons who have suffered serious injuries in reported road accidents,
DI - the number of persons who have suffered injuries that caused death within 30 days,

2) The coefficient of potential dangers (C_{PD}), which is determined by:

$$C_{PD} = \frac{MSDI}{365 \cdot AADT \cdot 10^{-6}}$$

where:
MSDI - number of accidents with minor and serious injuries and dead persons,
AADT - average annual daily traffic.

The ranking list of priorities is based on the value of the coefficient of priorities, which is calculated by the formula:

$$C = 0{,}8 \cdot C_S + 0{,}2 \cdot C_{PD}$$

Considering that the data on traffic accidents in the Republic of Srpska show that a large number of them happens on roadways and taking into account the functional and economic importance of roadways, this part of paper will give an example of determining the order of priority in the management of high-risk sections and dangerous spots on roadways M-5, M-18, M-19, M-19.3 and M-20, according to the division into sections by which a database is being made (calculation based on data of traffic accidents that have occurred in 2014, and the value of AADT for 2011) [8].

Table 1. Ranking road sections based on calculation of the coefficient of priorities

Roadway	Roadway sections	Length of the section (km)	AADT	C
M-19.3	Podromanija - Rogatica	28,598	2502	344,456
M-19	Sumbulovac - Ljubogošta	5,030	5224	241,744
M-5	Ljubogošta - Pale 1	4,460	5112	182,829
M-19	Han Pijesak 2 - Sokolac	27,483	1724	133,578
M-5	Sastavci - Ustiprača	11,195	2091	126,386
M-19	Sokolac - Podromanija	3,598	7047	113,111
M-5	Ustiprača - Međeđa	12,890	1892	83,269
M-20	granica RS/FBH (Kopači) - Ustiprača	8,127	3731	82,187
M-5	granica RS/FBH (Lapišnica) - Ljubogošta	6,884	7197	59,085
M-19	Podromanija - Sumbulovac	21,559	3769	46,399
M-18	Kula - Krupac	5,165	7746	38,895
M-18	Krupac - granica RS/FBH (Bogatići)	11,265	3360	35,689
M-5	Dobrun - granica BH/SR (Vardište)	6,226	872	35,314
M-5	Brodar - Višegrad 1	10,950	2680	22,809
M-5	Višegrad 1 - Višegrad 2	0,660	3240	22,107
M-5	Pale 1 - Podgrab	15,660	1860	12,589
M-19.3	Rogatica - Sastavci	6,422	2410	12,455
M-5	Podgrab - granica RS/FBH (Prača)	6,155	1728	1,917

Table 1 shows the results of the coefficient of priorities calculation, based on which sections are ranked according to priority of interventions or shares on which it is necessary to carry out detailed expert analysis, to identify all the defects on them that are potential causes of accidents. In order to implement more qualitative analysis it is necessary to have reliable information on exact location of accidents, aimed to precise identification of dangerous spots, taking into account the period of 3 consecutive years, as defined in the Regulations [4].

The Procedures of Road Safety Inspection Based on Traffic Accidents Data

In order to perform detailed and expert road safety inspection on identified high-risk sections and dangerous spots, it is necessary to dispose with adequate data on traffic accidents that have occurred, especially in terms of number, structure, consequences and characteristics and timing of the traffic accidents, participants in the accident, the condition of external factors and weather conditions at the time of occurrence of accidents and trip data (state of the road surface, infrastructure and equipment, damage on the road, obstacles, etc).

These data provide conditions to road management company to carry out field inspection of dangerous spots, which contains the following procedures: [4]

- Examination of the site and inspection of maps of dangerous spots;
- Inspection of a traffic accident location and obtaining detailed data on traffic accidents through access to the investigating documentation in accordance with special regulations;
- Inspection of condition of the road and road surface, traffic planning and regulation;
- Other known methods.

Considering the previous chapter provided the identification of high-risk sections on roadways M-5, M-18, M-19, M-19.3 and M-20, and that the priorities are identified for intervention, it is partially created a precondition for detailed expert analyses of sections. For the purpose of providing guidelines for the analysis of crash data and connecting their elements with the road damages, in this paper is given a brief analysis of certain elements of traffic accidents that occurred in 2015 on the roads in the area covered by the PSC East Sarajevo. As there were not available detailed data exclusively for the roadways, the analysis applies to all categories of roads that are located in this area, but statistics show that the largest number of registered traffic accidents (1068) happened just on roadways (483). Considering that fact, it is obvious that this category of roads have priority in taking measures and elimination of defects.

Also, if it is considered the location of traffic accidents on the road in 2015, it is noticeable that the largest number of them occurs in a urban area (604 accidents of 1068 totally registered) characteristical by frequent traffic flows intercestion, merging and dividing, which creates a greater number of conflicts and dangerous situations that can turn into an accident. Also, the traffic is more intense, and there is frequent appearance of large numbers of pedestrians and bicyclists. Because of that it is necessary to consider the needs of all participants in traffic (additional lanes, pedestrian and bicycle paths, etc) and traffic signs (horizontal, vertical, traffic lights) to clearly regulate movement and the right of passage.

Statistical data show that traffic accidents usually occurre on straight roads, horizontal curves and intersections, which can be seen from the chart 1.

