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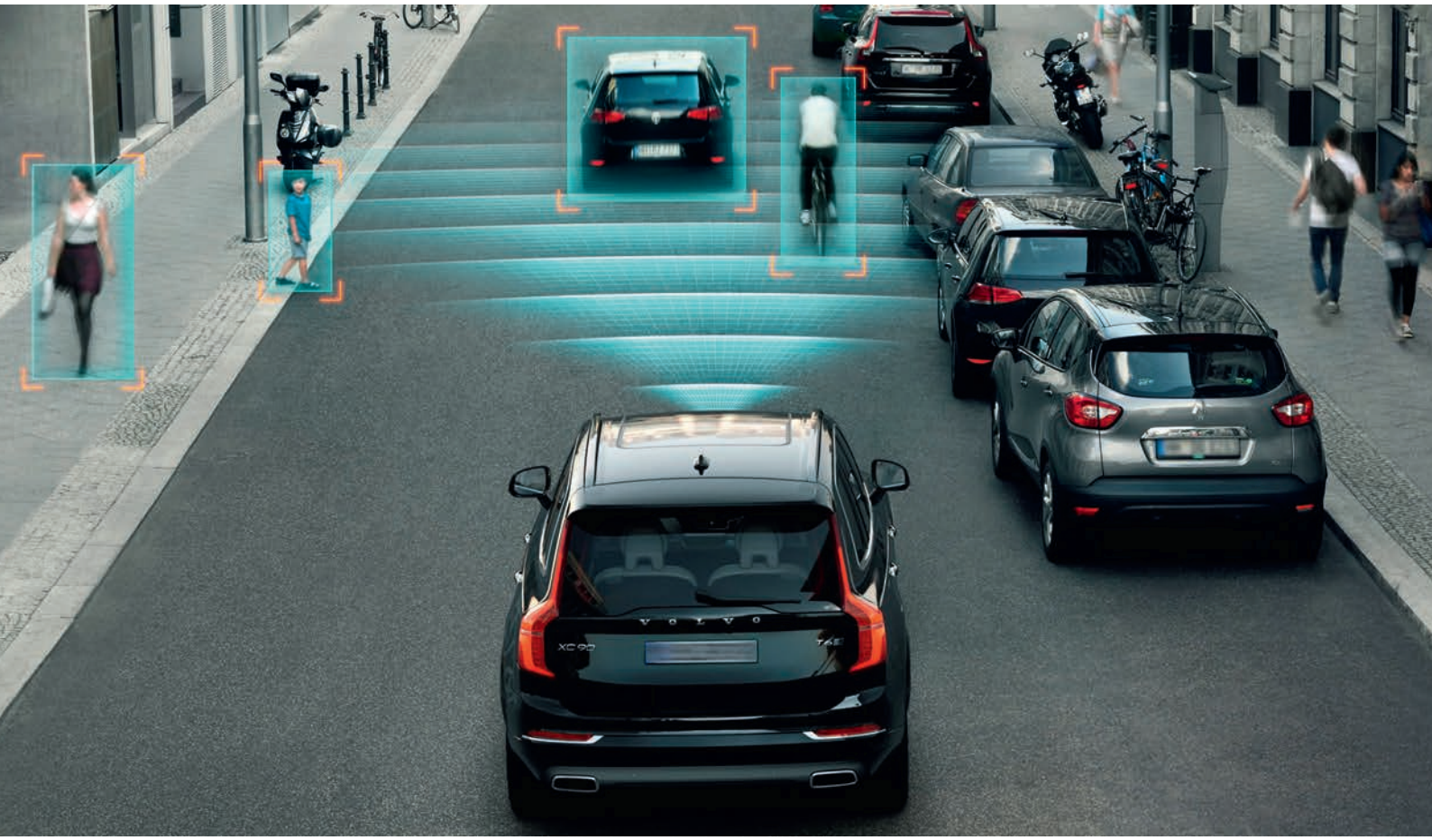

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The aim and scope of the Traffic and Transport Theory and Practice (TTTP) Journal is:

- 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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TRAFFIC AND TRANSPORT THEORY AND PRACTICE

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Contents

EDITOR'S WORD

Dear Readers,

This is the second issue of the internationally reviewed scientific journal "Traffic and Transport Theory and Practice -TTTP" published by Pan-European University "Apeiron" Banja Luka, Faculty of Traffic and Transportation Engineering.

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 publishing information, we publish papers from all scientific fields that gravitate toward traffic and transportation. We believe that reviews of the basic activities by other professionals would also be significant in the future. We will also nurture papers that are created in collaboration with students, trying to involve them in scientific work.

This issue proudly presents ten papers that explore different topics ranging from traffic safety, traffic air pollution, intelligent transportation systems, environment protection and public transportation.

We hope that the published papers will encourage your cooperation.

Sincerely
Mirsad Kulovic,
Editor-in-Chief

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ORIGINAL SCIENTIFIC PAPER

The possibilities of using biodiesel in service of reducing the urban air pollution

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Abstract: Using renewable energy is in line with the global strategy of sustainable development. The use of biofuels in transport contributes to increasing security of supply and reducing dependence of the transport sector on oil, reducing the share of greenhouse gas emissions from road transport and sustainable development of urban areas. The advantage of biodiesel in comparison to other alternative fuels can be seen in use in existing vehicles without or with minor modification of existing motors, depending on the concentration of biofuels in combination with fossil fuels. This paper discusses the possibilities of reducing the air pollution by using biodiesel, pollutants arising as a result of combustion of fuel in internal combustion engines, as well as the possibility of using waste cooking oil to produce biodiesel. The presented results show the reduction of air pollution using biodiesel as an alternative fuel, as well as the possibilities of solving the problem of wasting edible oil by using it for biodiesel production.

Key words: biodiesel, air pollution, edible oil.

INTRODUCTION

The viability of the environment considers that degree of the emitted pollutants does not exceed the capabilities of the air, the water and the soil to absorb and adapt them. At the same time, it entails constant preservation of the biological diversity, human health as well as the quality of the air, the water and the soil which are sufficient for life and the well-being of the man according to standards. [1]

The air pollution happens due to the emissions of gassy and solid materials, it often occurs as the result of human activity but also by the emissions from the natural resources. The air pollution happens when concentration of the certain substances (pollutants) reaches toxic amounts i.e. it starts to have negative effects on human health, flora and fauna. [2]

The ideas on the manners of reducing carbon-dioxide emissions into the atmosphere, have resulted in the use of bio and other renewable fuels. European Parliament Directive on Climate Change and Energy has the aim to ensure the reduction of the emissions of the gasses with the greenhouse effect by at least 20%, improvement of energy efficiency by 20% and the use of the renewable energy by 20% of the overall energy consumption in EU until 2020.

INTERNAL COMBUSTION ENGINES AS AIR POLLUTANTS

The internal combustion engines are the major sources of certain pollutants into the air. As the sources of the air pollution they are present in the road vehicles, airplanes, ships, agricultural and construction machines, static engines, electric power turbines. They pollute by emissions of carbon-monoxide with 73%, 56% of carbon-dioxide and with 50% of total NaOH emission into the atmosphere.

ROAD TRAFFIC AS THE SOURCE OF POLLUTION

The road traffic presents significant source of pollutants in the most of the countries. Although the introduction of the new standards has reduced the emissions from the car engines, the road traffic has still been the biggest source of carbon-monoxide and non-methane hydrocarbon and altogether with energy sources has been the biggest sources of nitrogen oxide; and with households it has been the biggest emitter of the smoke and soot.

Road traffic is the biggest cause of pollution in the urban areas. About 60% of total air pollutants in urban areas come from the internal combustion engines.

The emission of the air pollutants while burning in the internal combustion engines depends on many factors of which the most important ones are the following: the quality and type of the fuel, type of the motor, the driving conditions and heavy load of the vehicle (table 1.)

Table 1. The emission of the product of the combustion of fuel and diesel engine

	CO	Hydrocarbon	NO	SO_2	Solid particles
	%	ppm	ppm	ppm	g/m^3
Diesel engine	0,1	300	4000	200	0,5
Fuel engine	10,0	1000	4000	60	0,01

The combustion is a complex set of physical and chemical processes which, besides numerous thermal effects, are followed by the vibrational, sound, light and other phenomena. The time of the fuel mixture combustion is limited by the engine work cycle and other phenomena and lasts for a few milliseconds.

The real combustion processes are always incomplete. The main reason is that the air gets into the combustion process and makes one fifth, while nitrogen holds the biggest percentage. The second reason is that the fuels are mixture of different carbon-hydrogen so their combination and recombination is happening all the time during the combustion process. The third reason is that those fuel mixtures in the chamber are undefined in respect to make-up, and physical and chemical conditions that are undefined by the space and time (sometimes they are suitable for complete and sometimes for incomplete combustion).

THE POSSIBILITIES OF REDUCING THE AIR POLLUTION

The reduction of pollutants emission into the air in the internal combustion engine can be achieved by:

- Increasing the quality of the used fuel,
- Optimization of the work process in the engine,
- Additional processing of the exhaust gasses,
- Using the alternative/ substitute fuels.

The use of the alternate fuels for motor vehicles represents realistically one of the possible ways of cutting down the pollutant emission from the exhaust gasses of the vehicles. The use of alternative fuels may result in the reduction of dependence on conventional fuels, derived from the oil whose reserves are limited. The part of alternative fuel is renewable, so this is why the issue of the choice of the appropriate fuel can be observed in the big picture.

The most important ones are: gas fuels, alcohol fuels and biodiesel.

The Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) are used as alternative gas fuels. The use of the natural gas instead of conventional fuel cuts down the carbon monoxide, NaOH and solid particles emissions, it also reduces carcinogenic effects of the exhaust gasses and their influence to create smog *Alcohols* as alternative fuels are used in the mixture with the oil fuels. The most frequently used ones are: methanol, ethanol, isopropyl alcohol, secondary butyl alcohol and tertian butyl alcohol.

Weak lubrication of alcohol, low octane numbers and great hygroscopicity and corrosivity make the use of alcohol in diesel fuels difficult.

BIODIESEL AS ALTERNATIVE FUEL

Biodiesel is a mixture of Fatty Acid Methyl Ester which has standardized quality. Biodiesel - the name itself indicates the fuel derived from bio-material, first of all oil, but also from the animal fat as well as the oil and fat used for the cooking. [3].

Biodiesel is non-toxic, it is biologically renewable and degradable. It is produced by the reaction of transesterification of the plant oils (triglycerides). By transesterification of the vegetable oils, in the presence of catalyst triglycerides, it reacts with alcohol producing the mixture of Alice Ester Fatty Acids and glycerol's.

Transesterification is affected by multiple factors, such are: catalyst, the molar relation between reacting fluids, temperature, the pureness of reaction fluids and the make- up of the free fatty acids.

THE EFFECTS OF THE USE OF BIODIESEL ON THE ENVIRONMENT

A significant move has been made toward the improvement of the air quality in the most polluted urban areas in the past two decades. Using biodiesel as substitute to fossil fuels foresees further improvement of the air quality regardless of whether the fuels are used in the conventional engines with internal combustion or in the new, cleaner automobile technologies.

Using the biodiesel, instead of the fossil fuels, results in the significant reduction in emission of the gasses with the effect of the green house. The quantification of these effects to the environment is being conducted by the measuring of the net emissions during the complete chain of production and consumption. The water pollution is linked to the oil products and the oil spills which results in the contamination of the underground waters from the reservoirs and the outflow of the spilt fuel. Biodiesel, unlike the fossil fuel, quickly biodegrades, and does not represent hazard to waterways and underground waters. Biodiesel spill does not represent hazard to the environment [4].

The main advantage in the use of biodiesel as renewable fuel is the significant reduction in the carbon-dioxide emission. The emission of the sulphur oxides, suspended particles and carbon-monoxide is reduced. The advantages and the disadvantages depend on mixture used as well as the work of the engine. .

Table 2. shows the comparison of biodiesel emission (B 20-mixture 20% biodiesel 80% fossil diesel fuel and B 100-pure 100% biodiesel).

Table 2. The comparison of the emissions of the exhaust biodiesel gasses

Reduction in the emission in comparison with diesel fuel	Pollutant					
	NO_x	Solid particles	Carbon-Hydrate	CO	CO_2	Sulphur
B 20	+2	-10	-15	-11	-15	-20
B 100	+10	-50	-65	-52	-80	-100

Researches and comparisons were conducted on pure diesel, pure biodiesel (mark B100) and diesel fuel mixture and biodiesel in ratio 80:20 (mark B 20).

The values of the potential reduction in the individual pollutant emission using the biodiesel were [4]:

- Carbon-monoxide (CO_2)–each ton of fossil diesel fuel emits about 2,8 t of CO_2 into the atmosphere. Specific make up of carbon in one ton of biodiesel is smaller so the emission of CO_2 is about 2,4 t. Regarding the fact, that the plants absorb carbon-dioxide during the photosynthesis process; using the biodiesel the net emission of carbon-dioxide is almost zero.
- Sulphur-Oxides (SO2) – when fossil diesel fuel burns, sulphur is emitted into the atmosphere in the form of sulphur-dioxide contributing the emergence of the acidic rains. Biodiesel contains sulphur in traces. The European Union promotes the use of fossil diesel fuel containing sulphur under 50 ppm.
- Nitrogen-Oxides (NO_x) – emission of the nitrogen oxides from biodiesel can be increased or decreased in relation to the fossil fuel emission, depending on the type of engine and additional process of the exhaust gasses. Nitrogen-oxide emission from pure diesel is being increased by 10% comparing to fossil fuels.
- Carbon-Monoxide (CO) – biodiesel contains oxides, improving combustion process and reducing the carbon-monoxides emission for about 48% in comparison with fossil diesel fuels.
- Solid particles – inhaling suspended and solid particles is a serious problem and represents hazard for the human health. By using biodiesel, the solid particles emission from the exhaust gasses is by 47% lower than it is with fossil fuels.
- Unburnt hydro-carbons – The unburnt hydrocarbons emission in the exhaust gasses while using bio-diesel is approximately 67% lower than it is in the fossil diesel fuel.
- B100 reduces the risk of cancer by 94% and B20 by 27%.

THE RAW MATERIAL FOR THE BIODIESEL PRODUCTION

The basic raw material for the production of biodiesel are: vegetable and animal oils and fats or the waste oils or fats used for the alcohol and food preparation.

Biodiesel production uses catalyst, acid and demineralized water as auxiliary material.

Fats and oils are materials of vegetable and animal origin composed of Glycerol-Ester and fatty acids, the so-called triglycerides and non-glyceride components. The raw materials for the oil and fat production represent renewable sources and enable production of the series of products for technical and food purpose.

Under the influence of the high temperature during the exploitation, the *edible oil* produces carcinogenic polycyclic aromats whose technical decomposition on the hot surfaces creates extremely toxic and dangerous products.

The waste oils used for the preparation of food can be used as the raw material for biodiesel production. The used oil is often thicker, because of the hydrogenation, and contains vegetable and animal fats from prepared food. The advantage of the waste oil is that it is an available waste product. The intensive examinations on the possibilities of biodiesel production from the waste cooking oils, food processing, city waste and animal lard are being conducted.

Using the waste edible oils as raw material for the biodiesel production achieves the following:

- Gaining the ecological fuel,
- Resolving the waste oils problem and
- Gaining the useful by- product- glycerol.

CONCLUSION

The examinations have shown significant reduction in the solid particles, carbon-dioxide, carbon-monoxide, sulphur-dioxide and hydrocarbon into the atmosphere using B20 and B100 fuels compared with the conventional diesel fuels.

The use of biodiesel increases the nitrogen-oxide (NaOH) emissions which can be disregarded in comparison with the reduction of the emissions of pollutants listed above. The reduction of the nitrogen-oxide emission can be achieved by the additional processing of the exhaust gasses.

Using biodiesel as alternative fuel, besides positive influence in respect of the reduction of the exhaust gasses emissions, has the advantage of biodiesel being a renewable source of energy. Methyl esters and alcohol are derived from the raw materials of vegetable origin, and the combustion products like carbon-dioxide (CO2) and water (H2O) are used in the photosynthesis process by plants.

The use of waste edible oils as material for the biodiesel production should be encouraged through the selective collection of waste edible oils.

The possibilities of biodiesel production are limited, and the expected use in the near future is questionable. The main problem is in the low efficiency of production plants and engines which should use biodiesel.

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ORIGINAL SCIENTIFIC PAPER

Public Service Obligation System Principles

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Abstract: This paper tries to model the public passenger transport system in the railroad traffic from the aspect of the PSO obligation – the Public Transport Obligations, defined by a Regulation enacted by the state level of authority, in accordance with the EU Parliament Regulation 1370/2007/EC. The paper focuses on the aims of the Regulation which regulate the PSO principles, system financing, compensation and subsidies systems. It also establishes the conditions and trends in EU countries. There is also stress about the structure of expenses and income in the exploitation process in relation to the need for subsidies by local authorities for the transport of passengers.

Key words: Regulation, PSO- Public Transport Obligation, trends, expenses, income.

INTRODUCTION

Under the conditions of free market functioning in the sector of passenger public transport, operators/carriers would not undertake the obligation to provide services that are not cost effective. However, if those services are in general public interest, competent authorities at state and regional level have to ensure the services whereby they introduce and apply various regulations and instruments such as the obligation to provide non-commercial transport service.

It should be emphasised that regulation of the European Union (abbreviated the EU) reserves the right to impose the obligation of public transport service, but with the obligation to conclude suitable contracts with operators which define terms of transport and appropriate compensation for the provision of passenger public transport service. (abbreviated PSO). Such mechanism of ensuring passenger public transport service is named ''Public Service Obligation'' (abbreviated PSO), while the Law on Railroads in Serbia calls it "Public Transport Obligation" (abbreviated PTO).

Therefore, different countries (central, regional or city authorities) apply different models of awarding contracts depending on the institutional framework, available financial resources as well as the form and level of railway system restructuring. Differences are evident in several elements of awarding contract, out of which the most important ones are the following:

- services covered by PSO,
- market openness,
- method of awarding the contract,
- shared risk for revenues and costs,
- ownership over the means of transport,
- contract duration,
- use and control of budget resources for passenger public transport/passenger service obligation.

The development of transport as a part of technological process is a common requirement for quality life of the society and economic development. In all economically developed countries, transportation system structure is evident. This fact indicates that planned and conscious development o transportation system must be a part of economic policy of a country [1]

PSO PRINCIPLES OF PASSENGER SERVICE OBLIGATION SYSTEMS

PSO PRINCIPLES - BASIC ASSUMPTIONS

Two basic notions that are included in the new passenger public transport system are: ***Public Service Obligation – PSO)*** and ***Public Service Compensation***. Definitions of these notions are as follows[1]:

- ***Public Service Obligation – PSO*** means a requirement defined or determined by a competent authority in order to ensure public passenger transport services in the general interest that an operator, if it were considering its own commercial interests, would not assume or would not assume to the same extent or under the same conditions without reward;
- ***Public Service Compensation*** means any benefit, particularly financial, granted directly or indirectly by a competent authority from public funds during the period of implementation of a public service obligation or in connection with that period;

General aims of the regulation regulating the Public

[1] Definition of the above stated terms are given in EU Regulation 1370/2007/EC (Regulation on public passenger transport services by rail and by road and repealing Council Regulations No 1191/69 and 1107/70).

Service Obligation - PSO principles are the following:

- The regulation aims to oblige authorities to stop granting subsidies without control for the needs (the passenger transport) that can be satisfied solely by the market (the so-called profitable operators) and for the activities for which the market can ensure services at lower prices when applying the principle of open access and where there is a fair competition in place. These subsidies (but also the exclusive rights) are deemed to be sources of discrimination among operators.
- Only those needs that cannot be satisfied by the "strength of the market" (the so-called unprofitable transports), mainly due to the fact that they do not ensure profitable business, justify granting subsidies, however under the strict control and after the tendering procedure. Exempted may be passenger service obligation by rail so that Regulation 1370/2007 allows direct grant of the service contract on PSO.

Specific objectives and the concept of the new regulation are reflected in the following aspects:

- It is necessary to identify transport services in the general public interest and it is evident that an operator (or operators in another region) who is providing the service may not accomplish their own economic interest without compensation.
- Granting the competent authority (state, regional or city authority) the power to impose an obligation for an operator to provide such services (Public Service Obligation – PSO), which ensures the public interest protection.
- It is necessary to protect the commercial interest of operators in the way that PSO would get an appropriate compensation which is determined by specially defined methodology.
- It is necessary to protect the interest of the competition and the market principles so that the compensation granted to the operator must not be excessive, but to cover clearly and transparently presented costs of the provision of PSO and a reasonable (acceptable) profit, otherwise other operators (carriers) would be in an unfair position on the transport market;
- Mutual rights and obligations of the competent authority for the implementation of PSO and the operator must be defined by a CONTRACT.

