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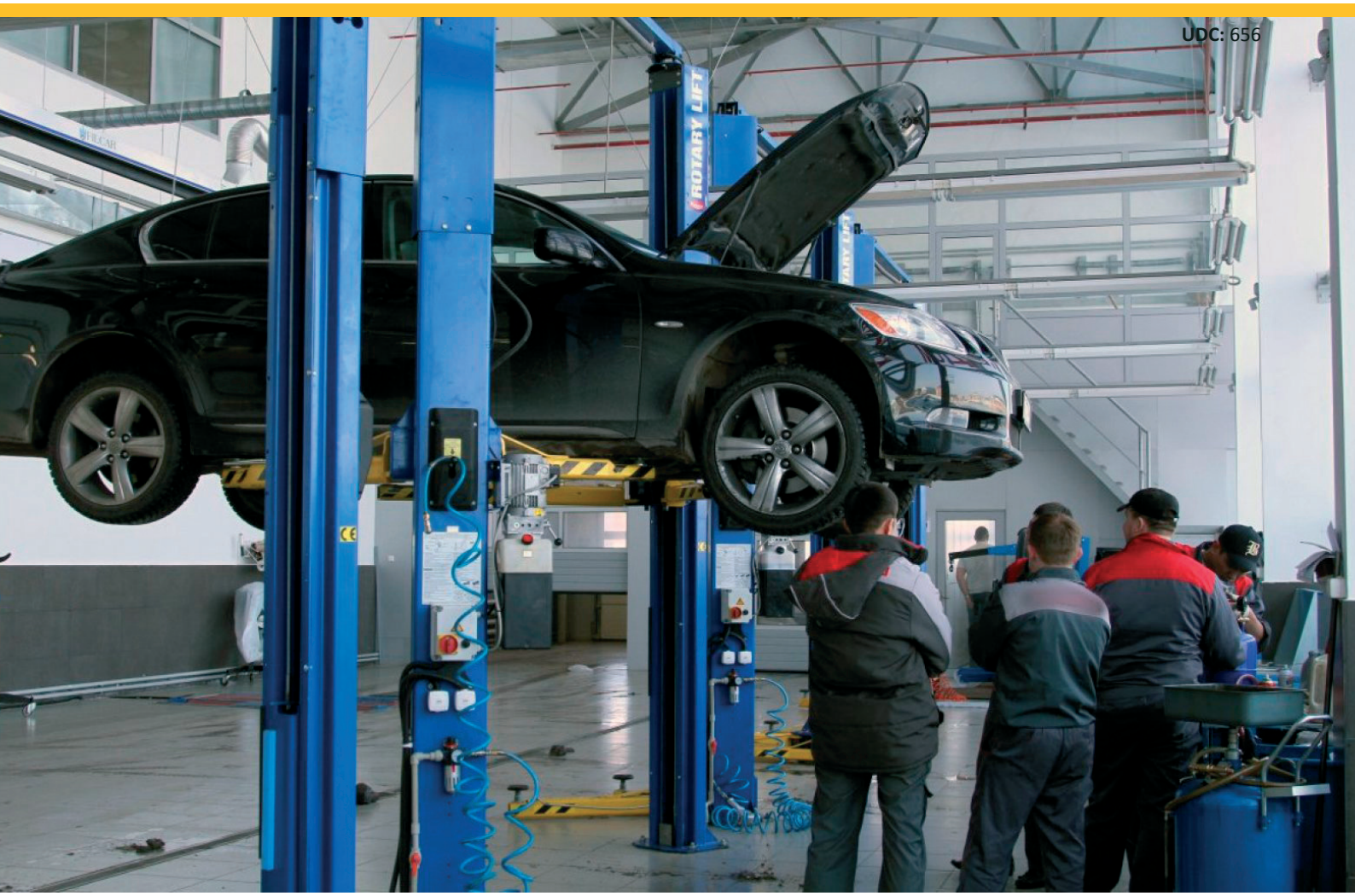

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- Provide international dissemination of knowledge and contributions to the science and practice in the field of traffic and transportation
- Promote and exchange information and knowledge in the transportation research arena and its application
-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

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

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Contents

EDITOR'S WORD

Dear reader, dear friend,

The Traffic and Transport Theory and Practice – TTTP Magazine has been placed in the second category of scientific magazines in the Republic of Srpska and Bosnia and Herzegovina. The trust of authors and reviewers of published papers is very important for the sustainability of the magazine and the increase in the quality of published papers and magazine's rating. The fifth issue of our magazine has seven papers by renowned authors and associates of the magazine that, the editorial board is pleased to report, have received positive reviews by respected reviewers from the country and abroad.

If you have new knowledge and methods, based on systematic research and analysis of results, describe them in our magazine, to the pleasure, foremost, of readers gathered in this Journal's family.

On behalf of the Editorial Board, and me personally, we like to thank you for being a part of the family of our Journal - Traffic and Transport Theory and Practice.

Editor-in Chief
Danislav Drašković

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ORIGINAL SCIENTIFIC PAPER

Technical inspection of vehicles in order to eliminate JACKKNIFE accidents

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Abstract: Traffic accidents involving articulated vehicles are characterized by severe consequences and great material damage. Particularly accidents involving articulated vehicles such as tractors with semi-trailers have these aforementioned characteristics. In a large number of accidents involving these vehicles, the main cause of the accident is the human factor, while in others it may be caused by technical failure on the tractor or semi-trailer, road conditions, unfavorable road characteristics, etc., or a combination of several conditions. According to the NHTSA data, about 6 million traffic accidents occur in the United States annually. Heavy goods vehicles are involved in about 10% of all accidents, of which more than 50% of accidents involve tractors with semi-trailers. Accidents involving tractors are caused by technical failure on vehicles in more than 30% of cases, which is significantly higher than in traffic accidents involving other types of vehicles. The most common form of these traffic accidents is a semi-trailer skid, also called jackknifing.

This paper explains the most common causes of jackknife accidents, as well as the phenomenon that is closely related to this type of accident, which in theory is called trailer swing. Special emphasis is given to the methodology of technical inspection of vehicles as a factor of preventive actions in order to eliminate technical malfunction of articulated vehicles as the cause of the destabilization of tractors or semi-trailers.

Key words: traffic accidents, articulated vehicles, jackknifing, trailer swing..

INTRODUCTION

Traffic accidents involving heavy goods vehicles generally end up with very severe consequences, both in terms of the victims and the pecuniary damage. In the overall structure of traffic accidents involving heavy goods vehicles, there is a significant number of those caused by external-objective factors, such as technical failure of vehicles, current malfunctions, state of the road surface, etc. According to the NHTSA data *(National Highway Traffic Safety Administration),* about 6 million traffic accidents occur in the United States annually [5]. Heavy goods vehicles are involved in about 10% of all accidents, of which more than 50% of accidents involve tractors with semi-trailers [6].

Technical defects or malfunctions cause approximately 30% of accidents involving this category of vehicles. One of the most common causes of traffic accidents arising from technical defects is the failure of the braking system, which can lead to a semi-trailer and/or towing vehicle skid. If this skidding is more intense, it can lead to a gradual or sudden reduction of the angle between the longitudinal axles of the towing vehicle and the semi-trailer with respect to their joint connection. This phenomenon is called *"jackknifing"*. If, for certain reasons, only semi-trailers skid, this is called *"trailer swing"*.

JACKKNIFING

Jackknifing is a term that refers to a random, uncontrolled folding of an articulated vehicle, i.e. a situation when the tractor with a semi-trailer skids in the way that the towing vehicle and the semi-trailer begin to move towards each other, whereas the semi-trailer slides laterally, so

that, practically, the two parts of the vehicle approach laterally to each other [3]. Each skidding of a semi-trailer greater than 90° is defined as a *jackknife* position, but at some point in time the vehicles can separate or fully connect, when there is a characteristic lateral contact between the towing vehicle and the semi-trailer. In the case of jackknifing at high speeds, there may be a rollover of the articulated vehicle [4].

Jackknifing can occur in two ways:

- **when the rear of the towing vehicle skids,** the tractor's rear wheels lock up, while the semi-trailer continues moving forward, it pushes the towing vehicle to the side and thus rotates it;
- **when the semi-trailer skids,** due to wheel lock-up or for some other reason, it slides and thus approaches the towing vehicle.

The term *jackknifing* is based on the movement of the semi-trailer and the towing vehicle to one another, which resembles the acute angle of a folding pocket knife.

Picture 1. An example of jackknifing

In most cases, when a *trailer swing* or *jackknifing* occurs, the driver is not able to control the movement of his vehicle or semi-trailer, as both of these occur suddenly. The consequences of these phenomena can be milder if only a part of the articulated vehicle slides off the road, or very serious if there is a contact with another participant in the traffic or a rollover of the articulated vehicle.