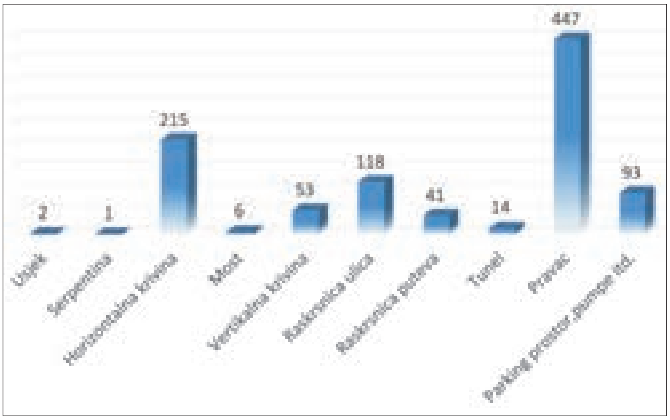

Chart 1. Traffic accidents with regard to location of occurance

Of the total number of traffic accidents (1068) that occurred in 2015 on the roads in the area covered by the PSC East Sarajevo, there were only 10 traffic accidents occurred as a result of sediment and rock falls on road, 8 accidents caused by defects or deficiencies or traffic signals road equipment, and 1 accident caused by road surface damage. For the remaining 1049 traffic accidents, during the investigation were not recorded obvious disadvantages on the road surface and/or its equipment, which does not necessarily mean that the individual elements (road surface condition, insufficient lighting, narrow road in horizontal curves, lack of pedestrian lanes) were not cause of road accidents or influenced the outcome and their consequences.

In order to make a systematic approach to the analysis of traffic accidents, it is necessary to consider the aspect of traffic accidents by their origin, where it is necessary to dispose with accurate information where those accidents occurred. Based on data on road accidents that occurred in the area covered by the PSC East Sarajevo in 2015, it is important to mention the significant number of accidents that resulted in collision with another vehicle (624), crashing vehicle off the road (151), vehicle rollover (34) and rush into the animals (10).

Since the state of road surface (wet, dry, icy or snow-covered) together with other elements of the road, can also be a risk factor and the cause of traffic accidents, it is important to consider these factors during expert analysis, considering that the individual defects can be eliminated by better maintenance (drainage regulation, sprinkling abrasive materials and intensive snow removal during the winter, etc). Analysis of data shows that 567 accidents occured on dry roadway, 331 on wet and 95 on icy and snowy driveway.

Considering the fact that bad weather conditions increase risk of traffic accident, it is necessary to analyze whether any elements of road during lower or normal visibility (day, night, fog) can additionally increase the risk. Therefore, it should be considered existence and visibility of horizontal and vertical road signs, protective fences and other road equipment and lighting on road junctions. Also, it is necessary to identify if are there any damages or obstacles on road/alongside the road, which reqiure additional temporary traffic signals, in order to alert all traffic participants on time about dangerous situations that cannot be noticed in lower visibility conditions. Previosly stated is caused by the fact that large number of traffic accidents registered in 2015 occured during the low visibility conditions (night, dusk and dawn - 281 traffic accidents, fog - 29 traffic accidents), of which 5 fatalities, 25 with seriously injured and 49 with minor injuries.

These are only some of the data on traffic accidents which may be considered during analysis and road safety inspection, but can be useful during the identification of road damages in order to establish and enforce measures to eliminate these problems or at least keep them at minimum, and thus reduce the risk of traffic accidents.

Considering the above data, it is necessary to perform analyses and road safety inspection based on following parameters:

- Function of road;
- Cross-section of road;
- State and maintenance of road;
- The road route;
- Apropriately designed and marked intersections;
- Adequately designed and marked tunnels;
- Public and private services, restroom facilities, public transport;
- The needs of endangere traffic participants;
- Adequate protection of road from wild and other animals;
- Adequate traffic signs, marking and lighting;
- Features of curbs and passive road safety.

It is important that road safety inspection procedure or technical analysis is carried out carefully and with consideration of all the road elements, by using the expertise and best practices in the assessment of the current situation. It is desirable that in the process of checking and analysis to involve experts with significant experience in design and construction of roads, road safety engineering and accident analysis and persons with knowledge related to maintenance of roads, including signaling, lighting traffic signals, vegetation and snow removal.

PROPOSING THE MEASURES TO ELIMINATE DANGEROUS SPOTS AND MONITORING

After completion of the technical analysis, summarizing the results, the identification of defects on the roads and finding ways for their removal, it is possible to suggest some of the following measures: [4]

- Removal or protection of the lateral interference;
- Speed limits, improving control of speed limits;
- Improving visibility in different conditions;
- Improving the passive protection of road and reconstruction of road safety equipment;

- Improving the logical connection, visibility, readability and location of traffic signs;
- Protection against escarpments, landslides and snow drifts,
- Improving intersections;
- Change the width of the road by adding side banks of solid surfaces;
- Installation of traffic control system;
- Reconstruction of the road in accordance with the applicable standards of design;
- Reconstruction or replacement of road surface;
- The use of intelligent transport systems (eg. variable traffic signs);
- Other known technical measures.

All proposed measures are necessary to be evaluated in order to deliver adequate and acceptable choice of those which will justify the investment in technical and security as well as economic terms. Firstly, it is necessary to make evaluation of the economic feasibility of investments, as well as a comparison of the proposed measures based on the criteria for selection of measures. It is important to note that while proposing measures aimed to removal of road defects their safety effects should be considered. Besides that, the following criteria are being considered:

- technical feasibility,
- economic justification,
- possibilities,
- convenience and
- compatibility.