The European Union regulated the system of PSO by Regulation No 1370/2007/EC, and pursuant to the said regulation the compensation for the provision of PSO amounts to [6]

$$C = C - E - R + RP$$

where:

C - means operator's operating costs of the provision of PSO,

E - *means* effects achieved by the award of the Contract on PSO,

R - *means* revenue from direct sale of tickets,

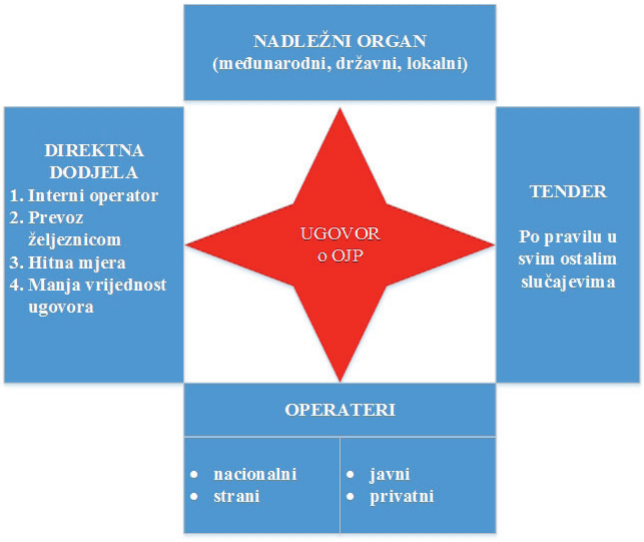
RP - means reasonable profit defined by the Contract on PSO.

It should be emphasised that a ten-year transitional period has been envisaged (until 2019), and all countries are obliged to provide the Commission with a progress report within the six months following the transitional period (2015). [2]

Competent authorities that can be local, state or even international award Contracts on PSO directly or through public tendering procedure (picture 2.3). In the case of a direct award of public service contracts, the competent authority shall make public the following information within one year of granting the award:

1. name of the contracting entity,
2. duration of the public service contract,
3. description of the passenger transport services to be performed,
4. description of the parameters of the financial compensation,
5. quality target (punctuality, reliability and other),
6. applicable penalties and bonuses,
7. conditions relating to essential assets.
8. PSO essentially means A CONTRACT ON PUBLIC SERVICE OBLIGATION. Regulation 1370/2007/EC stipulates the contents of the contract which must cover the following items:

- Precisely defined obligation of the transport that the operator should fulfil,
- Parameters and the methodology based on which the COMPENSATION shall be calculated,
- Arrangements for the distribution of costs and revenues
- Duration of the contract.



Picture 2.3 Principles of the award of a contract on PSO

Middle column:	**Left column:**	**Right column:**
COMPETENT AUTHORITY (international, state, local)	DIRECT AWARD 1. Internal operator 2. Rail transport 3. Urgent measure 4. Small value contract	TENDER As a rule in all other cases.
PSO CONTRACT		
OPERATORS		
national	public	
foreign	private	

In addition to these mandatory elements, the contract content may include: control over the execution of the contract – form and dynamic of reports, measures to penalise deviations from the contract, etc.

INTEGRATED PUBLIC TRANSPORT SERVICES

One of the most significant features of regional and suburban corridors is that PSO on these corridors is often provided by a number of operators providing different forms of traffic. In recent years, it has been a tendency that under such conditions the transport market is offered an integrated transport mode. The main aim of integrated system of PSO is to ensure, through united functioning of various systems, a higher level of the transport service quality and to increase accessibility of the region. [3]

Based on the definition of the integration of the system, PSO can be observed from three aspects, some authors consider these to be the minimum, namely:

- physical-network integration, which refers to the integration with several types of passenger transport;
- tariff, which presumes the use of a single ticket in vehicles of all operators that are taking part in the PSO;
- logical-informative, which refers to provision of full information to public transport users,
- in addition to the three above indicated integration levels, a "wider integration" is mentioned in relevant literature as the highest integration level.

PRINCIPLES OF PSO ORGANISATION IN EUROPE

Generally, most countries have effectively applied the legal EU framework for daily activities of their public rail services. Some other countries, dominantly the new EU Member States from Central and Eastern Europe apply this framework only formally. Although the EU, through the European Commission defined standards for this problem, passed unanimously adopted Regulation, it was obvious that harmonisation of rules may not be applied without taking into consideration the specific political and economic context of each Member State, which is the main reason for the existing set of differences in national legislation, mode and level of the application of the regulation and the models being applied. Analysis of the general situation of the application and organisation of PSO in the EU, in particular in the selected Member States was carried out on the basis of the document *CER (2011).*

SITUATION AND TRENDS IN EU MEMBER STATES

In the year 2011, these two models coexisted in the EU and both models allow development of the competition among the operators. In other words, these models do not exclude each other but they are complementary methods for the introduction of competition. The concept of regulated competition should be applicable to services requiring a contractual basis with the authorities due to the existence of PSO. The competition level in such regulated market depends on how effectively contracts are awarded. Competition is strongly developing throughout the EU and it is based on tenders and negotiation procedures. It is considered that this trend would continue, ensuring that the sensitive issue of financing the contracts is properly treated.

General framework for public services

Similar schemes for the organisation of public rail passenger services are applied in countries that were the subject of this research. There are three categories:

- public services provided solely at national level (central authority level),
- public services provided at regional and local level and
- public services provided through collaboration of national and local authorities.

Determination of the public service obligation requirements

Generally, public service obligation means "a requirement defined or determined by a competent authority in order to ensure public passenger transport services in the general interest that an operator, if it were considering its own commercial interests, would not assume or would not assume to the same extent (or under the same conditions without award)". In other words, the activity of the public transport service as rule is commercially unprofitable.

Regulation 1370/2007 provides a very general definition of public transport services: they cover the "services of general economic interest", under the condition that they are public and contracted on "non-discriminatory basis and continuously". However, national state authorities are free to decide which services fall under this category.

Main public service obligations that are currently required from the operators in the EU include:

- Tariff obligations covering tariff allowances for

certain categories of passengers. In certain cases the law leaves certain level of freedom to the operator to increase the tariff. In principal, limitation is that railroad companies may not increase their prices above the level determined by the authority;
- Service frequency includes services between big cities, during the peak times;
- Requirements relating to quality are explicitly included in the part relating to PSO or indirectly through the "Bonus-penal" system. This is a very important aspect of economic implication of the contract since quality has its price, so the price should be negotiated between the parties.

Quality requirement usually include:
- Punctuality;
- Booking of tickets/seats;
- Services for passengers with reduced mobility;
- Information to passengers at stations, on trains or general information;
- Requirements relating to the sale of tickets at railroad stations and on trains;
- Hygiene on trains;
- Number of unoccupied seats in peak hours and outside the peak hours;
- Attendance and appearance of the staff on trains;
- Characteristics of the rolling stock;
- Marketing possibilities of PSO / availability at certain level of tariffs;
- Reliability of the service –including efficient traffic of the planned train schedule and the obligation of substitution in the case of failure of the means of transport.

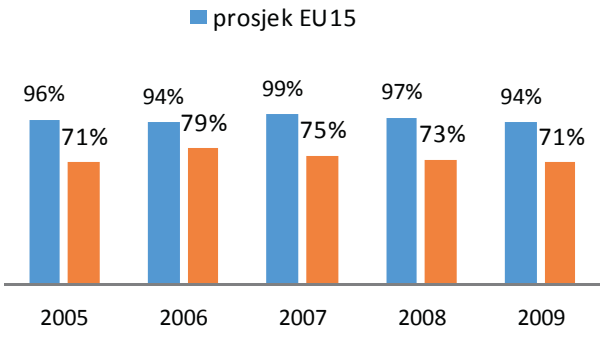
PUBLIC FUNDING OF - PSO

Financial aspect of the public service obligation is the essence of the problem, both from the business/economic and from the political perspective. Its content is dictated by the political decisions based on the national and/or decentralised social protection and the policy relating to environmental protection. In theory, these political objectives should be supported by an appropriate financial construction. Very often, short-term budget discretion has a significant impact on railway traffic. [4]

The main principle laid down in Regulation 1370/2007 is that costs incurred from public service obligation must be adequately compensated: no over-compensation or under compensation is permitted. These principles can be read in the said Regulation, and/or:

- This Regulation lays down the conditions under which competent authorities, when contracting for public service obligations, **compensate** public service operators for **costs incurred** and/or grant exclusive rights for the provision of the service (Article 1(1), paragraph 2).
- Public service contracts and general rules shall determine the arrangements for the **allocation of costs** connected with the provision of services (Article 4(1) c refers to "mandatory content of a public service contract and general rules").
- In order to avoid "pre-compensation" or under-compensation", quantitative financial effects on the network of the operator should be taken into consideration when calculating the net financial effect of the compensation (Annex indent 3).
- Public service costs **must** be balanced with the operating costs and compensation paid by competent authorities.

The gathered data indicate that in practice too many countries still under-compensate the public service obligation - PSO. The data presented in the picture 3.1 shows that on average only 71% of net costs connected with PSO were compensated by the competent public authority in Central and Eastern Europe in the year 2009. Even in EU15, where it is often assumed that operators are paid full compensation for the provision of the public service, data has shown that this is not the case. In the year 2009, on average 94% net costs that are connected with the provision of the public service obligation was compensated by the governments of EU15. It should be recalled that the year 2009 was the year when public budgets were quite tight due to the economic crisis.



Picture 3.1 Average public compensations in EU15 and EU13 (% in differences between the costs and revenues from the sale of tickets)

The question of a "reasonable profit" is also very significant, but it is not clearly determined in Regulation 1370/2007. It obviously depends on the degree of risk faced by an operator, and in practice it should be the subject matter of negotiations between the parties. "A reasonable profit" is envisaged in most contracts.

The problem of under-compensation

The data indicate the public service obligation in EU is not adequately compensated which has brought unacceptable losses which made the operators to take

short-term loans. 70%-75% of the loss suffered by the operators at this moment is being compensated by competent authorities in referent countries. This turns into a significant deficit: one country has stated the deficit of about 100 million € per year. Financial pressure caused by the economic crisis reduced the available resources in the public budgets. The result is that ministries in the countries of Central and Eastern Europe have reduced their budgets for public service contracts for about 50%, without any reduction of the level of the service required by the governments.

The phenomenon of under-compensation has many negative implications to the operation of an operator, but also to the organisation and implementation of the public service obligation system – PSO, out of which the following are most important ones:

- **Certain obligations are only implicitly and not explicitly required by competent public authorities:** railway companies sometimes continue providing the services that are not covered by the service contract concluded with competent public authorities in anticipation of political problems in case they cease to provide the services,
- **Compensation through commercial revenues**: losses are compensated through the allocation of revenues from rail freight to passenger public transport, which may affect the commercial sustainability of freight traffic. While this could be the commercial choice of healthy railways, it is not in accordance with the law if it is imposed by a competent public authority or where inactivity of the authority leaves no choice to the railway company concerned,
- **Quality implications**: railway companies, in particular but not limited to the new member states, suffer from a chronic inability to renew their rolling stocks. Average age of the rolling stock that is used for the public transport services in new member states is 30 years, which tells the passengers enough about the quality of the service.
- **Low availability of the rolling stock:** establishment of a rolling stock is expensive to manage because of running malfunctions and spare parts shortage. This is reflected in the offered capacity.
- **Change of the type of transport:** low reliability and quality of the service result in the change of the type of transport to environmentally worse types, such as road transport.
- **Competitiveness:** all above stated difficulties are reflected in the general competitiveness of railway companies in relation to new providers of the service or to those undertakings that receive an adequate compensation.

Any tendering procedure for the provision of the public service for which it is clear in advance that it would be under-compensated cannot be successfully carried out in any possible way. [5] The tendering procedure may be finished formally, but positive effects of the tender for the market may occur only when there is more than one offer. From economical point of view there are obvious solutions to this problem.

PUBLIC SERVICE OBLIGATION – PSO PRINCIPLES IN THE REPUBLIC OF SRPSKA

Under the current conditions, when it comes to PSO, the most usual forms of service are suburban bus lines that do not fall under the competences of local authorities, but under the competence of the Ministry of Traffic and Communications. Pursuant to actual regulation, the Chamber of Commerce has been entrusted the role of an arbitrator. With regard to the current method of registration of lines and timetables in the territory of the region (municipality) and/or given that passenger transport is "de facto" managed by operators (carriers), the option of the impact of the local self-government (municipality) to ensure for their citizens a functional and quality transport are very limited or even generally disabled.

Naturally, the function of the public transport may not be privatised, but for the execution of the function, as a public service, the responsibility lies on each unit of the local self-government.

Establishing legal frameworks and normative regulations of the activity of passenger public transport requires determination of the subjects or basic holders, who define the interaction between the **public transport function** on one hand and the **operator carrying out the transport of passengers** on the other hand. **The public transport function** presumes determination of legal regulations and procedures, which enable the establishment of transport system that would meet the needs of the process of social reproduction and all the needs in daily functioning of citizens. However, it should be emphasised that the actual legislation in the Republic of Srpska, even in BiH, do not allow implementation of the stated necessary requirements for the establishment of an efficient and satisfactory transport system.

Passenger transport presumes the full realisation of the scheduled timetable on the entire network of lines. It is clear that the function of the public transport has an accentuated social (holistic) character in the process of social reproduction, first of all the local self-government since the urban and suburban passenger public transport in its essence must be functional in the space and the time, and efficient in the peak time. Requirements so defined are contrary to cost-effectiveness and profitability. Therefore, a functional public transport that is not cost-effective and profitable contributes

the development of self-government to a much greater extent than the amount of resources for subsidising a part of the costs not covered from revenues from the tariff.

The existing concept of the urban and suburban public transport on territories of the local self-governments is left to sole interests of the operators. In order to create preconditions to change the current conditions and move a step forward towards a better transport system from the aspect of passenger transport many changes should be implemented, first of all in legislation (Law on passenger transport by road and in Regulation on harmonisation and registration of timetables).

One of the main obstacles for the improvement of PSO on the territory of a certain local self-government is in that the existing legislation does not allow a change of a route line and its length, as well as the inability of making a comprehensive proposal for a network line by the local-self-government. A more significant improvement of the offer and the quality of the service would be achieved by such a comprehensive proposal for the network lines and timetable implemented in the territory of the local self-government and the competent authority commission (chambers of commerce) should harmonise with the same comprehensive proposal of neighbouring local self-government units.

However, the existing Regulation takes into account, first of all, a mutual harmonisation among operators/carriers whereby it is presumed that operators would propose the lines which they evaluate to be profitable.

Simultaneous planning and defining the network of local and regional lines result in that there is no meaning and need to introduce any protected times. The protected times in the current state of things have not brought any good results, since the public transport is not carried out after the registered timetables which means that operators "protect" themselves on their own in the manner that they do provide all of their registered departures[2]. Limited length of lines cause numerous disadvantages when it comes to the technology and organisation of PSO, which first of all refers to: unsustainable transport organisation, poor utility of infrastructure facilities, disabling safe and functional change for passengers from one line to another, impossibility of using several lines with changes, impossibility of changing the traffic regulation, incompatibility with other traffic sub-systems, etc.

The competence of regulatory bodies (chambers) is not in the function of consistency of the network of lines but of protecting the formal boundaries of municipalities. This illogical thing should be corrected by amending and modifying the two Regulations so that true needs/demands are harmonised between the unit of the local self-government and the competent body authorised by the Ministry, and only after that ensure harmonisation among the operators (*Simeunović 2010*). The aim is to achieve the main purpose of harmonisation of timetables in order to achieve maximal satisfaction of citizens and passengers so that the local self-government units and competent authorities could manage the functional process among different sub-systems of the public transport, which has become a mass phenomenon in the developed EU states and the world, and that is missing today in the public service obligation system – PSO in the Republic of Srpska and Bosnia and Herzegovina.

Local self-government (actually, this is about municipalities) adopt, as a rule, Regulations on subsidising the costs of transport of regular pupils of primary and secondary schools in their respective territories. This regulation lays down general and special requirements that subsidised participants must meet, namely:

1. General requirements

- that they are registered as regular students of primary or secondary school which is in the territory of the subject municipality,
- that the distance between the departure station and their school is above 4 km[3],
- that they commute to school every day either to attend classes or practical teaching.

2. Special requirements (not applicable in all municipalities)

- that they come from families whose members (parents, brothers, sisters) receive financial support,
- that they come from families whose members (parents, brothers, sisters) receive care allowance and assistance from another person or a group,
- that they are classified in the category of children with special needs,
- that they come from families with more than four children.

The contract determines: the number of departures, departure time, traffic route and the amount of monthly fare. In most cases, this transport is provided only on working days. Some municipalities provide incentives for the transport carried out only on lines and routes/distances where there are no interested passengers for the registration of the respective municipality lines. Contracts are concluded for each school year on the basis of personal requests and at the requests submitted by respective local community.

The Department of Economy, Finance and Social Affairs in each municipality is responsible for the implementation of these Contracts, as a rule, and those

[2] Excuses are different, usually absurd and unacceptable, such as non-existent failures and fuel shortage.

[3] This distance is commonly applied, but the distance is not uniformly determined so that municpalities decide at their discretion.

departments establish a Commission to analyse the demands for the transport of pupils and the commission is obliged to monitor the realisation of the public service obligation – PSO provided by operators as well as to control invoices arising from the service provision.

When it comes to secondary school pupils, the municipalities, in accordance with their budget facilities, may pass a Decision to subsidise the costs of transport of special category pupils referring to the following:

- secondary school students, category of socially vulnerable families and single parents,
- secondary school students from the families of war invalids falling under the category I to IV, families with more than four children living in the territory of the given municipality who attend the school as regular students in other municipalities, provided that the courses they study are not provided by secondary schools in the territory of the municipality,
- students that come from families of fallen fighters and belong to socially vulnerable families who attend the school as regular students in other municipalities, provided that the courses they study are not provided by secondary schools in the territory of the municipality.

The above presented system of subsidising the public service obligation refers exclusively to transport by bus. Subsidising of passenger transport in the above indicated method, or in any other form does not exist. The Railway Company, Željeznice Srpske (ŽS) receives financial aid from the budget which is divided between both undertakings and the infrastructure and the operation (this implies passenger and cargo transport). Some special methodologies based on which compensation level is determined and the obligation of an undertaking providing passenger transport services are not being applied. ŽS are obliged to deliver annual report on the operation and/or the achieved revenues, on one hand, and on costs of the operation, on the other hand. It should be emphasised that there is no clearly expressed and defined methodology by means of which costs of an operation are determined.

CONCLUSIONS

The Regulation 1370/207, the repealing Regulation 1181/69, has resulted in the application of new principles of PSO in the passenger public transport system. This Regulation clearly and unambiguously determines the Public Service Obligation – and the Public Service Compensation. The European Union has regulated by the new system of PSO the compensation for the provision of PSO, in principal the problem of non-profitable service of the local, i.e. suburban or regional passenger transport has been resolved.

Regulation 1370/2007/EC lays down mandatory content of public service contract that includes the following items:

- Clearly defined public service obligation which the public service operator is to comply with,
- The parameters and methodology on the basis of which the compensation payment is to be calculated,
- Update and distribution of costs and revenues,
- The duration of the contract.

This paper obviously shows that it is necessary to provide a rational selection of criteria for the model solutions to the problem of under-compensation of operators for the provision of passenger transport service. It is necessary to allow comparisons of the variants of the solution to the problem of under-compensation to the operator, whereby the existing differences in the size of operators, economic power of the state (region), number of inhabitants, network infrastructure development etc. are not taken into account. This means that it is necessary to ensure that the value criteria includes an acceptable imprecision in the form of a total error, which would ensure reliability of results. The selected criteria should cover the entire field of occurrences, i.e. their identification should ensure the selection of those criteria that substantially affect the selection of the most favourable variant. The result of the selection of these criteria mostly affects the output results of the model applied to evaluate the balance sheet of the operation of the operator providing passenger service, i.e. operating costs are reduced and revenues from the sale of tickets increase.

From all the above stated it becomes clear that public service obligation – PSO is not fully implemented. Hence it is necessary to undertake some of the following activities to ensure that the model of integrated system of passenger service obligation is in place and/or implemented in practice:

- Conduct a study of the system and feasibility study,
- Take a comprehensive survey of potential passengers with special review of the employees, students and in particular motorised population with the aim of knowing the conditions for the transition to the public service obligation system.