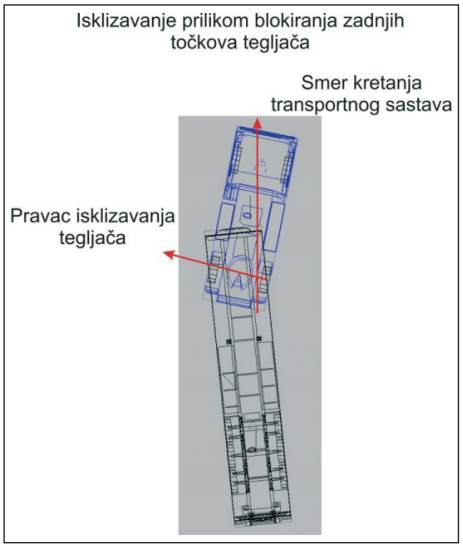
Picture 4. Jackknifing consequences

CAUSES OF VEHICLE DESTABILIZATION THAT MAY LEAD TO *JACKKNIFING* AND *TRAILER SWING*

Due to the special connection between the towing vehicle, the semi-trailer and large mass, after initial destabilization, the skidding process runs uncontrollably and most often ends with the vehicle sliding off the road. On two-lane roads, due to skidding, a part of the semi-trailer switches to the other traffic lane, which often causes collisions with vehicles moving from the opposite direction.

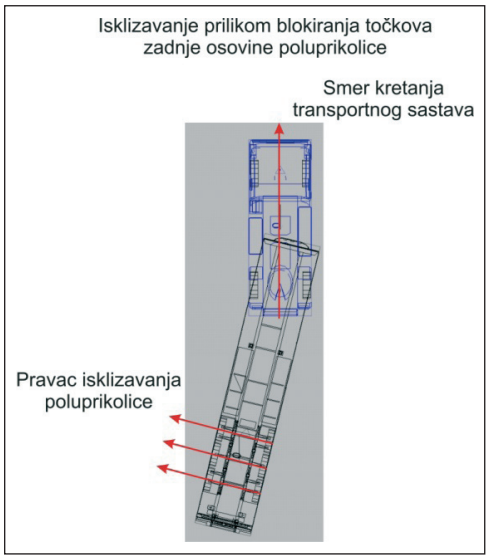
The most common causes of initial destabilization and *jackknifing* are [7], [8]:

- Braking on a slippery surface - leads to locking of the drive axle wheels and skidding;
- Locking the steering axle wheels of the towing vehicle - leads to the rotation of the towing vehicle around the front axle, while the semi-trailer continues moving straight forward;
- Locking the drive axle wheels of the towing vehicle - creates a difference in the braking forces between the drive axle and the axle of the semi-trailer;
- Locking the semi-trailer's axle wheels - primarily leads to *trailer swing*, which can lead to *jackknifing;*
- Sharp turning, sudden steering wheel rotation - leads to skidding of the towing vehicle;
- Rapid reduction in gear, when the towing vehicle is rapidly slowing down and skidding;
- Bad brake balance - causes uneven braking and skidding of a part of the articulated vehicle.



Picture 2. An example of ***jackknifing*** when the rear of the towing vehicle skids

Isklizavanje prilikom blokiranja zadnjih točkova tegljača- Skidding when the tractor's rear wheels lock up
Smjer kretanja transportnog sastava- Line of travel of the articulated vehicle
Pravac isklizavanja tegljača- Direction of slide of the tractor
Isklizavanje prilikom blokiranja točkova zadnje osovine poluprikolice - Skidding when the semi-trailer's rear axle wheels lock up
Smjer kretanja transportnog sastava- Line of travel of the articulated vehicle
Pravac isklizavanja poluprikolice- Direction of slide of the semi-trailer



Picture 3. An example of ***jackknifing*** when the semi-trailer skids

When a semi-trailer skids or swings to one side, this is known as *trailer swing*. It occurs when the semi-trailer's rear wheels lock up or on a slippery road surface in a curve when the vehicle is moving at a high speed, which may lead to side skidding of the semi-trailer.

Under certain conditions, if it comes to skidding and to a sudden slowdown of the towing vehicle, such movement may also lead to *jackknifing*. The above phenomena may also occur due to more intensive braking when the semi-trailer is not loaded. Namely, if the semi-trailer is empty, the contact surface between the semi-trailer's wheels and the substrate is reduced in case of braking, which directly affects the difference in the braking force and the occurrence of one of the aforementioned destabilization types of the articulated vehicle.

One of the most common causes of *jackknifing* in case of articulated vehicles is the unevenness of the braking forces on the towing vehicle and the semi-trailer, which may occur due to a failure of the braking system. The initial destabilization and rotation of the semi-trailer may also occur due to a little mismatch or delay in the response of the braking system of the semi-trailer.

Statistics show that the occurrence of *jackknifing* is not very common, but it is present in even 5.5% of all traffic accidents of freight vehicles with fatal consequences [6].

ANTI-JACKKNIFE SYSTEMS

Over the years, systems have been developed to prevent the occurrence of *jackknifing* on articulated vehicles. Attempts to find some construction solutions which could limit the angle of the longitudinal axles of semi-trailers and towing vehicles have not proved practical, given the limitations of articulated vehicles when turning in sharp curves and serpentines, at roundabouts, or when maneuvering at terminals.

Much more successful was a system that prevented the towing vehicle's wheels from locking up during braking, i.e. the ABS system (*Anti-lock Braking System*) [1], [2]. Since this system has become a part of mandatory equipment for heavy goods vehicles, this has significantly contributed to the reduction of *jackknifing* caused by locking of the towing vehicle's wheels. This system also provides more uniform braking forces on the towing vehicle and the semi-trailer, which also used to be one of the causes of their initial destabilization.

In addition to the above mentioned *jackknife* prevention systems, there is also a *load-sensing* device that regulates brake pressure. It is based on varying the pressure on the rear brakes in the case of heavy load or heavy braking, which prevents from big differences in the braking force between the towing vehicle and the semi-trailer.

Some vehicles are equipped with a lever in the cab which regulates the braking of semi-trailers. Using this lever, it is possible to slow down or brake only on the semi-trailer, without using the brakes on the towing vehicle. Theoretically, this is a safe way to prevent from *jackknifing*, but the use of this system has recently been reduced as there appeared a new problem of excessive use of semi-trailer brakes and the minimal use of towing vehicle brakes. Braking only with the help of semi-trailer brakes causes more overheating and faster wear of semi-trailer brakes, while the towing vehicle brakes remain virtually unused. This would cause uneven wear of brake lining, so that the braking system's condition of the towing vehicle and the semi-trailer were different. In the case of an unexpected danger and the need to stop the vehicle by forced braking, the driver would reflexively press the foot brake of the towing vehicle, which in some cases led to the locking of the towing vehicle brakes, while the semi-trailer brakes remained unlocked, which created the necessary conditions for the occurrence of *jackknifing*.

More recently, in order to allow more efficient braking of semi-trailers, and therefore of the whole articulated vehicle, towed vehicles are equipped with an electromagnetic brake which in practice has so far proved to be an effective way to prevent from *jackknifing*.

Certain preventive actions can prevent from *jackknifing*, even without the use of advanced systems to eliminate possible occurrence of this phenomenon. The following precautions are generally recommended:

- Whenever possible, ensure that the semi-trailer is loaded;
- Frequently checking the position of the semi-trailer in relation to the truck via side mirrors;
- Controlling the speed of the vehicle in situations that can lead to *jackknifing*;
- Avoiding sharp braking and sudden maneuvers;
- High-quality technical inspection of the articulated vehicle.

Another action that could help to avoid *jackknifing* in critical situations is increasing the speed of the towing vehicle, as this prevents from skidding of the semi-trailer and its lateral approach. However, increasing the speed of movement is not always possible, especially when forced braking is undertaken in order to avoid encountering obstacles or collisions with other vehicles.

TECHNICAL INSPECTION IN ORDER TO MANAGE THE RISK OF *JACKKNIFING* AND *TRAILER SWING*

Previous studies have shown that the most common causes of such accidents are inadequate driving technique, i.e. sudden maneuvering with the steering wheel with or without forced braking. In addition, it is necessary to educate the drivers of articulated vehicles about the impact of the load on the semi-trailer on the stability of the whole articulated vehicle as a system in cases of sudden braking or initial skidding.

However, a very common cause is also a technical defect of the vehicle or technical failure of the braking system. For this reason, it is very important to check the condition of the braking mechanism and to adjust the condition of the braking mechanism, i.e. braking forces, on the towing vehicle and the semi-trailer.

Unfortunately, the approach to testing the technical suitability of articulated vehicles in technical inspection service stations is very often lumpy and improper. Fictitious technical inspection of articulated vehicles or tractors without semi-trailers is done. Often, technical inspection of articulated vehicles is done in an improper manner, especially in service stations that do not record the axle load of the vehicle.

The braking system test of the articulated vehicle is done according to:

- the mass of the empty vehicle and
- the maximum permissible mass.

Although it does not provide a complete picture of the system's efficiency, the procedure based on the empty vehicle mass is mainly applied.

Technical norms are prescribed by the Rules on dimensions, total mass and axle load of vehicles, on devices and equipment that vehicles must contain, and on conditions that must be met by devices and equipment.

In accordance with the above mentioned Rules:

- The brake coefficient is prescribed in the range:
  - Service brake K ≥ 45%
  - Auxiliary brake K ≥ 20%
- Activation force ≤ 6.5 bar
- Difference of braking force on wheels of the same axle
  - Service brake ≤ 25%
  - Auxiliary brake ≤ 30%
  - Inequality of braking force on the wheel – ovality indicator of the contact surface of brake drums ≤ 20%

Brake coefficient k

$$k=\frac{\sum_{i=1}^{n}F_{ki}}{G}100[\%]=\frac{m\,a}{m\,g}100[\%]$$

Where:

- F_{ki} braking force at the i-th point,
- n number of wheels,
- m mass of the vehicle,
- $g=9.81\,\frac{m}{s^2}$
- a maximum acceleration achieved.