Since all the measures proposed, among other things, are being evaluated through economic justification, it is necessary that road management company provide an investment plan for implementation of these measures, in order to make decisions about necessary investments. After presented defects and proposed measures with a detailed analysis and evaluation of the same, the final decision whether the recommendations will be adopted or not is being made. It is desirable that all documentation arising from the very beginning of road safety inspection, starting from the data collected on traffic accidents remains a part of the project documentation.

After the proposed specific measures are implemented, it is necessary to conduct monitoring of the situation in order to determine the feasibility of the entire project, both in terms of efficiency and funding. Monitoring can take several years after the implementation of corrective measures.

CONCLUSION

Considering that unsatisfactory level of traffic safety requires appropriate individual and joint intervention of all subjects involved in the system and also directing of activities and financial funds, in segments of traffic safety system in which the “hidden” fundamental problems appear, it is important that mentioned subjects constantly perform monitoring and analysis of the situation, which is the basic prerequisite for traffic safety management. Considering that the road, as one of the elements of traffic safety has a key role in the smooth operation of traffic, it is necessary to maintain it in such a condition that the risks of traffic accidents would be minimal. If an accident does occur, road equipment should be adequate in order to mitigate the consequences of these accidents. However, providing the adequate road infrastructure and creating uniform conditions for safe traffic performance is a problem of entities responsible for road management to direct its activities and significant financial resources where needed.

The task to assess the impact of road on the occurrence of accidents can be difficult for the entities that manage the roads, so it is necessary to perform expert analysis and verification of safety of all road elements. Regarding to this, the objective of this study was to give an example of identifying the priorities to eliminate dangerous spots on high-risk road sections according to the Regulations document, as well as an example of data analysis on traffic accidents to determine the defects in the road which is necessary to be eliminated. Evaluating and adopting adequate measures being proposed can save a considerable amount of financial funds, and most importantly, improve roads and increase the level of traffic safety.

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PROFESSIONAL PAPER

Application of Modern Information Systems for More Efficient Removal of Parking Violators

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Abstract: PUC „Parking servis" Novi Sad, which has parking spaces organization and exploitation as its narrower activity, in its structure has the Transportation Office whose main task is the removal of parking violators by the order of a competent authority. In this paper Transportation Service's work organization, transport organization and potential upgrades in business conduct via modern information technologies, will, above all, be considered, as well as the roll of the Transportation Service inside the system of PUC „Parking servis", and it's contribution to the Company, from a financial aspect. Described income and cost data are based on the company's data of business conduct in 2013. Three main measure suggestions will be considered, all based on advanced use of information technologies, implementation of a dispatching unit, and suitable patrol unit- Vehicle of Observatory Purpose (VOP)- maximum, minimum, and real, type of advanced business management.

Key words: GPS, Modern information technologies, Organization of transport, removal of parking violators.

INTRODUCTION

Issues and goals of the paper

Public companies in Serbia are getting worse, in the sense of business conduct, due to various social irregularities and insufficient use of contemporary social achievements in the sphere of information systems, and insufficient effort on improving the management of each company.

In order to avoid this, and based on the example of PUC „Parking servis", Novi Sad, certain measures will be proposed to show potential income upgrades which the Company could actualize applying them in its business conduct, so that it remains sustainable (profitable) and consistent.

Research methodology

Key steps on which work research has been conducted are following:

- Possibilities of advanced GPS and GSM technologies use by the Transport Services work units,
- Integration of a dispatching centre and Vehicle of Opservatory Purpose (VOP units), as key factors of advanced GPS and GSM use.
- Transport Service income analysis,
- Transport Services potential future income analysis based on previous steps.

TECHNOLOGY OF IRREGULARLY PARKED VEHICLES REMOVAL

Information about irregularly parked vehicles are gathered from: citizens (tips), managers of parking control, communal inspectors, traffic inspectors, police officers on sight, vehicle owners and public intervention teams managers of Public Utility Companies, but also by personal insight of the special towing vehicles crews.

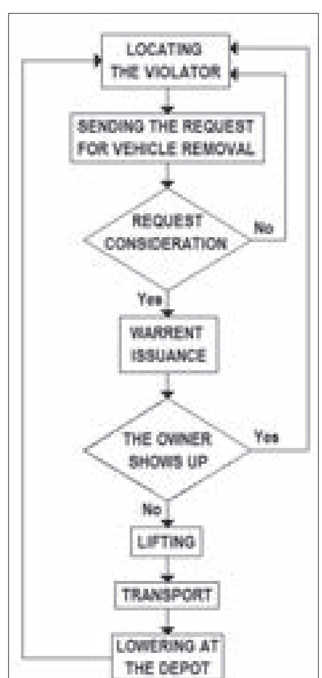

Figure 1. Process of a parking violator removal

All information concerning the necessity for vehicle removal, except those based on the crews personal insight, are forwarded to the vehicle admittance correspondent which based on those information send the Special Towing Vehicle (STV) crew on an intervention. Photographs of the vehicles in violation are delivered to the on-duty police officer seated on the Companies removed vehicles depot. Removal of vehicles by STVs, on any grounds, can only be authorized by a written warrant issued by an authorized law enforcer. The removal process is depicted on Figure1.