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PROFESSIONAL PAPER

RSI implementation in the countries of the region

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Abstract: As early as 2001, the Europeen Commision expressedin its White Book the need for assessing the impacts on road safety and conducting road traffic safety inspections with the aim of reducing the number of fatalities in car crashes from 2001 to 2010. In this context, the Directive 2008/96/EC on road infrastructure safety was issued. The purpose of this Directive was to ensure higher level of traffic safety during all phases of the road life cycle, from its planning, designing, constructing to the maintanance of the road already in operation.

The said Directive requires for procedures relating to the Road Safety Impact Assessment (RSIA), Road Safety Audit, Network Safety Management (NSM) and ranking of high accident concentration sections (Black Spot Management) and Road Safety Inspection (RSI) to be established and implemented.

This paper aims at showing the current state of affairs in countries of the region with regard to the implementation of the road safety inspections.

The results of this paper will provide the scientific and expert public with insights into the state of trafic safety of the region's countries with regard to Road Safety Inspection.

Key words: inspection, road, traffic safety.

INTRODUCTION

In 2001, the European Commission in its White Paper titled „European policy for 2010: time to decide" expressed the need for assessing the impacts on road safety (hereinafter referred to as: RS), and carrying out road safety inspections with the aim of reducing by 50% the number of fatalities in road accidents for the period 2001-2010. As proposed by the Commission, the European Parliament and the Council adopted the Directive 2008/96/EC on road infrastructure safety management [1].

The purpose of this Directive is to ensure that the appropriate level of RS is maintained during all phases of the road life cycle, from its planning, designing, constructing to the maintanance of the road already in operation.

This Directive applies to the roads forming part of the Trans-European road network but excluding tunnels that fall under the scope of the Directive of the European Parliament and the Council 2004/54/EC on minimum safety requirements for tunnels in the Trans-European Road Network (the Directive 2008/96/EC, point 5). One of measures adopted in this Directive in relation to increasing the level of road safety is the introduction of the Road Safety Inspection (RSI).

Road Safety Inspection is the study of an existing road or a section of road to identify any deficiencies that may lead to road accidents [14]. Numerous studies have confirmed the role and importance of RSI implementation with the view of reducing the number of road accidents and increasing the level of RS ([3], [6], [10], [4], [5]).

ROAD SAFETY INSPECTION

British traffic engineers were the pioneers of road safety inspection and first started, as early as 1980s, to carry out road safety inspections. However, the concept of road safety audits is much older. It reaches back as far as the 19th century, when military rail engineers were ordered to look into frequent rail accidents. Based on their discoveries and recomendations some changes were made in order to prevent similar accidents from happening in future, and the inspections became mandatory with respect to all railroads before their putting into service. The procedures developed in Great Britain during 1980s, were adopted by many other countries worldwide. Thus, in 1990s Australia, New Zeland and the South African Republic started to carry out inspections, while in Europe, the example first set by Great Britain was followed by Denmark, Island and Norwey. In the late 1990s, a large

number of countries began to show interest in conducting inspections, among others Austria, Canada, France, Germany, Spain, the USA, etc. [9].

The Directive requires member states to introduce and implement procedures relating to [13]

- Road Safety Impact Assessment (RSIA),
- Road Safety Audit (RSA),
- Network Safety Management (NSM), and Ranking of high accident concentration
- sections (Black Spot Management), and
- Road Safety Inspection (RSI).

Road Safety Impact Assessment (RSIA) and Road Safety Audit (RSA) are carried out during the phases of road planning, designing and puting into service, while the Network Safety Management and Ranking of High Accident Concentration Sections and the Road Safety Inspection are conducted on roads already in use. It is important to note that the cost-benefit ratio is inversly proportional to the road use time variable, that is to say the highest effects with the lowest costs are possible during the phases of planning and designing of roads.

Road Safety Inspection (RSI)

RS Inspection is a preventive tool to reduce the number of road accidents and consequences thereof through identification of deficiencies of a road and the surrounding area. According to Rune Elvik, road safety inspection is a systematic check of existing roads in order to identify hazardous points, and it promotes measures to deal with this issue. This process is carried out on existing roads according to the set methodology. RS inspection results in the preparation of the report on detected road hazards and road safety deficiencies, to which the client (road managing company or road authority) must provide response. RS inspection is not just the assessment on whether the standards relevant for existing roads are applied properly, but rather represents an comprehensive review of the state of play and potential problems existing on roads by observing it from the perspective of different traffic participants. Thereby, appropriate solutions to eliminate or at least to reduce road safety problems are suggested taking into consideration the needs of various traffic participants.

RS inspection must be carried out when:

- a road, a section of a road or an intersection is identified as dangerous, for example: according to the accident database or iRAP,
- there are other information about serious safety problems on a road, a section of a road or intersection given by the Police, Road Maintanance Unit, local administration etc.,
- a reconstruction or rehabilitation is planned in the near future,
- it is due according to the RSI time schedule.

The Client and the Inspector participate in the RS inspection. The Client, typically an organisation responsible for road management (road manager), orders the RS inspection. The Client delivers the required documents to the Inspector who then reviews and analysis them in detail in the office and after that conducts a field study, detects problems and prepares a report on RS inspection and proposes measures to be taken.

Not every detected problem must be covered by a proposed measure, nor the proposed measure binds the client to proceed according to it. The Inspector delivers the report to the Client who is required to provide written statement on measures accepted and rejected along with reasons behind such decisions. The Client is required to provide neccessary funds and other resources needed for the implementation of the accepted measures and to start implementation thereof as soon as possible.

RS Inspection is conducted by an independent expert team. The team has the task to review all the influence elements of a road (alignment, change of curve radius, width of cariageway, condition of carriageway, sight distance, etc.), that could directly or indirectly cause a road accident. The team must be disciplinary and composed of several members in order to minimise and, if possible, eliminate the subjectivity. In order to ensure an efficient field inspection and adequate selection of measures, the RS inspection should be conducted by highly experienced and well trained RS experts. The experience of the team is very important when it comes to making an assessment of the importance of detected problems and the selection of measures which will be the most effective in relation to the invested resources. It is very important that the RS inspection is conducted objectively. PIARC suggests a team consisting of a team leader, team members, specialist advisors (if needed), and observers.

When conducting the RS inspection, the team uses checklists which serve as a reminder to record problems detected during the check of a particular section. The RS inspection must take into consideration the following elements: time of inspection (day or night), seasonal variations (sun, snow, rain, ice, fog), and site specific matters (road passes near school, supermarket, etc.).

In order to identify hazards with certainty, the RS inspection should be conducted both by vehicle and on foot, and covering both traffic directions. The identified problems are broken into eight groups: function of a road; cross section; alignment; intersections; public and private services, service and rest areas, public transport; vulnerable road users; traffic signs, markings and lighting; roadside features and passive safety installations.

Function

This part defines the category of a road, does the road passes through cities or built-up areas, what types of vehicles are using the road and what is the percentage of certain categories' participation in traffic, are speed limits appropriate, what type of traffic generally prevails

(transit, local or mixed), and whether the road is being used by vulnerable road users (pedestrians, cyclists etc.)

Cross section

This part checks the width of a road and the width of traffic lanes, surface conditions, existance and width of shoulders, crossfall of carriageway, existance and width of separate lanes for cyclists/pedestrians.

Alignment

With regard to the alignment, it is important to determine whether there are horizontal curves and their number, the condition of vertical curves as well as are there adequate sight distances.

Intersections

In addition to road intersections, this part analyses and defines the condition of accesses to private properties as well as railway crossings condition, that is the intersection where railway line crosses a road.

Public and private services, service and rest areas, public transport

This part examines whether there are access roads to service and rest areas, schools, hospitals, supermarkets, restaurants, parking lots, loading and unloading facilities, etc. Likewise, it is necessary to look into the state of play with regard to public transport on the observed section as well as to check the location of bus stops.

Vulnerable road users

RS inspection includes the safety check of vulnerable road users, that is pedestrians, bicyclists, scuter-moper drivers and motorcyclists. In case there are no separate lanes intended for the use of vulnerable road users, it is necesarry to determine, based on the percentage of vulnerable road users who participate in traffic and those who get fatally injured in road accidents, is there a need to build such lanes or this category of road users can be protected by implementing some other measures.

Traffic signs, markings and lighting

This part includes the analysis of the state of play with regard to the horizontal and vertical traffic signals. It is checked whether the signals are legible, clear and visible both during the day and at night. Also, checks on the number and position of traffic signs, as well as checks on lighting conditions on roads or road sections are carried out.

Roadside features and passive safety installations

The issues that may arise in relation to the road surrounding include deep channels, high guardrails or cuts, foliage, trees or other objects located in the immediate vicinity of roads. Also, the elements of passive safety installations shuld be checked as they may pose a road safety risk (for example: incorrectly placed quardrails) [14].

RESULTS

Bosnia and Herzegovina

The Law on Fundamentals of Traffic Safety on Roads in Bosnia and Herzegovina [7] defines the term "road safety inspection" as the procedure for independent safety checks on existing public roads. Furthermore, the Law stipulates that the existing roads, in order to comply with the road safety requirement, must be subjected to the road safety inspection system by the competent road authorities. Also, envisaged to be adopted is an act of secondary law which will set out the basic requirements to be complied with by roads, their elements and facilities in terms of road safety, road safety audit and road safety inspection. To date the said act has neither been drawn up nor introduced.

The situation is significantly different when it comes to the RS inspection system implementation at the Entity and BiH Brčko District level, and, in particular, in case of the Republic of Srpska. Thus, the Law on Fundamentals of Road Safety in the Republic of Srpska [8] stipulates, inter alia, that in order to improve road safety a system of mandatory and independ safety checks of the existing public roads shall be put in place. Furthermore, the Law requires existing public roads to undergo compulsory safety checks aimed at preventing road accidents and identifying deficiencies that could affect safe traffic performance. The checks shall be mandatory with respect to main and regional roads, and also in the case of other public roads and streets in built-up areas, if needed. The checks shall be caried out by an independent licenced legal entity or natural person, who may not be involved in the process of managing the roads undergoing checks. The Traffic Safety Agency of the Republic of Srpska is in charge of licensing legal and natural persons. Also, the Law envisages the adoption of the secondary legislation, namely the Rulebook on Audit and Inspection and the Requirements and Manner of Licencing.

The Rulebook on Audit and Inspection and the Requirements and Manner of Licencing [10], sets forth the requirements and courses of action with regard to road safety audit, road safety inspection, the requirements with respect to duties of the road safety auditor and inspector, the procedure of licencing and monitoring over the work of road safety auditors and inspectors, the database, as well as valid lists of road safety auditors and inspectors.

The Rulebook prescribes that the RS inspection is a formal and independent assessment of an existing road safety made by an independent expert or a team. Further, the RS inspection is a preventative measure consisting of regular and systematic safety checks conducted on existing public roads, and covering the whole road network.

Road safety inspection can be:

a. periodic-which means the inspection of traffic signalization, the road and the surrounding, carried out every two years on international roads, motorways and expressways and every five years on main, regional and local roads; and
b. targeted-which means the inspection of road sections with the highest level of traffic risk.

According to the information available at the official website of the RS Agency for Traffic Safety [15] as seen on 02.06.2016, currently there are 20 natural persons and 6 legal entities that are licenced to perform road safety inspections. It is important to note that there are no offical information about road safety inspections carried out on public roads of the Republic of Srpska in the period following the adoption of secondary legislation, that is July 2012 onwards.

As for the Federation of Bosnia and Herzegovina and BiH Brčko District, no primary or secondary legislation has been adopted to regulate more closely the road safety inspection on the existing roads. Also, there are no official information on whether the existing roads are subjected to road safety inspection.

The Republic of Serbia

In the Republic of Serbia, the Law on Fundamentals of Road Safety stipulates that a public road manager shall ensure independent road safety inspection projects, as follows: periodic inspections in every five years for all sections of national roads, targeted inspections for the most dangerous sections of national roads and periodic and targeted inspections for other roads, if possible and needed. Also, the Law stipulates the adoption of secondary legislation which shall, inter alia, define requirements for road safety inspection. It shuold be also noted here that there are no information on whether the said legislation has been introduced in the meantime. Likewise, there are no official information on whether and to what extent the existing roads are subjected to the road safety inspection.

The Republic of Croatia

In the Republic of Croatia the terms inspection and auditor-inspector have been incorporated into the Law on Roads. In compliance with the Law on Roads, the audit of the project and other documents, within the Trans-European Road Network safety assessment is carried out by a road safety auditor. The road safety auditor is required to hold a certificate issued for a period of five years, and also the Register of Certified Auditors is provided for by the Law.

Meanwhile, in early 2016 The Rulebook on Road Safety Infrastructure Audit and Road Safety Auditors Training was adopted [12].

This Rulebook prescribes the procedure and scope of road safety audit activities, working experience and professional qualifications of road safety auditors, certification procedure, auditor training and aptitude test programme, additional training programme, the content and manner of keeping the Register of Certified Auditors, auditor report preparation procedure and the procedure for calculating road safety audit activities fee.

It is important to note that the Rulebook concerned applies only to the road infrastructure safety audit from the aspect of planning and construction of new roads or reconstruction of existing road network, and review of existing roads during the initial period of use. No secondary legislation has been introduced to regulate road safety inspection of existing roads. Also, there are no official information on whether and to what extent the existing roads are subjected to the road safety inspection.

CONCLUSION

On the basis of analysis of the road safety inspection implementation status in Bosnia and Herzegovina and the region's countries, that is, Serbia and Croatia, it can be said that the Directive has not yet been fully implemented. That is to say, with the exception of the Republic of Srpska, in the Federation of BiH, the BiH Brčko District and in Serbia and Croatia, there are no natural persons nor entities that are licenced by the competent authority to carry out road safety inspection. Also, notwithstanding the above, there are no information on whether and to what extent the existing roads are subjected to the road safety inspection. In view of the foregoing the guestion of road safety inspection at the level of local self-government arises.

The importance of road safety inspection is reflected in that it, as the last phase of a proactive activity, makes it possible to eliminate detected road deficiencies so that road accidents do not occur at all. The level of road safety is directly related to conditions prevailing on roads. The detailed analysis of the road influence elements identifies road deficiencies and suggests measures to increase the level of road safety, by applying the criteria of time scale and needed financial resources. This way, the number of accidents and the magnitude of consequences thereof are being reduced, thus directly achieving positive ratio between the resources invested in road safety inspection and the implementation of measures on one side and the potential costs which would be incurred by the road accidents on the other. This is the major benefit accrued from road safety inspection.

In view of the foregoing, and having in mind the worldwide experiences of road safety inspection effects and benefits, the status of road safety inspection in BiH and the region's countries, as well as the road network condition, it would be necessary for both, republic and local authorities to understand and recognize the benefits of road safety inspection and to start implementing this measure without delay in order to produce, as soon

as possible, results which would bring benefits.

Namely, there is a large number of measures proposed on the basis of road safety inspection which do not require substantial funds and with a short implementation period suggesting that the improvement may be brought about very quickly. Basically, there are two main strategies for the implementation of road safety inspection; actions pursued from a local level towards a national level and vice versa. Since the local community roads share in the overall traffic network is considerable, significant progress towards road safety improvement may be achieved by taking an approach from the the local level-local authorities responsible for road management, to the national level. Namely, a lot of parties in each local community may, by using collective influence, put „the pressure from the bottom".

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PROFESSIONAL PAPER

Application of Advanced Communication Technologies in the Improvement of Traffic Safety

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Abstract: Incorporation of advanced info-communication technologies into vehicular environment currently captures a large attention by numerous investigators, telecommunications operators, traffic safety regulatory institutions, car industry manufacturers and other interested participants. In this paper, we overview of some prospective wireless communication technologies, such as the DSRC (Dedicated Short Range Communications) and advanced LTE (Long Term Evolution) mobile communication systems, which are considered as two promising candidates to support future traffic safety applications in vehicular environment is presented. The communication requirements of some active traffic safety applications are pointed. A summary of various types of communications for intelligent VCS (Vehicular Communication System) applications is given. Some future directions and challenging issues for implementing traffic safety applications are also discussed. Our goal is to demonstrate the growing impact and importance of modern communication technologies in achieving future traffic accident-free roads.

Keywords: Traffic safety applications, vehicular communication system (VCS), dedicated short range communications (DSRC), LTE (Long Term Evolution) mobile cellular network, vehicle-to-everything (V2X) communication.

INTRODUCTION

The increasing number of vehicles on roads results in a greater number of traffic accidents with more and more injured and dead persons causing also huge financial costs. To improve traffic safety and consequently reduce the incurred costs, beside the traditional methods it is necessary to apply new and more sophisticated approaches. Rapid technological transformation that occurred during the last decade in automotive industry supported by an accelerated development and convergence of information and communication technologies (ICT) enable that the increasing number of vehicles are becoming nowadays connected to the Internet and to each other enabling the futuristic IoV (Internet of Vehicles) idea to be practically feasible [1]. The IoV concept of inter-connected vehicles is considered as a promising approach to improve traffic safety and save human lives.

The majority of modern automobiles are becoming equipped with numerous electronic sensors and devices enabling various advanced driver assistance systems. Furthermore, contemporary OBUs (On-Board Units) installed in vehicles are equipped with a number of communication interfaces, which enable information exchange between devices inside the vehicle, direct communications between vehicles V2V(Vehicle-to-Vehicle) as well as communications between vehicles and infrastructure equipment or RSUs (Road Side Units) in form of V2I/R (Vehicle to Infrastructure/Roadside). This offers drivers the ability to receive various useful data about current traffic environment (e.g. potential hazards, accidents, road or weather conditions etc.) as well as numerous driving information (such as the current vehicle position, velocity, acceleration etc). Based on such data, the OBUs are able to make intelligent (cooperative) decisions and adapt vehicle movements to the current traffic road conditions or to keep away vehicles from probable accident. By exchanging traffic related information between vehicles in real-time, road safety could be significantly improved.

Active traffic safety applications are based on possibility to avoid probably incident situations (such as collisions, slow moving or poorly visible vehicles, unexpected obstacles on roads, etc.) by alerting drivers promptly about such situations in their neighbourhood. Recent studies show that up to 82% of all traffic incidents could be prevented by implementing active traffic safety applications [2]. Besides V2V and V2I/V2R communications, which allow drivers to be informed about possible incident situations on roads, current massive usage of mobile smart phones opens an additional opportunity to make direct interactions between vehicles/drivers and pedestrians (V2P, Vehicular to Pedestrian) so as to prevent their possible mutual incidents, which is frequently the case on urban streets or crossovers. The forthcoming concept of human to vehicle cooperation, which includes communications between vehicles/drivers, roadside

equipment and pedestrians is known as cooperative vehicle infrastructure system (CVIS) [3] or C-ITS (Cooperative Intelligent Transportation Systems) [4].

Beside the vehicle safety applications, drivers could also access to different information services and passengers could employ various multimedia entertainment applications using the V2N(Vehicle-to-Network) type of communication. It is expected that progressively more vehicles in near future will be connected using heterogeneous communication types, such as V2V, V2I, V2R, V2P, V2N etc. To cover such broad range of communication in vehicular environment, the term Vehicle-to-Everything (V2X) is commonly used [5]. However, interconnecting ever-increasing number of vehicles will generate rigorous requirements from telecommunication network infrastructure to support various future intelligent traffic applications [6]. The crucial issues for implementing traffic safety application assume fast (on-line) data acquisition, low communication latency, high reliability of data transmission, as well as high security and privacy of communications. Recent development and implementation of traffic safety applications enabled by advanced VCS (Vehicular Communication System) technologies currently capture large attraction by numerous academic researchers, making manufacturers and consortiums in automobile industry, telecommunication operators and service providers, regulatory institutions consider traffic safety and other interested participants. Numerous research projects related to vehicular networking in Europe, USA and Japan have been completed during last few years [6]. In addition, the international harmonization of standards for vehicular networking currently occupies huge attention [7].

TYPES OF COMMUNICATION IN VEHICULAR ENVIRONMENT

Recent advances of various wireless communication technologies enable different types of communications to be used in vehicular environment [8-13]. The VCS communications could be broadly classified into following wide categories:

- infrastructure-less (or *ad-hoc*) communication,
- infrastructure-based communication, as well as
- hybrid communication, which integrate both types of communication.