In the case of a technical inspection of an articulated vehicle, i.e. a tractor with a semi-trailer, a problem occurs in service stations that do not record the axle load, or in the circumstances in which the system is statically indeterminate, since the rollers do not accept the whole mass because the tractor's "saddle" takes over 30% of the semi-trailer's mass, due to which the mass of an empty semi-trailer is reduced by 30% of the recorded mass of an empty semi-trailer.

In these circumstances, the following procedure shall be followed:

- The brake coefficient of the articulated vehicle (tractor and semi-trailer) shall be determined: k_{sv}
- The brake coefficient of the tractor after being separated from the semi-trailer shall be determined: k_t

After the above operations, the brake coefficient of the semi-trailer k_{pp} is calculated.

From the equality of measured forces of articulated vehicles and forces of the tractor F_{kt} and of the semi-trailer F_{kpp}, it follows:

$$F_{ksv}=F_{kt}+F_{kpp}$$

According to

$$k=\frac{F_k}{G}\qquad i\qquad F_k=k\,G$$

$$k_{sv}\left(G_t+G_{pp}\right)=k_t\,G_t+k_{pp}G_{pp}$$

So that

$$k_{pp}=k_{sv}\frac{G_t+G_{pp}}{G_{pp}}-k_t\frac{G_t}{G_{pp}}$$

In such way calculated, the brake coefficient of the semi-trailer must be higher than the one prescribed by the Rules on dimensions, total mass and axle load of vehicles, on devices and equipment that vehicles must contain, and on conditions that must be met by devices and equipment.

After the measurement, the analysis is performed, and the reasons for negative marks can be as follows:

- Large rolling resistance - system failure (brake system is not activated);
- Delay of system response on individual points (uneven time response of the system);
- Insufficient brake coefficient value;
- Excessive difference in braking force on wheels of one axle;
- Inequality of braking force on the wheel – indicator of contact surface ovality.

The pneumatic braking system in the semi-trailer is equipped with an automatic braking force control regulator that adjusts the braking force on the wheels according to the load of the vehicle. As there is a large difference in the mass of the empty vehicle and the maximum permissible mass, the brake coefficient according to the maximum permissible mass is calculated for the complete assessment of the brakes.

As technical inspection is performed on an empty vehicle, the calculation of the brake coefficient for the maximum permissible mass is required.

$$k = \frac{\sum_{m=1}^{n} F_{km} i_m}{G} = \frac{F_{k1} i_1 + F_{k2} i_2 + ... + F_{kn} i_m}{G}$$

Where

k - brake coefficient

G - maximum permissible mass

F_{km} - braking force of an empty vehicle on the m-th axle

n - number of axles

$$i_m = \frac{p_{m\max} - 0{,}4}{p_m - 0{,}4}$$

Where

$p_{m\max}$ - maximum pressure in the brake cylinder for the m-th axle

p_m - pressure in the brake cylinder for the m-th axle when braking an empty vehicle

$p_{m\max,m}$ - written on the plate containing data about the automatic braking force control regulator valve

The equation for k has as many members as there are axles and it is assumed that the pressure in the cylinder to overcome the rolling resistance is 0.4 bar.

CONCLUSION

Traffic accidents involving heavy goods vehicles are inherently complex and their consequences are generally more difficult than other types of accidents.

In addition to the importance that is reflected in the behavior of the driver, i.e. their skills of driving an articulated vehicle and their knowledge about the characteristics of such vehicles, it is also very important to know how a technical inspection is properly done. Regular technical inspection should be done every six months for articulated vehicles older than five years. This period of time is sufficient to achieve the effects of prevention, only if the technical inspection is done properly. Technical inspection of articulated vehicles is often done improperly, without any analyzes or described calculations, only of tractors without a semi-trailer. There are also fictitious technical inspections which are done without testing of the articulated vehicle.

As a factor of prevention, you can have an extra technical inspection of the articulated vehicle in the presence of an authorized, official and professional person at the technical inspection service station.

A high-quality technical inspection of articulated vehicles and education of driver regarding the so-called *jackknifing* or *trailer swing* can significantly reduce the risk of traffic accidents of the described type.

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ORIGINAL SCIENTIFIC PAPER

Flying an Unmanned Aerial Vehicle: Key Factors for Risk Management

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Abstract: Only theoretical training of drone operators is not sufficient for safe integration and use of drone aircraft both in controlled and uncontrolled air space.
Based on research and analysis of incidents caused by the use of drone aircraft during 2018. The global level can conclude that most of the incidents have been performed because of unskilled handling of drones, even though the persons who managed them were theoretically trained and possessed of drone management licenses.
Purpose – for the purpose of mitigation of the risk of adverse effects of human and material resources in the work, the analysis of the Drone management.
Design/methodology/approach – decision on which of the following key factors for risk assessment achieves the greatest impact on the safe handling of drone aircraft has been carried out by using the methods of analytical hierarchical processes, i.e. "fuzzy"Expanded AHP method based on"fuzzy"triangular numbers.
Findings – Based on the results of the research, it concludes that the alternative – "a terrorist and practical training for the safe handling of drone aircraft" is essential for the safe handling of drone aircraft in the second place The ranked alternative "the need for knowledge and skills of sports pilots" in third place is the ranked alternative "only practical training is needed," in the fourth place the alternative is "only theoretical training is needed" and the fifth match is a ranked alternative "is not Theoretical or practical training. "
Practical Implications – established frames to increase the security of flying drones through an obligatory theoretical and practical training of drone operators.
Social Implications – reduced risks of occurrence of adverse effects on human and material resources.

Keywords: drone, controlled air space, control of air space, drone operator, risk factors.

INTRODUCTION

The rise of air traffic affects the capacity of airspace, and the integration of drones in general and operational traffic implies the harmonization of knowledge, skills, procedures and technical systems used in the unique space. The European Organization for the Safety of Air Navigation has so far taken a series of measures to keep the flying of drones in the Legalist framework, while giving recommendations to Eurocontrol countries to regulate Areas.

Membership in EUROCONTROL by 2019. has 41 countries. Serbia's a member of the EUROCONTROL from July 1, 2005.The 26 countries have regulated drone flying (regulations, laws, regulations, recommendations, etc.). The Republic of Serbia brought the rules on drones on 11. December 2015.

Of the 26 countries that have legal regulations in 12 countries or 46.15% for flying drones, it is necessary to have theoretical knowledge and practical skills (depending on the severity of the drone), in 11 countries or 42.30% it is necessary only theoretical knowledge while in 3 countries or 11.53% do not require any theoretical or practical knowledge of drone management.

The sudden rise in the development of drone industries has expanded the palette of their use in almost all spheres of human society. In addition to the initial use for military purposes today, drones are used for entertainment, sport and hobby and for film industries, Assistance in agriculture,assistance in searching and rescue, monitoring of road, rail and water At the same time are the area that is still intensive (7),(9),(10),(2).

Especially smaller drone aircraft are increasingly used in the countries of European union (EU), but under fragmented regulatory framework. Although national rules on Security, the rules differ in the EU and a number of key protection measures are not addressed in a coherent manner(11),(18),(14).

After a four-month consultation period on the proposed amendment notification, NPA 2017-05, EASA issued Opinion 01/2018, including a proposal for a new regulation for unmanned aerial vehicles in the "open", "specific" and "certified" categories.

The creation of the category is a category of Operation anddrones which, taking into account the involved risks, does not require prior approval of the competent body or the statement of the drone operator Aircraft Before the start of Operation.

With specificationcategory a category of Operation andUndoneaircraft which, taking into account the risks involved, requires approval of the competent body before the start of the operation, taking into account the mitigation measures Determined in the operational risk assessment, except for certain standard scenarios where the declaration by the operator is sufficient, or when an aircraft operator has an approval.

The Certified category is a category of Operation and drone, which, taking into account the risks involved, requiresthe certification of drones and licensedand approved by the competent body, in order to ensure the appropriate level of security.[1]

In accordance with the opinion of the Easaonly for the certified category of drones, it is necessary that the drone operator be licensedbut without the explicitly specified conditions that the drone operator must Also have practical training and check skills of drone management, especially in emergency situations.

Given that the rise in the use of drones is evident, and consequently the number of incidents caused by the use of drone aircraft, an analysis of the causes of the incidents in order to minimize risk Occurrence of the incident.

Theabilityof the operator for safe handling of drones is in correlation with the risk of using drones (1), (15),(8),(12).Risk is the probability of an event in the specific case of incidents caused by the use of drones. The key factors for assessing the risk of drone management have been analyzed.

RESEARCH METHODOLOGY

Taking into account the European Aviation Safety Agency document: "Getting to Know the Regulatory Framework for Unmanned Aerial Operations", an analysis was made of the causes of incidents caused by the use of unmanned aircraft during 2018 through key risk assessment factors for unmanned aircraft management.