Table 1. Working performance of Transport Service in 2013 [1]

Month	All Removed Vehicles	Police	Communal inspection	Traffic inspection	Relocated	Distance travelled [km]	[km/ veh]
January	1042	825	172	0	45	12 695	12,2
February	898	727	114	0	57	11 352	12,6
March	961	881	51	0	29	13 331	13,9
April	851	745	66	0	40	12 670	14,9
May	868	615	165	4	84	11 465	13,2
June	726	565	71	0	90	11 323	15,6
July	819	460	236	0	123	12 482	15,2
August	501	341	121	0	39	9 274	18,5
September	785	551	166	0	68	11 959	15,2
October	1088	742	276	1	69	14 747	13,5
November	1080	817	207	0	56	13 717	12,7
December	1095	720	319	0	56	13 214	12,1
TOTAL	10 714	7 989	1964	5	756	148 229	13,8

TRANSPORT SERVICE BUSINESS ANALYSIS IN 2013.

It's necessary to review the business management of the Traffic Service, from natural and financial aspect. Table 1 gives insight to work performance of TS.

From Table 1 a conclusion emerges that the month with the highest number of removed vehicles is December ($N_{RVdec}^{2013} N_{RVdec}^{2013}$= 1095 veh), on the other hand the month with least vehicles removed is August ($N_{RVavg}^{2013} N_{RVavg}^{2013}$ = 501 veh).

Average number of removed vehicle in 2013 is 893 vehicles. Coefficient of imbalance in the number of vehicles removed is defined by the relation between the highest number of removed vehicles and the average number of removed vehicles of the same period in time, and in this situation it equals:

$$\eta_{veh}^{2013} = \frac{N_{RVdec}^{2013}}{\overline{N}_{RV}} = \frac{1.095}{893} = 1,23 \qquad (1)$$

$\eta_{veh}^{2013} \eta_{veh}^{2013}$ - Coefficient of imbalance in the number of vehicles removed in 2013, $N_{RVdec}^{2013} N_{RVdec}^{2013}$ - highest number of removed vehicles (December, 2013); $\overline{N}_{RV}\overline{N}_{RV}$- average number of removed vehicles in 2013.

As it can be seen in Table 1, total number of vehicles removed in 2013 is $* N_{RV}^{2013} * N_{RV}^{2013}$ = 10.714 vehicles. For further calculation reduced number of vehicles removed will be used, based on the subtraction of the number of Relocated vehicles from the total number of vehicles removed in 2013, due to the difference in the type of service.

Kilometrage realized by STVs in the discussed period of time is $AK_{2013} AK_{2013}$ = 148 229 km. Necessary upgrades in the work of the Transport Service will be based on reducing the number of redundant kilometers i.e. those kilometers travelled by STVs in order to find parking violators.

From the financial aspect[2] insight in costs and incomes must be given in order to deduce the profit in 2013, which is in direct connection to the natural aspect of business management. Data in Table 2 show the income of Transport Service (TS) in 2013 per month.

Table 2. Income of Transport Service by months in 2013.

	$N_{RVm}^{2013} N_{RVm}^{2013}$ (vehicles)	$\bar{P}^m \bar{P}^m$ [€]
January	997	60 265,44
February	841	50 835,74
March	932	56 336,39
April	811	49 022,34
May	784	47 390,28
June	636	38 444,15
July	696	42 070,96
August	462	27 926,41
September	717	43 340,34
October	1019	61 595,27
November	1024	61 897,50
December	1039	62 804,20
	Σ	601 929,04

Due to the existence of two different types of STVs in the vehicle depot of Companies Transport Service (big and small STVs) further in this paper cost analysis of 2013 will be conducted in dependence of the type and usage of the ones mentioned above. Table 3 shows different costs depending on the type of STV, and Total Costs in 2013.

Table 3. TS's costs in 2013

	COSTS			
	Big STVs		Small STVs	
	€/km	Total (€)	€/km	Total (€)
Fuel	0,35	31 916,26	0,20	11 873,39
Oil	0,06	4 787,44	0,03	1 781,01
Pneumatics	0,04	3 638,29	0,02	1 178,17
Maintenance and repair	0.24	22 146,12	0,12	7 171,46
Amortization	-	73 808,15	-	20 674,55
Insurance and registration	-	2 628,12	-	700,83
Total		138 924,40		43 379,41
Total	182 303,80			
Wages	211 931,70			
Liability insurance	17 520,81			
SUM	411 756,30			
Non-production costs (10%SUM)	41 175,63			
TOTAL	452 931,90			

The next step is to obtain the parameter based on the relation of total costs and kilometrage in 2013. Being so that the costs of the TS in 2013 were T = 452 931,90 €, above mentioned parameter will be:

$$\bar{t}_{km} = \frac{T}{AKm} = \frac{452.931,90}{148.229} = 3,06\ €/km \tag{2}$$

$\bar{t}_{km}\bar{t}_{km}$ - TS's cost per kilometer in 2013.

Table 4 contains data regarding the fuel poured kilometers travelled and fuel consumption for every STV of the TS.

Table 4. Individual relevant costs of STVs in 2013.

STVs Mark	Travelled [km]	Poured fuel [l]	Consupmtion [l/100]
B1 - IVECO	24 780	6 756,93	27,26
B2 - IVECO	26 500	7 066,16	26,66
B3 - DAILY	28 344	4 411,45	15,56
B4 - IVECO	23 282	5 360,73	23,02
B5 - DAILY	30 129	4 332,73	14,38
B6 - DAF	8 754	2 521,96	28,81
ZASTAVA ZŽ	6 969	1799	25,81

Since the income in 2013 was P = 601 929,04 €, and total costs were T = 452 931,90 €, the profit equals (untaxed):

$$\Pi = P - T$$
$$\Pi = 601\,929{,}04 - 452\,931{,}90 \tag{3}$$
$$\Pi = 148\,997{,}14\ €$$

$\Pi\Pi$ - TS's profit in 2013.