Infrastructure-less communications is implemented over self-organized *ad-hoc* communication networks, spontaneously created from near-by moving vehicles in mesh configurations without using any pre-installed infrastructure equipment. They are also known as VANET (Vehicular Ad-hoc NETwork) [8]. VANETs are highly suitable to be utilized for a broad range of traffic safety applications primarily due to its ability to provide direct V2V communication, which contributes to much lower latency compared to an indirect transmission via infrastructure based networks. In addition, VANETs could be also used for non-safety applications, such as those related to traffic efficiency (congestion control) and various comfort/infotainment applications intended for passengers [9].

V2V communication could be implemented as single hop or multi-hop communications. Single-hop communication is are established between nodes (vehicles) located in the vicinity, i.e. within the line of sight (LoS), while multi-hop communications could be used between more distant vehicles. In the latter case, a vehicle that is currently positioned between two distant vehicles behaves as a relay station, i.e. it receives the messages from near-by vehicle(s) and re-transmit them to other vehicles, which are currently in its LoS area. In such a way, using the relay transmission mode, a multi-hop communication could be established between distant vehicles, which are even much more away than the LoS range. However, to maintain the permanent communication between vehicles which are not in direct LoS, it is necessary to exist always at least one intermediate vehicle which is mutually in the LoS visibility to other vehicles. Hence, multi-hop communication could be used to increase the communication range outside the LoS and enable information dissemination in wider geographical areas.

Infrastructure-based communication (V2I) is realized over previously built communication infrastructure, such as the mobile cellular networks or dedicated communication networks based on RSUs to provide V2N or V2R communication. Unlike *ad-hoc* networks, all tipes of communication in infrastructure networks are realized using multiple network segments (such as the uplink and downlink transmission links in access network and transmissions over core network), which could significantly increase the communication latency compared to direct V2V communication. This is currently the main constraint of V2I communication to support time-critical traffic safety applications.

VEHICULAR TRAFFIC SAFETY APPLICATIONS

Traffic safety applications for vehicles are focused on decreasing the probability of accidents between vehicles. Such applications are based on transmission of safety warning messages to vehicles/drivers about various possible incident situations, such as the collision avoidance, lane changes, overtaking vehicle warning, emergency electronic brake lights, emergency vehicle warning, wrong way driving warning, stopped or slow moving vehicle warning, traffic condition warning, hazard warnings etc. [6].

A robust wireless communication network is required to enable traffic safety applications. The most significant network requirements for traffic safety applications include following [6,11]:

- traffic safety messages should have maximum end-to-end latency of 100 ms,

- messages generation frequency is up to 10 messages per second (10Hz),
- messages should be transmitted accurately on short to long coverage distances (300 m up to 20 km),
- low data rates are usually required (1 to 10 kb/s).

In addition, some other network requirements should be fulfilled for implementing traffic safety applications, such as the following [4]:

- high communication reliability (10-x): express a maximum tolerable packet loss ratio (PLR), for example, with PLR=10-5 (only one packet from 100 000 received packets is not successfully received within the maximum tolerable latency) the reliability is as high as 99.999%.
- high node mobility (km/h): maximum relative speed under which the specified reliability should be achieved,
- high network density (vehicles/km2): maximum number of vehicles per unit area,
- high positioning accuracy (cm): maximum positioning error tolerated by the application,
- high security: specific security features required by the application.

Table 1 illustrates specific communication requirements for some traffic safety applications [13]. To meet stringent requirements for traffic safety applications, VCS system designers are faced with serious and challenging issues that need to be carefully addressed.

Table 1. Communication requirements for some vehicle safety applications [13]

Safety application	Communication mode	Security/ reliability	Minimum messages frequency	Maximum latency
Emergency electronic brake lights	Time limited periodic broadcast on event	High/high	10 Hz	100 ms
Emergency vehicle warning	Periodic triggered by a vehicle mode	High/high	10 Hz	100 ms
Slow vehicle warning	Periodic triggered by a vehicle mode	High/high	2 Hz	100 ms
Wrong way driving	Time limited periodic broadcast on the event	High/high	10 Hz	100 ms
Stationary vehicle warning	Time limited periodic broadcast on the event	High/high	10 Hz	100 ms
Traffic condition warning	Time limited periodic broadcasting	High/high	1 Hz	100 ms
Roadwork warning	Temporary broadcasting on the event	High/high	2 Hz	100 ms
Overtaking vehicle warning	V2X cooperative awareness	High/high	10 Hz	100 ms
Lane change assistance	V2X cooperative awareness	High/high	10 Hz	100 ms
Pre-crash sensing warning	Broadcast of pre-crash state	High/high	10 Hz	50 ms

PEDESTRIAN TRAFFIC SAFETY APPLICATIONS

Probably the most attractive traffic safety application in vehicular environment relates to the collision avoidance between automobiles and pedestrians, as well as cyclist and motorcyclists. It is particularly attractive to be used in large cities with streets crowded by pedestrians/cyclists. As a result of massive usage of modern smart mobile devices by pedestrians, as well as due to extensive implementation of Wi-Fi interfaces in modern vehicles, it will be possible to establish direct communications between vehicles (drivers) and pedestrians (V2P) and thus to prevent their potential collisions. The traditional way of warnings between pedestrian and vehicles by sirens become inefficient nowadays taking into account that pedestrians are now more focused on their mobile phones than to the neighborhood traffic situations. Furthermore, they usually use the headphones while listening the music or making the conversations with other people and consequently don't hear or register the sound warning signs emitted by vehicle drivers. Hence, implementing of V2P applications to warm no-awareness pedestrians could be an efficient approach to improve pedestrian safety [14].

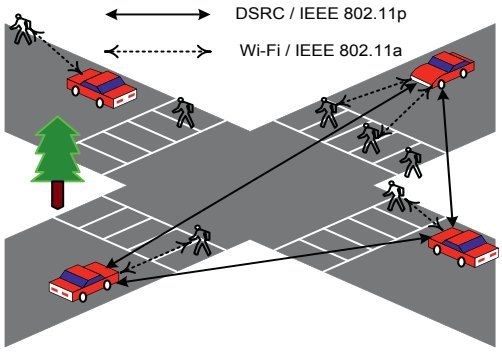

Figure 1. Illustration of V2P communications for pedestrians safety application

The architecture of V2P communication system for pedestrian safety applications contains the following components [14]: (*i*) OBU modules installed in vehicle, (*ii*) driver's tablet or smart-phone and (*iii*) pedestrians' mobiles. Communications between vehicles (i.e. OBU module) and pedestrians are established using the standardized Wi-Fi radio interfaces, such as the IEEE 802.11a, while the communications between vehicles (i.e. OBU-OBU modules) could be performed using the DSRC system based on IEEE 802.11p standard (Figure 1). Besides, OBU modules could be equipped with various additional radio interfaces, such as for mobile Internet access, GPS navigation (for location and speed measurements) as well as with Bluetooth interfaces intended for gathering data obtained by various in-vehicle sensor devices. Based on the gathered data of actual positions and

speed of pedestrians and vehicles in their near range, driver's mobile smart phone or tablet device performs the processing of such data to estimate possible incident situations between vehicles and pedestrians. If a possible collision is estimated, warming messages are transmitted to mobile phones of drivers and vulnerable pedestrians (using the Wi-Fi connections) to avoid their possible conflicts. V2P applications are currently in research focus of various studies and numerous challenging issues have to be solved before implementing such applications. Beside the strict requirements related to delay constraints and communication reliability, particularly important issues are related to efficiency and scalability of V2P communications in situations of large number of pedestrians, such as the usual case on crowded crossovers in large cities [14].

COMMUNICATION TECHNOLOGIES FOR TRAFFIC SAFETY APPLICATIONS

Various wireless communication technologies, such as DSRC (IEEE 802.11p), Wi-Fi (IEEE 8021.11a/n), WiMAX (IEEE 802.16m) or public mobile cellular networks, could be used for implementing of different intelligent VCS applications. However, two technologies that are currently imposed as the most favourite candidates to support future traffic safety applications are DSRC and advanced mobile cellular networks based on LTE (Long Term Evolution) and LTE-Advanced (LTE-A) technologies [11].

Dedicated Short Range Communications (DSRC)

DSRC are favorable communication systems for V2X communications in short coverage areas [7]. They are primary characterized by low communication latency (less than 100 ms), which is the key requirement to support (time critical) traffic safety applications. DSRC is the most suitable candidate to enable direct V2V communications within short distances (up to 1000m), but possible obstacles in the line of sight could reduce the communication range significantly. Besides V2V, DSRC also supports infrastructure based communications (V2I/R) between vehicles and dedicated RSUs installed along the roads/streets. RSUs can be deployed to increase the communication range, especially in non-line-of-sight (NLOS) scenarios, such as at urban intersections or in areas with small vehicle density.

A widespread accepted standard for DSRC is IEEE 802.11p [8]. It represents an extension of the former IEEE 802.11a WLAN (Wireless Local Area Network) standard applied to vehicular environment. It operates in 5.8 GHz band in Europe and Japan and 5.9 GHz in USA (U-NII frequency bands). Some specifications of IEEE 802.11p standard used in different world regions are given in Table 2.

Table 2. World-wide specifications of DSRC standard [8]

Specification	Europe	USA	Japan
Frequency band	5.8 GHz (5.795 - 5.815) GHz*	5.9 GHz (5.850 - 5.925) GHz	5.8 GHz (5.770 - 5.850) GHz
Bandwidth	20 MHz*	75 MHz	80 MHz
Number of channels	4	7	7 downlink; 7 uplink
Channel width	5 MHz	10 MHz	5 MHz
Type of communication	half-duplex	half-duplex	half-duplex (OBU); duplex (RSU)
Bit-rate	500 / 250 kb/s (downlink / uplink)	3-27 Mb/s (downlink/uplink)	4/1 Mb/s (downlink/ uplink)
Communication range	15-20m	< 1000m	30 m

* Additional 30 MHz is allocated in frequency band (5.875 - 5.905) GHz with possible 20 MHz extensions below and above this band.

DSRC systems are *de-facto* predetermined solution for traffic safety applications duo to their inherent ability to make direct V2V communications, which offer low latency and fast network connectivity [11]. Due to fully distributed operation mode, there isn't requirement for coordinating network infrastructure. In addition, network management is reduced to minimum, which enables immediate exchange of data among vehicles without complex signaling procedures. Nevertheless, there are numerous challenge issues which have to be solved to enable practical implementation of traffic safety applications using DSRC, such as the following [7,8,9,12,15]: *i*) reliable delivery of messages, *ii*) high vehicle mobility (100-200km/h) and dynamic network topology, *iii*) scalability issues or performance degradation in presence of high vehicle density (the probability of data collisions increases rapidly with the large number of vehicles in a network, resulting in large end-to-end latency and low channel utilization) as a result of un-coordinated probabilistic CSMA/CA(Carrier Sense Multiple Access/Collision Avoidance) medium access control mechanism, *iv*) routing protocol issues as well as *v*) privacy and security issues. In addition, it is evident that not all vehicles will be equipped with IEEE 802.11p communication interfaces in the initial phase of traffic safety applications implementation. It could produce serious troubles, because such vehicles are not able to transmit safety messages to other near-by vehicles with installed 802.11p communication equipment. However, this scenario could be avoided by installing particular RSU units equipped with short range radar sensors to detect precisely the position or movement of vehicles in its neighborhood and after that to broadcast such collected data to all vehicles equipped with 802.11p interfaces which are in the range of such RSU.

Although the main advantages of DSRC are the ubiquitous communication availability (it can operate without coverage by an infrastructure network) and fully distributed operation mode, there are several major weaknesses of DSRC systems [6,7,11,12], such as the limited communication range (typically 50-100m in urban areas and several 100 meters on highways), prohibitive infrastructure costs (a number of RSUs is required

to cover large portions of road networks), QoS (Quality of Service) is not guaranteed (due to uncoordinated probabilistic CSMA/CA contention based access strategy, throughput and delay performances degrades significantly with increasing network load, i.e. with high vehicle density). To overcome some limitations, mobile cellular communication systems could be used, particularly due to their already widespread deployment.

Mobile communication systems

Advanced mobile communication networks are becoming highly suitable candidate to be used as a complement (or even a concurrent) to DSRC systems. Contrary to DSRC, mobile cellular networks provide almost full radio coverage and usually do not require installation of additional equipment to support intelligent vehicular traffic applications. They could be used to extend the communication range of DSRC systems or as augment of RSUs (to reduce the installation costs). Recently, there is an increasing interest in adopting the LTE mobile cellular technology to support V2X applications [10,11]. However, due to infrastructure based type of communications, mobile cellular systems require serious technical challenges, primarily related to latency and scalability issues, to be carefully addressed.

Contrary to IEEE 802.11p standard used in DSRC, cellular communication systems are based on coordinated channel access strategy (i.e., involving a network scheduler) and with admission control, which avoids possible collisions and minimizes the mutual interference [4]. Hence, the mobile communication system is able to provide the QoS guarantees, such as the end-to-end delay or data rates performances, highly essential for traffic safety applications. Network scheduler is able to provide QoS guarantees by allocating radio resources based on the priority and QoS class parameters and by performing admission control, which is a major drawback of CSMA/CA access mechanism used in IEEE 802.11p standard.

However, there are also some limitations when using the mobile cellular systems for V2X communications [10]. For example, to enable the communication between vehicle and base station, a vehicle has always to be synchronized and registered to the cellular network. It could be troublesome if a vehicle is out-of-radio coverage of base station, such as in areas with poor radio coverage (for example, on hills, mountains, in tunnels etc.). Moreover, the signaling overhead and data transmission over cellular network architecture result in much larger communication latency than the tolerable latencies for traffic safety applications [7].

Although various prior mobile network technologies, such as the GSM, GPRS, EDGE, W-CDMA and HSPA have been to some extent used for different traffic intelligent applications, only with implementation of advanced mobile communication technologies, such as the 3GPP LTE and LTE-A a wide range of opportunities for the implementation of active traffic safety applications is enabled. The flat architecture of LTE system enables significantly reduced communication latency compared to previous generations of mobile technologies (theoretical LTE round-trip time is lower than 10 ms and the transmission latency in the RAN (Radio Access Network) is up to 100 ms [10]). Hence, LTE is intended to become the preferred solution for vehicle to RSU communications (V2R). However, some important issues have to be solved to support time critical traffic safety applications using LTE networks [4]:

- communication latency increases significantly with the numbers of mobile users in a cell, which could be a challenging issue, particularly in high vehicle density areas,
- data packets (even between two nearby vehicles) have to be transmitted through multiple network hops to the central server that each add its own latency, resulting in much higher delays compared to direct communications between vehicles (V2V) enabled by DSRC systems,
- since the LTE system was mostly designed to offer broadband services, it may not always be the optimal solution for frequent transmission of small amounts of data between large numbers of devices required for various intelligent vehicle applications, leading to scalability issues,
- a set of signalling messages have to be shared among all mobile users in a cell before the actual payload data are transmitted, which could introduce additional delays and downlink capacity limitations if the number of users per cell increases,
- in areas with weak radio coverage, network services are not available or reliability requirements could not be well satisfied. It requires additional equipment to be installed to enable traffic safety applications in such areas.

However, the advanced mobile communication technologies, such as the most recent LTE-A (4G) and next generation heterogeneous wireless networks (5G), will be able to provide direct device to device (D2D) communication between mobile terminals in close proximity (regardless of whether they are in or out of a base station coverage) without traversing the network infrastructure, which will enable direct communications between vehicles (V2V). By enabling V2V communication, future LTE mobile communication networks will provide much lower communication latencies and can become even a competitive alternative to DSRC systems. However, some challenging problems, such as the interference and node (vehicle) mobility issues have to be solved efficiently before D2D communication over LTE networks could be widely used [4].

Currently deployed LTE-A mobile technology is considered as an encouraged candidate for implement-

ing active traffic safety applications due to its outstanding network performances, such as high peak data rates (up to 1Gb/s) and user experienced data rates (up to 10Mb/s), low latency (up to 10ms), high node mobility (up to 350km/h), high node density (up to 10^5 devices per km^2), high spectrum efficiency etc. Furthermore, it is expected that future 5G networks will still improve the performances of current 4G mobile technology in terms of more peak throughput (up to 10Gb/s) and user experienced data rates (up to 100Mb/s), yet lower latency (5 ms end-to-end latency for infrastructure mode and 1 ms end-to-end latency for direct mode), ultra-high reliability (with a 10^{-5} packet loss rate for road safety-critical services up to even 10^{-9} for some industrial automation applications, such as automated driving), higher mobile nodes density (up to 10^6 devices per km^2), higher node mobility (up to even 500 km/h for high-speed trains), higher spectrum efficiency (3 times greater), high precision of positioning (with accuracy of 1m), which will be highly appropriate for implementation of vehicle safety applications [4]. 5G will also provide a better network coverage through the integration of various wireless access technologies (such as cellular, WLANs, broadcast, etc.) including direct D2D communication. Such heterogeneous (dynamic and flexible) network paradigm, called the Heterogeneous Vehicular NETwork (HetVNET), assumes that different network technologies suitable for diverse applications are combined to fulfill specific requirements [12,13,14,15]. One of the key challenges in future (5G) wireless networks operation is related to spectrum usage. It is envisioned that both, current mobile communication bands as well as new spectrum bands that could go as high as to the millimeter wave range (up to 6 GHz or even above) will be used. It is evident that current fixed frequency allocation scheme could not be a sustainable solution for future massive deployment of numerous wireless technologies and applications. Instead, the implementation of cognitive radio network technology is considered as a promising upcoming solution for better frequency spectrum usage and QoS guarantees [16].

CONCLUSION

Rapid development and integration of information and communication technologies with road network infrastructure and vehicles open broad possibilities to implement various intelligent vehicular applications related to road safety and traffic efficiency improvement. Active road safety applications have stringent requirements from telecommunication network infrastructure, primarily from the point of low latency and high reliability of communications. Various wireless communication technologies could be used to implement V2X commmunication. Currently, the most promising candidates to support traffic safety applications are DSRC and LTE mobile cellular communication systems. However, it could be observed that both technologies have their own limitations when used in vehicular environments and hence they are not suitable to support challenging future traffic safety applications. Although DSRC are well-designed for short-range communication offering low latencies, they have still serious shortcomings related to scalability issues (quick network performance degradation with increasing number of vehicles), supporting of limited vehicle mobility and possibly huge costs to cover wide areas. On the other hand, LTE mobile cellular networks are already widely deployed and can provide ubiquitous geographical coverage, high data rates, reliable communication and QoS support. However, they are not able to provide very short end-to-end latencies required by traffic safety applications due to infrastructure based network architecture. Although the latency in LTE networks is significantly reduced compared to previous mobile generation (3G WCDMA), there are also some scalability issues (quick rise of latency by increasing the number of vehicles), which have to be carefully solved to enable well performances in high density vehicle environments, such as the usual case in urban areas. It is noticeable that mobile cellular systems are much more suitable for V2I type of communications than DSRC. On the other side, DSRC is more suitable for V2V communication than D2D communications enabled by LTE mobile cellular networks. Hence, both existing (DSRC and LTE) together with some other candidate technologies, such as the Wi-Fi or Wi-Max, have to be improved and integrated to provide a robust next generation communication network intended to support efficiently various future intelligent traffic applications under dense (possibly thousands of vehicles) and highly dynamic vehicular environment leading to the forthcoming concept of HetVNET [13]. In HetVNETs, various wireless communication technologies will coexist and cooperate, which will require their full interoperability. An efficient and suitable wireless communication technology will be chosen such as to best capture the QoS requirements for a given vehicular application. However, there are numerous challenging issues which have to be answered in order to provide that HetVNETs be practically implemented [13,14,15]. One of the key topics is related to the intersystem handover, i.e. frequent handovers between various wireless technologies at high vehicle mobility. To overcome the consequent higher latencies, it will be necessary to develop more sophisticated handover protocols, based on compromises between QoS requirements, implementation complexity and signalization overhead. In addition, various other issues have to be researched, such as high vehicle mobility (up to 250km/h or even above), dynamic network topology, ultra-high communication reliability, cooperation issues (in order to minimize end-to-end latency and maximize throughput over unstable and capacity constrained wireless channels,

various cooperative approaches could be employed, such as the spatial diversity technique, multiple antennas technique, dynamic spectrum access techniques using cognitive radio technology etc.). Since numerous challenging technical issues have to be resolved before the VCS applications could be practically implemented, it is of particular importance to provide harmonization and coordination of worldwide ITS initiatives and development of standards, which currently capture extensive attention by numerous stakeholders and researchers in automotive and telecom munications industries.