[1] https://www.easa.europa.eu/easa-and-you/civil-drones-rpas

Key risk assessment factors for unmanned aircraft management:

- Area of operation and working space(hereinafter: PDRP):
  - Population density,
  - Areas with special protection,
  - Configuration of the terrain and time of stay.
  - impact on the airworthiness and control of general and operational air traffic,
  - Impact on the design of air space.
- Procedures (hereinafter: PO):
  - In case of an emergency situation caused by other aircraft,
  - In case of an emergency situation caused by an uncontrolled malfunction of the drone.
- Unmanned aerial vehicle design and type (hereinafter: DTV):
  - Features provided,
  - Redundancy and safety features.
- Operational Procedures (hereinafter: OP):
  - training of unmanned aerial vehicle operators,
  - organizational factors.
- Environmental Impact2 (hereinafter-ZS).

Deciding which of the following key factors for risk assessment has the greatest impact on the safe management of unmanned aerial vehicles was carried out using the analytical hierarchical process or fuzzy extended AHP method based on fuzzy triangular numbers (5).

In this paper, the key factors for risk assessment are taken as criteria for analysis.

The starting basis for alternative alternatives was analysis of the causes of the incidents caused by the use of drones during 2018., wherein 54.83% of cases as the cause of the incidents identified "loss of control" or the ability to manage drone management. The common characteristic of the incident is a bad "situation response" of drone operators that did not have practical training for drone management.

The following statements have been selected as alternatives to the safe operation and operation of unmanned aerial vehicles: Requirements of terrestrial and practical training (hereinafter: PTO) for the safe operation of unmanned aircraft, knowledge and skills of sport pilots (hereinafter: CFSP) required neither theoretical nor practical training (hereinafter referred to as BPTO), only theoretical training (hereinafter: WTO) is required and only practical training (hereinafter: SPO) is required.

Research Stages

The reduction of the risk of the incidents was considered in this work by examining the aforementioned impactson the security of drone aircraftthroughthree different research phases:

[2] https://www.easa.europa.eu/sites/default/files/dfu/Introduction of a regulatory framework for the operation of unmanned aircraft.pdf

- **In the first phase of the survey,** thecause of incidents in the management of drones was being reviewed by the incident in 2018.
- **In the second phase of the survey**, an on-line survey was conducted to identify the alternative that has the greatest impact on the safe flight of drones.
- **In the third phase**, an experimental study summarized and processed the data obtained to compare the results of on-line surveys and identified incidents of drones

First phase of research

In the first phase, there was a survey of all droneincidents at 2018. The year that were publicly publishedthrough public information funds. The analysis found that in 26 different countries of the world were recorded A total of 124 Incidentdroneaircraft. In Figure 1. A graphic representation of the comparative analysis of the number of reported incidents in relation to the number of incidents caused by the "loss of control" was given.

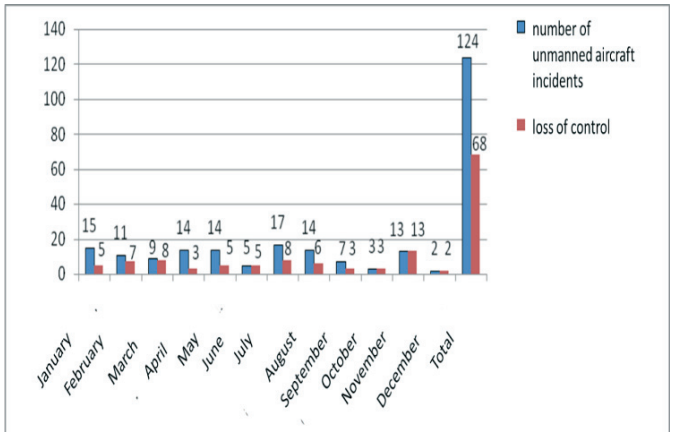

Figure 1. Comparative analysis of drone incidents

The second phase of the survey - interviewing

The online survey included 60 people, from January to April 2019, with a view to looking at attitudes toward similarity in understanding key risk assessment factors and identified alternatives. The questionnaire used in the survey was compiled according to Satie's linguistic scale for comparison by pairs (16). The respondents were divided into six groups, where each group was determined in relation to common interests: civil aviation organizations (hereinafter: CVO), academic domain experts (hereinafter: ADO), drones (hereinafter: KBV), Sports Aviation Associations (SVU), Aircraft Pilots (PA), and Helicopter Pilots (PH).

Third phase of research - experimental study

In the third phase, summation and processing of obtaineddata, methods that are more detailed in Chapter 3 of this work are realized.

Experimental study

The Order of the Linguistic scaled is played in table 1 is thecomparison phase in the few of these as shown in table 2.

Table 1. Satie's linguistic pairwise comparison scale (16).

Crips values (x)	Meaning	„fuzzy" values
1	Equal importance	(1, 1, 1 + D)
3	Weak domination	(3-D, 3, 3 + D)
5	Strong domination	(5-D, 5, 5 + D)
7	Demonstrative domination	(7-D, 7, 7 + D)
9	Absolute domination	(9-D, 9, 9)
2,4,6,8	Medium values	(x - 1, x, x+1)

Table 2. Fuzi comparison in pairs

	C1			C2			C3			C4			C5		
C1	1	1	1	1	3	5	1	3	5	1	3	5	0.09	0.11	0.14
C2	0.2	0.33	1	1	1	1	0.2	0.33	1	0.2	0.33	1	0.14	0.2	0.33
C3	0.2	0.33	1	1	3	5	1	1	1	0.2	0.33	1	0.2	0.33	1
C4	0.2	0.33	1	1	3	5	1	3	5	1	1	1	0.2	0.33	1
C5	7	9	11	3	5	7	0.09	0.11	0.14	1	3	5	1	1	1

The weights of all criteria were determined by Chang's analysis (17).First, synthetic values were calculated, based on Eq: (1)

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \quad (1)$$

Calculated values are,

$$\sum_{j=1}^{m} M_{gi}^{j} = (23.92467532, 43.08888889, 66.61904762)$$

Based on Eq (2),

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (2)$$

Calculated values are,

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = (0.04179785, 0.023207839, 0.015010722)$$

After (1) and (2) It can be calculated that the synthetic value of each factorial equation:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} * \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$$

$$S_1 = (4.090,10.111,16.142) * (0.015,0.023,0.0417) = (0.061,0.234,0.674)$$
$$S_2 = (1.742,2.2,4.333) * (0.015,0.023,0.0417) = (0.026,0.051,0.181)$$
$$S_3 = (2.6,5,9) * (0.015,0.023,0.0417) = (0.039,0.116,0.376)$$
$$S_4 = (3.4,7.66,13) * (0.015,0.023,0.0417) = (0.051,0.177,0.543)$$
$$S_5 = (12.09,18.11,24.14) * (0.015,0.023,0.0417) = (0.181,0.420,1.009)$$

The fuzzy values thus obtained were compared by Eq (3):

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2} = 1\ if m_2 \geq m_1, 0\ if\ l_1 \geq u_2, otherwise\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}$$

$$V(S_b \geq S_a) = 1\ if m_b \geq m_a, 0\ if\ l_a \geq u_b, otherwise\ \frac{l_a - u_b}{(m_b - u_b) - (m_a - l_a)} \quad (3)$$

The following values are obtained,
VSc1>=VSc2=1, VSc1>=VSc3=1 ,VSc1>=VSc4=1, VSc1>=VSc5=0.726,VSc2>=VSc4=1,VSc2>=VSc5=0,VSc2>=VSc3=0.686,VSc2>=VSc1=0.394,VSc3>=VSc1=0.895, VSc3>=VSc2=1, VSc3>=VSc4=0.840, VSc3>=VSc5=0.390,VSc4>=VSc1=1.10,VSc4>=VSc2=1,VSc4>=VSc3=1,VSc4>=VSc5=0.59,VSc5>=VSc1=1,VSc5>=VSc3=1,VSc5>=VSc2=1,VSc5>=VSc4=1.

V-Priority weightsare defined by the following,

$d(A_i) = minV(S_i \geq S_k) d(A_i) = minV(S_i \geq S_k)$, *for the* $k = 1,2,\ldots,n: k \neq i, = 1,2,\ldots,n: k \neq i,$

The following values are obtained,

$$d(A_1) = minV\ (1,1,0.726526695) = 0.726526695$$
$$d(A_2) = minV\ (1,0,0.686195921,0.394691991) = 0$$
$$d(A_3) = minV\ (0.89518486,1,0.840096923,0.39018014) = 0.39018014$$
$$d(A_4) = minV\ (1.100058686,1,0.598867597) = 0.598867597$$
$$d(A_5) = minV\ (1,1,1,1) = 1$$

The weighting factors are calculated as follows,

$$W' = \left(d'(A_1), d'(A_2), \ldots, d'(A_n)\right)^T$$

The following values are obtained,

$$W' = (0.726526695, 0, 0.39018014, 0.598867597, 1)^T$$

Normalized weight vectors are,

$$W_{factors} = (0.267540704, 0, 0.143682359, 0.220530724, 0.368246213)^T$$

After comparing pairs of criteria, the comparison of the alternative to individual criteria (3). was performed. The weight of the alternative is calculated in a similar manner as the severity of the criteria.