SUGGESTIONS OF UPGRADES IN BUSINESS MANAGEMENT

In order to reduce exploitation costs, mainly the variable ones, a more detailed usage of the existing GPS technology is being suggested, which is in direct connection to facilitation of the parking violators localization. An approach of this type requires a more intense communication line based on the relation VOP crew - Dispatching centre - STV crew. In a communication line like this the dispatcher as a subject must be enrolled in TS's affairs securing more efficient removal executions.

Main component of such system would be the GMS technology. Through it the dispatcher could be informed via VOP crews about cites of violation. This information can later be distributed orderly to different STV units, insuring every unit knows which cite to visit. Escort member of a single crew enters the data received via GSM into the GPS interface device inside STV, the shortest route is selected, and travel can commence. The dispatcher monitors the movement of every STV on field and ensures no double-action take place, by assigning every STV to a different removal task. In case of a citizen tip regarding a violation, dispatcher would be obligated to send out a VOP crew on the spot to ensure the validity of the tip, so that the STVs don't travel in vain.

GPS characteristics:

- uninterrupted connection of dispatching service and vehicles, regardless of their amount,
- unlimited area of vehicle tracking, only limitation - GPS coverage,
- simple installment and use of GPS interface,
- Possibility of a more efficient route planning and significant reductions regarding exploitation costs

GSM technology takes a very significant position in transport, due to its benefits like[3]:

- Communication on the base driver - dispatcher - other actors in Transport Company
- Emergency calls in case of an accident or any kind of failure,
- exchange of textual messages and other types of digital data
- Recording of the communication flow,
- Integration with other existing systems.

In order to avoid the interference of two or more STVs on the same assignment, the dispatcher must clearly define which vehicle is sent to a specific location. This would lead to a precise assignment distribution among the STVs patrolling in the same zone. Important issue in this case scenario would be how to evenly assign taskas, in order not to overload any specific STV crew.

The number of VOP units would be depending on the number of "empty" autokilometers travelled by STV's and the number of the kilometers that VOP units can realize with regard to their work hours, and technical-exploitative factors.

Main focus of the reorganization proposal lays on the tendency to transfer the „empty" autokilometers AK_p from STVs to the passenger vehicles which VOP unit is comprised of, and whom are in direct connection to the tracking of the parking violators.

PROJECTED STATES BUSINESS ANALYSIS

Considering the various measures of business reorganization three types stand out. First one is based on the use of the whole current TS's system. Ti comprises of TS in its current condition with added (necessary) VOP units (optimistic type).

Calculation in use for the considered type of business enhancement does not differ much from the other types, so many of the same figures and calculation methods will be used for the other two types of potential business advances, although the results will mostly be very different.

5.1Optimistic type of projected business conduct

This type shows all the potential of implementation of the VOP units, dispatching center into the TS's system with advanced use of GPS and GSM technologies, regarding the increase in work productivity.

Basic date needed for income and costs calculation in the case of this, and other types of projected business conduct, will be the autokilometers that STVs and VOPs have to realize, in order to define the indicators of projected business management, and give an insight to the advances that such system reorganization would offer.

Since the optimistic type of business conduct is approximately closest to the existing one in 2013, the biggest number of data necessary for its calculation (as well as other types) will be gathered processing the 2013 business indicators.

$$\bar{\bar{T}} = \bar{t}_{at} + t_w + \bar{t}_{wa} + \bar{t}_l + \bar{t}_{atw} + \bar{t}_{id} = 35 \text{ min} \tag{4}$$
$$\bar{\bar{T}} = \bar{t}_{at} + t_w + \bar{t}_{wa} + \bar{t}_l + \bar{t}_{atw} + \bar{t}_{id} = 35 \text{ min}[4]$$

$\bar{\bar{T}}\,\bar{\bar{T}}$ - average turnover duration; $\bar{t}_{at}\bar{t}_{at}$ - average travel time to violation location; $t_w t_w$ - time spent on waiting for the owner of the vehicle to show up; $\bar{t}_{wa}\bar{t}_{wa}$ - warrant affirmation time; $\bar{t}_l\bar{t}_l$ - lifting time; $\bar{t}_{atw}\bar{t}_{atw}$ - average time of confiscated vehicle transport; $\bar{t}_{id}\ \bar{t}_{id}$ - average time of lowering the vehicle on the TS's depot.

Use of VOP units would mean that when the crew of that unit would be, after sighting the violator, in obligation to inform the dispatching centre, only after the expiration of the time waiting for the owner to show up, so that the STV units can do their job.

This means that average turnover duration for STV changes and in this particular case is:

$$\bar{\bar{T}} = \bar{t}_{at} + \bar{t}_l + \bar{t}_{atw} + \bar{t}_{id} = \\ \bar{T} = 10 + 5 + 10 + 5 = 30 \text{ min} \tag{5}$$

The next thing to do is to determine the maximum number of vehicles that can be removed per shift, based on the 30 minute turnover:

$$N_{ic}^{RV} = (n_{rv/h} \cdot H_r \cdot A_r) \cdot (n_s \cdot N_{wd} + n_{ssun} \cdot N_{sun}) = \\ N_{ic}^{RV} = (2 \cdot 8 \cdot 6) \cdot (2 \cdot 313 + 1 \cdot 52) = 65\ 088 \text{ veh} \tag{6}$$

$N_{ic}^{RV} N_{ic}^{RV}$ - total number of potentially removed vehicles in an ideal case; $n_{rv/h} n_{rv/h}$ - number of removed vehicles per hour; $H_r H_r$ - duration of the shift; $A_r A_r$ - number of working STVs; $n_s n_s$ - number of working day shifts; N_{wd} N_{wd} - number of working days in 2013 (including Saturdays); $n_{ssun}\ n_{ssun}$ - number of shifts on Sunday; $N_{sun} N_{sun}$ - number of Sundays in 2013.

