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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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Editorial Office
Pan-European University Apeiron
Pere Krece 13, 78 000 Banja Luka, B&H
Tel: +387 51 247 910
Mob: +387 65 141 619
Fax: +387 51 247 921
http://www.tttp-au.com/
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info@tttp-au.com

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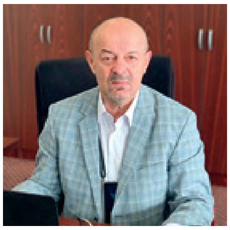
Contents



EDITOR'S WORD

Dear readers,

It is my pleasure to present to you the tenth, printed and electronic magazine " Traffic and transport theory and practice – TTTP" which successfully resists the challenges set in areas of contemporary processes of traffic and transport engineering.

It is important that we have managed to have continuity of two regular issues annually, with high criterion of selection and discretion in relations between the editor and authors. Topics of papers in this issue include alternative fuels, management and transport of dangerous materials, traffic regulation and management of speeds in roundabouts, the analysis of TWSC junctions in the focus of access roads. We have also presented contemporary methods for safety risk management in traffic, as well as artificial intelligence which is today drives the development of economic and social processes as a whole.

The magazine has ensured an open access to previous issues on its own website (https://apeiron-uni.eu) which enables wider population of researchers to publish and protect the copyright of their papers.

Editor-in-Chief
Prof. Danislav Drašković, PhD Eng.

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ORIGINAL SCIENTIFIC PAPER

Time based separation model in high density U-space traffic environment

Vladimir Milošević
Master of Science degree of Aeronautical Engineering from the Faculty of the Transport and Traffic Engineering of the University of Belgrade, Serbian; vladimir_milosevic@hotmail.rs

Mirjana Vasiljević
B.Sc. Engineer in Business and Informatics, Singidunum University, Faculty of Informatics and Computing, Belgrade, Serbia; mirjana.vasiljevic@ymail.com

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Abstract: This paper is based on actual U-space regulatory framework defined by the international regulators like EASA, JARUS, FAA and connected actors like AIRBUS, EUROCONTROL or AMAZON. The aim of the work is to analyze requirements for the most complex use cases and define possible deficits in time, capacity and safety. The result should define possible more efficient methods, technologies and procedures and emphasize main development directions for efficient and robust traffic management system.

Keywords: drones, UTM, U-space, CORUS, ATM, UAV, BVLOS, VTOL, time-based separation.

INTRODUCTION

Modern time of 21st Century has brought technological advancement in many areas, but expansion of air and space industry is the most remarkable one. The revolution in communications and IT technology requires more efficient transport of people and goods to the destination all over the world. Large cities are looking for more efficient way of commuter transportation, with easier and more efficient way to construct and maintain transportation system in their areas of responsibilities.

The Unmanned Aerial Vehicles (UAV), well known as “drones”, showed as very useful and efficient tools with many applications, from personal entertainment up to the large scale of business cases in many areas. Low price, flexibility of use, vertical takeoff and landing (VTOL), with no need for large infrastructural systems like airport or road network, which have to be constructed and maintained, are the main advantages which put the UAVs development on a very fast lane.

Expansion of UAVs, and air safety sensitive use cases like transportation of humans or goods, initiated the need for development of specific U-space system based on principles of the ATM system which is developed for the General Aviation. The ICAO, and regulators from different part of the world, initially identified risks for the General Air Traffic (GAT) and started regulatory processes [1].

Today, with support of different UAV organizations like Joint Authorities on Rulemaking for Unmanned Systems (JARUS), basics for further development of U-space system include classification of UAVs, Air Space Classification of UAV operations, types and phases of UAV operations, list of services which will be provided in U-space environment, U-space development phases from U0 to U4 with projected services for every phase [2].

MAIN CHARACTERISTIC OF UAVS AND U-SPACE SYSTEM

Main configuration of UAVs or drones is quadcopter configuration with four or more rotors and with weak or no aerodynamic performance. This allows motions in 3D environment in all directions with slow speed and hovering or landing over the point. Also, the future of UAVs is mainly perceived as personal transportation, at short routes, beyond the visual line of sight (BVLOS), fully automated in business cases or remotely piloted in emergency operations, like Firefighting or Rescue missions in urban or suburban areas.

Characteristics of U-space system, in their most developed and most demanding U-4 phase, includes high level of automation, augmented GNSS navigation, intensive 6G based exchange of information in many layers for long list of services, no human in loop decision making processes [3], personalized and automated vehicles as basic traffic units, on demand transportation of humans and goods, high density traffic operations, strong information security environment.

Summarizing all characteristic there are two use cases which are technically and procedural most demanding, and they cover all aspect of the U-space system which have to be developed for safe, smooth and efficient environment for whole list of operations and use cases [4], and those are:

- "Beyond the skyline" or "Delivery operations" which are settled in modern cities at very low level (VLL) where corridors are defined among the buildings, and it is used for delivery of goods.
- "Above the skyline" or "Air taxi" for the on request and short routes transportation of small groups of people in large cities [5].

DEFICIT OF TIME, ENERGY AND INFORMATION MANAGEMENT CAPABILITIES

Density of some traffic system is connected to the number of traffic units and number of traffic participants, where traffic units are transportation vehicles and traffic participants are number of persons who are transported or number of persons that certain delivery covers. Relation among those elements can be described with simple equitation:

$$\text{Traffic Density} = \frac{\text{Traffic Units}}{\text{Traffic Participants}} \times 100\%$$

In situation where personalization of traffic is ongoing process the number of traffic units will be increased closer to the number of traffic participants (e.g., one car for one person) which will result of higher traffic density.

Complexity of traffic management is referred to the amount of information that has to be processed in real time for decision making process. If we compare actual way of transportation (Air, Road, Rails …) we can conclude that problem of complexity is solved with decentralization of the traffic management so the amount of data that should be processed in decision making process is significantly low. Car driving is personalized, relatively self-sustainable, with high traffic density but quite low data load in decision making processes, which is based on traffic participant.

As the flying is quite complex activity based on many precaution activities in pre-flight, and later in-flight phase, number of services and demanding data exchange is relatively high and centralized what increases complexity of the U-space traffic data exchange system. Data filtration and management in decision making process will be main problem in future of U-space design.

Volume of certain area where traffic is organized directly influence the available reaction time for the conflict resolutions and decision-making processes. Volumes of the U-space areas, settled over the large cities, are significantly smaller than the areas of ATM systems what will increase the possibility of conflict situations and cause the reaction time deficit.

Deficit of fuel or energy that is capable to overcome gravity for the certain mass requires highly efficient U-space traffic system, capable to provide shortest and synchronized routes without stops and unnecessary hovering over certain points, and lower altitude levels, having in mind that the lack of aero-dynamical capabilities.

A requirement of the high level of data security, like Blockchain technology has promoted, combined with large amount of data processing in real time requires provision of the significant computational force, and can cause longer latencies, and many communicational problems.

If we translate everything mentioned to the U-space traffic management, high density on demand traffic operations will inevitably require decentralization of decision-making processes, simplification of procedures and techniques and higher level of automation based on Artificial Intelligence.

U-SPACE CONFLICT RECOGNITION AND RESOLUTION

All mentioned deficits have opened many airs safety issues. Basic safety regulation for U-space divided UAVs operations in three phases: Strategic (Pre-flight) separation, Tactical (In-flight) separation, Collision avoidance with Detect and Avoid (DAA) equipment [2].

Based on tradeoffs between operations safety and freedom of actual aircraft U-space structures can be composed by one of four proposed strategic concepts [2] [5]:

1. Basic flight (Layers),
2. Free route (Full Mix),
3. Corridors (Tubes),
4. Fixed Route (Zones).

Large cities already have intensive air traffic with helicopters in police, rescue and firefighting operations and high-end business use cases, open drone operations in Visual Line of Sight (VLOS) for commercial and personal use [6]. This does not leave much possibilities and space to stack many layers over large cities to accommodate intensive U-space traffic, and to construct complex approaching areas to many landing zones and sectors [7] [8].

Everything implies that all traffic should be accommodated in one or a few layers, and the horizontal separation and conflict resolutions method will be primary one, as difference to the regular ATM systems. Longitudinal procedures related to the time-based separation will be core of preflight and in-flight phases of operations, while lateral separations will be main method for collision sense and avoid procedures.

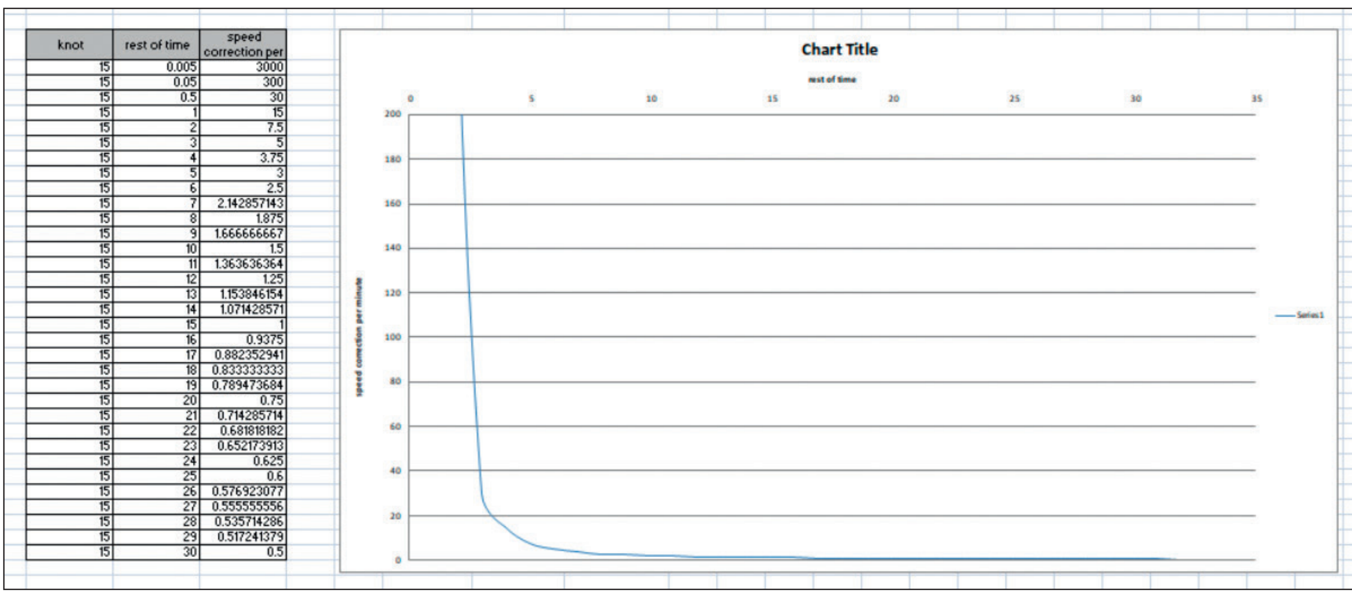
With all mentioned deficits, the future U-space structures will be hybrid, with combinations of those strategic concepts with higher level of precision in positioning and navigation, time-based separation, time gates on crossings and block-chained flight plans, network centric data broadcasting and exchange.

SPEED CORRECTIONS IN TIME-BASED ENVIRONMENT

The time-based separations are based on exact time of arrival targeting over the certain point. This requires precise navigation in all three dimensions plus precise speed-time control as a tool for longitudinal position manipulation. Time based separation provides avoidance of traffic fluctuation and cut delays and holdings, and provide savings in needed energy for flight, spare fuel and protect nature in many ways.

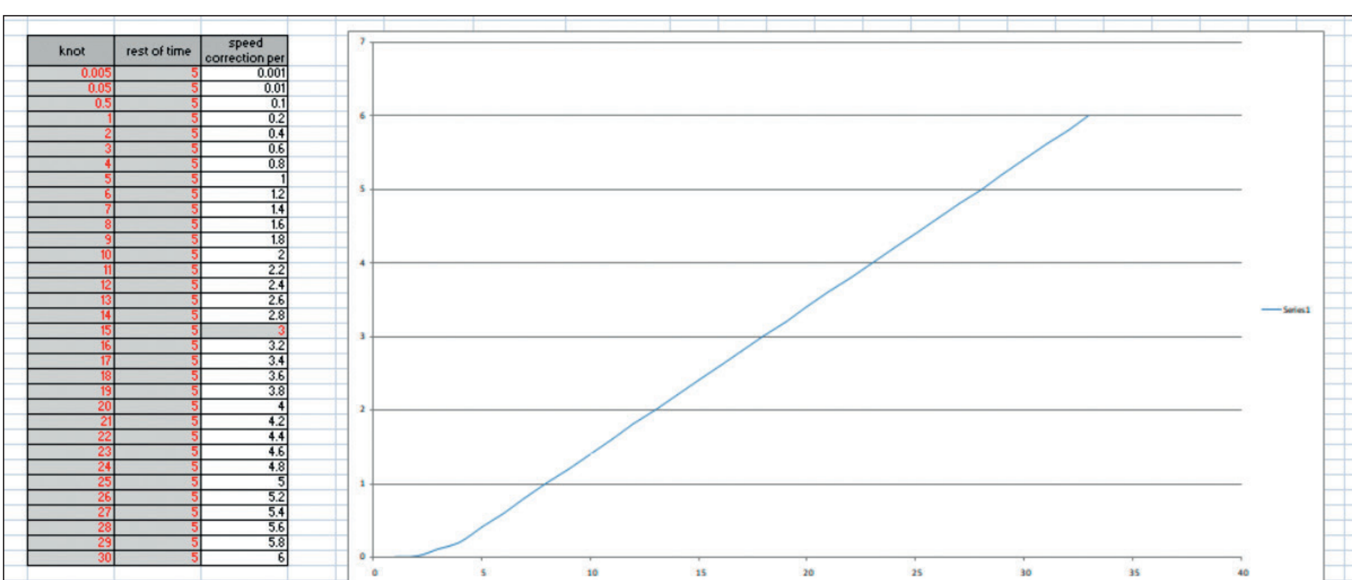
Future hybrid network centric U-space structure should be defined as dense network of lanes which can provide routes “as close as it is possible” to direct fly-to routes with many crossings which will have opened and closed time gates. The UAVs as traffic units in preflight phase will define exact combination time gates up to the destination, and during the flight will manipulate with small speed corrections to target dedicated time gate on every crossing. The density of network should provide automated in-flight avoidance re-routing procedures, as second level of conflict resolution.