C1	A1			A2			A3			A4			A5		
A1	1	1	1	1	3	5	7	9	11	7	9	11	0.09	0.11	0.14
A2	0.2	0.33	1	1	1	1	1	3	5	1	3	5	0.14	0.2	0.33
A3	0.09	0.11	0.14	0.2	0.33	1	1	1	1	3	5	7	0.2	0.33	1
A4	0.09	0.11	0.14	0.2	0.33	1	0.14	0.2	0.33	1	1	1	1	3	5
A5	7	9	11	0.2	0.33	1	0.09	0.11	0.14	0.2	0.33	1	1	1	1

C2	A1			A2			A3			A4			A5		
A1	1	1	1	1	3	5	5	7	9	7	9	11	0.09	0.11	0.14
A2	0.2	0.33	1	1	1	1	3	5	7	1	3	5	0.14	0.2	0.33
A3	0.11	0.14	0.2	0.14	0.2	0.33	1	1	1	3	5	7	0.2	0.33	1
A4	0.09	0.11	0.14	0.2	0.33	1	0.14	0.2	0.33	1	1	1	3	5	7
A5	7	9	11	0.14	0.2	0.33	0.09	0.1	0.14	0.14	0.2	0.3	1	1	1

C3	A1			A2			A3			A4			A5		
A1	1	1	1	1	3	5	5	7	9	7	9	11	0.09	0.111	0.14
A2	0.2	0.33	1	1	1	1	1	3	5	1	3	5	0.14	0.2	0.33
A3	0.111	0.14	0.2	0.2	0.33	1	1	1	1	3	5	7	0.2	0.33	1
A4	0.09	0.11	0.14	0.2	0.33	1	0.14	0.2	0.33	1	1	1	1	3	5
A5	7	9	11	0.2	0.33	1	0.09	0.11	0.14	0.2	0.33	1	1	1	1

C4	A1			A2			A3			A4			A5		
A1	1	1	1	1	3	5	5	7	9	7	9	11	0.09	0.11	0.14
A2	0.20	0.33	1.00	1	1	1	1	3	5	0.14	0.20	0.33	0.14	0.20	0.33
A3	0.11	0.14	0.20	0.20	0.33	1	1	1	1	0.11	0.14	0.20	0.20	0.33	1.00
A4	0.09	0.11	0.14	3	5	7	5	7	9	1	1	1	1	3	5
A5	7	9	11	0.20	0.33	1	0.09	0.11	0.14	0.20	0.33	1	1	1	1

C5	C1			C2			C3			C4			C5		
C1	1	1	1	1	3	5	7	9	11	7	9	11	0.09	0.11	0.14
C2	0.20	0.33	1	1	1	1	1	3	5	1	3	5	0.14	0.20	0.33
C3	0.09	0.11	0.14	0.20	0.33	1	1	1	1	0.11	0.14	0.20	0.20	0.33	1
C4	0.09	0.11	0.14	0.20	0.33	1	5	7	9	1	1	1	1	3	5
C5	7	9	11	0.20	0.33	1	0.09	0.11	0.14	0.20	0.33	1	1	1	1

RESULTS AND DISCUSSION

After implementing the fuzzy AHP method, as Chang's analytical method, we obtain the following results:

Criteria	Ponderized values	Alternatives				
		A1	A2	A3	A4	A5
C1	**0.26754**	0.34287	0.303967	0.319555	0.38745	0.364274
C2	**0**	0.109059	0.151158	0.130807	0.021366	0.110393
C3	**0.14368**	0.237334	0.202872	0.225072	0	0
C4	**0.22053**	0.154462	0.201578	0.148429	0.38745	0.364274
C5	**0.36825**	0.156274	0.140425	0.176136	0.203734	0.161059
weight acquired		**0.217443**	**0.206638**	**0.215428**	**0.264128**	**0.237101**

A Consensus Convergence Model – CCM) (13) is developed for the purpose of deciding which of the defined alternatives has the greatest influence on the achievement of the defined goal. It is based on the model proposed by Lehrer and Wagner (1981), which is based on the weighting of decision makers on the basis of mutual respect, that is, the competence of other participants in the decision-making process. The new model is based on determining the differences in the "weights" of decision makers based on the value assigned by each decision maker to the appropriate elements (criteria, sub criteria and / or alternatives) (6).

If the initial severity of the elements in the hierarchy that values the decision$p_1^0, p_2^0, \dots, p_n^0$-making, the determination of the weight is

$$W_{ij} = \frac{1-\left|p_i^0 - p_j^0\right|}{\sum_{j=1}^{n} 1-\left|p_i^0 - p_j^0\right|} \qquad (4)$$

The difficulty gained in the preceding step is used to form the Wdimension Matrix
n x n

$$W = \begin{bmatrix} W_{11} & W_{12} \dots W_{1n} \\ W_{21} & W_{22} \dots W_{2n} \\ \dots & \dots \dots \dots \\ W_{n1} & W_{n2} \dots W_{nn} \end{bmatrix} \qquad (5)$$

If Pvector is the initial weight of the hierarchy elements, the condenszous vector is obtained using the equation,

$$P_c = WP_{c-1} \qquad (6)$$

The procedures are repeated until the vector values P_c и $P_{c-1}$are equal. When two consecutive vectors have the same value, the procedure is terminated and the result is adopted as final.

Based on the evaluation results, a joint - final decision on the alternative of highest value for the safe management of unmanned aircraft - was made for all six stakeholders involved in the research. The final weight vectors for the CVO, ADO, KBV, SVV, PA, and PH interest groups are shown in Table 3. These values represent the input data for applying the consensus convergence model.

Table 3.

	WEIGHT VECTORS					
	CVO	ADO	KBV	SVV	PA	PH
A1	0,217443	0,256449	0,291121	0,276306	0,322671	0,27165
A2	0,206638	0,247448	0,278575	0,259572	0,270139	0,257494
A3	0,215428	0,239744	0,264759	0,243652	0,216346	0,249921
A4	0,264128	0,237792	0,267448	0,24323	0,226449	0,234603
A5	0,237101	0,21749	0,282413	0,238011	0,310816	0,234982

For obtaining the concentration of the vectors for alternatives, calculations have been carried out in more instrumentation (Blagojevicet al.,2016). The Consezusna weight for alternative A1 is obtained insixth Intermentation, for A2 in the fifth, for A3 in the fourth, for A4 and A5 seventh interagency. Calculation procedure with the concurrent converging model will be explained for an alternative to A1. For calculations, it is a necessary initial weight for the alternative A1 and the so-called. Respect matrix for a given alternative. Initial weight for alternatives of A1 are the difficulty that this the alternative to assigning all interest groups.

$$P_0^{A_1} = \begin{bmatrix} 0{,}250 \\ 0{,}216 \\ 0{,}244 \\ 0{,}259 \\ 0{,}265 \\ 0{,}244 \end{bmatrix}$$

Based on the formulas (4) and (5) It is calculated the matrix of respect for alternative A1, in the sixth inersion $P_6^{A_1}$ and$P_5^{A_1}$ are equal, which means that the resulting consesion weight for a1 and is 0.077.

The same procedure is applied for the calculation of consection weight vectors and for other alternatives and as a result of the values shown in table 4,

Table 4.

Alternatives	condensation weight vectors	Rank
A1	0,077	1
A2	0,069	2
A3	0,060	5
A4	0,061	4
A5	0,062	3

Based on the results shown in Table 4, it is concluded that Alternative A1 - "requires theatrical and practical training for the safe operation of unmanned aircraft" is of paramount importance for the safe management of unmanned aircraft; pilot "ranked third with" only practical training required "ranked, fourth with" only theoretical training required "and fifth with" no need n theoretical or practical training".

CONCLUSION

Carried out the cause of theincident in the management of free aircraft and theMulticriteria analysis of the method „fuzzy" of theexpandedAHP method thingummynumbers indicate that the safe handling of drone aircraft is necessary for theoretical and practical training of drone operatorsregardless of the category of drone aircraft.

Respecting the general laws of physics and taking into account the mass of drones, the speedand altitude on which it flies, in case of losscontrolcan be caused by serious injury of people and animals as Damage or destruction of natural resources and material goods.

This work should provide the basis for the development of regulations in the area of drone management, on the one hand, and on the other side to give the basics for drafting a plan and program for the training of drone users.

The resulting survey results can be applied in the course of increasing security in the area of drone flight management through the creation of a plan and a programmefor safe handling of drones.

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ORIGINAL SCIENTIFIC PAPER

The Research Into the Influence of Non-Resident Drivers on the Critical Headway and Follow-Up Headway at an Unsignalised Intersection

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Abstract: The input parameters in the procedure for calculating the minor movement capacity of the unsignalised intersection are the values of conflict flow, critical haedway and follow-up headway. The conflict flow value is established in exact measuring, on the basis of flow values on approaches and their distribution by driving directions. On the other hand, the values of the critical headway and the follow-up headway are the parameters which depend on the estimate and the behaviour of the drivers doing the minor movement. On account of that, these parameter values depend on different factors and influences, therefore, they are not identical at all intersections. In the procedures for calculating the capacity of two-way stop controlled inersections, the values of critical headway and follow-up headway are given as recommendations. Some of the methods for capacity calculations, such as Highway Capacity Manual, recommend the research on these parameter values in local conditions, considering different influences. This paper presents the results of the research into the influence of non-resident drivers on the features and values of critical headway and follow-up headway, and thereby on the intersection capacity as well.

Keywords: unsignalised intersection, capacity, driver behaviour, non-resident drivers, critical headway.