Therefore in the ideal case of exploitation, with the use of VOP units to shorten the turnover time for STVs, the number of potentially removed vehicles would be $N_{ic}^{RV} N_{ic}^{RV}$ = 65 088 vehicles.

In correlation to the average fee price from 2013 (60,45€), income on an annual level would be:

$$P_{aps}^{2013} = N_{ic}^{RV} \cdot f = 65\ 088 \cdot 60{,}45 = \\ P_{aps}^{2013} = 3\ 934\ 360{,}00 \tag{7}$$

Having in mind that this operative level is practically unfeasible, due to the lack of that amount of parking violators, and impossibility of all STV being functional for work, it can only be used as absolutely ideal i.e. the borderline of advanced business management in this particular case.

Average speed of a STV is $\bar{v}\bar{v}$ = 25 km/h. This means that the ideal kilometrage necessary for the removal of one parking violator is:

$$\bar{s} = \bar{v} \cdot \bar{t} = 25 \cdot \frac{20}{60} = 8{,}33 \text{ km} \tag{8}$$

$\bar{s}\bar{s}$ - Ideal travel kilometrage per turnover; $\bar{v}\bar{v}$ - average speed of a STV; $\bar{t}\bar{t}$ - average time of travelling.

Combining the existing data on the number of removed vehicles in 2013, average number of kilometers necessary for the removal of that amount of violators can be calculated:

$$AK_{id} = \bar{s} \cdot {}^{*}N_{RV}^{2013} = 8{,}33 \cdot 10\,714 = \\ AK_{id} = 89\,248 \text{ km} \tag{9}$$

AK_{id} AK_{id} - Total ideal autokilometers traveled in 2013; ${}^{*}N_{RV}^{2013}$ ${}^{*}N_{RV}^{2013}$ - Total number of removed vehicles in 2013;

The next necessary thing to do is to subtract the ideal autokilometers from the total number of autokilometers in 2013, in order to acquire autokilometers traveled during "patrolling" - those realized while searching for the violators.

$$AK_{pat} = AK - AK_{id} = 148\,229 - 89\,248 = \\ AK_{pat} = 58\,981 \text{ km} \tag{10}$$

$AK_{pat}$$AK_{pat}$ - autokilometers realized during patroling; AK AK - total autokilometers of STVs in 2013.

Obtained information represents the kilometrage that needs to be switched to VOP units, in order to liberate STVs from patrolling, and by doing so reduce their exploitation costs.

From earlier calculations the need emerges to derive the patrolling and useful kilometers from total autokilometers, and to give insight to their participation:

$$\%_{id} = \frac{89\,248}{148\,229} \cdot 100 = 60{,}2\% \tag{11}$$

$$\%_{id} = \frac{58\,981}{148\,229} \cdot 100 = 39{,}8\% \tag{12}$$

In an ideal annual level case STVs could remove the following number of vehicles:

$$N_{ia}^{RV} = n_{rv/h} \cdot (H_r - 1) \cdot A_r \cdot (n_s \cdot N_{wd} + n_{ssun} \cdot N_{sun}) \\ N_{ia}^{RV} = 2 \cdot 7 \cdot 5 \cdot (2 \cdot 313 + 1 \cdot 52) = 47\,460 \text{ veh} \tag{13}$$

This leads to the fact that the number of ideal autokliometers in this particular case is:

$$AK_{id}^{al} = \bar{s} \cdot N_{ia}^{RV} = 8{,}33 \cdot 47\,460 = 395\,342 \text{ km} \tag{14}$$

When this, above shown, total ideal kilometrage on annual level is divided by the percentage of ideal kilometrage, and afterwards multiplied by the patrolling kilometers percentage, the result represents the patrolling autokilometers for that projected annual level.

$$AK_{pat}^{al} = \frac{AK_{id}^{al}}{\%_{id}} \cdot \%_{pat} = \frac{395\,342}{60{,}2} \cdot 39{,}8 = \\ AK_{pat}^{al} = 261\,372 \text{ km} AK_{pat}^{al} = 261\,372 \text{ km} \tag{15}$$

$$AK_{VOP}^{pot} = \bar{v}_s \cdot (H_r - 1) \cdot (n_s \cdot N_{wd} + n_{ssun} \cdot N_{sun}) = \\ AK_{VOP}^{pot} = 35 \cdot 7 \cdot (2 \cdot 313 + 1 \cdot 52) = 166\,110 \text{ km} \tag{16}$$

AK_{VOP}^{pot} AK_{VOP}^{pot} - Potential kilometrage a VOP unit could realize on annual level.

As can be seen from stated above there is a need for two VOP units, to cover the projected patrolling autokilometers (261.372 km). In this case the necessary number of VOP workers is ten.