Speed corrections are core of longitudinal position manipulation and exact understanding of the nature of speed can provide engineering of methods and tools which will be capable to instantly detect delays or overtimes. Correlating the value of speed correction with rest of time till the destination point in function the resulting speed correction has tendency to the infinity as the time for the correction goes toward zero, and vice versa if correction time goes toward infinity. In



knot	rest of time	speed correction per
15	0.005	3000
15	0.05	300
15	0.5	30
15	1	15
15	2	7.5
15	3	5
15	4	3.75
15	5	3
15	6	2.5
15	7	2.142857143
15	8	1.875
15	9	1.666666667
15	10	1.5
15	11	1.363636364
15	12	1.25
15	13	1.153846154
15	14	1.071428571
15	15	1
15	16	0.9375
15	17	0.882352941
15	18	0.833333333
15	19	0.789473684
15	20	0.75
15	21	0.714285714
15	22	0.681818182
15	23	0.652173913
15	24	0.625
15	25	0.6
15	26	0.576923077
15	27	0.555555556
15	28	0.535714286
15	29	0.517241379
15	30	0.5

Fig. 1. The value of speed correction in correlation with rest of time till the destination



knot	rest of time	speed correction per
0.005	5	0.001
0.05	5	0.01
0.5	5	0.1
1	5	0.2
2	5	0.4
3	5	0.6
4	5	0.8
5	5	1
6	5	1.2
7	5	1.4
8	5	1.6
9	5	1.8
10	5	2
11	5	2.2
12	5	2.4
13	5	2.6
14	5	2.8
15	5	3
16	5	3.2
17	5	3.4
18	5	3.6
19	5	3.8
20	5	4
21	5	4.2
22	5	4.4
23	5	4.6
24	5	4.8
25	5	5
26	5	5.2
27	5	5.4
28	5	5.6
29	5	5.8
30	5	6

Fig. 2. The speed corrections in correlation with corrections per minute.

another hand, small speed corrections require smaller corrections per minute.

Combining dose two principles the longitudinal maneuver could be shaped with list of requirements as a basis of future methods for time-speed-distance manipulation tools. Those requirements are:

1. Delay or overtime early warning and reaction provide small speed corrections which can be divided in smaller portions over longer time period for speed/time corrections.
2. Smaller portions of speed correction provide seamless and synchronized flight.
3. Every, even shortest period of time in flight could be used as time gate, or check point, with precise passing time as unique code and capability to alert smallest deviations in longitudinal navigation.
4. Graphically if every point or time unit on route has unique time code which mathematically could be calculated:

$$\Delta Vcorr = Vplan - \frac{\text{S plan}-\text{Sflown}}{\text{Tarr}-\text{Tact}},$$

As we plan routes without delays,

$$Vplan = \frac{\text{S plan}-\text{Sflown}}{\text{Tarr}-\text{Tact}},$$

and time on any point could be expressed as,

$$Tact = Tarr - \frac{\text{S plan} - \text{Sflown}}{\text{V plan}}$$

Using this equitation, we can project navigational time marker for every point of route as a tool for precise longitudinal position and speed manipulation.

CONCLUSION

U-space is much smaller volume which should settle very intensive and demanding traffic system based on high density, high level of automation, on demand operations and totally new safety cases. It is very hard to copy actual ATM system on U-space without deep reconstructions and accommodation. Actual level of

U-space development established basic regulations for UAVs and U-space classification, list of services divided by the phases of development, phases of U-space operations based on safety issues and possible traffic structures for aircraft separations and collision avoidance.

Due to many factors and characteristics of U-space system this work determined crucial deficits of time, capacity and energy which led us up to the new list of requirements which most demanding U-space operations and use cases will need. Basically, future U-space structure will be hybrid, very close to "direct fly to capability", based on time gates and horizontal navigation and separation. Tools which will provide precise longitudinal position manipulation, continuous time control and seamless speed corrections will be crucial for future development of U-space structures.

Future traffic structures will need to be energy efficient for all and every traffic unit, especially because the UAVs are without or with very weak aerodynamics and any kind of power loss will initiate emergency situation. Compared to the ground traffic, synchronized U-space should provide a drive through the city always on green light.

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ORIGINAL SCIENTIFIC PAPER

Influence of geometric elements of roundabouts on circulating lane speed (roundabout)

Slavko Davidović
Pan-European Apeiron University, Faculty of Transport and Traffic Engineering Banja Luka, Bosnia and Herzegovina; info@tttp-au.com

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Abstract: Research conducted in recent decades has shown that there are significant variations in speed at roundabouts depending on the geometric elements. Due to the characteristics of roundabouts and the way vehicles move, there is a reduction in speed, not only in the roundabout zone, but also in circulation (roundabout). This paper analyzes the influence of different types of roundabouts as one of the elements of the street system, on speed as one of the basic parameters of traffic flow that defines the functionality and quality of traffic conditions.

Keywords: roundabout, speed, circulation, geometric elements.

INTRODUCTION

Roundabouts are increasingly being part of the city's arteries, and their impact on traffic conditions is specific compared to other types of intersections. Compared to other types of intersections, roundabouts, due to their specific geometry, significantly affect the speed of traffic flow for all movements and maneuvers, on all part of raoundabout. Ever since the first scientific and professional papers, the functional connection between the geometric and constructive characteristics of the functional parts of the road and street network and the speed of traffic flow (HCM, 1950), and thus the conditions of traffic, has been established (Bogdanović, V., 2005).

Many papers have investigated the relationships between certain geometric characteristics of roundabouts and average speed, which they defined as the average value of input speed, speed at the roundabout (circulation) and output speed (Chen, Y., Persaud, B., Lyon, C., 2011), (Akçelik, R., 2011), (Almoarawi M., D. E., 2018), (Bezina, Š., Dragičević, V., Stančerić I.,, 2019)

The connection between the geometric characteristics of roundabouts, speed and capacity, traffic flow parameters and traffic conditions has been confirmed in many studies (Davidović S., Bogdanović V., Garunović N., Papić Z., Pamučar D., 2021) (Vincenzo, G., Rosolino, V., Teresa, I., 2014), (Rodegerdts, L., Bansen, J., Tiesler, C., Knudsen, J., Myers, E., Johnson, M., & O'Brien, A., 2010). The combination of the influence of geometric elements, traffic flow parameters and driver behavior makes the conditions of traffic at roundabouts very complex with significant variations in speed and other traffic flow parameters.

Speed is one of the basic parameters defined in simulation models in order to describe as much as possible the real conditions of traffic at roundabouts (Nikolic, G, Pringle, R., Bragg, K., 2010), (Gallelli, V., Vaiana, R., Iuele, T.,, 2014)

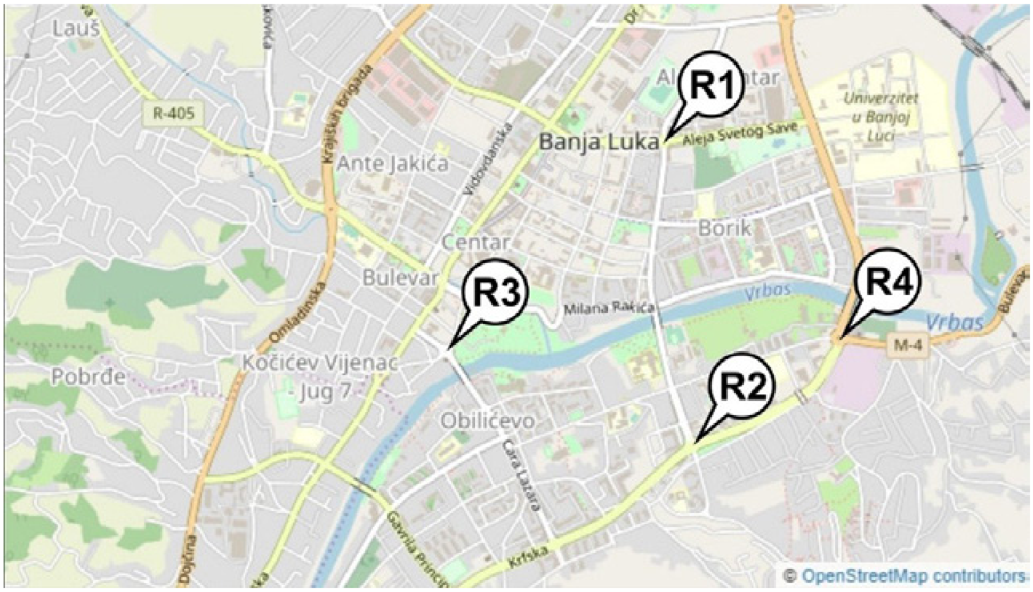
There is no methodology for calculating traffic flow parameters, capacity and service levels related to the part of the street network where the conditions of uninterrupted traffic flows prevail (Highway Capacity Manual, 2010) in which the influence of the geometric elements of the road is not included and valorized through various parameters.

The main goal of this research is to define and model the influence of geometric characteristics of roundabouts on the speed of vehicle circulating lane speed (roundabout).

In order to realize the goal, research was conducted in the real conditions of traffic, and the dependence between the geometric characteristics of roundabouts and the speed of traffic flow in circulation (roundabout) was analyzed and defined.

Data collection was done by recording the real traffic flow at four roundabouts (picture 1) in the urban area of the city of Banja Luka (Republika Srpska - Bosnia and Herzegovina). The roundabouts where the research was done belong to the roundabouts of medium size and large city roundabouts.

4 roundabouts with different geometric characteristics were selected: R1 Aleja svetog Save – Gundulićeva (picture 2); R2 Majke Jugovića – Bulevar Desanke Maksimović (picture 3), R3 Patre – Isaije Mitrović (picture 4) i R4 Bulevar Stepe Stepanovića – Bulevar Petra Bojovića (picture 5). During the research, it was sunny weather with a temperature of 15-35 ^{o}C, without fog, rain, strong wind and other unfavorable climatic conditions, the road was dry and without damage, without situations that would affect the flow of traffic.



Picture 1. Positions of analyzed roundabouts on the street network of the city of Banja Luka

Picture 2. R1 Aleja svetog Save – Gundulićeva

Picture 3. R2 Majke Jugovića – Bulevar Desanke Maksimović

Pisture 4. R3 Patre – Isaije Mitrović

Pisture 5. R4 Bulevar Stepe Stepanovića – Bulevar Petra Bojovića

Table 1 shows data on the GPS position of roundabouts.

Table 1. data on GPS position of roundabouts

Position of roundabouts in WGS-84 coordinate system	R1	R2	R3	R4
Latitude	44.773963	44.762172	44.765897	44.766366
Longitude	17.199593	17.201245	17.187834	17.209049

Traffic recording was done by the "DJI Mavic 2 Pro" drone. The created video material has a frequency of 24 fps and is processed by the software "Data From Sky" which enables marking of reference lines, analysis of the movement of objects (vehicles) on the image and review of the image by sequences with an accuracy of approximately 0.042 seconds.

By viewing the videos, two categories of vehicles were formed: vehicles that were obstructed and those that were not obstructed. Obstructed vehicles are those that had to stop at the approach to the roundabout (significantly reduce speed, below 10 km / h) for the following reasons:

- In front of the pedestrian crossing due to pedestrians,
- Before the entrance due to the traffic situation in the circulation zone.

Vehicles were also considered obstructed if they stopped at the exit from the roundabout due to pedestrians or other reasons (for example due to another vehicle that stopped due to pedestrians).

Tables 2 and 3 show the vehicle speed in circulation (roundabout) - S_crc, for unobstructed (CON) and obstructed vehicles (DIS).

Table 2. Characteristics of the vehicle speed in circulation (roundabout)- S_crc, unobstructed vehicles (CON)

INT	DEP	N	Mean	SE Mean	StDev	Min	Q1	Med	Q3	Max
R1	A	2	24,88	4,64	6,56	20,24	*	24,88	*	29,52
	B	8	22,59	0,98	2,76	19,68	20,49	21,69	24,27	28,06
	C	2	19,84	1,73	2,44	18,11	*	19,84	*	21,57
	D	1	23,20	*	*	23,20	*	23,20	*	23,20
R2	A/1	-	-	-	-	-	-	-	-	-
	A/2	-	-	-	-	-	-	-	-	-
	B/1	21	27,82	1,05	4,79	21,18	24,67	25,93	32,04	40,14
	B/2	54	28,77	0,77	5,68	18,91	25,06	28,54	30,87	51,85
	C/1	22	23,00	0,47	2,22	19,08	21,39	22,92	24,48	27,48
	C/2	14	23,31	0,49	1,84	19,50	22,39	23,13	25,06	25,79
	D/1	5	21,19	0,50	1,12	20,38	20,38	20,98	22,11	23,10
	D/2	-	-	-	-	-	-	-	-	-
R3	A	15	24,57	0,94	3,62	20,49	20,93	24,01	27,08	31,85
	B	35	25,12	0,35	2,05	19,77	24,03	25,14	24,46	29,11
	C	12	23,69	0,55	1,89	20,82	21,80	23,85	24,92	26,83
	D	2	25,73	0,63	0,89	25,10	*	25,73	*	26,36
R4	A/0	3	25,54	3,31	5,73	20,29	20,29	24,67	31,65	31,65
	A/1	1	22,40	*	*	22,40	*	22,40	*	22,40
	A/2	39	28,82	0,70	4,36	20,16	26,06	27,97	31,32	38,19
	B/0	13	26,70	0,50	1,79	23,53	25,70	26,71	28,00	30,05
	B/1	22	27,44	0,53	2,48	23,07	25,51	27,24	29,43	32,65
	B/2	24	29,69	0,59	2,90	25,08	27,31	29,67	32,51	34,89
	C/0	7	26,68	0,74	1,95	22,66	25,96	26,48	28,41	28,49
	C/1	20	26,87	0,50	2,25	22,86	24,48	27,143	28,86	30,77
	C/2	5	29,01	0,87	1,95	26,21	27,25	28,83	30,85	30,87
	D/0	-	-	-	-	-	-	-	-	-
	D/1	1	26,76	*	*	26,76	*	26,76	*	26,76
	D/2	-	-	-	-	-	-	-	-	-

Table 3. Characteristics of the vehicle speed in circulation (roundabout)- S_crc, obstructed vehicles (DIS)