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PROFESSIONAL PAPER

Analisys of the influence of alcohol on the motor skills and attention of a driver

- simulation of alcohol intoxication in the testing system "Vienna test" -

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Abstract: Alcohol is recognized as one of the factors in the occurrence of traffic accidents, which significantly affects the occurrence of accidents and the severity of their consequences. In this paper, the results of the pilot survey present the measures of influence of intoxicated drivers on the status of their motor skills and attention in traffic. The effect of alcohol is simulated using the "drunk glasses" that simulate the effects of the alcohol on the human body: reduced alertness, slowed reactions, confusion, distortion of the visual field, change of distance and depth perception, narrowing of peripheral vision, poor judgment and decision making, image duplication, lack of muscle coordination and the like. Motor skills were tested using the "Vienna test" system which measures the reaction speed, motor skills, attention, concentration and the assessment of traffic situations. For the purposes of this study the results of the "Vienna test" were analyzed-a driver without "drunk glasses" and wearing the glasses. Glasses for alcoholic level of 0,6- 0,8 ‰ were used in the study. Through a comparative analysis obtained by this research we point to the impact that alcohol has on the perceptual skills of drivers.

Keywords: alcohol, perceptual skills, attention, drivers, impact.

INTRODUCTION

Traffic participants who consume alcohol have significantly greater chance of being involved in a traffic accident. A research of the case study conducted in the countries with low and medium average incomes (a category also including the Republic of Serbia), stated that the alcohol content was present in the blood of 4% - 69% of injured drivers, 18% - 90% pedestrians injured in traffic accidents and 10% - 28% injured motorcyclists. The problem of traffic accidents that occurred as the consequence of driving while being intoxicated is addressed through the special programs insisting on more severe law provisions, their implementation and reinforcement of coercion. Global report on the prevention of injuries in traffic on the roads points out the influence of alcohol abuse and contribution of alcohol use to injuries and victims among the persons in vehicles (passengers), drivers and pedestrians [4] .

Irrespective of traffic system development and traffic safety system, the problem of driving while being intoxicated is always present and generally recognized as the element with the significant influence on traffic safety. Through development and establishment of traffic safety system, there is a constant presence of traffic safety measures and activities directed to combating driving under the influence of alcohol. Contemporary approach to this problem is successful to a certain extent and gives the results but nevertheless, complete overcoming of the problem is still not in sight. The combination of permanent public campaigns, high fines and the application of better and targeted repressive measures resulted in the fact that the majority of people treat driving under the influence of alcohol as a dangerous, selfish and socially unacceptable activity.

Alcohol consumption contributes to driver's false sense of confidence and reduces:

- reaction time,
- coordination,
- estimation of speed, time and remoteness (distance) and
- concentration.

The expansion and presence of great number of campaigns and educational activities focused on drivers and influence of alcohol have contributed to the fact that the negative aspects of this problem are more transparent and familiar to the majority of traffic participants. Nevertheless, the problem of driving under the influence of alcohol is still present and despite the awareness of additional risks and dangers arising from driving under the influence of alcohol, drivers decide to drive while being drunk.

Campaigns and educational activities conducted are directed to the increase of awareness of dangers and risks of driving while being intoxicated. The examples from practice, studies and analyses theoretically indicate the accidents and their consequences which occurred due to significant contribution of alcoholic intoxication of at least one participant. This is a way to develop the awareness of people concerning the risks to which they are prone when being drunk. The activities are in the form of detailed explanation to the traffic participants how exactly the alcohol reduces their psychophysical abilities in traffic and to which extent this affects their estimations and behaviour in traffic.

The emphasis of great majority of measures and campaigns points out the situations which occur after a drunk driver gets into a vehicle, i.e. after making decision to drive a vehicle. Nonetheless, the influence of alcohol on drivers and traffic safety begins much earlier, when a driver makes the decision to drive a vehicle despite being drunk. Besides the influence on the psychomotor abilities in the course of driving, perhaps the greatest influence on making decision to drive has the presence of alcohol itself, since the driver undertakes a range of activities which are directed exactly to his plan to sit behind the wheel while being drunk.

Results of the anonymous research in which 600 drivers participated showed that the probability of driving under the influence of alcohol is mainly determined by the range of decisions taken long before it. The information, obtained by the phone, in which the respondents were driving a vehicle under the influence of alcohol were analysed in detail. The conclusions of this research are focused on the fact that in order to reduce the probability that a person will drive a vehicle under the influence of alcohol, it is necessary to change earlier estimations concerning the expected activities at the visited events, decisions taken regarding the way of transport and choice of a fellow traveller, encouragement of alcohol consummation and driving in the aftermath. Additionally, the key factors are planning the alcohol consumption and the influence of the environment on those who show readiness to drive despite alcohol consumption. In fact, redefinition of the "responsibility" regarding the acts which finally lead to driving under the influence of alcohol contributed to the decision in the greatest number of cases [1].

Aggravating circumstance of alcohol influence research i.e. the effect it has on the decision making in this process, is that the persons under the influence of alcohol change their consciousness, the way they perceive events and problems and even completely lose the awareness of their reactions. Due to this experience, driving under the influence of alcohol is not possible to be analysed from driver's perspective, in terms of their perception of the whole situation. The influence of alcohol on psychomotor abilities of driver is experimentally analysed on the basis of tests done by the persons under the influence of alcohol, by which the level of reduction of these abilities is determined. However, the influence of alcohol intoxication of a driver on the estimation of the concrete traffic situations is difficult to define due to risks of exposure to such situations.

Numerous researches indicate a significant increase of risks to which drivers under influence of alcohol are exposed while the influence of alcohol is explained through the reduction of psychomotor abilities. The possibility of simulation of traffic participation under the influence of alcohol has not been realized until now. Such simulation would introduce the unacceptable risk, while the results regarding participants would be modest due to change of consciousness under the influence of alcohol and inability to consider the situation in detail and realistically after a certain period of time [6].

In order show the effect of alcohol to psychomotor abilities of people, the glasses which simulate alcohol influence and unable exactly psychomotor abilities have been available in practice since 2012. In addition to the effect these glasses have on the eyesight, they also have a significant impact on the sense of balance. Intensity and the way in which these glasses have an impact are determined experimentally when working with people under the influence of alcohol. These exact glasses represent a great possibility to depict to sober people the effect alcohol has on their psychomotor abilities, whereby the effect on the user's consciousness is absolutely excluded. This proactive approach has created the connection between consciousness and manifestation of the alcohol effect on the psychomotor abilities when sober people have the opportunity to feel the way in which alcohol disturbs their perception.

MATERIALS AND METHODS

The primary aim of the research realized for the needs of this work is to indicate the influence of alcohol on the perceptive abilities of driver i.e. on the difference between relation and reaction of driver in traffic situations when the influence of alcohol on the concrete traffic situations is simulated. Simulators used for the needs of this research are simulators of alcohol effect on driver's perceptive abilities and simulator examining the psychomotor abilities of driver.

For the needs of this research, the effect of alcohol on the perceptive abilities of driver was simulated by application of special glasses which simulate the effects of alcohol influence on human organism (so called "drunk glasses"): reduced alertness, slow reactions, confusion, visual field distortion, change of perception of distance and depth, peripheral eyesight narrowing, poor judgement and decision making, duplication of images and lack of muscle coordination. The influence of alcohol on human organism is multiple while the intensity of influ-

ence is complex and depends on great number of parameters the most important of which are sex, body weight, consumption period, consumption speed and similar. By the application of these glasses, the effect of simulation is achieved through the sense of sight whereby the intensity of the effects is approximately the same for all respondents regardless of physical constitution, sex and similar. There are glasses in the market that perform simulation for 4 levels of alcohol intoxication and these are the following:

- 0,4 – 0,6 ‰, *State of transient intoxication*; In this phase of intoxication most people do not show visible signs of intoxication. Change of mood, emphasized communication and subjective pleasant feeling are characteristic for this state. Certain number of people are incapable of driving when it comes to this concentration of alcohol since it may result in attention decrease, hearing disorders and similar, to the extent which depends on personal psychophysical characteristics;
- 0,6 – 0,8 ‰, S*tate of slight intoxication;* Characteristics of this phase of intoxication are the excess of thoughts, poor memory, excessive self-confidence, the need to stand out, whereby the visual acuity is reduced, eyesight reactions (eye accommodation) become weaker by 30% and hearing reaction become weaker by 40% and it comes to the occurrence of pulse acceleration;
- 0,8 – 1,5 ‰, *State of heavy intoxication;* Characteristics of this phase of intoxication are walking difficulties and limb movements, frequent occurrence of nausea, reduction of intellectual functions and similar. Alcohol intoxication becomes obvious and clearly identifiable in this phase;
- 1,5 – 2,5 ‰, *Drunken State;* An extremely discernible effect in this phase of intoxication is the effect on motor abilities, i.e. the centre of balance, to the extent of being unable to stand in upright position which leads to staggering while cognitive functions are significantly reduced. The loss of consciousness, instability and irritability of a person as well as increased aggressiveness are discernible in this phase.

Figure 1. Glasses for simulation of four intoxication levels

So far there have been numerous examples of the use of these glasses through tests related to motor abilities involving simple activities such as catching a ball, handshaking, walking the line and the like. For the needs of this work, a pilot research has been realized in which the used glasses were those simulating the state of slight intoxication (0,6 – 0,8 ‰). This category is chosen as most frequent intoxication category among drivers since the oversight of alcohol influence is most easily made and drivers frequently estimate that they are completely ready to drive.

Simulation of drivers' perceptive characteristics was done by the application of "Vienna Test System". This device is intended for the estimation of psychomotor skills of drivers through realization of 8 types of tests. This device consists of hardware and software components which check all the parameters of driver's psychomotor characteristics. Hardware part represents the computer to which a console enabling the use of arms and legs when checking capabilities. The console consists of response panels (7 coloured keys, 10 numeric keys, 2 castors, 2 analogue joysticks, 2 joystick routers, jack for connection with pedals, speaker and 2 headphone jacks) and pedals (left and right pedal). On this console it is possible to realize all 8 types of tests, that is tests regarding the estimation of safety on the road (5 tests) and tests regarding the estimation of personal characteristics related to driving (3 tests).

Figure 2. Vienna Test system for examination of psychomotor skills of drivers (Schuhfried, 2014).

- Tests which could be realized at the Vienna Test system:
- *Reaction Time Test;* Measures the abilities of respondents to react quickly and precisely to a certain combination of stimulants. It shows the average reaction time, time covering the period from the beginning of signal stimulant (colour and/or tone) until the beginning of reaction;
- *Determination Test;* Represents a complex multistimulant reaction test which measures the abilities of quick and precise reaction under the conditions of significant sensory stress. It measures the accurate reactions through elasticity of reaction capabilities under the conditions of sensory stress;

- *Cognitive Ability Test;* Represents a test which is used for the estimation of alertness and concentration ability. Test assesses the average time of accurate rejection: time starting from stimulant beginning until the beginning of reaction, i.e. the provision of correct answer concerning the lack of concurrence among figures;
- *Traffic situation overview test;* Represents an adaptable test of nonverbal estimation of traffic situation overview. The test represents a number and type of traffic participants as well as the traffic elements detected correctly in the photographs, the change of reaction speed and gaining an insight into the situation;
- *Adaptive matrices test;* Represents a test of nonverbal type which is used for the estimation of logical reasoning skills. Basically, it represents an intelligence test i.e. test of logical skills of drivers;
- *Environmental Attitude Test;* Measures personal and emotional characteristics of a person which can indicate the inclination to risky behaviour during the drive. It assesses the tested drivers within three categories: emotional stability, self-control and sense of responsibility;
- *Test of attitude to other traffic participants;* This test is used for the prediction of behaviour while driving and relation to other traffic participants. On the basis of testing, a driver is assessed in terms of aggressive interaction and emotional attitude to driving ;
- *Risk acceptance test;* This test measures a subjective acceptable level of risk in traffic situations, i.e. degree to which a person is ready to be involved or to bear a certain level of risk in driving. The results analyses if the level of acceptable risk in driving is increased.
- This device is usually used for checking the capabilities of professional drivers.

Test of visual orientation ability and perception skill (ATAVT test) is used for the needs of this research. ATAVT test checks the observational skill by promptly showing the photograph of traffic situation. The test is based on detailed analyses of cognitive processes, taking into account the research results related to the perception of scenes and objects so that it simply determines the abilities of driver to recognize a certain traffic situation through recognition of the object shown in the photograph. This serves to gain an insight into the abilities of a tested person to perceive the complex traffic situation in a quick and accurate way.

Test contains the photographs of traffic situations (image no. 3) which are shown to a respondent within the short time interval (2s). After having seen the photograph, a respondent should tick the objects spotted on the observed photograph from the offered list of all objects.

Figure 3. An example of one of traffic situations shown to respondents

The test begins with simple situations shown in the photographs while the complexity of situation gradually increases during the test. A respondent has ten minutes to complete the test. In addition to the ability of spotting the object precisely, an element also measured and quantified is the speed of response. A respondent responds in the test by selecting a key with the right number whereby each key indicates one of 5 categories of objects that could be spotted in the shown photographs of traffic situations. These photographs are offered to a respondent in order to recognize the following:

- pedestrians,
- automobiles (passenger cars, buses and trucks)
- bicycles, motorcycles, scooters
- traffic signs and
- traffic lights.

The test results are presented through a number of objects spotted in the photographs shown (a number of true, i.e. false answers) and speed of identifying the situation (the speed of answering).

Pilot research realized for the needs of this work covered 30 respondents. All respondents are drivers who have passed "B" category and have a permanent driver's license (there were no drivers with a probationary driver's license).

The testing was conducted in a way that each respondent:

- was introduced to the aim and point of the research,
- has undergone probationary tests which involved the use of at least two categories of glasses for simulation of alcohol effect while performing simple activities such as: handshaking, passing the ball, moving between the pins and similar and
- was tested on a console with and without the glasses for alcohol intoxication simulation. >The glasses used for the realization of testing

were those simulating "the state of slight intoxication" (0,6 – 0,8 ‰). Before the test commencement, a respondent is introduced to the test on console and each respondent has undergone a short introductory test in order to get acquainted with the content and way of implementation of the test on console.

All respondents used console for the first time within this pilot research, thereby ensuring the objectiveness from the eventual practising of motor skills. The number of photographs and gravity of the situation, which were shown to the respondents, were defined by software whereby the age of respondent was taken into account.

RESULTS OF THE RESEARCH

By processing the results of respondents' perceptive skills when spotting the objects in different traffic situations, it is observed that the respondents without the use of glasses for simulation of alcohol intoxication (image no. 4) made the lowest number of mistakes when spotting the pedestrians and motorcyclists, while the greatest number of mistakes referred to spotting light traffic signals (traffic lights).

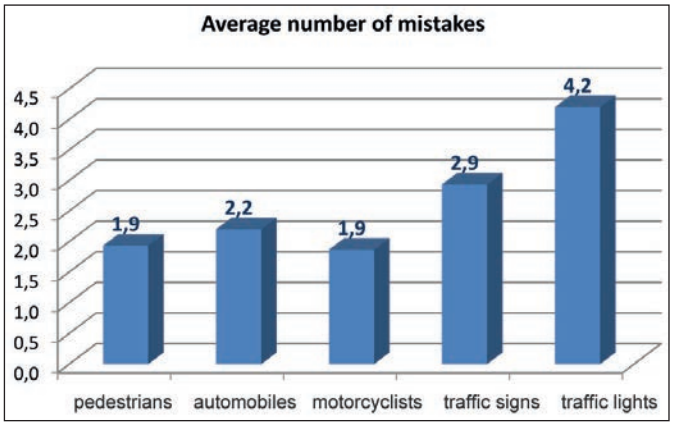

Figure 4. Average number wrongly spotted objects without the use of "drunk glasses"

The use of "drunk glasses" contributes to the fact that the most "evident" objects in traffic are - automobiles, while the most frequent oversights are made when spotting traffic signs (Figure no. 5).

When comparing the average number of mistakes with and without the"drunk glasses", it can be noticed that the number of mistakes when "drunk glasses" are used i.e. in the state of slight intoxication is by 18,5% higher than in case when a driver "in a sober state" does the test, without the use of glasses. (Figure no. 6).

Scores in per cents (PR) and T-score represent the indicators of successfully spotted objects in relation to the total number of objects which appear, taking into account that T-score represents the indicator in relation

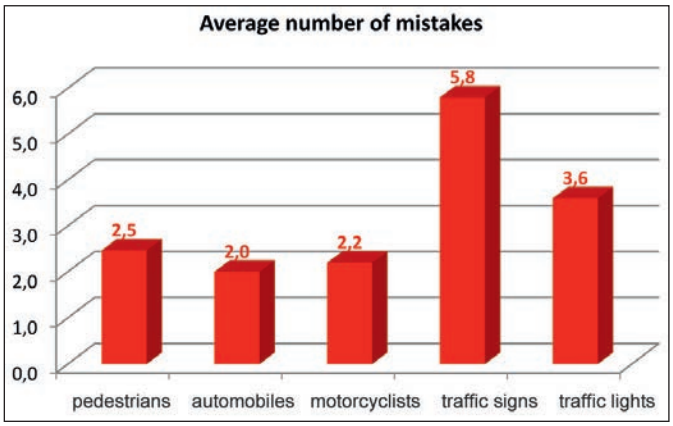

Figure 5. Average number of wrongly spotted objects during the use of "drunk glasses"

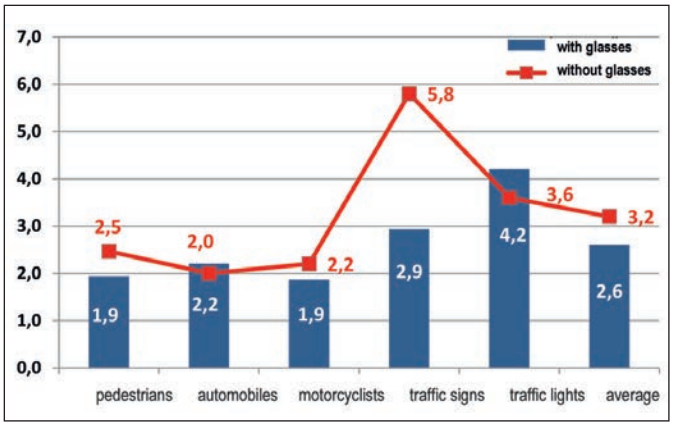

Figure 6. Average number of wrongly detected objects without and with the use of "drunk glasses"

to the tested population of 1190 respondents for which the values are entered into the existing software. A high score indicates the ability of quick and complete overview of the situation, as well as the ability of a person participating in traffic to detect all the essential elements of a traffic situation in the short period of time and estimate and plan further course of action on the basis of the given. People who have not developed this skill (people with low score) miss the details in traffic situations and thereby cannot adequately estimate and plan their activity in a given moment.

Values <16 are treated as the skills below average, 16-24 lower level of average skills, 25-75 average skills, 76-84 higher level skills and above 84 extraordinary skills.

In addition to this there is also a value of adjusted results which also takes into account the age of respondent. (PR (2) i T-score (2)).

It can be seen in the figure no. 7 that on the basis of PR indicator, the skills of respondents without the use of "drunk glasses" are in the range 24-75, which means that they are classified in the average group of skills unlike the case when the glasses are used and this indicator is less than 16, which means that the respondents possess

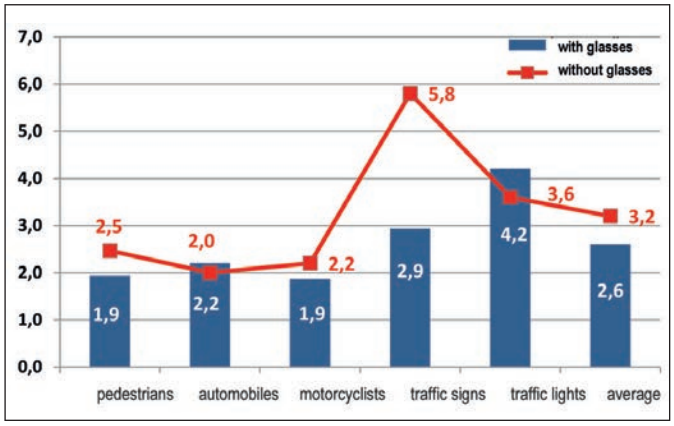

Figure 7. Skills of the driver expressed through PR and T-score

the skills which are below average for the proper identification of traffic objects.

In the end, it is also interesting to point out the indicator of the speed of responding to the asked questions. Without the use of glasses, the average speed of responding to the complete set of questions was 3 min and 22 sec, while during the use of "drunk" glasses that time is for about 11% shorter and amounts to 2 min 59 sec.