Table 5. Total costs of the Transport Service in the projected state

TROŠKOVI						
	Big STVs		Small STVs		VOPs (Skoda FABIA)	
	€/km	Total (€)	€/km	Total (€)	€/km	Total (€)
Fuel	0,35	85 245,29	0,20	31 309,42	0,12	31 941,65
Oil	0,06	13 858,96	0,03	4 700,47	0,02	4 785,53
Pneumatics	0,04	9 718,17	0,02	3 106,63	0,004	984,58
Maintenance and repair	0.24	59 154,11	0,12	18 909,92	0.04	11 448,62
Amortization	-	73 808,15	-	20 674,55	-	3 673,99
Insurance and registration	-	2 628,12	-	700,83	-	334,80
Total		244 412,80		79 401,82		53 169,17
Total	376 983,80					
Wages	253 981,60					
Liability insurance	17 520,81					
SUM	648 486,21					
Non-production costs	64 848,62					
TOTAL	713 334,83					

Since the suggested type is far more massive than the standard annual performances, it is clear that the number of failed removal procedures will increase, but not more than 50%. Being that the TS's incomes are in direct correlation with the number of removed vehicles it is clear that they will change in the same nature.

$$\bar{P}_{proj}^{real} = P_{proj}^{real} \cdot 0{,}50 = N_{ia}^{RV} \cdot f \cdot 0.50 = \\ \bar{P}_{proj}^{real} = 47\,460 \cdot 60{,}45 \cdot 0{,}50 = \\ \bar{P}_{proj}^{real} = 1\,434\,402{,}10\ € \tag{17}$$

Having in mind that the costs don't change, not even in the case that the vehicle owner appears, one thing left to do is to calculate the real potential profit - gain from this type of projected state.

$$\bar{\Pi}_{proj}^{real} = P_{proj}^{real} - T_{proj}^{2013} =$$
$$\bar{\Pi}_{proj}^{real} = 1\,434\,402{,}10 - 713\,334{,}83 = \quad (18)$$
$$\bar{\Pi}_{proj}^{real} = 721\,067{,}27\text{ €}$$

The following part of this paper gives insight to the ratio regarding the increase of income and costs based on real (2013) and projected state comparison.

$$\uparrow \bar{T} = \frac{713\,729{,}05}{452\,931{,}90} = 1{,}57 \quad (19)$$

$$\uparrow \bar{P} = \frac{1\,434\,402{,}10}{601\,929{,}4} = 2{,}38 \quad (20)$$

Figure 2 graphically describes the increase ratio for incomes and costs.

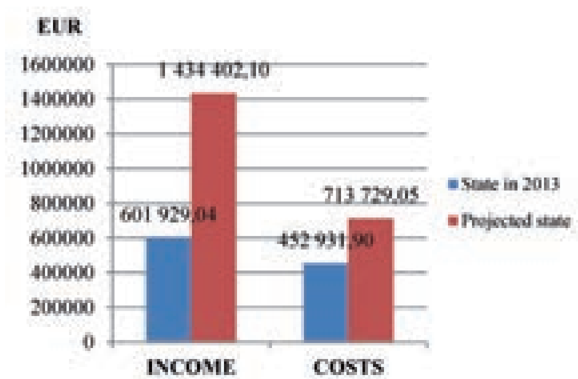

Figure 2. Comparative financial state for the 2013 and the projected state

Pessimistic type of projected business conduct

In case that the pessimistic type is applied the use of only one VOP unit would be needed, and complementary to that one STV. In this case coefficient of VOP unit exploitation would be under 1, while the STV's would equal 1 annually.

Maximum annual kilometrage that one STV can travel is:

$$AK_{STV} = \bar{v} \cdot (H_r - 1) \cdot (n_s \cdot N_{wd} + n_{ssun} \cdot N_{sun}) =$$
$$AK_{STV} = 25 \cdot 7 \cdot (2 \cdot 313 + 1 \cdot 52) = 118\,650\text{ km} \quad (21)$$

As the average number of autokilometers travelled, if the place of violation is known, is $\bar{s}\bar{s}$ = 8.33 km the total number of potential removed vehicles would be:

$$\bar{N}_{min}^{RV} = \frac{AK_p}{\bar{s}} = \frac{118\,650}{8{,}33} = 14\,244\text{ veh} \quad (22)$$

Based on this the expected income for this type of business conduct can be calculated, with review of exploitation parameters in 2013 (50% decrease applies here as well as in the other types). Expected income would than equal:

$$\bar{P}_{min} = N_{min}^{RV} \cdot f \cdot 0.50 =$$
$$\bar{P}_{min} = 14\,244 \cdot 60{,}45 \cdot 0{,}50 = \quad (23)$$
$$\bar{P}_{min} = 430\,502{,}00\text{ €}$$

In a system like this, it is necessary to include the crews for the VOP unit. This means that three shifts are needed, so six employees will be assigned to the VOP unit.

Expenses of such system are significantly smaller compared to those of 2013 because they need only one of every unit, and they are shown in Table 6.