INT	DEP	N	Mean	SE Mean	StDev	Min	Q1	Med	Q3	Max
R1	A	18	22,56	0,97	2,76	19,68	20,50	21,69	14,27	28,06
	B	40	20,70	0,36	2,27	19,82	18,59	2064	22,46	26,13
	C	12	19,99	0,48	1,67	17,83	18,26	20,03	21,18	22,98
	D	-	-	-	-	-	-	-	-	-
R2	A/1	-	-	-	-	-	-	-	-	-
	A/2	1	16,02	*	*	16,02	*	16,02	*	16,02
	B/1	21	21,57	0,73	3,36	15,71	19,07	21,93	24,16	26,89
	B/2	63	22,32	0,46	3,68	15,39	20,30	22,15	24,70	32,13
	C/1	46	20,19	0,36	2,42	15,42	18,53	19,95	21,59	27,95
	C/2	12	20,41	0,42	1,45	18,42	18,85	20,74	21,58	22,60
	D/1	15	19,95	0,33	1,29	17,80	18,99	20,16	21,09	22,58
	D/2	6	20,52	0,57	1,40	18,16	19,56	20,64	21,78	21,91
R3	A	32	21,21	0,81	4,81	10,08	19,09	21,34	24,77	29,98
	B	57	21,57	0,34	2,55	15,56	19,86	21,30	23,32	27,36
	C	23	21,54	0,44	2,10	16,95	20,40	21,39	23,37	24,80
	D	1	19,50	*	*	19,50	*	19,50	*	19,50
R4	A/0	1	25,96	*	*	25,96	*	25,96	*	25,96
	A/1	-	-	-	-	-	-	-	-	-
	A/2	27	20,34	0,64	3,35	13,35	18,02	21,06	22,04	27,72
	B/0	16	25,066	0,90	3,61	21,00	22,20	25,08	26,32	35,55
	B/1	19	24,90	0,55	2,40	20,80	23,14	24,78	27,20	29,28
	B/2	30	24,25	0,41	2,23	19,63	22,83	24,22	25,81	28,46
	C/0	12	24,21	0,76	2,63	20,31	22,28	24,02	26,53	29,06
	C/1	22	24,16	0,34	1,59	22,05	22,68	23,73	25,47	25,88
	C/2	4	23,63	1,46	2,92	21,08	21,43	22,82	26,66	27,82
	D/0	1	32,58	*	*	32,58	*	32,58	*	32,58
	D/1	3	25,02	0,50	0,87	24,44	24,44	24,59	26,02	26,02
	D/2	1	18,47	*	*	18,47	*	18,47	*	18,47

Based on the results of previous research and field observations, fourteen geometric parameters have been identified that could potentially affect vehicle speed:

En_lane	Parameter that defines the movement of the vehicle on the approach, entrance to the circle, roundabout and exit;
N_lne	Number of traffic lanes on the approach;
W_lne	Width of the traffic lane at the approach (m);
W_en	Entrance width (m);
R_en	Radius of entrance (m);
D1	External diameter of the roundabout (m);
D2	Diameter of the central island (m);

N_cr	Number of traffic lanes in the roundabout;
W_lnc	Width of the traffic lane in the roundabout (m);
W_cr	Road width in a circle (m);
N_lnx	Number of traffic lanes on the exit branch to which the observed vehicle flow exits;
W_lnx	Width of the traffic lane on the exit branch to which the observed vehicle flow exits (m);
W_ex	Width of the exit at which the observed flow of the vehicle exits (m);
R_ex	Exit radius at the exit branch where the observed vehicle flow exits (m);

In tables 4., 5., 6. i 7., the geometric elements of roundabouts are shown.

Table 4. Geometric parameters of the roundabout R1: Gundulićeva – Aleja svetog Save

R1 – Gundulićeva – Aleja svetog Save					
General geometric characteristics	External diameter of the roundabout (m)	33,6			
	Diameter of the central island (m)	22,0			
	Road width in a circle (m)	5,8			
	Number of traffic lanes in the roundabout	1			
	Width of the traffic lane in the roundabout (m)	5,8			
Geometric characteristics of the approach		**Approach**			
		1	**2**	**3**	**4**
Number of traffic lanes on the approach		1	1	1	1
Approach	Width of the approach (m)	3,6	3,6	5,0	3,6
	Width of the traffic lane at the approach (m)	3,6	3,6	5,0	3,6
Entrance	Entrance width (m)	5,0	5,2	5,3	5,0
	Width of the traffic lane at the entrance (m)	5,0	5,2	5,3	5,0
Radius of entrance (m)		14,0	21,2	15,0	20,0
Entrance angle (0)		26,9	20,9	28,7	25,3
Exit	Exit width (m)	5,3	4,6	5,5	5,0
	Number of traffic lanes on the exit	1	1	1	1
Width of the traffic lane at the exit (m)		4,0	3,6	4,5	3,6
Radius of exit (m)		16,9	17,4	23,3	22,1
Dividing island width (m)		1,8	2,9	3,0	2,6

Table 5. Geometric parameters of the roundabout R2: Majke Jugovića – Bulevar Desanke Maksimović

R2 – Majke Jugovića – Bulevar Desanke Maksimović					
General geometric characteristics	External diameter of the roundabout (m)			33,0	
	Diameter of the central island (m)			16,0	
	Road width in a circle (m)			8,0	
	Number of traffic lanes in the roundabout			2	
	Width of the traffic lane in the roundabout (m)			4,0	
Geometric characteristics of the approach		Approach			
		1	2	3	4
Number of traffic lanes on the approach		2	3	2	2
Approach	Width of the approach (m)	7,0	9,8	6,4	7,5
	Width of the traffic lane at the approach (m)	3,5*	3,4+3,4+3	3,2*	3,75*
Entrance	Entrance width (m)	7,4	13,0	7,6	7,6
	Width of the traffic lane at the entrance (m)	3,7*	3,7+3,7+5,6	3,8*	3,8*
Radius of entrance (m)		12,6	15,8	15,9	12,3
Entrance angle (0)		23,8	21,8	50,7	42,2
Exit	Exit width (m)	7,6	8,2	9,2	7,2
	Number of traffic lanes on the exit	2	2	2	2
Width of the traffic lane at the exit (m)		3,5*	3,6*	3,2*	3,4*
Radius of exit (m)		12,0	14,2	14,0	18,2
Dividing island width (m)		1,2	3,1	1,1	4,6

* traffic lanes of the same width

Table 6. Geometric parameters of the roundabout R3: Patre, Cara Lazara – Teodora Kolokotronisa, Isaije Mitrovića

R3 – Patre, Cara Lazara – Teodora Kolokotronisa, Isaije Mitrovića					
General geometric characteristics	External diameter of the roundabout (m)			43,0	
	Diameter of the central island (m)			31,0	
	Road width in a circle (m)			6,0	
	Number of traffic lanes in the roundabout			1	
	Width of the traffic lane in the roundabout (m)			6	
Geometric characteristics of the approach		Approach			
		1	2	3	4
Number of traffic lanes on the approach		1	1	1	1
Approach	Width of the approach (m)	4,6	4,6	4,1	4,3
	Width of the traffic lane at the approach (m)	4,6	4,6	4,1	4,3
Entrance	Entrance width (m)	5,1	4,7	5,9	5,1
	Width of the traffic lane at the entrance (m)	5,1	4,7	5,9	5,1
Radius of entrance (m)		15,4	13,4	21,6	15,2
Entrance angle (0)		35,3	25,8	31,0	33,8

Exit	Exit width (m)	5,4	4,7	5,5	4,7
	Number of traffic lanes on the exit	1	1	1	1
Width of the traffic lane at the exit (m)		4,3	4,5	4,1	4,3
Radius of exit (m)		18,4	22,5	15,0	62,2
Dividing island width (m)		3,4	11,5	3,9	8,4

Table 7. Geometric parameters of the roundabout R4: Bul. Desanke Maksimović – Bul. VojvodeStepe Stepanovića

R4 – Bul. Desanke Maksimović – Bul. Vojvode Stepe Stepanovića					
General geometric characteristics	External diameter of the roundabout (m)			57,2	
	Diameter of the central island (m)			34,8	
	Road width in a circle (m)			9,4	
	Number of traffic lanes in the roundabout			2	
	Width of the traffic lane in the roundabout (m)			4,7	
Geometric characteristics of the approach		**Approach**			
		1	**2**	**3**	**4**
Number of traffic lanes on the approach		2	1	2	2
Approach	Width of the approach (m)	7,2	4,3	7,4	7,6
	Width of the traffic lane at the approach (m)	3,6*	4,3	3,7*	3,8*
Entrance	Entrance width (m)	8	4,2	8,4	9,2
	Width of the traffic lane at the entrance (m)	*	4,2	4,2*	4,6*
Radius of entrance (m)		23	17,9	20	23,7
Entrance angle (0)		43,4	31,9	35,9	28,0
Exit	Exit width (m)	9,4	4,7	9,4	5,8
	Number of traffic lanes on the exit	2	1	2	1
Width of the traffic lane at the exit (m)		3,6	4	3,7*	3,8
Radius of exit (m)		26,9	20,2	26,2	20,2
Dividing island width (m)		2,6	6	3,6	4,1

*traffic lanes of the same width

FORMATION OF THE MODEL OF THE AVERAGE FLOW SPEED IN CIRCULATION (ROUNDABOUT) - S_CRC

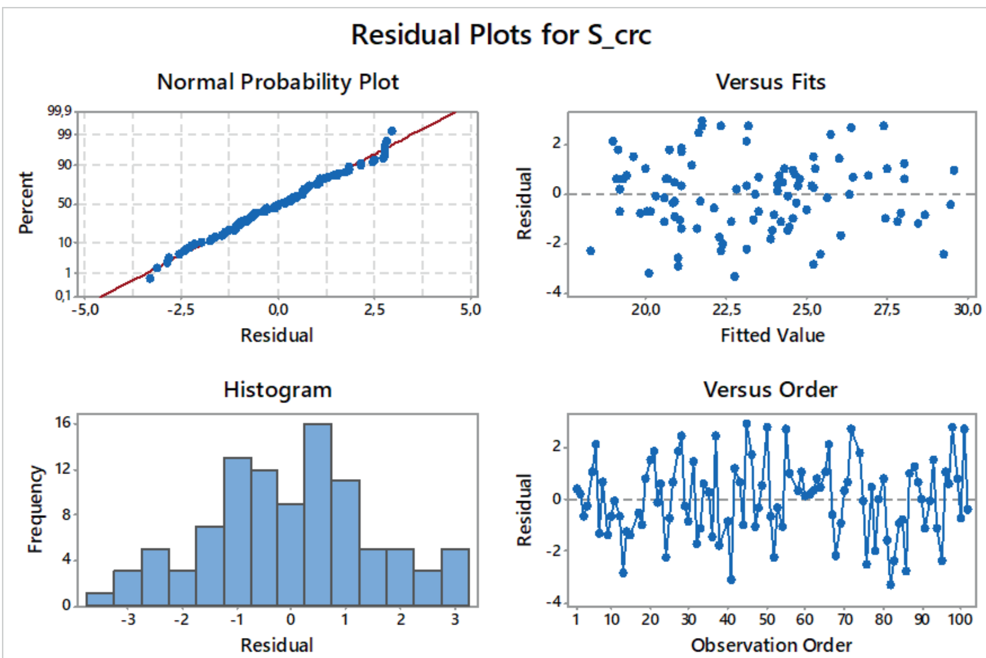
In accordance with the analysis that was done, the model of speed S_crc was formed:

$$S_{crc}^{A} = 9{,}396 + 0{,}3040\ S_{ent} + 0{,}1287\ D1 + 0{,}609\ N_{cr}$$
$$S_{crc}^{B} = 11{,}554 + 0{,}3040\ S_{ent} + 0{,}1287\ D1 + 0{,}609\ N_{cr}$$
$$S_{crc}^{C} = 10{,}250 + 0{,}3040\ S_{ent} + 0{,}1287\ D1 + 0{,}609\ N_{cr}$$
$$S_{crc}^{D} = 9{,}354 + 0{,}3040\ S_{ent} + 0{,}1287\ D1 + 0{,}609\ N_{cr}$$

$S_{crc}^{A;B;C;D}$ - Average flow speed in circulation (roundabout) (km/h), depending on the type of movement (A – right/first exit; B – right/second exit; C – left/third exit; D – u-turn / fourth exit);
S_{ent} - Average flow speed at the entry into the circle (km/h);
$D1$ - External diameter of the roundabout (m);
N_{cr} - Number of traffic lanes in circulation (roundabout);

The obtained regression has a derivation coefficient R2 = 77.85%. The corrected coefficient of determination R2 (adj) = 76.39%, while the predictive coefficient of determination is R2 (pred) = 73.94%. The standard regression error of the speed model S_crc is S = 1.54 (km / h). Based on the summary parameters of the model, it can be concluded that the determined equation very well describes the dependence of the speed S_crc and the selected predictors.

The analysis of the residues determined that they were randomly distributed around the line representing the regression curve. Residuals agree with the normal distribution (AD = 0.252; P-value = 0.731). The mean residual value is very close to zero and is 2,53765E-16. The following figure shows a graphical representation of the residuals of the velocity model S_app.



Picture 6. Residual from the speed model S_crc

CONCLUSION

At the beginning, roundabouts were mainly used on the secondary street network, but due to the positive effects of use, they quickly began to be used on the main city arteries. For the needs of traffic planning and regulation, as well as in operational and planning analysis, the effects of roundabouts are analyzed using classical methods, without taking into account the specific traffic conditions generated by geometric elements of roundabouts. Many studies since the end of the last century have shown in an objective way that roundabouts affect the speed of traffic flow.

The research in this paper was focused on the analysis of the influence of roundabouts and its basic geometric elements on the change of circulating lane speed (roundabout). The research was done in real traffic flow at four roundabouts with different geometric elements. The influence of the geometry of roundabout elements has been the subject of various studies, but in this paper, in addition to geometric elements, the influence of traffic flow, ie interaction with other vehicles at the roundabout, ie interference resulting from interaction. After the formation of the database of characteristic velocities, 14 geometric parameters of the roundabout were defined, which could potentially have an impact on the speed on the segments of the roundabout, as well as the mutual influence of speed.

With multiple regression analysis, a model was formed for calculating the average speed of traffic flow in circulation (roundabout) - S_crc, which shows depending on the type of movement (right/first exit; right/second exit; left/third exit; u-turn fourth exit), average flow speed at the entry into the circle (km/h), external diameter of the roundabout (m), number of traffic lanes in circulation (roundabout). Further research should focus on a wider area of roundabout approaches than the one covered by the analysis in this paper.