CONCLUSION

On the basis of the realized pilot research, it can be concluded that the effect of simulation of alcoholic intoxication achieved the significant impact on the results of testing. During the realization of the test under normal conditions, respondents showed significantly higher results than while doing the test with the use of "drunk glasses".

Besides the presented results, this research also achieved the impact on all persons who participated in the research and who personally had the possibility to feel alcohol effect and its influence on the perception and reactions in traffic situations. In this research, the state of slight intoxication was also simulated while research was planned for all levels of alcohol intoxication. The effect of intoxication and the influence alcohol has concerning the basic reactions and perceptions in traffic have been achieved by the application of these two simulators and their combined effect on the respondents who are completely sober. Based on this pilot research, there are grounds for implementation of significantly broader research according to the similar model which would encompass professional drivers and wider age structure.

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PROFESSIONAL PAPER

Analysis of the level of satisfaction of road network users - case review of road section Koprivna – Modriča (r-465)

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Abstract: The paper conducts a survey of satisfaction level of users of two lane road in regards to constructional-geometrical factors influencing unimpeded traffic and influence of human element during its maintenance. Establishing the satisfaction level of users of existing road network is the primary goal of the paper, through the definition of Level of Service of relevance for the analysis of traffic of inter-urban road network. The survey was conducted on the road section Koprivna – Modriča, regional road R-465 (Bušletić- Modriča). Using a questionnaire, the values of influence to the level of users' satisfaction were established. Traffic infrastructure and elements of horizontal road signs have been identified as two main indicators giving negative grade to the level of satisfaction. The end of paper gives a review of measures for the improvement of existing conditions.

Keywords: Level of Service (LOS), road network, road section.

INTRODUCTION

Basic parameter of analysis of traffic and traffic infrastructure characteristics has been given through the analysis of capacities and Level of Service using calculations of practical capacities. Capacity or permeability of functional parts of road networks, in its broadest definition means a maximum number of vehicle flow that can be reached on observed functional section of road network in a time frame and in conditions of technical-exploitation, traffic, regulations and environment.

The HCM-2000 and HCM-2010 [1, 2] manuals represent quantitative values of Level of Service. Term Quality of Service is noted as a new change in approach to methodology for appropriate elements of the system.

According to HCM-2010 [2] Quality of Service means an indicator of satisfaction of users with completed travel (movement). Manuals [1, 2] provide basic functional interdependence of Quality and Level of Service with perception – users' satisfaction that Quality of Service is based upon.

The second chapter provides theoretical view of the analysis of capacities and Level of Service on two lane road with emphasis on final outputs of this analysis. The third chapter is methodology of research and discussion on the most significant results. The final chapter of this paper shows a set of measures for the improvement, results of which should be verified by increase in the Level of Service on observed road section.

THEORETICAL FOUNDATION FOR ANALYSIS OF CAPACITY AND LEVEL OF SERVICE ON TWO LANE ROADS

Analysis of the capacities and Level of Service are based on three levels [3]:

- operational analysis,
- design analysis and
- planning analysis.

Operational analysis establishes the practical capacity and Level of Service on the existing two-lane roads in achieved sizes and characteristics of traffic, as well as the calculations of practical capacity and Level of Service on existing or planned - designed roads in future sizes and characteristics of traffic. These analyses are separately conducted in segments of average road and terrain conditions and separately for segments of specific longitudinal slopes.

Design analysis of capacity can also be used for establishment of influence of design elements to both the capacity and Level of Service, such as the number of lanes and visibility, curve diameters and other. Detailed data of the expected traffic and conditions are necessary along with standard geometrical measures used in de-

sign of lane width, side interference, calculation speed and horizontal and vertical curves. Design of road sign plan can also be established with the help of analysis of the capacity and Level of Service.

Analysis of traffic conditions in planning of new roads help road planners to determine value of PGDS (Annual Average Daily Traffic (abbr. AADT)) accepted by a two-lane road for different Level of Service and terrain conditions. Considering that number of lanes when planning a two-lane road is already determined, the improvement of traffic conditions or increase of AADT on a planned road is possible through improvement of design elements, decrease of road ascents as well as additions on ascending sections.

HCM-2000 and HCM-2010 manuals give a new, multi-mode approach to analysis of capacity and level of service. Research will often use, according to these two manuals, the Level of Service and Quality of Service (QS) as two cornerstone indicators. Quality of Service is an indicator of satisfaction of users with travel (movement). Level of Service is a qualitative measure describing traffic conditions with the help of indicators such as speed and time of travel, traffic distractions, freedom of maneuvering and comfort [3]. Level of Service is a qualitative measure of network traffic. Level of Service means a qualitative measure of traffic conditions. Descriptions of individual Levels of Service define these conditions with the help of indicators such as speed and time of travel, traffic distractions, freedom of maneuvering and comfort. [1, 2]

Roads (segments) with two lanes are methodologically based on traffic operations measuring along the sections (segments) of the road, based on terrain, geometric elements and traffic conditions. This methodology is typical for sections of two-lane roads with segment length of 3 km. The data received must be applied for methodology of two lane road including hourly frequency in both directions, peak hourly frequency (PHF) and direct distribution of traffic. [4] Also, additional research needs to be conducted when establishing the capacity of two-lane roads. The research needs to include the influence of effects which decrease traffic flow such as overtaking zones, horizontal/vertical road lane, and influence of existence of capacity in access to roads. [5]

The conditions are quite different because of expectations of drivers and operative characteristics in categories of two lane roads, and therefore it is difficult to use single definition of travel conditions per each Level of Service (LOS). [2, 3, 6]

Wider analysis area is a combination of connected transportation objects. The analysis systems include combination of objects and order in the region. These levels of analysis are usually used in models of travel search and other networks of wider analysis. [5, 7]

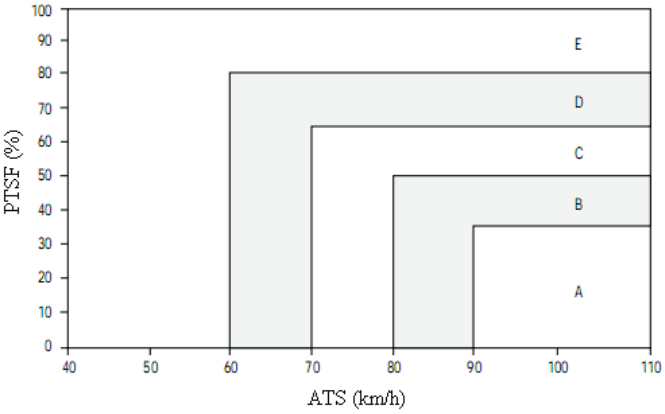

Figure 1. Criteria of Level of Service (graphic) for two lane roads [1]

Very important indicators are established through analysis of capacity and Level of Service [6]:

1. "Bottlenecks" on the existing network and basic cause of bottlenecks in comparison to achieved and expected traffic.
2. Technical measure necessary for the removal of bottlenecks on the existing network (through increase in capacity and/or improvement in Level of Service) through new construction, renovation and/or regulation measures.
3. Ability of designed technical solutions to intake projected traffic on a satisfactory Level of Service.
4. Indicators on traffic conditions in access to intersections in level (relation traffic/capacity through access and loss of time) are necessary for optimization of direction measures which improve traffic conditions in intersections in the level.
5. Indicators on conditions of movement of vehicles in the network, that is, the input data for:
   - Analysis of costs of usage of motor vehicle (fuel, lubricants, tires, spare parts and other),
   - Analysis of loss of time drivers and goods experience on the road as well as and
   - Analysis of gas emissions and noise in the network (both existing and improved).

RESEARCH RESULTS AND DISCUSSION

A research has been conducted using a questionnaire on 100 people where data on the Level of Satisfaction of the given road section has been acquired.

Research methodology and basic hypothesis

The observed section is on regional road R-465 (Bušletić- Modriča 2). The regional road connects to main road M-17 Doboj- Šamac. The regional road R-465 is 31,782 km in length, and connects in Modriča to the aforementioned main road M-17 (Doboj- Modriča-Šamac). The observed section is 17.71 km in length and

goes through inhabited places. AADT value of road section Koprivna – Modriča have in the past ten years moved from 1331 to 1174 (veh/day), and is in mild decline.

The survey was anonymous with 100 people on observed section Koprivna – Modriča, 17.71 km in length and it was aimed at establishing level of satisfaction of user with existing regional road network Koprivna – Modriča. Subject of the analysis was the Level of Satisfaction of users of regional asphalt road. Persons under the age of 18 were not surveyed, but drivers only, in order to determine research and positive and negative remarks to existing road section. Tables 3.1. and 3.2. show the number of surveyed people as well as questionnaire questions.

This paper aims at the establishment of adequate indicators influencing the decrease of quality of service given to users by this road section through the research conducted on a two-lane road.

Analysis of research results

The research produced results shown in tables 3.1. i 3.2. The first table shows gender and age structure, as well as purpose of travel on the road section.

Table 1. Structure of surveyed people

Structure of surveyed people:			
Gender	Male	70	70%
	Female	30	30%
Age	18-30	30	30%
	31-40	12	12%
	41-50	23	23%
	51-60	21	21%
	Over 60	14	14%
Purpose of travel	Work	35	35%
	Returning home	2	2%
	Education	0	0%
	Healthcare	20	20%
	Entertainment/ recreation	7	7%
	Shopping	26	26%
	Other	10	10%

Observing the structure of surveyed people, demographically speaking it can be seen that male presence is significantly higher (70%) than female (30%). Furthermore, observing the age range of surveyed people, most people come from age group from 18 to 30 years, 30%. The next most represented age group is 41 to 50 years of age (23%) and the age group from 51 to 60 years of age is represented in the percentage of 21%.

Table 2. Results of the questionnaire in percentages related to questionnaire's questions

	Questions:	Grades:					
1.	How do you grade the influence of traffic infrastructure to the quality of service in this road?	1		0		0%	
		2		0		0%	
		3		15		15%	
		4		48		48%	
		5		37		37%	
		6		0		0%	
2.	How much does the longitudinal slope affect the speed of travelling in this section?	1		0		0%	
		2		7		7%	
		3		64		64%	
		4		29		29%	
		5		0		0%	
		6		0		0%	
3.	Grade your motivation to drive?	YES		15		15%	
		NO		85		85%	
		Horizontal		Vertical		Horizontal (%)	Vertical (%)
4.	Grade the visibility of horizontal and vertical road signs?	1	0	1	0	0%	0%
		2	4	2	0	4%	0%
		3	82	3	7	82%	7%
		4	14	4	87	14%	87%
		5	0	5	6	0%	6%
		6	0	6	0	0%	0%
5.	What grade (1-6) would you give to frequency (number of vehicles) on the road?	1		0		0%	
		2		0		0%	
		3		1		1%	
		4		14		14%	
		5		79		79%	
		6		6		6%	
6.	Give a grade 1-6 for the maintenance of road section?	1		0		0%	
		2		22		22%	
		3		57		57%	
		4		21		21%	
		5		0		0%	
		6		0		0%	
7.	How would you grade the placement of speed limit signs on the section?	YES		43		43%	
		NO		57		57%	
8.	How would you grade the traffic safety of the road?	1		0		0%	
		2		7		7%	
		3		78		78%	
		4		12		12%	
		5		3		3%	
		6		0		0%	
9.	How would you grade the occurrences of sudden curves (minimal radius) on the road?	1		0		0%	
		2		4		4%	
		3		32		32%	
		4		53		53%	
		5		11		11%	
		6		0		0%	

Grades: 1-N/A, 2- very bad, 3- bad, 4- good, 5- very good, 6- excellent

It can be pointed out that 87% of people graded vertical road signs as good, and 79% of people graded the level (degree) of possible high frequency of the road section as very good. Opposite to this, the most expressed

answers, and the most negative ones in terms of level of satisfaction of users were given to the following questions:

- *Road condition grade*, where 64% of people graded the road conditions on the observed road section as bad,
- *Traffic infrastructure grade*, where 74 % of people answered that bad infrastructure has a negative impact to quality of service of the observed road section,
- *Horizontal road signs grade*, where 82% of people graded the conditions and visibility of horizontal road signs on the observed road section as very bad,
- *Maintenance of the road section grade*, where 57% of people graded the road maintenance of the observed road section as bad.

CONCLUSIONS WITH IMPROVEMENT MEASURES

As seen in the previous analysis and discussion, it can be concluded that the grades of road condition, traffic infrastructure, horizontal road signs and road maintenance worsen the quality of service offered to users by the observed road section.

A subjective grade of existing conditions of the observed road section, according to relevant indicators for the analysis of capacity and Level of Service which are based on aforementioned factors of traffic and road, gives the conclusion that the observed road section received a grade between B and C.

To reduce the negative factors, the following suggestion of measures can be implemented:

1. Improvement of traffic safety through Road Safety Inspection of observed road section with road geometry, longitudinal and transverse profile,
2. Improvement of road condition in certain segments of the observed road section, where needed,
3. Improvement of traffic infrastructure to prevent negative effects arising from inadequate maintenance or reconstruction of noticed existing facilities by jurisdictional authorities on the observed road section,
4. Improvement of visibility of horizontal road signs by applying a new layer of paint on several segments of the observed road section,
5. Road maintenance as a main priority, as all other negative factors directly depend on it,
6. Improvement of regulation and traffic management on the observed road section through jurisdictional organizations,
7. Placement of additional speed limit signs in inhabited areas with the speed limit of 50 km/h, and the speed limit of 30 km/h in school areas, which is not currently visible in the observed road section,
8. Placement of target improvement for road and traffic conditions, which directly influences better Level of Service (A-B).

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PROFESSIONAL PAPER

Insurance Telematics Using GPS Tracker and Smartphone

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Abstract: Insurance telematics is widely used in Europe by young and first-time car drivers[1] [1]. It relies on an insurance premium that is based not only on static measures, but also on dynamic measures. The dynamic measures are the current position of vehicle, the current speed at that position, time spent on the road, the driver's style of driving etc. When we talk about insurance telematics, we refer to insurance schemes pay-as-you-drive (PAYD), pay-how-you-drive (PHYD) and manage-how-you-drive (MHYD). Telematics could be smartphone based insurance with technology which relies on insurance premiums that reflect the risk profile of drivers and the traditional in-car mounted devices for insurance telematics. This telematics work is experience from a recent insurance telematics validation and analyst pilot run in England on motorway around the Heathrow airport. In this telematics test, the global positioning system (GPS) and smartphone is used as receiver.

The small global positioning system (GPS) transmitter is a small tracker in-car mounted devices with SIM card with is set up for sending SMS to smartphone every ½ minutes. The smartphone is the receiver equipment which is used to collect telematics data which is ready for analysis. There are many companies around with data analytics expertise who use the latest big data analytics technology such as Hubio Dynamic Data Warehouse[2] [2]. They analyse data from a wide range of different data sources, including databases, sensors, smartphones and social media.

Keywords: Insurance, Insurance telematics, smartphones, GPS tracker.

TELEMATICS GPS DATA

This research shows the example of telematics model processing GPS data in order for an insurance company to bring a number of important decisions on the insured vehicle. One of the important indicators is vehicle speed, that is, whether the driver is speeding and exceeds speed limit on the road. This test was executed in London and it was used on different types of roads such as regular roads and highway around the Heathrow airport.

EQUIPMENT USED IN RESEACH

The following equipment was used in this research:

GPS Tracker Car Vehicle Tracking Device TK102 [3][3]. This device is a global positioning system (GPS) transmitter, a small tracker in-car mounted device with a SIM card.

Any smartphone which is enabled to download data could be used in this test. The smartphone is set to receive SMS from in-car tracker and process the data to SQL server.

GPS Tracker Car Vehicle Tracking Device TK102 CITATION htt6 \l 2057 [3][3]

Type:	Compact magnetic GPS Tracker
Model:	TK102
Cover:	MAGNETIC BASE
Functions:	SHOCK SENSOR, MOTION SENSOR, LISTENING DEVICE
Brand:	iTrack UK
Battery capacity:	000 mAh
Manufacturer Part Number:	TK102
GPS sensitivity:	-159dBm

SMS MESSAGES

GPS box is located in the vehicle and sends to the Centre for Management of sms message for processing messages, every 30 seconds as shown in the attached list. GPS tracking box can be controlled from a distance, sending a certain message from the Centre for Management (Telemat-

ics office insurance). The parameters from the GPS tracker are set to send messages to a collection centre including vehicle position, vehicle speed and current time.

lat:51.46907 long:-0.32860 speed:010.4 T:06/13/16 19:14
http://maps.google.com/maps?f=q&q=51.46907,-0.32860&z=16
lat:51.46815 long:-0.32939 speed:039.4 T:06/13/16 19:14
http://maps.google.com/maps?f=q&q=51.46815,-0.32939&z=16
lat:51.46711 long:-0.32959 speed:030.4 T:06/13/16 19:14
http://maps.google.com/maps?f=q&q=51.46711,-0.32959&z=16
lat:51.46453 long:-0.33094 speed:043.3 T:06/13/16 19:15
http://maps.google.com/maps?f=q&q=51.46453,-0.33094&z=16
lat:51.46149 long:-0.33184 speed:039.3 T:06/13/16 19:15
http://maps.google.com/maps?f=q&q=51.46149,-0.33184&z=16
lat:51.46074 long:-0.33164 speed:002.8 T:06/13/16 19:16
http://maps.google.com/maps?f=q&q=51.46074,-0.33164&z=16

SMS GATEWAY DATA

SMS messages are collected via the SMS Gateway and logged into to the database (SQL Server). The table No.1 shows the data which are supposed to be automatically loaded into the SQL Server.

The data loaded into database:

1. LAT - Latitude
2. Londe - Longitude
3. Speed - vehicle speed
4. DATE - date
5. TIME –time
6. MAP - map (position of the vehicle on the road)

This research showns import data from SQL Server to Excel where it is possible create various forms of graphs and diagrams to analyze the data.

Microsoft SQL Server is a relational database management system developed by Microsoft which is used in this resarch. As a database server, it is a software product with the primary function of storing and retrieving data as requested by other software applications, which for this research is run either on the computer across a network (including the Internet).