Table 6. Projected costs of pessimistic type of business conduct

	Costs			
	Big STV		VOP (Skoda FABIA)	
	€/km	Total (€)	€/km	Total (€)
Fuel	0,35	41 940,67	0,12	9 586,33
Oil	0,06	6 818,61	0,02	1 436,23
Pneumatics	0,04	4 781,34	0,004	295,49
Maintenance and repair	0.24	29 103,81	0.04	3 435,96
Amortization	-	14 761,63	-	1 836,99
Insurance and registration	-	525,62	-	167,40
Total		97 931,68		16 758,42
Total	114.690,10			
Wages	39 737,19		31 537,45	
Liability insurance	2 917,21			
SUM	188 881,95			
Non-production costs	18 888.19			
TOTAL	207 770,14			

Profit of this type of business conduct would equal:

$$\bar{\Pi}_{min} = P_{min} - T_{min} =$$
$$\bar{\Pi}_{min} = 430\,502{,}00 - 207\,770{,}14 = \quad (24)$$
$$\bar{\Pi}_{min} = 222\,731{,}82\text{ €}$$

Real type of projected business conduct

It is necessary to consider which type of business conduct would be most feasible, based on contemplating the relation between internal interest of the Transport Service, and the external aspect (interests of the local community).

Since the considered number of STVs in the year 2013 was six, to maintain the jobs of all employees in the process, a management reorganization of such nature so that the TS will consist out of four STVs and two VOP units, will be considered.

Total kilometrage that four STV's can travel annually is:

$$AK_{STV}^{real} = n_{STV} \cdot AK_{STV}$$
$$AK_{STV}^{real} = 4 \cdot 118\,650 = 474\,600\text{ km} \quad (25)$$

In accordance to that the annual VOP kilometers (patrolling kilometers) can be calculated:

$$AK_{VOP}^{real} = \frac{AK_{STV}^{real} \cdot 0{,}398}{0{,}602} =$$
$$AK_{VOP}^{real} = \frac{474\ 600 \cdot 0{,}398}{0{,}602} = 313\ 772 \text{ km} \quad (26)$$

Having in mind that one VOP unit can annually travel up to $AK_{VOP}^{pot} AK_{VOP}^{pot}$ = 166 110 km it is clear that in this particular case two VOP units would be needed. Since the crews of STV and VOP units are of the same quantity, necessity would emerge that a part of STV's crew transfers to the work assignments of VOP units.

In this case the number of workers would remain the same, so there would be no need for hiring additional work force. Wages in that case for the VOP units crew could go up from 438 to 626 EUR.

The expected number of vehicles that could be removed for the referred kilomtrage is:

$$\bar{N}_{real}^{RV} = \frac{AK_{STV}^{real}}{\bar{s}} = \frac{474\ 600}{8{,}33} = 56\ 975 \text{ veh} \quad (27)$$

Incomes of this system are calculated in the same manner as those for the other type of business conduct:

$$\bar{P}_{real} = N_{real}^{RV} \cdot f \cdot 0.50 =$$
$$\bar{P}_{real} = 56\ 975 \cdot 60{,}45 \cdot 0{,}50 = \quad (28)$$
$$\bar{P}_{real} = 1\ 721\ 978{,}00\ €$$

The STV assembly should consist out of 2 Small STV's and 2 Big STV's. With a review of the kilometers distribution (60,7%; 39,3%) in the current kilometrage the distribution would be $AK_{STV}^{b} AK_{STV}^{b}$=288 082 km and $AK_{STV}^{s} AK_{STV}^{s}$=186 518 km.

The costs of the real type of business conduct are shown in Table 7.

Table 7. Projected costs of the real type of business conduct

	COSTS					
	Big STVs (2)		Small STVs (2)		VOP (Skoda FABIA) (2)	
	€/km	Total (€)	€/km	Total (€)	€/km	Total (€)
Fuel	0,35	101 831,88	0,20	37 875,49	0,12	38 345,32
Oil	0,06	16 555,57	0,03	5 686,22	0,02	5 744,93
Pneumatics	0,04	11 609,09	0,02	3 758,14	0,004	1181,97
Maintenance and repair	0,24	70 664,00	0,12	22 875,62	0.04	13 743,85
Amortization	-	59 046,52	-	20 674,55	-	3 673,99
Insurance and registration	-	1051,25	-	700,83	-	334,80
Total		260 758,30		91 570,85		63 024,87
Total	415 354,02					
Wages	208 777,92					
Liability insurance	11 651,34					
SUM	635 783,28					
Non-production costs	63 578,33					
TOTAL	699 361,61					

So the profit is:

$$\bar{\Pi}_{real} = \bar{P}_{real} - \mathrm{T}_{real} =$$
$$\bar{\Pi}_{real} = 1\ 721\ 978{,}00 - 699\ 361{,}61 = \quad (29)$$
$$\bar{\Pi}_{real} = 1\ 022\ 616{,}39\ €$$

In this (real) type of business reorganization, compared to the state recorded in 2013, for 50% higher costs, the income would be almost 300% higher, having in mind that the accounts are made for the first year of the exploitation of the new business system. The expected profit would be seven times bigger than the one in 2013. The advantage of such system would reflect in the maintenance of work places, more rational and eco-friendly use of STV units, no need for special investments since the Company already has all the necessary equipment and resources for such reorganization.

CONCLUSION

Generally, the various parking policies are vital nowadays for every developed city regardless its' size.

They can contribute greatly in organizing the traffic system of an area and ameliorate the driving conditions for the users of the streets[5].

Applying the contemporary information technologies the STV units work efficiency can be significantly optimized, and in accordance with that the state of Companies management as well. In the PUC „Parking servis" Novi Sad, Transport Service is not the only revenue maker. It represents only a part of the Companies system. Having in mind that it plays a repressing role, it is clear that there is the necessity for her to act only in the case of a violation. The Company itself should invest more from its budget in order to improve the parking conditions in the city.

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