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ORIGINAL SCIENTIFIC PAPER

Contemporary methods of road safety risk management

Danislav Drašković
PhD Engineering, Pan-European University Apeiron, Banja Luka, danisalv.m.draskovic@apeiron-edu.eu

Vladimir Gatarić
BSc Engineering, Pan-European University Apeiron, Banja Luka, vladimir.j.gataric@apeiron-edu.eu

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Abstract: The problem of road safety is an important factor in traffic safety, recognized as one of the main goals in the process of improving traffic safety. Improving both the capacity and safety of roads requires, along with large financial investments, planning and developing new tools in order to ensure prevention of traffic accidents and mitigation of their consequences. Establishing a road safety system is based on detailed knowledge of the current safety of the road, as well as on implementing adequate countermeasures that would eliminate existing safety risks. For this, traffic safety tools used for assessing safety are very important, especially in the road design stage, as well during assessment of traffic safety on the existing road.

Key words: traffic safety, tools, road check, road design.

INTRODUCTION

The issue of road safety is especially considered and treated in the design and construction stages, i.e. during the operatinal stage after certain changes occur over the road and the road belt. The existing road infrastructure should meet increasingly rigorous safety requirements. Improving, building new and reconstructing the existing roads that had been built over 30 years ago involves implementation of modern road surfacing materials, modern carriageway markings and vertical signalling, as well as adjusting bend radiuses and road areas, first of all in order to prevent traffic accidents from occurring, and then to mitigate their consequences. In contemporary international relations, road safety is treated through prevention based on the Directive EC/2008/96.

Road safety improvement tools are:

1. Risk mapping (iRAP/EuroRAP methodology),
2. Black Spot Management,
3. Road Safety Impact Assessment,
4. Road Safety Audit,
5. Road Safety Inspection,
6. Network Safety Management,
7. In Depth Analysis and
8. Independent assessment of road's contribution to occurrence of traffic accidents. [1]

ROAD SAFETY IMPROVEMENT TOOLS

That is why this approach is called "proactive" because it is not necessary to wait for a traffic accident to occur in order to realise that a section of the road is particularly dangerous or with a high risk factor. Road safety improvement tools included both primary and secondary road network.

Risk mapping (iRAP/EuroRAP methodology)

Developed countries that are leaders in traffic safety analyse their road networks by using iRAP/EuroRAP methodology. The iRAP model is based on the assessment of road safety characteristics without using data on traffic accidents and their consequence. iRAP analyses road safety by using contemporary road camera recording equipment, collecting large quantities of data about the road, which are then processed in a special software.

The iRAP provides for identifying high risk locations, as well as proposed measures to mitigate those risks. Unlike the iRAP methodology, the EuroRAP is based on calculating objective risk, i.e. the risk calculated based on traffic accidents and consequences of traffic accidents on sections of the road network.

This methodology involves the following activities:

- Recording the roads with cameras; in accordance with the iRAP methodology, based on the determined road network, using high-resolution cameras placed on a vehicle and GPS coordinates,
- Coding the recorded material: the recorded material is turned into coded data on road safety properties, in accordance with iRAP specifications,
- Collecting supporting data: data on the number of traffic accidents, killed and severely injured

people, number of vehicles, speed and other data in accordance with iRAP specifications on necessary supporting data,
- Processing and analysing the data: processing and analysing the data in accordance with iRAP specifications, as well as imputing processed data into specialised online iRAP software (ViDA),
- Creating an accessible and economically sustainable counter-measure programme, which includes recommendation for road improvements and assessment of the numbers of killed and severely wounded that could have been prevented,
- Report: Along with the standard project report, this report will be also available through the online iRAP software (ViDA). [2]

The methodology being used in the EuroRAP has been developed by a workgroup with representatives from the Swedish Road Administration, Ministry of Traffic of the Netherlands, National Roads Authority of the Republic of Ireland, Traffic Research Laboratory (TRL), with contributions from the National Highways Agency from England, German Federal Highway Research Institute (BASt), and engineers and analysts from leading European motor vehicle organisations and EuroRAP. Both methodologies are based on the road safety assessment using stars aimed to rank 100-metre sections of the road from the aspect of safety and recognise even the smallest of risks, formulate proposed remediation measures that would improve the safety of that particular section.

The iRAP programme for assessing and raking road safety using stars is also recognized in the Global Status Report on road safety published by the World Health Organization in 2015 as a methodology providing a single assessment of road safety from the aspect of road user, separately for categories of drivers and passengers in motor vehicles, motorcyclists, pedestrians and cyclists. This methodology has been used on over 500,000 km of roads in 62 countries. Standards are set up for comparing sections of roads and their ranking, with recommendations for improving each specific location and moving them to one of the "higher" safety ranks, with higher number of stars. The use of this methodology is increasing globally, because it is a proactive method relating to road safety, while analysing the road without the need for traffic accidents to and their consequences to occur in order to analyse them.

Black spot management

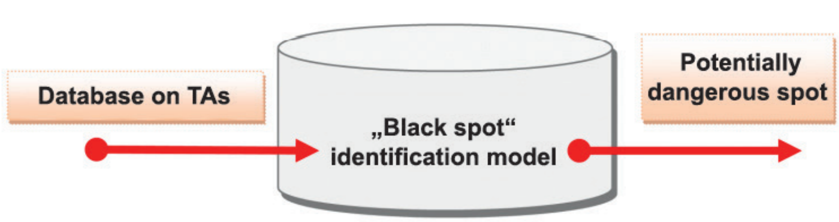
Black spot management is one of the oldest reactive tools – it is a reaction to dangerous spots on the road, identified based on data on traffic accidents and their consequences. The European Union Directive (2008/96/EC) on road infrastructure safety management, which is covered and monitored within the negotiation Chapter 14 – Transport Policy is important for meeting preconditions of B&H for the accession to the EU.

Black spot management consists of the following activities:
- defining and identifying black spots on roads,
- analysis of traffic accidents and risk factors at black sports in order to identify safety risk and propose adequate "treatment" of black spots, and
- implementation and evaluation of applied treatments over black spots.

Defining and identifying black spots is the first step of the "black spot" management procedure, and it is conducted in order to recognise parts of the road network where the road and its surroundings represent the most significant factor contributing to traffic accidents (Picture 1).

After the black spots have been identified the black spot analysis project follows which processes in detail all safety aspects at that particular location, as well as an in-depth analysis of traffic accidents at that particular location. This is followed by defining guidelines for the black spot remediation project, which takes into consideration all recommendations defined in the traffic safety analysis. After the project has been developed we move to the remediation of the black spot, while the results of realised measures are analysed in the following time period. An important segment of this stage is monitoring of realised measures in order to point out their efficiency so that there would be further improvement of safety at those locations.

A black spot is each spot on a public road up to 300 metres in length outside populated areas, or up to 100 metres in populated areas, where in the time period of consecutive three years there were at least six traffic accidents with consequences on lives and health of people,



Picture 1. Black spot identification process [8]

or four traffic accidents of the same characteristics with consequences on health and lives of people.

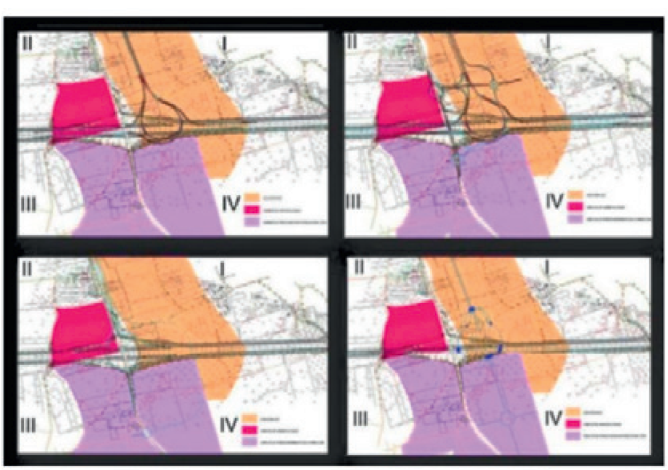
The second level, i.e. the second step involves more concrete requirements in terms of the selection of a black spot. In the second step there is a more detailed analysis in order to determine whether the traffic accidents on this particular place are in a direct link with the road and a more precise definition of the black spot location (up to 500 metres in length).

Local risk factors include all specifics of the microlocation where an increase of traffic accidents has been recorded. Those specifics could, for example, be: small radius of the bend, poor condition of the carriageway, presence of dangerous objects in the road belt, insufficient visibility, etc. After the identification has been finished, further steps are taken in the black spot management. There are proposals and analysis of black spot remediation measures. We can select optimal measures, calculate remediation costs, assess effects and analyse cost/benefit relation of investments. After the cost/benefit has been calculated for all black spots, we can rank all of them again and define the remediation sequence (black spot programme evaluation).

Road Safety Impact Assessment

RSIA - Road Impact Assessment or Road Safety Impact Assessment is an analysis conducted in the process of designing roads and routes. RSIA is a strategic comparative impact assessment of the new road or a modification of the existing network on the safety properties of the network.

This analysis is aimed at establishing difference of potential impact between several building solutions for a particular part of the network and selection of the best solution from the aspect of traffic safety. Examples of several technical traffic solutions during the construction of a part of the network is shown in Picture 2, and the application of the RSIA is aimed at identifying the version with the best performance in terms of traffic safety.



Picture 2. Several models of technical traffic solutions on a particular location [8]

Road Safety Audit

The road safety audit is a formal safety check of the existing or future road by an independent team of auditors. This activity is ordered by a same procedure as the design process. The road safety audit can be performed in any stage of project development: from the planning stage and preliminary design, to the main project and construction stage. It can be performed on any project bearing in mind its size – from a small junction to a road, which is being modified in order to fit into much larger and wider projects (regional, international). [3]

RSA – Road Safety Audit – „traffic safety audit in road traffic" is an independent and detailed systematic safety check relating to designed properties of roads in all design stages, until the early construction stage. These activities are focused so that they can recognise and remove all deficiencies and potentially dangerous details in the early design stage of the road.

It is suitable to conduct the road safety audit in five following stages:

Stage 1: General project audit

During this stage the nature and the scope of the project are being assessed, starting points for concrete design are determined, such as different versions of direction of the road, important design standards, connection with the existing road network, number and type of junctions, access control, locations and types of intersections, impact on the existing infrastructure, as well as whether the new road needs to be open for all types of traffic. The whole of project is observed from the aspect of traffic safety.

Stage 2: Audit of the preliminary design

The audit can be conducted after the general project design is finished. The primary goal of the audit is to asses relative safety of junctions and intersections, horizontal and vertical profile, cross section, visibility and width of traffic and stop lanes, total slope and pedestrian capacity (children, elderly, disabled persons and cyclists) and other design standards, as well as visual appearance of junctions, before the design is adopted and before the acquisition of land. The audit in this stage should be finished before the purchase of land.

Stage 3: Audit of the final design

During this stage, the audit team examines properties of the final geometric design, traffic signs and pavement markings plans, lighting plans, land development, junction and intersection elements, such as funnels, acceleration and deceleration lanes length and turn radiuses. The team also considers elements for special groups of traffic users, drainage, protective fences and other facilities along the road, as well as possibility for their construction.

Stage 4: Audit of complete design immediately before and/or after the opening

Immediately before the road is opened the audit team should conduct a field visit in order to assess whether the safety requirements of all traffic users (pedestrians, cyclists, motorcyclists and other) have been adequately met. The audit team should take a day and a night drive during the inspection and, if possible, to conduct the inspection during different weather.

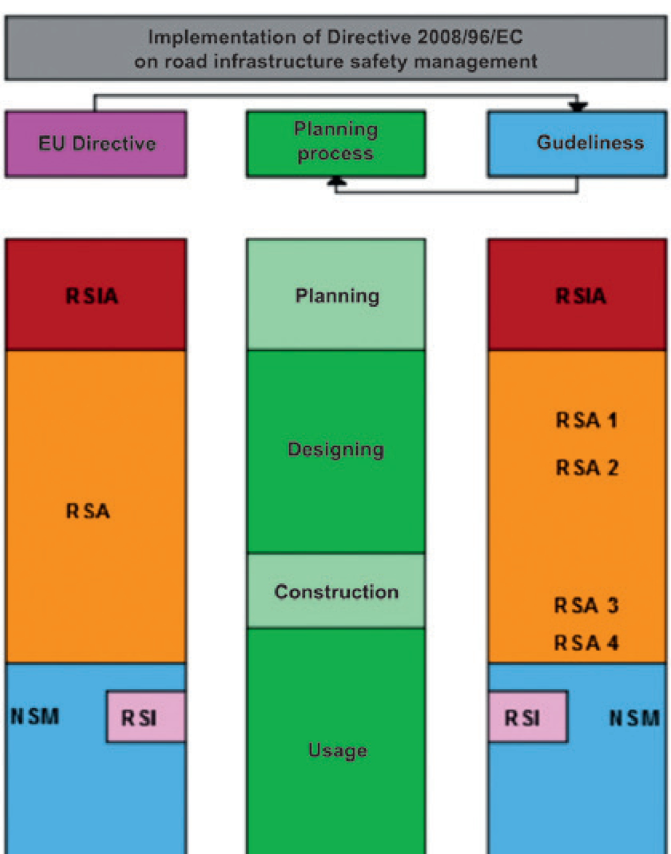
Stage 5: Monitoring.

This is an insight into the works and problems that were not easy to notice before the road was opened. Corrective measures, although they are more expensive in this stage, can still be cost effective. It is possible to assess whether the road is being used in a planned manner and whether changes in design are needed, all based on the actual behaviour of traffic users.

The number of audit stages depends on the type of project, and the audit during all five stages will usually be conducted only in cases of large new projects. In case of small facilities or reconstruction projects, separate audits in three first stages are rarely done (general, preliminary and final design).

Road Safety Inspection

Road safety inspection is an independent, formal and systematic check of elements of the existing road from the aspect of traffic safety. The aim of these checks is to identify all unsafe elements of the road that contribute to traffic accidents or their consequences.



Picture 3. Tools for improving road safety depending on the stage of road use [8]

[4] RSI – Road Safety Inspection – "inspection of safety on existing roads" is a periodic, detail check of traffic safety aimed at identifying deficiencies and necessary maintenance of the existing road in order to ensure required level of traffic safety. Picture 3 shows activity diagram for improving road safety, depending on the design stage, i.e. the operational stage it is being implemented in. This diagram shows the stages from design to use and activities on improving road safety that can be implemented within these stages.

Contemporary road design and remediation principle must include the use of these tools in order to have more efficient investment and direction of traffic safety measures on the most important traffic safety details.