INTRODUCTION

Two-way stop controlled (TWSC) intersections (unsignalised intersections) are the most common form of road and street crossings in a road network. Traffic at these intersections is regulated by priority signs, and according to the signalization, manoeuvres can be classified as major and minor ones. The capacity of an unsignalised intersection is calculated partially, on the basis of the capacity of minor movements on intersection approaches. The capacity of minor movement is most affected by the character of the observed manoeuvre, as well as by the values of conflict flow, critical headway (t_c) and follow-up headway (t_f). The conflict flow value is determined in the calculation on the basis of the values of approach flows and traffic features of the approach, that is, the distribution of approach flows by driving directions [1].

The critical headway of vehicles is defined as the minimum interval in the main flow which enables the minor movement being carried out. The follow-up headway represents the period from the moment of minor movement performing for the vehicle first positioned in the line on the minor approach, to the following vehicle coming to the position of the first vehicle [2]. Values of the both stated parameters depend on different factors and on the behaviour of the drivers who create the traffic flow on the minor approach. In procedures for calculating the capacity of unsignalised intersections, local measuring is advised in order to establish the influence of different local factors, which is not identical in all environments, through the determined values of critical headway and follow-up headway. In calculating the capacity of roads and intersections, different factors are considered for explaining the influences of traffic flow features. In the procedure for road capacity calculation, the influence of driver characteristics is also taken into account. The basic conditions for a highway flow include a driver population primarily consisting of commuters.

Studies have shown that resident (commuters) and non-resident (non-commuters) drivers do not demonstrate the same characteristics. Thus, the fact that resident

and non-resident drivers take part in traffic significantly influences the features of traffic flow and road capacity. Taking into consideration previously stated facts, it can be assumed that driver characteristics also influence the intersection capacity, since the behaviour of resident and non-resident drivers significantly differ. Taking into account input parameter features for calculating the capacity of unsignalised intersections, it can be assumed that the presence of resident and non-resident drivers on minor approaches influences the values of critical headway and follow-up headway. As the influence of driver behaviour and driver characteristics has been experimentally confirmed at signalised intersections [3], as well as at roundabouts [4], it is expected that the influence of behaviour of different driver groups will also be confirmed at the TWSC intersection.

In a situation when the size of traffic flow parameters is measured within operational analysis, it can be considered that the influence of driver characteristics have been taking into account. However, in a situation when the project analysis of the capacity and service level of the unsignalised intersection is performed, the influence of driver characteristics, according to existing methods, cannot be valorised in any way. Considering the recommended values of driver population factor in procedures for analysing road capacity, it can be assumed that driver characteristics can significantly influence the capacity and service level of the unsignalised intersection.

In this paper, the analysis of values of accepted critical headways and follow-up headways with resident and non-resident drivers has been completed, within more consecutive local measurements, to determine whether driver characteristics can influence the capacity of an unsignalised intersection (TWSC intersection).

PREVIOUS RESEARCH STUDIES

The procedures used today for the calculation of unsignalised intersection capacity are based on gap acceptance theory. This theory is based on the assumption that vehicles will pass through the intersection when the interval between vehicles in the conflict flow, a higher priority flow, is bigger than the minimum – critical headway. Gap acceptance theory was developed in the second half of the previous century. On the basis of gap acceptance theory, different models have been developed, like [5] and [6], which represent the basis of engineering procedures for capacity calculation. In engineer practice in the world, the most commonly used edition of manuals for the calculation of capacity and roads is *Highway Capacity Manual – HCM*. In the 1985 edition of this manual, the stated models were implemented as the basis of the procedure for calculating the capacity of unsignalised intersections. According to this method, firstly the potential capacity for each minor movement is calculated, and then, the capacity of the approach and finally the capacity of the whole intersection [7]. According to the *HCM* [2,8] the potential capacity of minor movements is calculated by the relation based on *Harder's* model [5].

The direct application of the *HCM* procedure for the capacity calculation of unsignalised intersections, with the recommended values of input parameters sometimes does not provide objective results [9]. The experience of many countries has shown that it is very useful to make corrections of input parameter values in the existing procedures for capacity calculations, that is, to adjust the recommended values of parameters to the results of the research [10]. In many procedures for calculating the capacity of unsignalised intersections, it is emphasized that field research results have been used [2,8,11,12,13]. Critical headways and follow-up headways are performed by the reaction of the drivers steering the vehicles in the traffic flow. Since mentality, habits and behaviour of drivers in the local environment differ in relation to the research conditions, on the basis of which recommendations have been given, it can be assumed that the values of critical headways and follow-up headways are not the same for all intersections. For that reason, many research studies have been carried out in the world, related to different factors which influence the values of critical headway for the minor movement and follow-up headway for the minor movement. The research studies have been performed in several directions: research into the influence of limited speed, the type of traffic signalization, the complexity of movement, local surroundings and the position of the intersection, the intersection geometry, traffic flow structure, etc.

The research studies in Sweden have shown that there is a difference of almost 40% in critical headway values, depending on the type of traffic signs and speed limit [14]. The complexity of the movement affects the observation span and driver's decision-making, which provokes the bigger delay from the start. All that causes higher values of critical headway and follow-up headway [12,13,15]. Some research studies have shown that their values are influenced by the characteristics of the local environment, such as the size of the town where the studied intersection is situated [10]. Influences of intersection geometry and traffic flow structure in *HCM* have been considered since the 2000 edition [8], which was also established in some previous research studies of this subject [16].

DEFINING THE AIM AND THE BACKGROUND OF THE RESEARCH

According *to the Highway Capacity Manual 2016 – HCM 2016* [2], the potential capacity of the minor movement is given in the following Equation (1):

$$C_{p,x} = V_{c,x} \frac{e^{-V_{c,x} \cdot t_{c,x}/3600}}{1 - e^{-V_{c,x} \cdot t_{f,x}/3600}} \quad (1)$$

where:
$C_{p,x}$ – potential capacity of movement x (veh/h)
$V_{c,x}$ – conflicting flow rate for movement x (veh/h)
$t_{c,x}$ – critical headway for minor movement x (s)
$t_{f,x}$ – follow-up headway for minor movement x (s)

As it can be seen from the previous Equation (1), the potential capacity of the minor movement, and thereby the unsignalised intersection capacity, is affected by the value of the conflict flow. The value of the conflict flow is determined in the calculation for each minor movement by the established procedure, on the basis of the traffic flow value on intersection approaches and on the basis of flow distribution by driving directions. No additional factors can influence the conflict flow value or, through it, the intersection capacity.

Taking into consideration the fact that the conflict flow value is precisely determined in calculations, it ensues that the values of critical headway and follow-up headway, through the potential capacity value, directly influence the practical capacity of an unsignalised intersection, i.e. capacity in real existing conditions. These parameter values are usually given in the form of recommendations, in accordance with the intersection geometry. Values of critical headway and follow-up headway are always given on the basis of real research within the standards and traffic regulations and social environment where the traffic is happening. In *HCM 6*, it has been emphasized that the value of critical headway for the minor movement and follow-up headway for the minor movement in some cases can have some other values as well, hence, field measurements are recommended.

As shown in Chapter 2, the previous research studies have implied that the values of critical headway for the minor movement and follow-up headway for the minor movement are affected by different factors.

In traffic flow theory, it is known that traffic flow participants who use the same section every day behave differently in relation to the drivers who use the same section occasionally, rarely or for the first time. These facts related to driver behaviour are considered in calculations of road capacity. The research studies of this subject have shown that capacities for recreational traffic can be up to 20 percent lower than for commuter traffic on highways and 10 to 15 percent on the freeways. If this possible effect of driver population is taken into account, locally derived data should be obtained and used carefully, according to the methodology. The influence of driver characteristics on road capacity is expressed by the value of Driver Population Factor [2,8].

The aim of the research is to determine whether driver characteristics influence unsignalised intersection capacity on the basis of local measurement results, that is, whether there is a difference between the value of headway for the minor movement and follow-up headway for the minor movement with resident and non-resident drivers.

At unsignalised intersections, drivers individually estimate the traffic situation, which means that the values of critical headway and follow-up headway while performing the desired movement are 'determined' by the drivers, on the basis of their habits, previous knowledge, skills and the features of the vehicle they are driving. For that reason, it can be assumed that the value of critical headway for the minor movement and follow-up headway for the minor movement depend on driver characteristics. Considering these facts, the main hypothesis of this paper is that values of critical headway for the minor movement and follow-up headway for the minor movement are higher with non-resident drivers.

Non-resident drivers appear in higher percentage on transit directions and in tourist regions, where these drivers often represent the majority of driver population in periods of holidays. Therefore, calculation of priority intersection capacity with recommended values of input parameters can provide unreal results. All these can influence the wrong estimate of measures which are to be taken in order to improve a service level.

THE RESEARCH METHODOLOGY

The measurement of the values of critical headway for the minor movement and follow-up headway for the minor movement of vehicles is a relatively simple procedure. The local measurement of these parameters have been carried out in the world since last century but they have to be carefully considered. For the measurement it is necessary that, on the minor approach, there are conditions of the saturation flow, i.e. there is a queue, and on the main road direction, in certain periods, there are conditions for time gap occurrence which enable the minor movement being performed. The occurrence of a queue, i.e. a line of vehicles on the minor approach, is an obligatory and necessary assumption for determining the follow-up headway. On the other hand, in order to carry out the measurement of critical headway, it is necessary that, at the moment of measurement, there are conditions on the main approach similar to those of the saturation flow. For that reason, there are rarely conditions for the simultaneous measuring of both critical headway and follow-up headway at the same intersection. The occurrence of any disturbance of minor or the main flow while doing the measurements is not allowed [4,10].