Table 2. GPS data imported into Xcel

Telematic GPS vehicle details					Road route		
DATE	TIME	SPEED [KM]	LAT	LOND	ROAD	ROAD SPEED	KM
06/13/16	19:14	10	51.46907	-0.3286	A310	30	48
06/13/16	19:14	39	51.46815	-0.32939	A310	30	48
06/13/16	19:14	30	51.46711	-0.32959	A310	30	48
06/13/16	19:15	43	51.46453	-0.33094	A310	30	48
06/13/16	19:15	39	51.46149	-0.33184	A310	30	48
06/13/16	19:16	3	51.46074	-0.33164	A310	30	48
06/13/16	19:16	0	51.46056	-0.33157	A316	30	48
06/13/16	19:16	34	51.46045	-0.33215	A316	30	48
06/13/16	19:17	47	51.45987	-0.33738	A316	30	48
06/13/16	19:17	19	51.45867	-0.33921	A316	30	48
06/13/16	19:18	1	51.45878	-0.3399	A316	30	48
06/13/16	19:18	1	51.4588	-0.33977	A316	30	48
06/13/16	19:19	1	51.45878	-0.33978	A316	30	48
06/13/16	19:19	0	51.45879	-0.33982	A316	30	48
06/13/16	19:34	75	51.40097	-0.52949	M3	70	113
06/13/16	19:34	61	51.39922	-0.53589	M3	50	80
06/13/16	19:35	60	51.39905	-0.53793	M25	50	80
06/13/16	19:35	74	51.40267	-0.53892	M25	70	113
06/13/16	19:35	94	51.40916	-0.54108	M25	70	113

Table 1. Telematic test data

Telematic Test5 13-06-2016					
LAT	LOND	SPEED	DATE	TIME	MAP
51.46907	-0.3286	10.4	06/13/16	0.801388889	http://maps.google.com/maps?f=q&q=51.46907,-0.32860&z=16
51.46815	-0.32939	39.4	06/13/16	0.801388889	http://maps.google.com/maps?f=q&q=51.46815,-0.32939&z=16
51.46711	-0.32959	30.4	06/13/16	0.801388889	http://maps.google.com/maps?f=q&q=51.46711,-0.32959&z=16
51.46453	-0.33094	43.3	06/13/16	0.802083333	http://maps.google.com/maps?f=q&q=51.46453,-0.33094&z=16
51.46149	-0.33184	39.3	06/13/16	0.802083333	http://maps.google.com/maps?f=q&q=51.46149,-0.33184&z=16
51.46074	-0.33164	2.8	06/13/16	0.802777778	http://maps.google.com/maps?f=q&q=51.46074,-0.33164&z=16
51.46056	-0.33157	0.1	06/13/16	0.802777778	http://maps.google.com/maps?f=q&q=51.46056,-0.33157&z=16
51.46045	-0.33215	34.2	06/13/16	0.802777778	http://maps.google.com/maps?f=q&q=51.46045,-0.33215&z=16
51.45987	-0.33738	46.9	06/13/16	0.803472222	http://maps.google.com/maps?f=q&q=51.45987,-0.33738&z=16
51.45867	-0.33921	18.7	06/13/16	0.803472222	http://maps.google.com/maps?f=q&q=51.45867,-0.33921&z=16
51.45878	-0.3399	1	06/13/16	0.804166667	http://maps.google.com/maps?f=q&q=51.45878,-0.33990&z=16
51.4588	-0.33977	0.7	06/13/16	0.804166667	http://maps.google.com/maps?f=q&q=51.45880,-0.33977&z=16
51.45878	-0.33978	1.4	06/13/16	0.804861111	http://maps.google.com/maps?f=q&q=51.45878,-0.33978&z=16
51.45879	-0.33982	0.4	06/13/16	0.804861111	http://maps.google.com/maps?f=q&q=51.45879,-0.33982&z=16
51.45872	-0.3398	0.2	06/13/16	0.805555556	http://maps.google.com/maps?f=q&q=51.45872,-0.33980&z=16
51.45869	-0.33979	0.1	06/13/16	0.805555556	http://maps.google.com/maps?f=q&q=51.45869,-0.33979&z=16
51.45872	-0.33981	1.2	06/13/16	0.80625	http://maps.google.com/maps?f=q&q=51.45872,-0.33981&z=16
51.45874	-0.33984	0.4	06/13/16	0.80625	http://maps.google.com/maps?f=q&q=51.45874,-0.33984&z=16

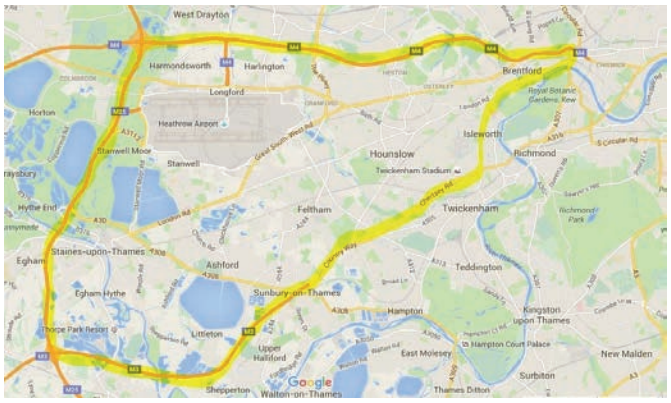
GPS DATA IN XCEL

Using the data from SQL Server, it is possible to make data analysis and comparison with other relevant data.

VEHICLE ROAD MAPS

The map shows the route of the vehicle (Isleworth, Twickenham, Sunbury-on-Thames, Egham, Stanwell

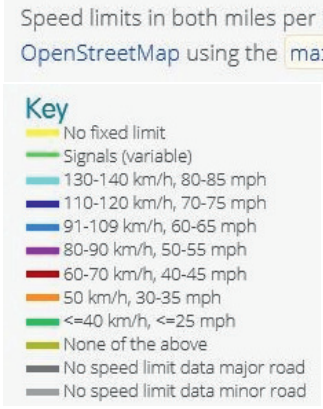
Moor, around airports Heathrow, Brentford, Isleworth). The road tags on these routes are: A310, A316, A317, M3, M25, M4, A315, A310.



Map 1: The map with route of the vehicle

This map shows the route (OpenStreetMapCITATION htt7 \l 2057 [4] [4]) of the same vehicle with the vehicle speed limit. On the map there are different colors representing speeds that are allowed on these routes. For example, black color shows the speed limit on the highway is 110 km / h (70 m / h). The permitted speed of the vehicle in the country is used for comparison with the real speed of the vehicle and on this basis can be determined vehicle speeding at the time. These data could be dowloaded from OpenStreetMap CITATION htt7 \l 2057 [4][4]forthe entire country and uploaded to SQL Server. There is other possibility of determining the permissible speed of the vehicle based on the LAT - Latitude and Londa – Longitude.

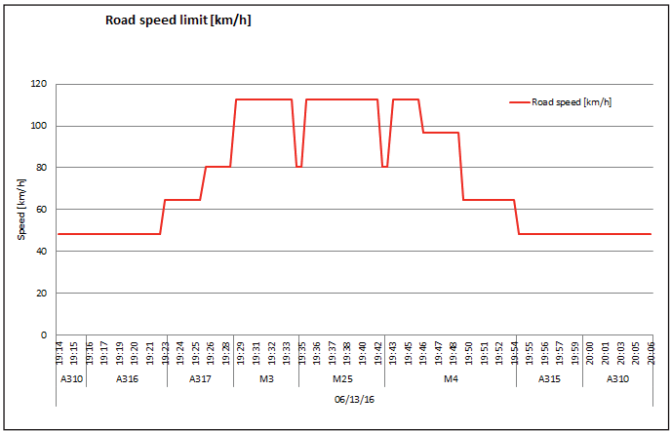
Map 2. The route of the same vehicle with the vehicle speed limit



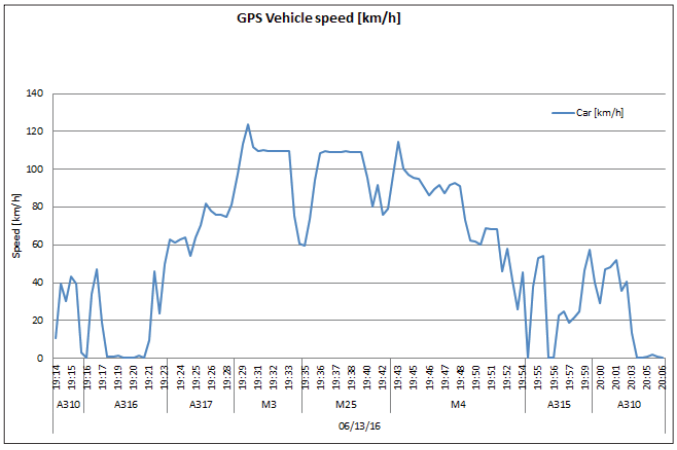
Key 1. Speed limit in [m/h] and [km/h]

GRAPHS & DIAGRAMS

Graph 1 shows the speed of the vehicle during the period of driving the vehicle. The diagram shows the time intervals to drive on certain categories of times. As an example, the vehicle was on the highway M25 in the period between 19:35 and 19:42 and driving from one to another highway is shown and the speed limit reduces from 110 km / h to 80 km / h. This diagram is presenting a reference for determining whether the vehicle was in the permitted speed limit. This parameter is essential for the insurance company to determine the behavior of drivers in driving on the basis of which it may determine an increase or decrease in the premium of the insurance policy in the next year.



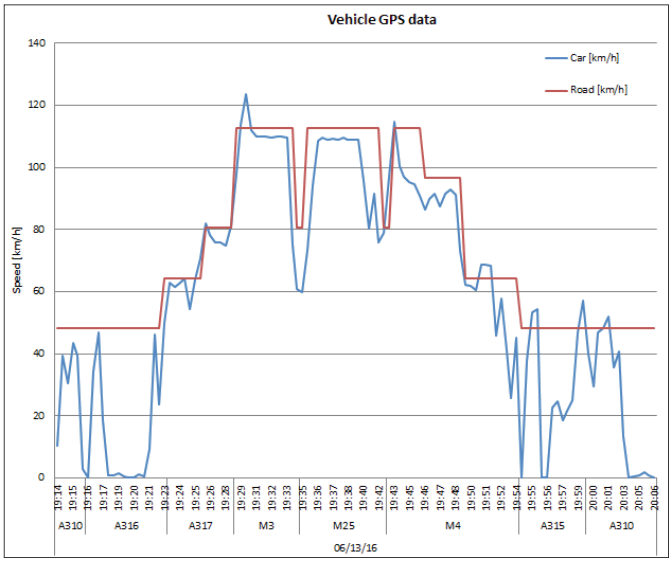
Graf. 1. The speed limit on the road in the test drive period



Graf. 2. The speed of vehicles in the test drive period

Graph 2 shows the real speed of the test vehicle in the time period and position of vehicles on the road.

Graph 2 shows permeted speed limit of the vehicle (in red) and the real speed of the test vehicle (blue). This graph shows that the driver speed limit is several times in certain intervals.



Graf. 3. Permeted speed and the real speed of the test vehicle

ANALYSIS OF DATA

From the data collected it is now posible extract data speeds of vehicles that exceed the speed limit of vehicles at a particular possition on the road.

Table 1 shows the speeds limit exceeding in the time and the particular vehicle position on the road. From this table it is possible to determine the vehicle speed which was exceeded in the time period, the percentage of speeding and other important data for analysis. If set percentages that represent the limit speed for example up to 10% the data from table shows that the overspeed occurred in two time intervals 19:55 and 19:59. Other important parameters are how the driver drives the vehicle in the period (year), where the vehicle is parked, how often breaking the vehicle etc.

Time	Car speed	Speed limit	Road	%
19:26	71	64	A317	8.82
19:26	82	80	A317	1.75
19:28	81	80	A317	1.15
19:29	114	113	M3	0.75
19:30	124	113	M3	8.78
19:43	115	113	M4	1.70
19:51	69	64	M4	6.16
19:51	69	64	M4	6.02
19:51	68	64	M4	5.61
19:55	53	48	A315	9.42
19:55	54	48	A315	11.09
19:59	57	48	A315	15.59
20:01	52	48	A310	7.33

Table 3. Speeding vehicles in a certain period of time

ALGORITHM

Using data analysis is possible to determine the pattern of driver's behavior on the road and hence use algorithm that directly affect the increase or decrease in the price policies in the coming insurance driver year.There are many companies around with data analytics expertise who is using latest big data analytics technology like Hubio Dynamic Data Warehouse CITATION Dat17 \l 4122 [2] [2]. They analyse data from a wide range of different data sources, including databases, sensors, smartphones and social media.

Input parameters used in analytics technology:

1. The road number
2. Vehicle position
3. The time of vehicles movement
4. Vehicle speed
5. Exceeding the speed limit of vehicles
6. G-force (braking sharply and rapidly changing direction and reversible driving)

CONCLUSION

Using telematics with GPS tracker and smartphone is good example where the Information and telecommunication technology enables new applications for intelligent transportation systems. This technology has the capability to improve existing business models in the insurance industry. This researchdiscussed the technical challenges and highlighted the main obstacles for successful applications in terms of information quality, integrity and availability. This paper has discussed of how to measure driver behavior and how to present a scoring procedure, described the risk profile base on parameters as road number, vehicle position, time of vehicles movement, vehicle speed, exceeding the speed limit of vehicles etc.In this research is highlight and discuss the challenge involvedtransferring data (sms message) from the communication devices such as GPS tracker to smartphone what showing that is possible use cheap and available equipment of low cost to gather telematics data and successfully use in insurance industry.

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PROFESSIONAL PAPER

The impact of the application of technological solutions in passenger transport on the environment

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Abstract: The main objective was to reduce the retention time at the bus stops, time for drivers' administrative actions, fuel consumption, air pollution emissions of SO2 and to increase the solvency of the company.

For the realization of the set objectives it was needed: to introduce electronic billing system with the use of contactless- chip card as a monthly ticket, all vehicles will be equipped with electronic conditions for the sale of individual tickets and recording contactless - chip card and receive training for direct partcipants.

All vehicles are equipped with electronic conditions for the sale of individual tickets and recording contactless- chip card. All the participants involved in the use of electronic ticketing systems are trained and equipped with the necessary means.

The result of the introduction of electronic toll collection system is to reduce: the retention time at the bus stops and to ensure good performance of administrative driver. The importance of introducing electronic toll collection system is the reduction of fuel consumption, air pollution emissions of SO2, faster handover and discharge of collected cards and increase the solvency of the company.

Keywords: electronic payment system, contactless smart cards, emissions, solve.

INTRODUCTION

The company was founded on March 21, 1958 under the name of "Zenicatrans". Its operation began with 3 trucks for passenger transport at the three city bus lines. Throughout its development, the company has been going through a great deal of organizational changes. In the year of 1989, it reached its maximum development: transporting 36 million passengers, travelling 10.4 million kilometers with 154 busses. In the time period between 1992 and 1995, a high number of driving units was destroyed. After the year of 1995, the company operated with a few obsolete buses.

In 2007, the company got a new name – Javno komunalno preduzeće (JKP) "Zenicatrans-prevoz putnika" d.d. Zenica (Public Utility Company "Zenicatrans - Passenger Transportation" joint stock company, Zenica.). "Zenicatrans-prevoz putnika" is a joint stock company with 80% state-owned share and 17% private share. The core business involves transport of passengers in the city, suburban and intercity transit. Today, the company has 176 employees and 50 buses with 600 departures in the area of municipality, canton and BH Federation.

By March 2007, the system of transport operation data processing was based on travel orders which did not allow an insight into the most of the activities in the process. Due to everyday organizational and subjective problems such as: issue of the individual and monthly tickets, signing them in and out, and settlement of funds by drivers and cashiers, the continuous and daily control of funds inflow was impossible. This way of data processing did not provide the company management the continuous and timely information crucial for smooth business operation.

In March 2017, a decision was made on starting the pilot project of the electronic ticketing system introduction. The main objective of the electronic ticketing system was the following - a contactless smart card was to reduce the time of: ticket issue at bus stops, time spent at bus stops, operation of motor vehicles in the neutral position. All of the vehicles, cash register and technological service were equipped with electronic devices for the sale of individual tickets and recording contactless smart cards. The application of this kind of ticketing system resulted in the reduction of: time of the issuance of individual and monthly tickets, administrative activities of bus drivers, time spent at bus stops. The electronic ticketing system also made a positive effect on the reduction of fuel consumption when at bus stops which directly influenced environmental pollution reduction.

DESCRIPTION OF ELECTRONIC TICKETING SYSTEM

Handheld terminal IT 3000

Picture 1. Handheld device IT 3000 [2]

IIn March 2007, various activities were initiated regarding the introduction of the electronic ticketing system for passenger transport in cooperation with the company "Četrta Pot" Ltd. from Kranj, Slovenia. The first phase included the installation of two handheld electronic devices IT 3000 and the individual sale of tickets in the bus. Picture 1 shows the handheld device IT 3000 designed for ticket sale onboard a bus as well as ticket inspection carried out by bus inspectors.

Technical features of the IT 3000 device include: terminal, integrated terminal printer, integrated e-card reader, integrated SQL base, TFT touch screen, Windows CE OS, 32 MB RAM.

A detailed data analysis of the features brought about by the new system, indicates the useful information with respect to improvement of technical, technological and economic parameters for a particular means of transportation. Based on the analysis on the IT 3000 handheld device application, the decision was madeto embark on the second phase of the electronic ticketing system implementation.

Stable device TA – 400 including terminal BT3 and electronic ticket

The second phase of the implementation is the continuous procurement of handheld devices and stable TA – 400 devices including terminal BT3 and electronic tickets (smart cards). Picture 2 shows the stable device TA – 400 including terminal BT3 (reader) in the vehicle. The device is installed next to the driver who operates the device using touch screen and issues tickets in a simple way. Picture 3 shows the smart card.

Picture 2. Stable device TA 400 including terminal BT3 in the vehicle [2]

Technical features of a stable device TA – 400 including terminal BT3 are as follows: information on the funds available; full POS application, data key, WLAN or GPRS, integrated SQL base, connection to GPS system, LED displays, big TFT color touch screen. Passenger terminal BT3 is designed for the passenger who approaches the terminal with his/her card and in this manner does everything necessary for his/her ride. Technical features: e-card reader ISO-14443, fast terminal printer with a cutter and simple paper change, big graphic LCD display FSTN, electronic ticketing system.

Picture 3. Smart card [2]

Electronic ticket provides for a fast and simple daily payment of travel in passenger traffic. When the electronic ticket is held close to the terminal BT3, the computer checks the ticket functionality and distance and based on the complex algorithm approves or denies the entrance and at the same time reduces the amount of funds available at the card and prints a payslip.

The system also allows cash payments for occasional travelers who are then issued a bus ticket.

All those transactions are recorded and transferred into the central database, and additionally they provide a basis for internal calculations, drafting reports and traffic analysis.

Nowadays, PUC "Zenicatrans – Passenger Transporttion" has installed electronic ticketing system in all

its driving units. In addition, the bus inspectors, ticket (smart cards) sale officers, cash handling and registration officers handling the drivers and their daily paperwork are also equipped with the same electronic devices.

Picture 4 shows a bus at a bus stop.

Picture 4. Bus at a bus stop [1]

BUS4i Application

PUC "Zenicatrans – Passenger Trasportation" joint stock company Zenica operates through servers in Kranj, Slovenia owned by the "Četrta Pot" Ltd. Kranj Company which actually installed this program in our buses. This includes the following:

- operation by travel order (lines, station, departure time)
- all code lists, price lists, lines etc. are adjustable in the database,
- parallel tariff system
- selection of price list for given line, country, departure/arrival stations, cooperation etc.,
- automatic price calculation for all sorts of passenger, luggage and package tickets,
- higher discount categories (disabled people, employees and others),
- fast printing of tickets with all the data,
- the possibility of cancellation and traffic review,
- the use of contactless card as a ticket (term-based, work, school, coupon ticket),
- recording of each particular ticket sale,
- handling travel orders.

Picture 5 shows electronic ticketing system.

EFFECTS OF THE ELECTRONIC PAYMENT SYSTEM APPLICATION

The introduction of the electronic ticketing system resulted in:

- raising the quality of services in transport
- improvement of technological discipline of employees,
- increase of the capacity availability,
- reduction of fuel consumption and other expenses,
- increased safety etc.

This kind of system provides for a continuous flow of a huge amount of information. The timely and quality information enable the company management to make a comprehensive and high quality analysis of all phases and elements of the transport system with the aim to make informed business decisions for the effective operation of the transportation process.

The system records each particular ticket sold including the place and time of sale, and also registers ev-

Picture 5. Electronic ticketing system, source: copyrighted [1]

ery single buyer of a monthly ticket. This type of passenger entry recording system opens up endless possibilities for operation analysis on individual routes, as well as the performance of every driver, especially the ticket sale officer who sells smart cards and includes the possibility of monitoring how many of the monthly smartcard rides have been actually realized.

Daily analysis of all the operational elements show that this system has directly influenced the company's survival and its future.

Analysis of fuel consumption especially during bus stopping at bus stops shows that the time the vehicle spent at bus stops has been greatly reduced. The reduction of bus stop time is caused by faster sale of individual tickets and faster inspection and recording of monthly smart cards, which led to reduced fuel consumptions, the fact that directly brings about the reduction of environment pollution caused by exhaust gasses from vehicles.

The effects of the electronic payment system application on the air pollution reduction

Based on daily information provided by the electronic ticketing system, a detailed analysis of the fuel consumption and bus stop time was made for the year of 2014. The table 1 shows basic parameters of the analysis required for the calculation of the amount of sulfur dioxide emissions (SO2) and carbon dioxide (CO2) for the year of 2014.

TABLE 1 Parameters for the calculation of the amount of SO2 and SO2 emissions [1,2,3,5]

Paremeters	Value
Passengers transported, number	5.510.687
Departures for all bus lines in one day, number	600
Average number of bus stops per single departure	11
Average number of passenger boards per stop	3
Reduction of bus stop time per passenger, seconds	5
Daily number of bus stops, number	6.600
Average fuel consumption, 1/100 km	35
Fuel consumption in one hour during engine operation in the neutral position (idling) as driver sells tickets on the bus, 1/h	6
Daily reduction of the bus operating time at bus stops, h/day	27,50
Daily reduction of fuel consumption due to short bus stop time, 1/day	165
Average content of the sulfur in the fuel, mg/kg	6,49
Average specific weight of oil, kg/l	0,85
Combustion of 1kg of fuel, generating the quantity of mg SO2	12,98
Combustion of 1kg of fuel, generating the quantity of m^3 SO2	0,7
Combustion of 1kg of fuel, generating the quantity of kg SO2	2
Combustion of 1kg of fuel, generating the quantity of kg CO2	3,22
Density of the gaseous CO2, kg/m^3	1,98

The table 1 shows that in the year of 2014, the fuel consumption was reduced by 50.490 kg of fuel, all due to shorter bus stop time. Based on the aforementioned parameters and lesser quantity of the consumed fuel, the emission was reduced by 162,57 tons or 82.106 m^3 CO2 and 655,36 kg or 458,75 m^3 SO2.