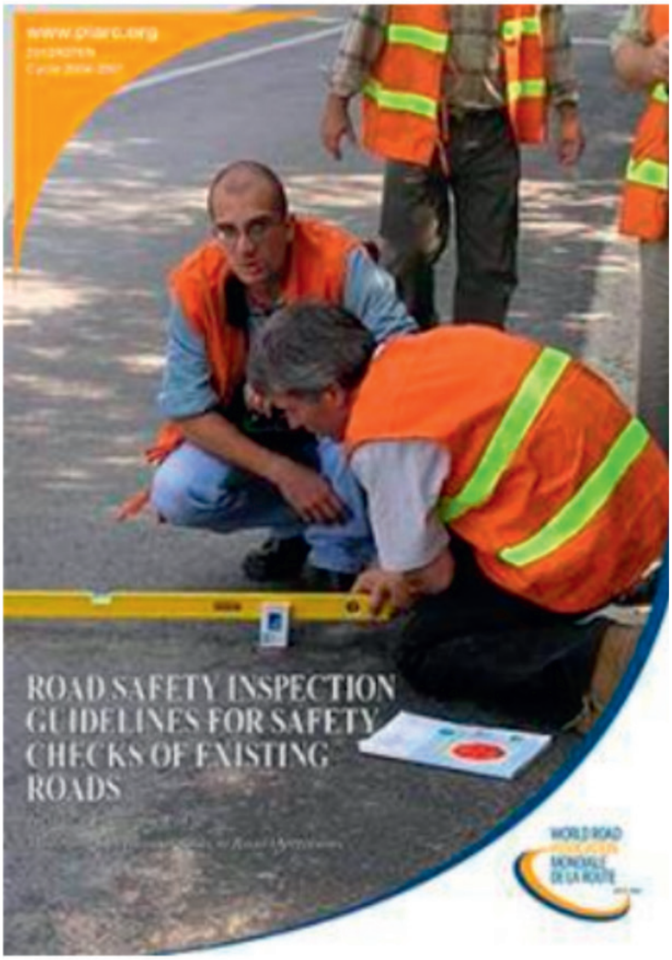
These activities are being realised based on the Directive 2008/96/EC of European Parliament and of the Council that was adopted on 19 November, 2008 on proposition of the European Commission.

In order to efficiently realise obligations from this directive, the idea is have specially trained and licensed staff to handle the activities relating to road safety, so-called "traffic safety auditors".

Traffic safety inspection needs to be conducted in the following cases:

- when a section of the road or an junction has been identified as dangerous (according to data on traffic accidents or based on some of the road assessments (iRAP for example),
- when there are other information on serious traffic safety problems on the road, a section of the road or a junction received from the police, road maintenance service, local self-administration unit, or similar,
- when there is a planned reconstruction or remediation of the road in near future.

Participants of the road traffic safety audit are both the client and the auditor (the traffic safety auditor position is also recognized in the Draft addendum of the Law on Road Traffic Safety). The client orders a check and as a rule it is an institution in charge of road management (road manager). The client delivers necessary documentation to the auditor, who, after examining it and after conducting a detailed analysis, goes out into the field, identifies problems, and then produces a report on the check (Picture 4).



Picture 4. Traffic safety audit process [8]

Network Safety Management

NSM - Network Safety Management - management (classification) of road network from traffic safety standpoint involves the implementation of known and verified models of identification and ranking of the sections of a road that have been in use for more than three years and where there are records of increased number of traffic accidents. This activity is focused on recognising dangerous sections with increased risk of traffic accidents, and defining the list of priority sections that will be the focus of analysis and improvement of traffic safety.

In-Depth Analysis of traffic accidents

Around the world in-depth analyses of traffic accidents have been recognised as a good method to determine factors influencing the occurrence and consequences of traffic accidents. The European Council has defined the in-depth analyses as one of basic procedures to determine factors influencing the occurrence and consequences of traffic accidents. In order to develop a contemporary model of in-depth analyses it is necessary to collect as many road factors influencing traffic accidents as possible, so that they could be systematically organised and determine which of them cause traffic accidents, which give contribution for the accidents to occur, and which influence the possibility to avoid them or avoid severe consequences.

The task of traffic accidents in-depth analyses is to conduct detailed data on the traffic accident in order to determined factors that caused it, as well as factors that influenced the consequences of that traffic accident. The SafetyNet project defined a large quantity of variables in relation to the accident that are necessary to collect, using a research principle known as the SafetyNet Accident Causation System (SNACS). In terms of defined factors of influence the best work has been done in Germany, where they defined several thousands of factors of influence within the GIDAS in-depth analysis database. In-depth analysis of traffic accident is based on high quality databases, i.e. high quality collection of data on traffic accidents. The key for in-depth analysis is establishing high standards of investigation of traffic accidents and the manners of fixing tracks on the scene.

Speed is one of the basic parameters defined in simulation models in order to describe as much as possible the real conditions of traffic.

Independent assessment of road's contribution to occurrence of traffic accidents

The road as a safety factor influences both the number and the consequences of traffic accidents due to:

- size of longitudinal and cross slope being incompatible with the speed and properties of the vehicle,
- geometric elements of the road being incompatible with calculated speed and gauge of the vehicle,
- insufficient longitudinal and cross visibility splay of the road in the bend and in the line,
- insufficient width of the carriageway,
- poor quality of surfacing, so there is insufficient adhesion force between the wheel and the surface,
- insufficient and inaccurate information for the drivers on the road, facilities on the road, along the road and other,
- insufficient width and unreliable shoulders,
- placing road elements that force the driver to suddenly change the mode of driving,
- existence of conflict zones along the road where roads intersect,
- insufficient sensitivity of dangerous junctions, pedestrian crossings, intersections, facilities in the road area, etc.,
- incorrect implementation of horizontal and vertical road signalling, and others. [5]

The independent assessment of road's contribution to traffic accidents occurring is recognised as an obligation of the road manager, according to the Law, for all

Picture 5. Forgiving road concept [8]

traffic accidents with fatalities. This procedure is an in-depth analysis model, but the focus is directly on the road's contribution, which does not exclude considering other contribution factors, but definitely required direct identification of road's contribution.

Contemporary road design

Contemporary approach to the deseing and remediation of the road has established contemporary road development concept that involves implementation of contemporary technical and technological measures. The contemporary principles involve designing of "self-explanatory" and "forgiving" roads. Both domestic and global literature has a large number of papers and documents where experts specialised for this area stated, examined and described the implementation and results of technical, regime and other measures for improving traffic safety from the aspect road and its surroundings. The "forgiving road" concept is based on the tendency to develop the road and its surroundings in a way that they can compensate for drivers' mistakes, in order to mitigate the consequences that occur from traffic accidents. This concept of the road and its infrastructure is a measure aimed at passive safety of the driver and passengers (Picture 5).

The "self-explanatory roads" concept is based on the tendency for the road with its surroundings to offer complete information on the line of the road, conditions on the road and the mode of driving that that the driver needs to adhere to in order to be safe on the road.

CONCLUSION

Road network safety management in its original meaning should enable the road manager (at state or local level) to simplify the use of legally prescribed traffic safety tools: risk mapping, section ranking, "black spot" management, traffic safety check, storing check results, audits, independent assessment of road's contribution to occurrence of traffic accidents with fatalities, etc.

Road safety management should provide for the very management decision process to be raised to a higher level. The manner in which the comprehensive use of road network traffic safety tools is described it should provide that all legal obligation of the road manager are initiated timely from one location, that all implementation of tools is monitored, and that the results are easily available, which certainly makes for easier management (Network Safety Management).

The road manager would have available data on the safety of the road network, where it would be most efficient to implement measures, and it would be possible to monitor investments into the road network, as well as efficiency of measures taken. This would provide for a systemic road network management. To start a high quality road network safety management you need a good database containing digitalised road network and data on traffic accidents. These two sets of data should be considered a basis. All other data such as: road categorisation (road markings, nodes, sections, etc.), road signs cadastre, school zones position, areas in/outside populated areas, quality of lighting, automatic use of road safety management tools, etc. are all upgrades that are much easier to implement if there is a basis. [6]

The implementation of the methodology presented here, i.e. the road safety improvement tool, is considered efficient if after its implementation over a long period of time we can conclude there is improvement of traffic safety, which is at the same time the direction of further research into effects of measures taken.

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PROFESSIONAL PAPER

Management of transport of hazardous materials

Slavojka Lazić
Pan-European University APEIRON, Banja Luka, Republika Srpska, BiH; slavojka.n.lazic@apeiron-edu.eu

Zoran Ž. Avramović
Pan-European University APEIRON, Banja Luka, Republika Srpska, BiH; zoran.z.avramovic@apeiron-edu.eu

Danislav Drašković
Pan-European University APEIRON, Banja Luka, Republika Srpska, BiH; danislav.m.draskovic@apeiron-edu.eu

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Abstract: Transportation of hazardous goods is a demanding and risky job. The greatest risks, dangers and consequences for the population and the environment are associated with the transport of hazardous goods. Today, numerous systems and software packages have been developed, the aim of which is to improve the performance of this type of transport and mitigate the consequences of possible accidents. By monitoring and adaptive management of the transport of hazardous goods in road traffic, the consequences of traffic accidents can be repaired more quickly and the movement of vehicles with hazardous goods can be directed to safer routes.

Keywords: hazardous substances, transport, risk, consequences.

INTRODUCTION

Hazardous substances are considered to be all those substances which, during production, transport, storage or handling, can cause consequences harmful to health and the environment [1]. Hazardous materials are regulated by the European Agreement on the International Carriage of Hazardous Goods by Road (ADR) and the International Regulations on the Carriage of Hazardous Goods by Rail (RID) [2]. ADR contains provisions for road traffic regarding packaging, cargo insurance and labeling of hazardous goods. ADR is so widespread in transport that almost everyone in every country understands it. It is adapted every two years to the latest technical and legal knowledge and changes [3].

In the total transport of cargo, a very significant share of hazardous materials. These are substances that, due to their characteristics (danger from radiation, toxicity, corrosive properties, flammability) or chemical reactions (flammability, volatility, explosiveness, corrosiveness, solubility) during production, handling, storage or transport, can endanger the health and life of people, pollute the environment or cause damage to material goods [4]. Hazardous substances are increasingly used in various economic activities: chemical industry, agriculture, pharmacy, military industry, as a source of energy, etc. Therefore, although they represent a risk for man and his environment, their transportation is present and unavoidable every day. Due to the aforementioned negative impact of such substances, their transport must be organized according to certain rules in order to minimize the risk of accidents, that is, to minimize the consequences of accidents that have already occurred [1].

HAZARDOUS SUBSTANCES

Based on the Law on Transport of Hazardous Goods (Official Gazette of RS, No. 15/2016), hazardous substances are classified as follows:

Class 1 – explosive substances and objects with explosive substances,
Class 2 – gases,
Class 3 - flammable liquids,
Classes 4.1 - flammable solids, self-reactive substances and desensitized explosive solids,
Class 4.2 - self-igniting substances,
Class 4.3 - substances that in contact with water develop flammable gases,
Class 5.1 – oxidizing substances,
Classes 5.2 – organic peroxides,
Class 6.1 – toxic substances,
Class 6.2 – infectious substances,
Class 7 - radioactive substances,
Class 8 - corrosive (corrosive) substances, and
Class 9 – various hazardous substances and objects.

Hazardous goods are classified according to the European Agreement on the International Carriage of Hazardous Goods by Road (ADR), the Convention on International Carriage by Rail (COTIF), the Regulations on the International Carriage of Hazardous Goods by Rail (RID) and the European Agreement on the International Carriage of Hazardous Goods by Inland Waterways (ADN).

CHARACTERISTICS OF ACCIDENTS WITH HAZARDOUS GOODS

Traffic accidents in road traffic have long been a global problem that is being tried to be solved by implementing systematic measures and taking appropriate actions. The potential danger of a vehicle increases if it is transporting a hazardous substance. Some of these substances, even without traffic accidents, are inherently hazardous and can injure people or cause material damage (self-igniting). Therefore, when transporting such materials in road traffic, it is necessary to comply with special regulations. Certain UN bodies deal with this area, and the European Agreement (ADR) defines in detail the issue of the transportation of hazardous goods, on which our regulations are based [5].

The economic development of any society is undoubtedly related to the movement of various types of goods. More than 3300 goods and their products are included in the list of hazardous goods. Their number is constantly growing in various areas because there are more and more goods that exhibit the characteristics of hazardous substances [5].

In order to reduce the risk in road traffic when transporting hazardous goods, it is necessary to develop a system for managing the transport of these goods. The main goal should be to reduce the probability of traffic accidents involving vehicles transporting hazardous goods. The following is the reduction of consequences in the event of traffic accidents.

In order to reduce the probability of an accident, preventive measures should start already in the process of production, packaging and storage of hazardous goods. Later, all risk factors, which are a consequence of human error or lack of infrastructure, should be minimized. The reduction of the consequences of traffic accidents in which a vehicle transporting hazardous materials was involved is achieved by applying the appropriate regulations, which aim precisely to minimize the damage caused by a possible accident.

During the transportation of hazardous materials, an unwanted event is called an accident, and the consequences of that event an incident (explosion, release of material, fire, etc.). Incident statistics show that 40% of them occur in production facilities, 35% during transportation and 25% during storage of goods. Every transport carries a certain risk of accidental events. In the event of an accident, there is a danger of an ecological disaster with unforeseeable consequences. An accident most often results in the uncontrolled release of hazardous and harmful substances into the environment and pollution on a significant scale. The consequences are huge: injuries (victims), material damage, destruction and degradation of the environment, with huge consequences for a long period of time. Analyzes so far show that the most common causes of accidents in road traffic are: defective means of transport, irregularities when loading cargo (most often exceeding the useful carrying capacity of the vehicle) or unloading it, as well as traffic accidents involving vehicles transporting hazardous goods.

MONITORING AND MANAGEMENT OF THE TRANSPORT OF HAZARDOUS MATERIALS

In order to influence the reduction of the risk of accidental events during the transport of hazardous goods, the management of this type of transport is applied today. The application of various software solutions leads to the automation of the process of working with hazardous materials, increasing their transport speed and reducing risks. Such solutions offer assessments and forecasts of difficult situations in traffic that have arisen as a result of accidents with hazardous substances. An accident is defined as a sudden and uncontrolled event that occurs due to the release, spillage or spillage of hazardous substances, the performance of activities during production, use, processing, storage, disposal or long-term inadequate storage [6].