Restrictions regarding possibilities for measuring the follow-up headway occur when the traffic flow intensity is low on the minor approach, as well as in the situation when the flow is very intensive on the main road direction, and for these reasons it is not possible to perform two consecutive movements from the minor ap-

proach. On the other hand, while measuring the critical headway, the restrictions occur when the traffic flow intensity is low on the main approach, since, at that time, two consecutive movements from the minor approach are performed very often. Thus, favourable conditions for direct measurement of critical headway and follow-up headway on the minor flow are not always practically feasible during the whole research period [4].

In order to determine the influence of non-resident drivers on the values of the parameters t_c and t_f, and thus on the capacity of TWSC intersections, the parameters t_c and t_f were measured in such a way as to eliminate the possibility of commercial vehicle impact on the values of parameters t_c and t_f when performing the minor manoeuvre by resident and non-resident drivers. For that reason, the values of the parameters t_c and t_f were considered in the analysis only if a passenger car was performing the minor movement, and if all the vehicles in relation to which the measurement was performed were also passenger cars. The homogeneous traffic flow composed exclusively of passenger cars has proven to be a good method for processing data and determining the influence of the diversity of particular groups of drivers (resident and non-resident drivers) on the capacity of unsignalised intersections [4].

For the research needs, the measuring of the critical headway and follow-up headway of vehicles was carried out in the town of Bijeljina, situated in the northeast of Bosnia and Herzegovina (Figure 1). The measuring was performed at the four-forked intersection of the streets Miloša Obilića – Solunska (44°45'38.9"N 19°12'46.3"E), situated in the town centre. At the both of minor approaches in Solunska Street there is the traffic sign YIELD.

The YIELD sign is a traffic sign used as the primary means of establishing a hierarchical structure, i.e. enhancing the legal superiority of one traffic flow over another, in poorly congested locations, where most traffic can cross an intersection without stopping. In terms of capacity, there are no major differences between the intersections with two approaches controlled by STOP and YIELD signs. In locations controlled by the sign YIELD, where the traffic congestion is high, practically every vehicle on the bypass approaches controlled by the sign YIELD will stop in particular because of the stop control. For this reason, the capacity at the intersection controlled by the sign YIELD can be observed as it is an intersection where two approaches are controlled by the sign STOP [10].

Figure 1. The Studied Intersection

The research was carried out using a digital video camera in July and August, 2018. The recordings were later on analysed in video players used for measuring parameters of the flow in real time. The results were statistically processed in the Microsoft Excel software (Table 1 and Table 2).

Table 1. Collected Values of The Sample for the Critical Headway (t_c)

Manoeuvre	Resident Drivers	Non-Resident Drivers	Total
Left from major	111	30	141
Right from minor	101	21	122
Through on minor	82	24	106
Left from minor	88	29	117
Total	382	104	486

Table 2. Collected Values of The Sample for the Follow-up Headway (t_f)

Manoeuvre	Resident Drivers	Non-Resident Drivers	Total
Left from major	193	45	238
Right from minor	161	38	199
Through on minor	89	29	118
Left from minor	93	26	119
Total	536	138	674

In Figure 2, a typical manoeuvre, recorded by a video camera, is shown. The town of Bijeljina has been chosen for the research because of the fact that in the research period there is a higher number of drivers who spend their time in this town only several times a year. Namely, a significant number of Bijeljina residents are temporarily working in European states, and they could easily be identified by registration plates (Figure 2).

Figure 2. The Minor Movement Performed by a Vehicle Steered by a Non-resident Driver

RESEARCH RESULTS

Within the framework of this research, 486 values of critical headway and 674 values of follow-up headway (Table 1 and Table 2) were recorded when performing the minor movement (left from major, right from minor, through on minor and left from minor). The results of critical headway measured values are given in Table 3.

Table 3. Measured Values of Critical Headway (t_c) at the Studied Intersection

Manoeuvre	HCM 6	Local measurement				Percentage of non-resident drivers
		Mean value	Resident drivers	Non-resident drivers	Difference non-resident –resident	
Left from major	4.1	4.63	4.43	5.37	0.94	21.28 %
Right from minor	6.2	5.62	5.44	6.49	1.05	17.21 %
Through on minor	6.5	6.15	5.96	6.79	0.83	22.64 %
Left from minor	7.1	5.92	5.71	6.57	0.86	24.79 %

Results of follow-up headway measured values are given in Table 4.

Table 4. Measured Values of Follow-up Headway (t_f) at the Studied Intersection

Manoeuvre	HCM 6	Local measurement				Percentage of non-resident drivers
		Mean value	Resident drivers	Non-resident drivers	Difference non-resident - resident	
Left from major	2.2	2.91	2.86	3.13	0.27	18.91 %
Right from minor	3.3	3.31	3.24	3.63	0.39	19.09 %
Through on minor	4.0	3.76	3.66	4.09	0.43	24.58 %
Left from minor	3.5	3.64	3.57	3.91	0.34	21.85 %

In the previous tables (Table 3 and Table 4), the basic values of critical headway for the minor movement and follow-up headway for the minor movement are given, recommended in *HCM 6* for the TWSC intersections. Additionally, the same tables show the values obtained in the research, where the values for resident and non-resident drivers have been separated.

DISCUSSION

The research results have confirmed the importance of local measurements of the critical headway for the minor movement and follow-up headway for the minor movement. Based on the results given in Table 3 and Table 4, graphically shown in Figure 3 and Figure 4, it can be concluded that the values of the measured parameters of critical headway and follow-up headway deviate from those recommended in *HCM*, which implies that it is useful to perform local measurements. The largest deviations from the recommended values given in *HCM 6*, for the parameter t_c are regarding minor movement - manoeuvre "left from minor" (1.18s), while for the parameter t_f, the largest deviations of local measurements from the recommended values given in *HCM 6* are recorded when performing the minor movement – "left from major" manoeuvre (0.71s).

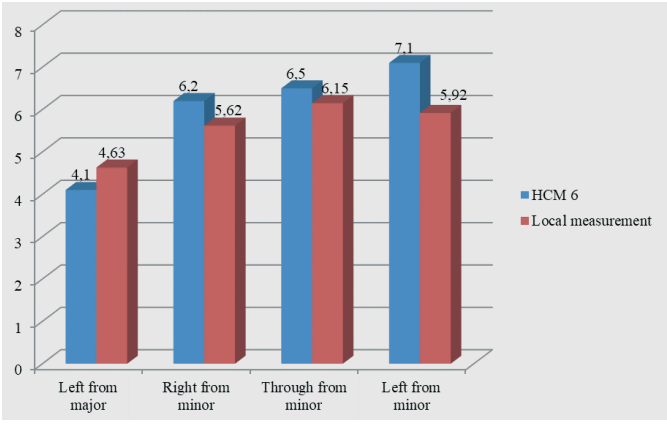

Figure 3. The Ratio of the Recommended Values of Critical Headway (t_c) for the Minor Movement to The Values Determined in Local Measurements

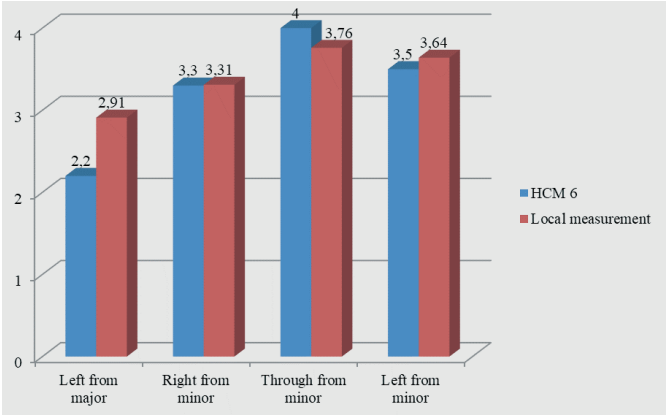

Figure 4. The Ratio of the Recommended Values of Follow-up Headway (t_f) for the Minor Movement to the Values Determined in Local Measurements

It is important to emphasize that the results of the analysis have provided that non-resident drivers use higher values of critical headway and follow-up headway to perform the minor movement, i.e. they need more time to make a decision and perform the minor movement than non-resident drivers. Consequently, the participation of non-resident drivers in a traffic flow directly leads to a decrease in capacity for each minor movement, and thus a decrease in capacity of the entire intersection. As it can be seen in Figure 5 and Figure 6, there are clear differences between the critical headway and follow-up headway accepted by resident drivers on the one hand and non-resident drivers on the other.

Resident drivers use less critical headways and follow-up headways when performing the minor movement, i.e. they respond faster and more explosively. The research has shown that, regarding the minor movement "right from minor", the largest difference in measured values of critical headway for resident and non-resident drivers is 1.05s, while the smallest difference in measured values of critical headway for resident and non-resident drivers is 0.83s recorded for the minor movement "through on minor". The conclusion based on the result analysis of the measured values of the critical headway is that non-resident drivers, for performing minor movements, use the critical headways in the major flow, which are by about 1.0s higher than the interval used by resident drivers.