CONCLUSION

Having analyzed all the information registered by the electronic ticketing system and information acquired, it is obvious that the application of new technologies in traffic contributes to the reduction of emissions of sulfur dioxide, carbon dioxide and other components caused by fuel combustion.

The reduction of emissions is caused by shorter bus stop time and lower fuel consumption. The system provides a great deal of information required for quality management of traffic processes.

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PROFESSIONAL PAPER

Analysis of road safety before and after road safety assessment carried out on the road section no. 16 Banja luka – Celinac, intersection "Groblje-Vrbanja"

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Abstract: The Republic of Srpska implemented three procedures provided by the Directive 2008/96/EC, namely: road safety audit for infrastructure projects (Road Safety Audit, RSA), road safety impact assessment (Road Safety Assessment RSI), as well as the procedures of identifying, ranking and remedying and black spots management (BSM).

This paper presents a concrete road safety inspection of intersection on the primary road (major road) M4 in the place Vrbanja near Banja Luka. The said intersection is where the major road and access road to newly constructed cemetery in Banjaluka intersect. After the inspection, the Public Company "Republic of Srpska Motorways" as road administration implemented some recommendations from the final Report on road safety inspection in order to improve these procedures.

Also, an analysis was carried out to identify the conditions before and after the audit and partial implementation of recommendations.

Keywords: 2008/96/EC, Republic of Srpska, RSA, RSI, BSM.

INTRODUCTION

Regulation on audit and inspection, requirements and manner of licensing (Official Gazette of the Republic of Srpska, number 72/12) road safety audit is defined as follows: "Road safety inspection is a formal safety assessment of the current road conducted by a competent individual or a team". Road safety inspection is carried out by an auditor having a license for road safety audit which is issued by the Road Safety Agency, pursuant to provisions laid down in the said Regulation.

During the year 2014, and given the higher number of traffic accidents at the said spot, road safety inspection was carried out [1], on the section Banja Luka (Rebrovac)-Čelinac, major road M4, for the micro-spot of the intersection of the access road to the New city cemetery in Banjaluka and previously mentioned section of the major road M4.

The said intersection, in the form it currently exists, was constructed in several different phases, based on the project documentation developed for the purpose of constructing the said intersection, which included significant construction works and violation of property relations, the existing residential buildings within the intersection zone. It is necessary to highlight that certain elements of the intersection are constructed within the borders of available land in the manner that some elements of the intersection provided for by the project documentation were constructed in an improvised manner, in order to suit the current property situation.

In the course of the year 2013, on previously constructed area of the intersection, channelling island was constructed which was fully compliant to the project documentation, whereas other elements of the intersection were not in line with solutions from the project documentation.

Given the nonconformity, traffic accidents occurred more frequently, featured by hitting the channelling island which made the administrator to remove the island after the order of the road inspection and to require a road safety audit to be carried out (RSA, RSI).

METHODOLOGY

Through previously mentioned road safety audit procedure, an analysis of the subject spot was conducted relating to road safety, in accordance with methodol-

ogy determined for this procedure. The report provides short-term, medium- and long-term measures to improve the traffic conditions on this spot.

Picture 1. An overview of road safety audit coverage (Google earth, 2016)

This paper provides an analysis of activities undertaken after the procedure of the road safety inspection was conducted on the section of the major road M4, in the place Vrbanja in Banjaluka, first of all from the aspect of civil-engineering and other measures on the subject section and/or concrete spot, as well as the analyses of the effect of certain measures on safer traffic at the very spot.

The analysis was conducted with the aim of bringing it as close as possible to the content of the report [1] and to make as simple as possible the comparison of the conditions before the report was made and the conditions on the day this paper was produced. In this regard, the results of the research and discussion relating to the research included the following segments which are typical for the implementation of road safety audit procedure:

1. Function and road environment;
2. Cross-section of the road;
3. Road route;
4. Intersections;
5. Public and private services, services and rest area, public transport;
6. Needs of vulnerable participants in the traffic;
7. Traffic signalisation and road equipment.

Finally, this paper provides final considerations relating to the importance of implementing this procedure to the concrete spot.

RESULTS OF RESEARCH

The subject spot presents a zone of intersection of the major road M4 and access roads to the newly constructed city cemetery "Vrbanja" in Banja Luka, which is presented in the picture 1

Function and road environment

Conditions before the road safety audit was carried out

The subject section is used for mixed traffic, whereby it should be emphasised that along the section, to the left, looking from the direction of Banja Luka towards Čelinac, there are two individual residential buildings with connections to the road, and the connection spots of individual residential buildings and connecting roads are not marked. Further on, the road spreads in the form of a sharp curve to the left in the radius of 90 m, and then 80 m far from the curve to the left separates the connecting road to the new cemetery which spreads like a sharp right curve in the radius of 120 m.

Proposed measures

Through short-term measures, the report recommends removal of the trees and overgrowth from the right side of the road, looking from the direction of Banjaluka towards Čelinac, in the entire length between the two adjacent curves.

Implemented measures

In this moment, it can be stated that no significant interventions have been implemented in order to reduce the impact of the road environment and its effect to traffic accidents.

Road function is a parameter that is changed in the long run and by systematic measures and in the given context so that the change of the road functions was not envisaged in the short period which elapsed from the period of this report until now.

Cross-section of the road

Conditions at the time road safety audit was carried out

At the time the Road safety inspection was carried out, the road was divided in two lanes with one traffic lane, whereby the right lane was 3.40 m wide and the left one 3.30 m. On the very surface of the intersection, the right lane included one traffic lane 3.0 m wide, while the left lane included three traffic lanes at the width of 3.20; 3.30 and 3.00 m respectively (end left traffic lane). After the intersection the road was divided in two lanes with one traffic lane each, the right one 3.20 m wide and the left one 3.40 m.

Access road to the new cemetery consisted of two lanes whereby the right lane, looking from the direction of the cemetery, was divided in two traffic lanes, right- and left-turn lanes, and the left-turn lane consisted of one traffic lane.

Water drainage from the connecting road was resolved in the way that a culvert with grids was constructed over the entire width of the connecting road, whereby the grid was partially damaged. At the very crossroad, the surface of the lane was different, and particularly emphasised are colours of the asphalt on certain traffic lanes which can confuse participants in the traffic.

On the observed section, the width of traffic lanes is not widened in curves.

There are no pedestrian lanes on this section except for the 60 m long sidewalk which spreads from the right edge of the connecting road, looking from the direction

of the major road towards Čelinac.

There is a real danger of vehicles congestion on the observed intersection when drivers turn to the cemetery and back at the time of funerals, which was not properly marked. Given that there is no special left-turn lane, when looking from the direction of Banja Luka towards Čelinac, and that the length of the right traffic lane leading from the curve is relatively short (about 75 m) there is a real danger of vehicles congestion and hitting vehicles from the back due to insufficient visibility.

Proposed measures

Within medium-term measures, a reconstruction of the intersection is envisaged, with special accent on the channelling island on the direction towards Čelinac with recommended length of at least 250 m, as well as construction of a bus stop that is a lay-by.

Long-term measures predict reconstruction of the subject intersection and turning the current three-leg crossroad into roundabout.

Implemented measures

Partial reconstruction has been made in the zone of the subject intersection, whereby channelling island was constructed in the length of ~128 m, while channelling island was physically constructed at the length of ~90 m, and the remaining part is in the form of horizontal traffic signalisation.

Picture 2. Condition on the subject spot from 2011 (Google earth, 25 October 2016)

Picture 3. Condition on the subject spot from 2016 (Google earth, 25 October 2016)

Road route

Conditions in the time road traffic safety audit was carried out

The report states that the current speed limit of 50 km/h is not in compliance with elements of the road route and that visibility at the right curve is not ensured due to the overgrowth and trees on the right side of the road. Within the very zone of the intersection, it was stated that the road route is not appropriate and/or that after the direction (direction from Čelinac) at the length ~300 m the route enters the curve with a radius of 120 m.

Proposed measures

Neither short nor medium-term measures presume the change of horizontal geometry of the road in the zone of the subject intersection, while long-term measures suggest correction of the horizontal geometric elements of the road.

Implemented measures

Compared to the analysed conditions, no change in the horizontal geometry of the road occurred so that the same curves are retained in the same conditions as recorded in the course of the year 2014.

Picture 4. Condition on the subject spot from 2011 (Google earth, 25 October 2016)

Picture 5. Condition on the subject spot from 2016 (Google earth, 25 October 2016)

Due to the overgrowth and trees on the right side of the road when looking from the direction of Čelinac, horizontal visibility is still reduced at the right curve.

Intersections

Conditions in the time the road traffic safety audit was carried out

There is an intersection on the observed section where the access road to Novo groblje (New Cemetery) connects to the major road, to the left, when looking from the direction of Banja Luka towards Čelinac. The connecting road collides with the major road at an angle

of about 100°. The lane of the intersection is 12.50 meters wide and the width of the right traffic lane is 9.50 meters wide, looking from the direction of Čelinac, which can confuse drivers when they are to choose the traffic lane and encourages them to drive faster, which is very dangerous when we take into consideration the vast curve from both directions and the crossroad in the zone of two consecutive curves from opposite directions.

Traffic priority in the crossroad can be recognised, but traffic flow is not fully comprehensible because of the three traffic lanes on the left lane. The crossroad project does not meet the needs of road users, which particularly refers to the needs of users driving to the new cemetery. There is no left-turn lane, looking from the direction of Banja Luka towards Čelinac, although it is expected that funeral processions move from the direction of Banja Luka.

Proposed measures

The surface of the intersection has been considered through all the three levels of measures in this report and/or short-, medium- and long-term intervention measures on the subject locality.

Short-term measures presume installation of traffic signalisation and equipment in order to reduce the speed of driving through the surface of the intersection, and in terms of an appropriate and timely identification of horizontal elements of the road and the intersection.

Furthermore, medium-term measures propose partial reconstruction of the intersection with the aim of separating the traffic lanes for different directions, while the long-term measure proposes the reconstruction of the said intersection in a wider context and its transformation into a roundabout.

Implemented measures

At this moment, it can be concluded that short- and medium-term measures have been partially implemented. The intersection has been reconstructed in the manner that traffic lanes were separated by construction (item 3.3.3), so that appropriate vertical and partial horizontal signalisation has been installed along the road (item 3.7.3), as proposed by the short-term measures, which enables drivers to timely and properly notice certain elements in the intersection, including the elements of the road horizontal geometry.

Public and private services, services and rest areas, public transport

Conditions in the time the road traffic safety audit was carried out

Public suburban traffic is carried out along the subject intersection and/or the intersection zone, within the system of the public and suburban transport of passengers in Banja Luka. At the time the road traffic safety inspection, the cemetery was not in function so that a bus stop was not needed in the subject zone.

Proposed measures

Considering the fact that relative to the time of preparing this report on traffic safety inspection commissioning of the location intended for the cemetery was expected, in this regard auditors of the road traffic safety provided concrete proposals for the construction of bus stops on the part of the road in that direction, directed towards Čelinac. Besides the above stated we need to say that auditors reported that zebra crossings and sidewalks should be planned for pedestrians in addition to bus stops.

Implemented measures

Compared to the conditions before the road traffic safety inspection, no substantial changes occurred, except that one public transport line was introduced to the city cemetery, in accordance with the timetables, while only one bus stop with turning option was formed within the complex so that buses coming from the direction of Banjaluka approach the cemetery and the bus stop via the crossroad.

Needs of vulnerable users of the road

Conditions at the time the road traffic safety audit was carried out

At the times this report is developed, needs of pedestrians are not taken into consideration because there are no zebra crossings. The subject section is not lighted so that movement of pedestrians is not safe at night. Due to reduced visibility, visual contact between a driver and a pedestrian is not ensured. The observed section does not provide biking paths or lanes.

Proposed measures

Having in mind that short-term measures envisage substantial construction works, and given that no activities are planned in this respect to improve the safety conditions and movement of pedestrians, it was planned through medium-and long-term measures instead, where construction of appropriate footpaths have been envisaged.

Implemented measures

A higher number of pedestrians are expected on the observed section once the cemetery is in function. Needs of pedestrians have not been taken into consideration since zebra crossings are not provided. The subject section is not lighted so that movement of pedestrians is not safe at night. Due to reduced visibility, visual contact between a driver and a pedestrian is not ensured. There are no biking lanes or paths on the observed section.

Traffic signalisation, marking, light

Conditions at the time road traffic safety audit was conducted

At the time this Report was developed, not all vertical traffic signalisation was installed on major or on access roads. There are traffic signs of speed limitation of 50 km/h from both directions of movement. When approaching the subject intersection, danger signs for connection roads are missing. Horizontal signalisation at the very intersection is missing as well as signs to guide traffic in the intersection – permitted directions and direc-

tions of movement.

Proposed measures

Traffic signalisation and equipment are integral part of the road so that installation of appropriate traffic signalisation and road equipment are planned to this respect in all three levels of the proposed measures.

Concrete development of traffic signalisation is given through the implementation of short-term measures, first of all because of the fact that the installed traffic signalisation and equipment make the basis for these measures.

In medium-term measures, the proposed traffic signalisation and road equipment are in the function of final solutions and the road safety auditors fail to provide any concrete traffic-technical solutions in this context, but the designer was given the task to design the appropriate traffic signalisation and equipment in accordance with positive legal regulations.

DISCUSSION

Guidelines for traffic safety assessment [3], adopted by the Republic of Srpska Government, traffic safety assessment is defined as follows: "Traffic safety assessment is a regular and routine assessment of characteristics and possible errors and/or defects on the roads that require maintenance for safety, which means that it is about assessing and/or defining possible deficiencies incurred after commissioning of the road".

Within the report on road safety assessment [1], in addition to the analysis of conditions and the proposed measures, certain problems were identified that are reflected through the following:

- Intersection for the newly constructed cemetery lies between a sharp right and a sharp left curve whereby the distance between these two curves amounts to 159 m,
- Visibility on the mentioned section leading to the newly constructed cemetery lies between s sharp right and a sharp left curve whereby the distance between the tops of these two curves amounts to 150 m,
- Visibility on the said section is insufficient due to the trees and overgrowth which do not allow participants in the traffic to spot the curve timely. Visibility problem is particularly difficult for drivers who turn left,
- Speed measurement, which is given in the attachment herewith, showed that the current speed limitations are not observed. This particularly stands for vehicles driving from the direction of Čelinac towards Banja Luka,
- Left-turn lane is missing, looking from the direction of Banja Luka towards Čelinac, where several tens of vehicles are expected to gather in the time of funerals,
- Connection road for the new cemetery is not at the level of the major road, it is on the ascent with the longitudinal slope of 6 to 10%,
- There is a problem of traffic management in the intersection due to the three traffic lanes for vehicles driving from the direction of Čelinac towards Banja Luka, while there is one traffic lane for vehicles moving from the direction of Banja Luka towards Čelinac,
- There is a problem for vehicles connecting from the direction of the cemetery towards Banja Luka when they turn right. The time needed to make sure that the road is free, to turn right and to achieve the permitted speed of 40 km/h (traffic flow speed) amounts to about 8 seconds. There is a real danger that drivers driving from the direction of Čelinac towards Banja Luka who exceed the permitted speed of driving (which was indicated in speed measurement), will not notice a vehicle connecting the road from the direction of the cemetery on time and that this vehicle might be hit from behind.
- There is no public bus transport stop nor the pedestrian path on the observed section.[1]

Pursuant to article 10 of the actual Regulation [2], once the auditor has completed the report, provided recommendations and submitted the report, the authority shall be obliged to analyse the assessment carried out and make a written statement on recommendations given by the auditor.

In this concrete case [1], there is no track on the statement on auditor's recommendations so that it is not possible to make an analysis of attitudes the authority on recommendations of the road safety auditor in this segment.

Analysis of implemented measures brings the conclusion that the authorities (the City of Banja Luka for the access road and the public company "Republic of Srpska Motorways" Ltd. Banja Luka for the major road), have not implemented the measures and recommendations given in the report to a significant extent. [1].

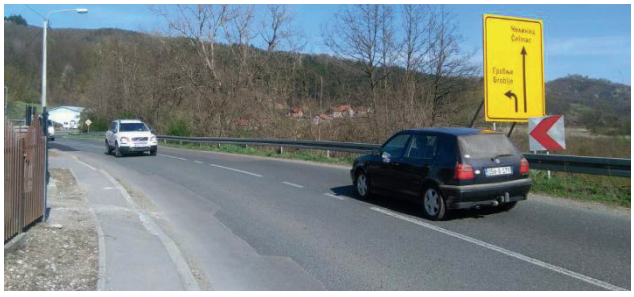
Auditor's recommendations, stated in the report are defined as short-term, medium- and long-term measures. Short-term measures were in the function of fast action with the aim of reducing the number of traffic accidents and they could not have been analysed from this point of view given that realisation and implementation of these measures was not observed, so the time when the authority implemented a number of medium-term measures was not recorded. The implementation of long-term measures is not the subject of this discussion either, because they have not been implemented.

When it comes to medium-term measures, it is obvious that they have been implemented to the extent that the form of recommendations was met in the segment of channelling the road surface, additional lanes were formed for left-turn, and a part of signalisation system and equipment was installed.

In the report, auditors indicated the need for one channelling island at the length of at least 250 m, with the aim that the channelling island and the current horizontal curve that are of relatively small radius could be noticed much earlier so that drivers could adjust the driving speed to the conditions.

Within the presentation of the research results, it was stated that the speed in the intersection zone is limited to 50 km/h. However, taking into consideration the fact that disregard for speed occurs mostly on sections where the speed limit is 50 km/h or 60 km/h, 58%, and/or 68% drivers who disregard the permitted speed were recorded [4], while it was expected that most drivers disregarded the prescribed speed limit in the zone of the intersection, which prompted auditors to define the minimum length of the channelling island. In this connection, the consequences on the channelling island (direction from Čelinac), which can be seen on the picture no. 6, support the fact that the lack of visibility and inadequate speed prevent a certain number of drivers from establishing the contact with the channelling island, the traffic signalisation and the road equipment, which obviously existed in the given moment.

Picture 6. Condition on the subject spot from 2016 (4 March 2016)



Picture 7. Condition on the subject spot from 2016 (4 March 2016)

According to the above stated, it can be concluded the channelling island was not constructed in the right manner and in appropriate dimensions so as to make it visible to all motor vehicle drivers.

From the direction of Banja Luka (Picture no. 7), a separate left-turn lane was constructed (n=2), which prevents vehicle congestion, while the traffic signalisation that marks the spot where the sharp curve starts (sign "Direction post" (III-71) and (III-72), was installed in an appropriate manner, which can be said for another direction as well (from the direction of Čelinac).

Compared to the conditions before the report was produced, the safety level was increased and traffic signalisation installed so that it can be concluded that this notably reduced the consequences arising from the insufficient implementation of the required construction measures.

CONCLUSION

The above text presents the research results that refer to traffic conditions in the zone of the intersection of the access road towards the new cemetery and the major road M4 in the place Vrbanja in Banjaluka.

In the course of the year 2014, a team of auditors produced a report on road traffic safety assessment, in which they stated problems in an unambiguous manner, and provided recommendations in terms of short-term, medium- and long-term measures to improve the traffic safety on the subject site.

The assessment of the expert team aimed at informing the authority about the real scope of the problem on the subject spot and recommending the authority to undertake measures following an appropriate dynamic plan, adequate and quality measures.

After the analysis was carried out, it could be concluded that the authority failed to appropriately recognise the scope of the problem which is the result of the construction of three-leg crossroad on the subject microlocation, whereby the authority failed to recognise the importance of the traffic safety assessment procedure.

Development of laws and bylaws in terms of strengthening the procedures of audits and safety assessment is one of the ways for the appropriate implementation of recommendations, as well as the appropriate and quality measures with a suitable dynamic plan.

Besides the above indicated, auditors must justify the trust through their report on implemented measures and audits and give recommendations and propose measures that can be implemented in the given moment with the best ratio between the "invested and gained".

In addition to the above stated, in further context of traffic safety improvement on the subject site, it is necessary to track the occurrences of traffic accidents and consequences thereof, and to undertake appropriate actions and implementation of the remaining recommendations that have not been implemented yet.

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[1] Zahavi Y. and Ryan, M. James. Stability of Travel Components Over Time. *Transportation Research Record*, 750 (1980), 70-75.

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Article in a Periodical [3]

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