Incidents or traffic accidents involving hazardous materials can happen anytime and anywhere. In particular, the peripheral parts of cities, where large chemical plants and their warehouses are located, are potential sites of accidents, with incalculable consequences for human lives and their environment. Often the consequences go beyond the crash site and affect many more people than were directly involved. That is why accident management is a very complex and complex process, which requires a lot of expertise and maximum involvement in all phases [7]. The use of appropriate software packages provides multiple benefits: quick access to data on hazardous materials is enabled, their use for assessing a specific emergency situation and transmission of information to competent authorities, if necessary in the event of an adverse event [7]. In this way, accident management is raised to a higher level.

Program packages are upgraded and developed every day, the goal of which is to reduce the risk of any type of accident and increase the level of safety during the transportation of hazardous goods. However, the application of developed models often remains difficult to achieve in practice.

As an active participant in traffic, a vehicle with a hazardous substance must comply with the regulations adopted in the Law on Traffic Safety and Transportation of Hazardous Substances. Failure to comply with traffic regulations can cause accidents, regardless of the fact that other measures related to proper packaging, handling and storage have been observed. This is especially present in road traffic and is especially hazardous if it happens in a populated place. Easier tracking of transport is made possible by equipping all transport vehicles with appropriate digital devices for global positioning [8]. In this way, one can gain insight into the complete transport of hazardous materials, which should certainly be directed as far as possible from kindergartens, schools, residential areas and parks. In this way, possible unwanted events are moved away from sensitive places and objects. When managing the transport of hazardous materials, the condition of the roadway on the sections of the road over which the vehicle moves should not be neglected. The poor condition of the road and the potholes on it can threaten the safety of transport.

ELEMENTS OF SAFE TRANSPORT OF HAZARDOUS MATERIALS

Every vehicle that transports hazardous material becomes an active participant in traffic, surrounded by other vehicles.

Motor vehicles and trailers used to transport hazardous goods must be subjected to a special inspection in terms of meeting the conditions stipulated by the Law and ADR, for the transport of certain hazardous goods. This implies the determination of reliability and safety from the aspect of operational conditions in road traffic. Examination of vehicles for the transport of hazardous materials includes: vehicle performance, determination of functional characteristics, from the aspect of special requirements for the transport of certain hazardous materials, i.e. determination of the structural characteristics of devices and equipment, as well as the structural performance of the vehicle as a whole, from the aspect of special requirements defined for the transport of hazardous materials [9].

The vehicle testing methodology is based on the characteristics of the hazardous material that will be transported. When testing a vehicle, one should take into account all applicable regulations, recommendations and requirements [9].

The volume of traffic flow affects the speed of movement of vehicles transporting hazardous materials. Optimum organization of this type of transport implies the movement of vehicles in calmer, less burdened traffic conditions. Due to the constant increase in the number of motor vehicles on the total road network, this is not always possible. If a vehicle transporting hazardous materials finds itself in a saturated or forced traffic flow, the potential danger of an undesirable event increases. The effort is made to ensure that vehicles transporting hazardous materials spend as little time as possible on the road network, and at least in densely populated areas. Determining the optimal routes for the transportation of hazardous goods represents a significant step in increasing the level of safety of their transportation, and this should always be kept in mind.

Vehicles transporting hazardous goods are subject to general regulations related to stopping and parking places. They are allowed to park in specially designated areas. These areas in the open space are generally far from large traffic jams, settlements and gatherings of people.

In the event that such vehicles transport characteristically hazardous substances or hazardous substances in excess of the determined quantity, they are also subject to special regulations regarding supervision during transport.

Drivers participating in the transport of hazardous goods must have a license for the transport of hazardous goods, and the vehicles must have special equipment. These include folding and unfolding orange warning signs, a helmet and goggles, as well as two fire extinguishers.

In addition to the vehicle crew and drivers who must undergo appropriate training, other persons who directly participate in the transport of hazardous goods and are employed in a company dealing with the transport of hazardous goods must have appropriate training in this field. Training implies determining their duties and obligations during work with hazardous substances. The training of persons must be regularly adjusted to changes in legal regulations. Companies that regularly transport hazardous materials employ at least one person responsible for transporting hazardous materials. It is theirs duty to take care of the transportation in accordance with the regulations and requirements for hazardous materials [10]. The responsible person initiates the approach to risk management during the transportation of hazardous goods.

Risk management requires a multidisciplinary approach to the organization of transport, which should ensure: the implementation of prevention, preparedness, response to an accident and remediation, that is, elimination of the resulting consequences. This implies a set of measures and procedures aimed at reducing risk and creating conditions under which risk can be acceptable. A management system based on good analysis, with computer support, can contribute to a much more efficient system of protection during the transportation of hazardous goods.

It is of particular importance that through the continuous professional training of all persons participating in the organization and carrying out of the transport of hazardous goods, the possibility of accidental situations is reduced to a minimum.

All those who participate in the transport of hazardous goods should responsibly take all necessary protective measures in order for the transport to take place safely and to avoid possible irregularities or accidents that could endanger people's lives or have consequences for the environment.

Regular checks on the application of preventive protection measures increase the safety of all participants in the transport of hazardous goods.

CONCLUSION

Organizing and safely managing the transportation of hazardous goods today is a very demanding and complex job. If it is not approached responsibly and on time, the consequences can have enormous proportions. People getting sick or dying, environmental pollution, destruction of natural wealth, damage to technical equipment, are just some of the possible consequences.

Traffic accidents involving vehicles transporting hazardous goods follow the development of society. Today, we encounter a large number of traffic accidents involving vehicles carrying out this transport. The degree of risk and consequences is much higher if the vehicles transport matter that can cause deaths and unfathomable environmental disasters.

Looking at the effects and consequences of hazardous materials, with a large number of victims, injuries and illnesses, as well as material damages and other consequences, initiates the need for improvement in this area of transportation. As a result of the improvement, various software solutions were applied in managing the transportation of hazardous goods.

Appropriate program packages increase the speed of transportation of hazardous goods and reduce risks. The use of software packages in the function of risk reduction is useful in many ways because it enables quick access to data on hazardous substances and their use in specific situations. Such solutions also offer assessments and forecasts of difficult situations in traffic that have arisen as a result of accidents involving hazardous substances.

A detailed analysis of all types of risk is the starting point for determining the level of risk and determining the guidelines for action in order to reduce it to an acceptable level. Then it is possible to start taking measures for prevention, preparedness and responding to a possible accident.

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PROFESSIONAL PAPER

Artificial intelligence in insurance companies

Jaroslav Lupačov
PhD student, third generation Pan-European University APEIRON, Banja Luka, Republic of Srpska, Bosnia and Herzegovina; yaroslav.lupachov@apeiron-edu.eu

Željko Stanković
Pan-European University APEIRON, Banja Luka, Republic of Srpska, Bosnia and Herzegovina; zeljko.y.stankovic@apeiron-edu.eu

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Abstract: In this article given is the analysis of the development of artificial intelligence- AI in insurance companies, which has caused the execution of the following tasks: analysis of the role and significance of artificial intelligence in insurance;description of software tools in insurance; description of implementation of artificial intelligence in insurance industry. Based on the conducted analysis it is concluded that possibilities of artificial intelligence in insurance are almost infinite. Technology contributes to better clarified claims, helps insurance companies to identify fraud and automatically avoid losses. Due to all this, the insurance companies on the market improve their production cycle while clients are provided with better service and better rates. Artificial intelligence assists us in improving the business today and will do so in the future: increase competitiveness, enhance the engagement of clients, accelerate innovations, increase profitability and productivity of employees.

Keywords: artificial intelligence, types of artificial intelligence in insurance, personalisation, improved data protection, software for insurance.

INTRODUCTION

As it is well known, with the development of information systems an objective overview can be obtained of the state od present and past conditions of information technologies in insurance companies, as the basis for their further development and use in that field. Hence, in this paper we will attempt to describe the application of artificial intelligence (AI) in insurance.

The goal of the research is the analysis of development of AI in insurance companies, which requires the execution of the following tasks: *analysis of the role and significance of AI in insurance; description of software tools in insurance; overview of use of AI in insurance (health insurance; car insurance; property insurance; interpretation of advantages and disadvantages of artificial intelligence in insurance).*

In this paper we used the methods for studying information technologies that is quantitative and qualitative approaches to analysis, such as: *descriptive method, comparative method of studying information systems (IS) in insurance, inductive and deductive approach to research of IS in insurance companies, abstraction and implementation of researxh of IS in insurance companies, methods of analysis and synthesis of information control systems in insurances.*

ARTIFICIAL INTELLIGENCE (AI) IN INSURANCE

There are a few definitions of AI – Artificial Intelligence. In the paper by Dragan Botic and Zeljko Stanivukovic named *The role of artificial intelligence in optimization of field teams of telecom operators by using the software package CLICKSOFTWARE* given is the following definition of AI: ‘ Artificial intelligence represents the ability of artificial systems, most often caomputers, in other words hardware and software to execute certain functions in the manner containing some features of human thinking- human intelligence. One of the key aspects of AI is the capability to plan’. (1) In the aforementioned paper applied is the definition according to Jean-Louis Lauriere (2) and two other authors, Predrag Janic and Mladen Nikolic (3): AI is the concept which refers to the field of computer technology dealing with development of smart computers, which have a similar way of thinking to humans, function and react as humans. For creating AI there exist the following specialized program languages: Basic, Delphi, Object Pascal (the first of program languages for AI prvi programski jezici za veštačku inteligenciju), Lisp, Smalltalk, STRIPS, Planner, POP-11, C++, Haskell, Prolog, Python (Python is still widely used today se i danas široko koristi).

AI is present in the technologies as follows> sensible sensors, processing of program language, machine learning, scientific papers, recognizing texts, speech and photos, business intelligence, intelligent information security system, automated/ mechanical translations and other technologies and development directions (4)

AI has also made insurance business faster, better and smarter. Insurance companies were among the first ones which started to use AI. Insurance industry began using machine learning quite early as it analysis large quantities of data and many repetitive activities. AI offers a great potential for improving value in insurance. It will also facilitate automating processes in insurance in order to obtain better client experience. Due to all that, preparing insurance policies and covering/ balancing losses are to become quicker and more efficient. (5) Giving the stimuli to data analysis, AI is also to provide much better understanding of their risks, both for clients and insurance companies and this, new solutions can be developed and those risks lowered (6). For example, analytics based on AI can assist companies to comprehend cyber risks better and improve protection. At the same time, technology is to help insurance companies to identify measurable risks1. Last but not least, AI is to change the way insurance companies interact with their clients, enabling for 24 hour service.

The impact of AI on creating value in insurance Ai is also to affect the value an insurance carries for clients. In other words, present technologies based on AI improve/ enhance the chain of values in insurance, making it more efficient in meeting the needs of clients and providing services, timely and on reduced tariffs. Such technologies increase the insurance performances by ensuring clients better values and more benefits.

Intelligent agents In the future, AI is to offer support to insurance companies in analyzing data and risk assessment. There exist many areas/ fields such as reputation risks, cyber risks, risks in supply chain and also economic and climate risks when machine learning can assist companies to understand those risks better. For example, sensors on shipping containers already provide data on location and condition of the cargo/,which after analysis can activate to cover the insurance or measures to reduce the damage if goods are faulty (7). The results of the data analysis and analytics will asisst in moving the boundaries to transfer risk in the areas like termination of production without physical damage or ruined reputation. The way AI has an effect on operations in insurance is presented in the table below.

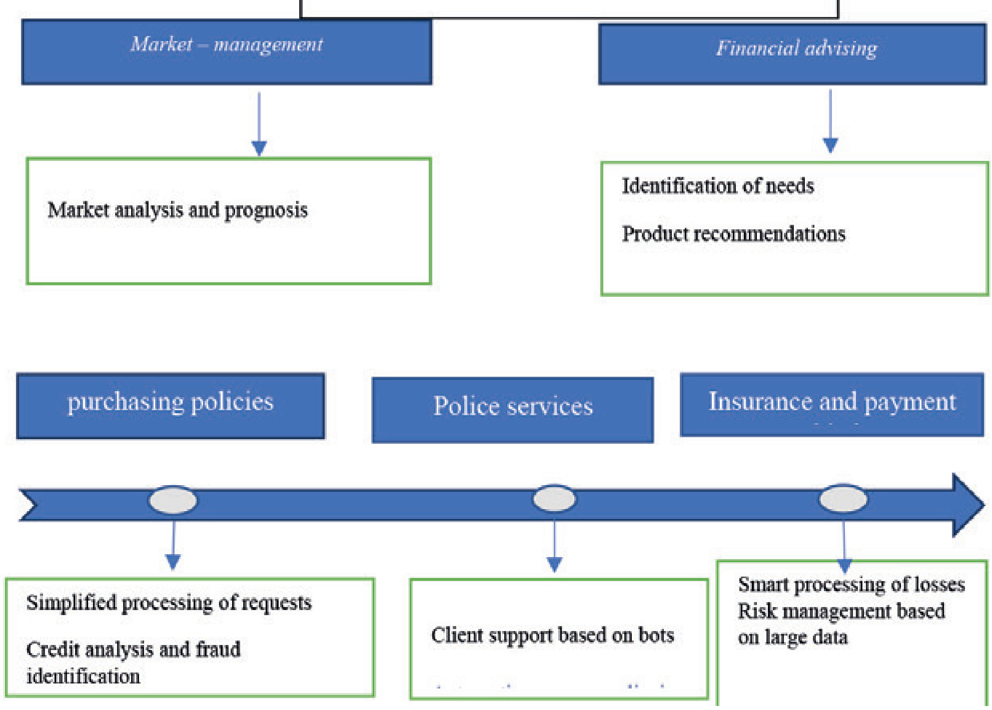
Role of AI in market management and interacting with clients

As opposed to other industries, insurance sector is characterized by relatively low frequency of client involvement as usually clients communicate with insurance companies when purchasing their product or claiming for compensation upon loss. Thus the possibility to use data on client to understand their preferences is of extreme importance. AI can also be useful in sorting and analyzing information on clients and providing accurate client profiles when designing successful individual marketing campaigns.

Financial advising

Technologies based on AI also facilitate recommending new products to potential clients. To specify,

Table . *AI and insurance operations*



when individual profiles and aims of clients match the available products, the process of advising becomes faster and more efficient. Considering the fact that insurance products are inherently complex, AI could provide adapted product illustrations and assist clients in identifying their needs of insurance, especially in regard to products containing multiple components, such as cumulative life insurance.

Purchasing an insurance policy

In the course of purchasing an insurance policy, that policy should be processed and analyzed. That process can last a few hours, even a few days if done manually. AI enable that processing to be automated by taking over different kinds of checks and facts, such as fraud identification and credit analysis. As a result, clients is awarded with a better experience in his dealing with a company.

Maintaining a contract

During the policy validity, chat bots can provide clients with 24 hour service.

What is more, adapting policies such as portfolio diversification and profiling risks can be done automatically using algorithms based on AI.

Solving insurance cases

Perhaps the most important issue in assessing the quality of work in an insurance company is organizing processes in solving insurance cases. At this stage most often dissatisfaction and complaints emerge and in the end that has a negative influence on reputation of insurance company. Negative emotions are not always connected to the amount of money to be compensated. Even those who agree with the decision of insurance company often give negative comments on the procedure for solving losses itself. To be more specific, organization of operational remote overview/ investigation of the scene using satellites, truths or photo/video shootings of scenes in the network with special applications will enable to avoid the intervention of authorities and/or experts. Insurance businesses are aware that wrong decisions on insurance can have fatal consequences on their profit or reputation. By integrating AI into their business, insurance industry invest in ways of automation1 of components in operations of requesting/ claiming without affecting correctness1. Such insurance companies either buy or develop their own software which enables for adjusters to spend less time on assessing claims.

Insurance and covering for losses

Having in mind high quantities and relevance of data on economic, demographic, nature and market conditions there exists a great potential to assess risks more precisely.AI offers support in the process of interpreting data on risks, so that actuaries possess the latest models for efficient risk management. Investments of insurance companies into AI have risen 8 times in 2017 (8). As a consequence, high qualified professional will devote more attention to important tasks and software is to provide routine work.1 So, experts are to have more time and thus, their value on the employment market is to grow.

Types of AI in insurance companies

Personalization

Surveying clients using AI makes it possible to obtain detailed information on physical world and thus contributes to detailed client analysis. Thanks to AI, insurance companies can access data using portable devises, sensors based on locations, sensors in different facilities due to geo-info systems. Insurance companies can apply AI to collect individual data and make more precise analysis in real time. Each individual cases can serve as the basis for contract, contributing to its accuracy and flexibility. In that manner, AI is to create a more favorable environment for clients.

Clients' road to purchasing without delays

Clients won't have to wait for long hours in call centers: new technologies with AI revolutionize the world of services for clients. In some typical cases, clients will have to go through just a few control points to find out about the premiums, for instance and to acquire the policy. The claiming process also is to become fast and with no problems. Usual claims with low amounts can at least partially be substituted with chat bot, in order to register application, check details, confirm it is not a fraud and forward it to bank for further processing.

Enhanced safety

Sometimes insurance agents save money for their personal needs, instead of sending that money to insurance company or they sell insurance policies without license to pay off claims1. AI in insurance business is to enable companies to recognize such false schemes and try to fight frauds. The more statements and data, the smarter that AI system is to be In addition, analysis of data obtained from sensors in surveillance systems could open new possibilities for business insurance. With to goal to alleviate damage caused by breaching safety, a company may benefit from insurance covering a wide range of losses, starting from cyber risks then hacking and use of malware software. The designs of that insurance as for visualization serves as detailed use interfaces whose aim is to understand the core of cyber -attacks.

Software tools in insurance

It should be pointed out that in modern day insurance business the most popular software tools are: *Clicksoftware, an opplication package to optimize work of field groups. Standard ClickSoftware packafe in insurance com-*

panies consists of:ClickSchedule, ClickMobile, ClickAnalyze, ClickContact i ClickLocate.

Typical package in insurance companies contains the following modules: ClickContact module is an interactive tool that enables for automated notification to client using email, SMS or IVR, based on status and location in real time. Click Locate Module is in charge of locating positions of field workers within regions and districts of their responsibility and forwarding data on GPS, coordinates of their locations into ClickSchedule module in order to based on them support planning, distributing work tasks such as emergencies and late field outings. Dispatchers have the ability1 to read those positions. Based on that data in contingencies decisions are made different from those which the system made in automated module.

By that in interactive module of functioning achieved is additional work optimization under extraordinary/ special circumstances. ClickMobile Module is HTML5 mobile platform with an application which supports business processes in the manner of checking up maps, provides an overview of information on allocated work tasks, location of field insurance agents, enables the status of work records1 to be updated and also sending messages. Field insurance agents can use their tablets/ devices to look at the plan of their activities, history of work, data on clients, details of their work records and other information useful to accomplish the tasks.

ClickAnalyze Reporting is a module offering completely easy viewing1 of KPI (*Key Performance Indicator*).

This module offers possibilities to notice opportunities to improve process or prevent the problem before it escalates1. The central module of this software system is ClickSchedule, module for making intelligent decisions in regard to planning and delegating work tasks for workers in installation and maintaining the service. The plan for engaging an insurance agent is made based on previously defined criteria- service policy and corporate company rules, ClickSchedule automatizes and optimizes the functioning of insurance companies and added1 resources using the processes of planning activities in implementing work tasks. Work tasks1 are generated in CRM, if they refer to starting up services1 with new clients or EAM, an ERP system module if there is need to eliminate issues with services with existing clients.

For both types of tasks in charge are insurance companies, having territorial kind of jurisdictions, defined through regions and districts and those service jurisdictions determined by domain and level of competences.

Within one group/ set of competencies there exist different levels determined by level of knowledge and skills, The point of these levels is that in the course of making decisions in the process of allocating resources for more complex tasks planned is the involvement of servicemen with higher level of competencies from the field required and vice versa. With all the afore stated, the system takes care also on the level of how overloaded certain insurance agents are, that is on implementation of KPI (9)

Fields of where to apply AI

Main fields of insurance business actually are in line with technological advances. In order to provide for better accuracy and speed, solutions for detecting fraud based on AI and other applications using AI have already been integrated into insurance business chat boxes.

Health care

Choosing the most efficieny health insurance package is of vital importance in the world where new health threats appear all the time and the premiums and complexity of health insurance are actually increasing. Basically, AI has an impact on efficiency as for costs and health insurance. Insurance companies provide their clients with new platforms which choose the most favorable1 cover for the user whose goal is to promote a healthy lifestyle.

Car insurance

Analyzing telemaths data on cars using algorithms of machine learning, services of insurance companies with AI create personalized risk profiles for drivers. Some insurance companies use the data collected in order to enable drivers some discounts if they use safe driving habits and punish some dangerous actions like speeding or sharp braking. Yet, the main advantage of car insurance when using AI is that in case of an accident those same data assist in assessing damage in real time using smart phone camera. The system of insurance using AI is capable of determining how serious the damage is, assess the costs of repair and analyze the impact of the accident on future premiums for the given driver.

Property insurance

Market fragment of smart gadgets amounted to almost 17 billion US dollars in 12019 and it is expected to increase for almost 20% by 2023, as stated by statistics (10). As using AI software insurance companies can process large data bases with unbelievable speed, it is possible to obtain property insurance premium options in any time from 60 seconds to 15 minutes. Using the internet and AI, premium values can be calculated for each property separately.AI is one of the tools which can assist in that.

AI is already taking part in almost all business activities in insurance industry. Companies have been working on substituting part of their employees with program software using AI in a short period as those can work 24 hours a day without a stop and lunch break. Accumulated is a large quantity of data for analysis using AI software systems and that provides high chances for improving, speeding up and lowering costs of business activities in insurance industry. Still it is not clear which human activities1 will be completely substituted by computer systems using AI as insurance industry is at the very beginning of the path of introducing those programs into automatisation of business activities.

CONCLUSION

1. Potentials of AI in insurance are almost infinite. Technology contributes to clearer claims, assists insurance companies in identifying frauds and automatically avoid losses. Insurance industry is one of the most conservative1 parts of financial market. Just a few years the 'trendiest' insurance companies started to introduce different solutions, such as InsurTech. That experiment was successful and now AI has steadily taken its place in various business activities in insurance companies.

2. Speaking robots of last generation sometimes cannot be differentiated from real speakers. Such assistants do not get tired or frustrated, do not require salaries for their work and if necessary, can cope with thousands of claims daily. Using machine learning, speaking robots are getting more and more perfect and the moment of them standing in for large and expensive teams in call centers is coming closer. This optimization will of course in the future affect the appeal1 of tariffs in insurance for clients.

3. AI really assists insurance companies in stages1 of scoring and onboarding. With that facilitation, insurance companies make decisions on accepting clients to be insured and determine a suitable tariff. Based on machine learning, insurance agents assess the probability of client making false claims at the time of acquiring policy and possible financial losses. Calculations are made considering all the data on clients.

4. Majority of insurance companies have implemented a system which enables them to quickly accept automated solutions for taking on complex risks with new clients in life insurance. The system actually learned to digitalize data from scanned medical records, photos, faxes, tables and other sources and that process was almost impossible in the past.

5. Robot is capable of solving certain insurance cases using algorithms which can determine some suspicious use of policy and provide instructions for further checks and supervision. A lot of companies are now introducing loss analysis based on clients' profiles and presence of false statements by witnesses in accidents about vehicles or occurring damage1. It is considered that the participation of AI can minimize or even completely eliminate false claims and that will result in lowering tariffs for honest insurance clients. AI enables for insurance companies to reduce costs and depend on investigators1. One of the tasks of AI is to identify the obvious or even those not so obvious dependencies between non profitability and hidden factors.

6. The number of processes in insurance industry in which AI is used is constantly increasing. There appear all inclusive IT insurance platforms. Due to all that, insurance companies improve their production cycle on the market and clients are provided with better services and more favorable tariffs. Implementation of AI is seen as the greatest technological trend on insurance market, and that into different processes, digitalization, simplification of procedures for clients, including enhanced conveniences of process in the course of policy validity, communication using chat and voice mails, convergence of insurance policies and bank services using eco systems and mobile gadget application. In general, it can be concluded that AI is to facilitate business today and in the future, *increase competitiveness, raise client engagement, speed up innovation, increase profitability and employee productivity.*

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PRELIMINARY REPORT

Biofuels as an alternative drive for vehicles

Novak Damjanović
Apeiron Pan-European University, Banja Luka, novak.v.damjanovic@apeiron-edu.eu

Dejan Kojić
Univerzitet PIM Banja Luka, kojic.d@hotmail.com

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Abstract: Due to the increase in the number of vehicles on the roads, the environment is becoming increasingly burdened by exhaust gases produced by the combustion of fuel in internal combustion engine vehicles (ICEVs).
The most significant gases produced by the combustion of fossil fuels in ICEVs are: nitrogen oxides (NOx), sulfur oxides (SOx), carbon oxides (CO and CO2), water steam, particulate matters (PM) and various hydrocarbons (CH).
Alternatives to fossil fuels are increasingly being explored in order to reduce the harmful impact of exhaust gases on the environment.
One of the possibilities of reducing harmful gas emissions is the use of alternative drives and fuels. An alternative to fossil fuels produced from crude oil are biofuels produced from renewable sources.
The use of biofuels in internal combustion engines leads to a significant reduction in the emissions of harmful exhaust gases from vehicles and, therefore, to a reduction in environmental pollution.

Keywords: internal combustion engine (ICE), fuel, pollution, emission, alternative fuels.

INTRODUCTION

We are witnessing the daily increase in the number of vehicles on the roads. With the increase in the number of vehicles, the environment becomes more and more burdened by exhaust gases produced by the combustion of fuel in the internal combustion engines (ICE). In order to reduce the harmful impact of exhaust gases on the environment, alternatives to fossil fuels used in internal combustion engines are increasingly being researched.

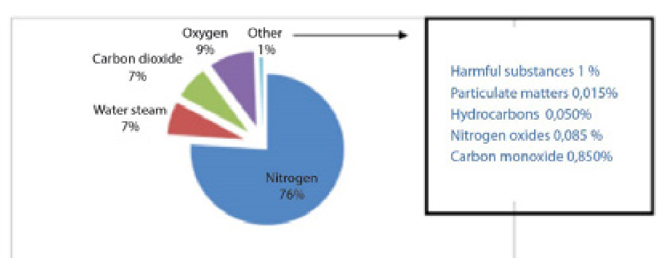
One of the alternatives to fossil fuels for vehicle drives are biofuels. Biofuels are fuels produced from renewable energy sources that can be used to start an engine through internal combustion.

EXHAUST GASES FROM INTERNAL COMBUSTION ENGINES

As a product of the combustion of conventional fossil fuels obtained from crude oil in internal combustion engines, besides the useful mechanical work, a certain amount of exhaust gases is produced that contain smaller or larger amounts of dangerous harmful substances.

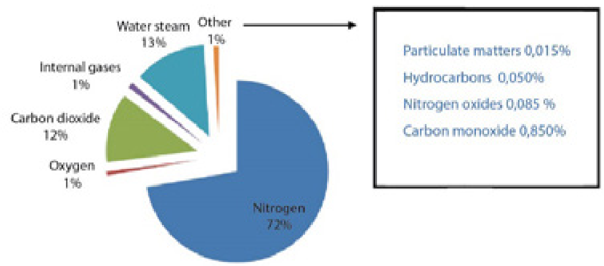
Exhaust gases produced by the combustion of fossil fuels in internal combustion engines are a mixture of: nitrogen oxides (NOx), sulfur oxides (SOx), carbon oxides (CO and CO2), water stream, nitrogen, oxygen, solid particles and various hydrocarbons (CH).

Compared to gasoline engines, in the process of fuel combustion, diesel engines emit more nitrogen oxides (NOx) and more particulate matters (PM), which are carcinogenic and harmful to human health. Image 1 shows the composition of diesel engine exhaust gases.



Picture 1: Composition of diesel engine exhaust gasses

Compared to diesel engines, gasoline engines emit a larger amount of carbon monoxide (CO) and unburned hydrocarbons (HC). Under normal operating conditions there are no particulate matters (PM) in the exhaust gases of gasoline engines. Picture 2 shows the composition of the exhaust gases of gasoline engines.



Picture 2: Composition of exhaust gases from gasoline engines

ALLOWABLE EMISSIONS OF HARMFUL SUBSTANCES

From the beginning of the 1970s the European countries began to deal with the quality of exhaust gases in the form of homologation regulations, which prescribe the amount of harmful pollutants in the exhaust gases of new vehicles. The maximum permitted amounts of certain harmful substances in the exhaust gases are shown in Table 1.

REDUCTION OF HARMFUL GAS EMISSIONS

Reduction of harmful gas emissions can be achieved by: optimizing the fuel combustion process in engines, after-treatment of exhaust gases, increasing the quality of used fuel and using alternative drives and fuels.

In the last ten years intensive work has been done on improving the alternative drive of electric powered vehicles, either in combination with a classic internal combustion engine or an independent electric motor.

Biofuels produced from renewable sources represent an alternative to fossil fuels produced from crude oil and their use is one of the realistic possibilities to reduce harmful exhaust gas emissions from vehicles.

The basic criteria important for evaluating the applicability of alternative fuels for drive of internal combustion engines are:

- emission of exhaust gases,
- fuel consumption
- price of alternative fuel
- performance of vehicles powered by alternative fuels
- locations, method of obtaining and reserves of alternative fuel
- costs of conversion or production of vehicles
- ways and possibilities of fuel storage in the vehicle
- general vehicle safety

The three most promising alternative fuels for internal combustion engines are:

- biofuels
- natural gas and
- hydrogen on its own fuel cells

ELECTRIC VEHICLE DRIVE

An electric vehicle is a vehicle that is powered by an electric motor, using electricity stored in a battery. One of the limiting factors for the mass use of electric cars is their price and limited autonomy of movement.

Currently, the price of an electric vehicle is higher than the price of a vehicle powered by an internal combustion engine.

Table 1: Maximum permitted amounts of certain harmful substances

Standard	Year of entry into force	CO	HC	HC + NOx	NOx	PM
Diesel engines (g/kg)						
Euro 1	1992	3,16	-	1,13	-	0,18
Euro 2	1996	1,00	-	0,70	-	0,08
Euro 3	2000	0,64	-	0,56	0,50	0,05
Euro 4	2005	0,50	-	0,30	0,25	0,025
Euro 5	2009	0,50	-	0,23	0,18	0,005
Euro 6	2014	0,50	-	0,17	0,08	0,005
Gasoline engines (g/kg)						
Euro 1	1992	3,16	-	1,13	-	-
Euro 2	1996	2,20	-	0,50	-	-
Euro 3	2000	2,30	0,20	-	0,15	-
Euro 4	2005.	1,00	0,10	-	0,08	-
Euro 5	2009.	1,00	0,10	-	0,06	0,005
Euro 6	2014.	1,00	0,10	-	0,06	0,005

The main advantage of electric powered vehicle is the reduction of air pollution because electric powered vehicles do not release harmful substances into the environment during movement. The negative impact of electric vehicle on the environment is the disposal of used up batteries. Components of batteries are heavy metals: lithium, nickel and copper, which if disposed of irresponsibly have a harmful effect on the environment.

Electric motors are more efficient in converting stored energy into the energy needed to move the vehicle than internal combustion engines. Electric vehicles do not waste energy while stationary, and part of the energy lost during deceleration and braking is reused to charge the battery. Hybrid vehicles use two or more energy sources as drives, those are gasoline or diesel engine and an electric motor. Compared to conventional vehicles, hybrid vehicle emission of harmful gases is reduced, and nowadays great importance is related to their production and use.

BIOFUELS FOR INTERNAL COMBUSTION ENGINES

Biomass is an organic matter created by the growth of plants and animals. Renewable biofuels can be produced from biomass.

There are several types of biofuels, depending on the source of production materials, production technology, price and carbon dioxide emissions.

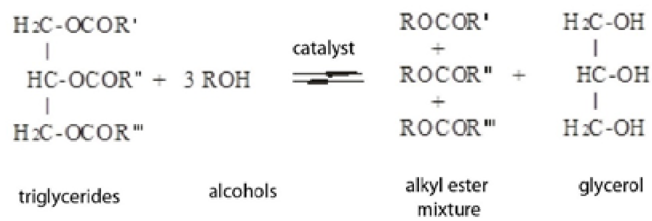
Biofuels are divided into three groups:

- First generation - the same raw materials are used for production as for food production (sugar, starch, vegetable oils or animal fats). The most important biofuels of the first generation are: ethanol, biodiesel and biogas.
- Second generation - agricultural and forest waste is used for production. The most important biofuels of the second generation are: biohydrogen, bio-DME (biodimethylethene), biomethanol, DMF (dimethylformamide), HTU diesel (Hydro Thermal Upgrading diesel), Fischer-Tropsch diesel and alcohol mixtures.
- Third generation – is produced by using algae. Based on laboratory tests, algae can produce up to thirty times more energy per hectare of land than cereals. With the increase in the price of fossil fuels, there has been an increasing interest in growing algae for fuel production.

BIODIESEL

Biodiesel - methyl ester of fatty acids (MEMK) is a biodegradable fuel, which is obtained by the reaction of transesterification of oils (vegetable oils, animal fats and waste edible oils) and alcohol. Biodiesel can be used in internal combustion engines in two ways:

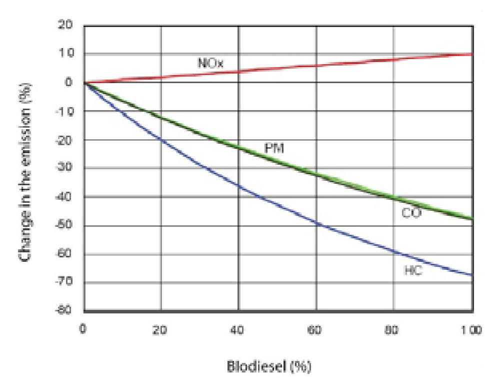
- as an addition to fossil diesel, by mixing it with fossil fuel in certain proportions and
- as pure biodiesel



The use of biodiesel compared to fossil diesel fuel leads to a significant reduction in environmental pollution. In particular, the emission of carbon dioxide is reduced as well as the emission of sulfur oxides, suspended particles and carbon monoxide, while the emission of nitrogen oxides increases slightly, as shown in Table 2 and Image 3.

Table 2: Changes in emissions by using biodiesel

Emission type	B 100 (%)	B 20 (%)
Carbon monoxide (CO)	-48	-12
Unburned hydrocarbons (HC)	-67	-20
Solid particles (PM)	-47	-12
Nitrogen oxides (NOx)	+10	+2



Picture 3: Changes in emissions by using biodiesel

The advantage of biodiesel over fossil diesel fuel, from an environmental point of view, comes from a more favorable carbon dioxide balance. The basis for the production of biodiesel is the oil of an oilseed crop. The plant consumes a certain amount of carbon dioxide for its growth, while the carbon dioxide produced by fossil diesel fuel is constantly accumulating in the atmosphere. A closed cycle of carbon dioxide is created by growing an oilseed, producing fuel, burning it, and re-growing it.

The disadvantages of using biodiesel as a fuel are as follows:

- Biodiesel is more expensive than normal fossil diesel fuels

- Possibility of injector clogging on a diesel engine
- Difficult fuel injection and its dispersion, which results in poorer mixing with air, i.e. incomplete combustion;
- Lower energy value than ordinary fossil diesel
- Due to the increased demand for raw materials for the production of biodiesel (oilseeds), which are also used for food production, the oilseed price has also increased
- Biodiesel in older vehicles can affect the dissolution of paint and the decomposition of plastic materials used as construction materials for fuel storage and distribution

ALCOHOLS

The most important alcohols used as biofuels are ethyl alcohol or ethanol (C_2H_5OH) and methyl alcohol or methanol (CH3OH).

All organic compounds that can be broken down to simple sugars, which the yeast can use for its metabolism, can serve as raw materials for the production of alcohol. The mentioned sugars and polysaccharides are very widespread in plants, so there is a large number of potentially possible raw materials for the production of bioethanol.

Raw materials for production of bioalcohol can be: sugar (sugar beet, sugar cane and molasses), starch (grains and various crops) and lignocellulosic materials (wood, old paper, corn, straw and similar agricultural by-products).

A limiting factor in the use of alcohol for internal combustion engine propulsion can be the low density and incompatibility of alcohol with engine construction materials.

BIOGAS

Biogas is a renewable source of energy that is created by anaerobic processes of converting biomass into a gaseous state and the resulting product is a mixture of methane and carbon dioxide.

HYDROGEN

Hydrogen is a renewable fuel. It can be produced from water, but the energy consumption for hydrogen production is higher than the amount of energy obtained from hydrogen.

CONCLUSION

With the increase in the number of vehicles on the roads, the environment becomes more and more burdened by exhaust gases produced by the combustion of fuel in the internal combustion engines. The most significant gases produced by the combustion of fossil fuels in internal combustion engines are: nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon oxides (CO and CO_2), water stream, particulate matters (PM) and various hydrocarbons (CH).

One of the possibilities of reducing harmful gas emissions is the use of alternative drives and fuels. An alternative to fossil fuels produced from crude oil is biofuels produced from renewable sources. The use of biofuels in internal combustion engines leads to a significant reduction in the emissions of harmful exhaust gases and to a reduction in environmental pollution.

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The length of each paper, including the abstract and references may not exceed **7,500 words**; that is, a paper that is only text should contain no more than 7,500 words. Each figure, photograph, or table accompanying the text counts as 250 words. For example, if two figures and three tables are submitted, the text may be no more than 6,250 words.

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Table Titles and *Figure* Captions

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FIGURE 3 Example of results.
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The **Introduction** should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of disciplines.

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The following examples illustrate the basic TTTP style for references.

EXAMPLES OF ACM PUBLICATION REFERENCES

Journal article [1]
[1] Zahavi Y. and Ryan, M. James. Stability of Travel Components Over Time. *Transportation Research Record*, 750 (1980), 70-75.
Book [2]
[2] Shinar, D. *Psychology on the Road: The Human Factor in Traffic Safety*. John Wiley & Sons, Inc., New York, 1978.
Article in a Periodical [3]
[3] Jolliffe, J.K. and Hutchinson, T.P. A Behavioural Explanation of the Association Between Bus and Passenger Arrivals at a Bus Stop. *Transportation Science*, 9, 3 (August 1, 1975), 248-282.
Government Report [4]
[4] Dempsey, J. Barry. *Climatic Effects of Airport Pavement Systems: State of the Art.* Report DOT2DRD-75-196. FHWA, U.S. Department of Transportation, 1976.

Web Page [5]

[5] Stevens, R.C. Testimony Before United States Senate Special Committee on the Year 2000 Technology Problem. Sept. 10, 1998. http://www.senate.gov/~y2k/statements/091098stevens.html. Accessed Oct. 5, 1998.

CD-ROM [6]

[6] Martinelli, D.R. A Systematic Review of Busways. *Journal of Transportation Engineering* (CD-ROM), Vol. 122, No. 3, May–June 1996.

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Pay particular attention to determining whether weight is to be expressed in mass (kilograms) or in force (newtons), and express poundforce per square meter (N/m^2) of pressure or stress in pascals Pa).

Use prefixes instead of powers for SI units. -In figures and tables, provide only the units in which the original research was conducted.

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Acknowledgments

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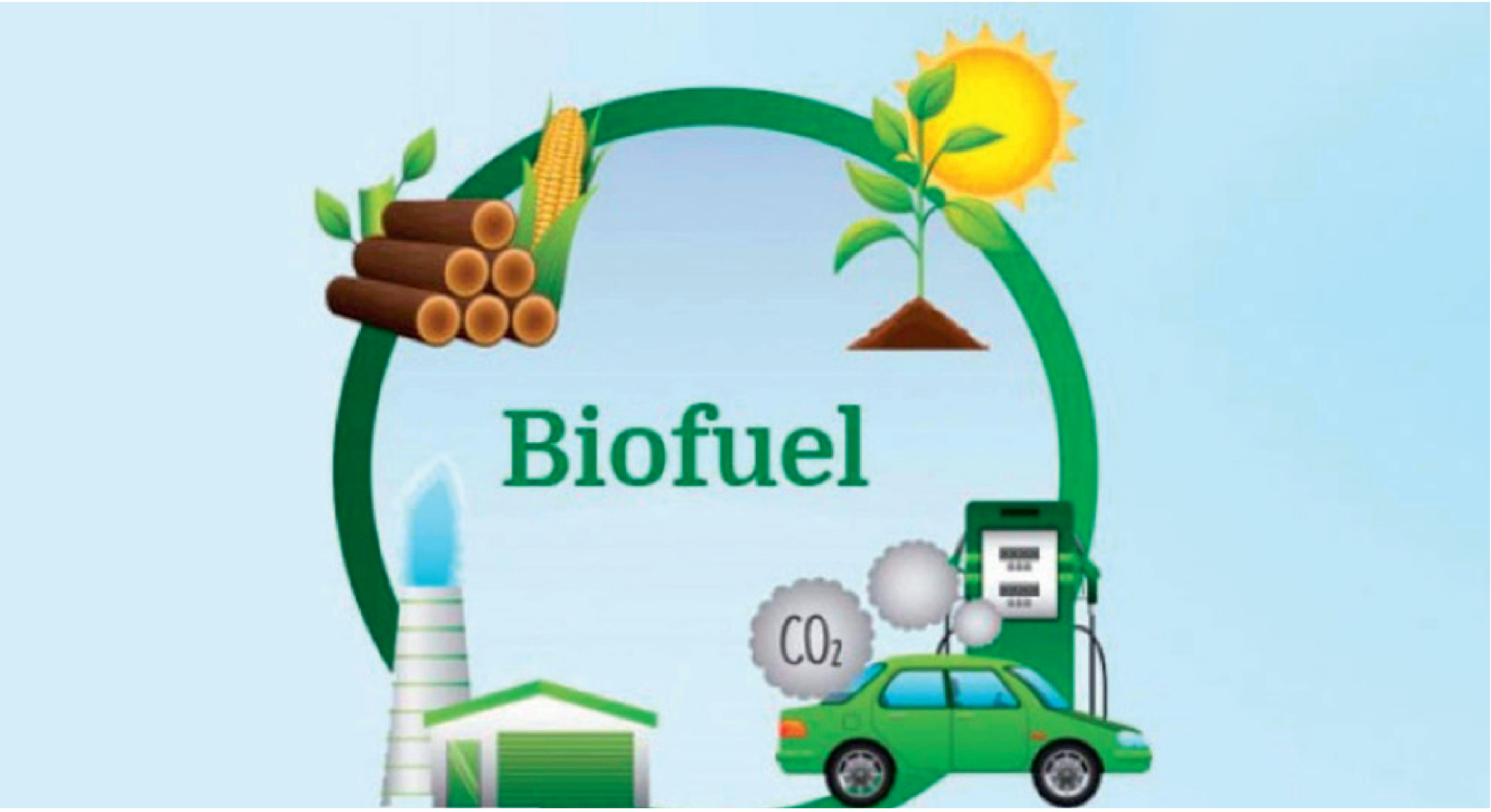

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