On the other hand, the differences in the measured values of follow-up headway for resident and non-resident drivers range from 0.27s to 0.43s, with certain deviations depending on the type of minor movement. The conclusion based on the result analysis of the measured values of the follow-up headway is that non-resident drivers require averagely 0.3 – 0.4 seconds more than resident drivers for consecutive joining the major flow.

Obviously, habits, behaviour, customs, and different regulations influence non-resident drivers to use larger critical headways and follow-up headways to perform the minor manoeuvre.

Having analysed the established values of parameters, it can be concluded that non-resident drivers, while performing the minor movement create higher values of critical headway for the minor movement and follow-up headway for the minor movement than resident drivers for all movements, as it can be seen in Figure 5 and Figure 6. This is a scientific confirmation that the participation of the examined groups of drivers significantly influences the capacity of TWSC intersection.

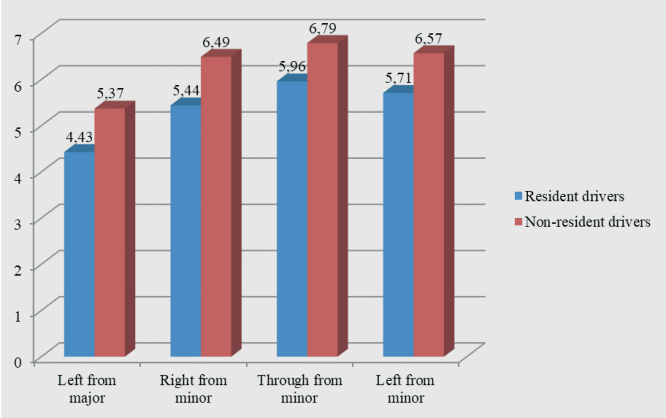

Figure 5. Parameter Values of Critical Headway (t_c) Obtained by Local Measurements for Resident and Non-resident Drivers, Depending on the Minor Movement

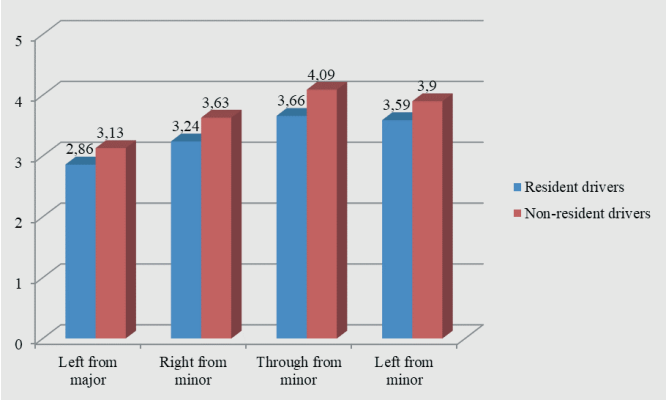

Figure 6. Parameter Values of Follow-up Headway (t_f) Obtained by Local Measurements for Resident and Non-resident Drivers, Depending on the Minor Movement

The research has completely confirmed the basic hypothesis that non-resident drivers create higher values of critical headway for the minor movement and follow-up headway for the minor movement. In further research studies, it would be necessary to study and establish the dependence on the participation of non-resident drivers in the traffic flow and the increase of critical headway values for the minor movement and follow-up headway values for the minor movement at two-way stop controlled intersections.

CONCLUSION

The previous research studies have shown that road capacity is significantly affected by driver characteristics and driver behaviour. The biggest difference in behaviour of resident (commuters) and non-resident (non-commuters) drivers has been noticed, hence, this influence is expressed as Driver Population Factor in the procedures for capacity calculation. In engineer procedures for capacity calculation of unsignalised intersec-

tions, the influence of driver characteristics and driver behaviour has not been valorised.

In previous research studies, it has been proved that the values of critical headway for the minor movement and follow-up headway for the minor movement are affected by different factors, therefore, it is useful to carry out local measurements. Within the framework of this paper, the influence of resident and non-resident drivers on the values of input parameters for calculating the capacity of unsignalised intersection has been analysed. In local measurements carried out in this research, non-resident drivers are the drivers at the intersections steering vehicles with foreign registration plates, since they only occasionally or very rarely use the intersection where the measurement has been performed.

As in many other previous research studies, it has been confirmed that there are certain deviations in parameter values determined in local measurements in relation to those recommended in *Highway Capacity Manual*.

The hypothesis that there is a difference in obtained values of critical headway for the minor movement and follow-up headway for the minor movement, with resident and non-resident drivers, has been completely confirmed. The research results have shown that non-resident drivers use higher values of critical headway and follow-up headway when performing the minor movement, leading to a decrease in the capacity of unsignalised intersection. The research into the influence of non-resident drivers on the capacity of unsignalised intersections should be performed in other locations as well, and these research results can be significant especially if capacity analysis is carried out in tourist regions.

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PRELIMINARY COMMUNICATIONS

Bus Drivers Whole-body Vibration Exposure, Evaluation Procedures, Prevention and Control

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Abstract: Public transport bus drivers are exposed to a wide range of hazards which can endanger their occupational safety and health. Risks of possible traffic accidents, stress (due to traffic jams, pace of work, conflicts with passengers and other road users, etc.), fatigue, long sitting hours, vibration, noise, exposure to air pollution, adverse microclimatic conditions are just some of the factors that can endanger a driver's health and are characterized by a different likelihood of occurrence and consequence severity. Whole-body vibration transferred to human over many years of exposure have the potential to endanger health with respect to the onset of musculoskeletal disorders, especially in synergy with prolonged sitting. In addition, whole-body vibration exposure is a possible source of discomfort, which, combined with other factors, can contribute to the negative effect on the general physical and mental state of the driver, and therefore the occurrence of fatigue and stress.

In order to manage the exposure of bus drivers to vibration, it is necessary to evaluate the exposure, using methodologies defined by international standards, based on expert analysis and measurements. The paper presents the dominant health risks arising from the whole-body vibration of professional bus drivers, the parameters of exposure evaluation, measurements and evaluation procedure in accordance with European Directive 2002/44/EC and ISO standards, as well as an overview of the precautions to be taken in to reduce the risk associated with bus drivers occupational whole-body vibration exposure.

Keywords: bus drivers, whole-body vibration, health risks, evaluation..

INTRODUCTION

Vibration in the work environment are physical agents that are divided into three basic categories from the point of view of human response: vibration transmitted by the hands and arms (HAV), vibration transmitted by the whole body (WBV) and vibration that cause motion sickness, which actually belong to the subset of whole-body vibration and occur when persons are exposed to very low frequencies, usually below 1 Hz.

Whole-body vibration occurs when the body is supported on a surface that is vibrating (e.g., sitting on a seat that vibrates, standing on a vibrating floor or lying on a vibrating surface). Whole-body vibration occurs in transport (e.g., road, off-road, rail, air and marine transport) and when near some machinery [1]. Bus drivers are included in the working population, who, due to the nature of their work, are exposed to whole-body vibration on a daily basis, and this exposure is usually long-term, that has multiannual and decade-long character. Whether it is bus drivers in urban, suburban or intercity bus services, exposure to WBV depends on a variety of variables related to the condition and performance of the vehicle, road characteristics and driving modes: age of bus, bus maintenance, position of the bus engine, bus suspension type, low-floor or high-floor bus, seat design and its suspension, road type (smooth freeway, rough freeway, city streets, speed humps, etc.), roads' conditions, moving speed [2-7]. On the other hand, the degree of manifestation of the negative effects of WBV is also influenced by factors related to the driver itself: age, body size and weight, body dynamic response, gender, experience, fitness [1] as well as vibration dose accumulated over a lifetime [8]. Due to the complexity and heterogeneity of the various effects on the exposure of whole-body vibration bus drivers, a systematic approach to exposure assessment is necessary in order to obtain the most relevant results. This is a prerequisite for later selection of the best whole-body vibration management strategies and programs in this workplace.

Basically, the effect of whole-body vibration on humans is considered from the aspect of positive and negative effects. Exposure to whole-body vibration for therapeutic purposes is present in medical practice for many age-related chronic conditions including balance and gait deficiencies, fibromyalgia, multiple sclerosis, cystic fibrosis, Parkinson's disease, and peripheral neuropathy [9]. On the other hand, exposure

to vibration in the work environment is an undesirable phenomenon, since it can lead to lasting effects on the safety and health of professionally exposed persons and have a negative impact on work performance and comfort.

Numerous epidemiological studies have examined the relationship between exposure to WBV and their health effects. Although there are not yet fully proven doubts that WBV contributes to the development of a number of systemic diseases, studies to date have shown that exposure to WBV is primarily associated with an increase in lower back, neck and shoulder pain. Along with vibration, other exposure factors that may induce musculoskeletal pain in workers include maintaining statistical positions for a long period of time and twisting or torque while seated. These factors, along with the vibration from the vehicle and the impact from driving on rough roads, can result in compression of the disks and soft tissue strain, which both contribute to back pain [5,10].

In accordance with current knowledge, Directive 2002/44/ EC in the definition of WBV lists the possible health risks, dwelling only on musculoskeletal disorders (MSDs): the mechanical vibration that, when transmitted to the whole body, entails risks to the health and safety of workers, in particular lower-back morbidity and trauma of the spine [11]. The risks are greatest when the vibration magnitudes are high, the exposure durations long, frequent, and regular, and the vibration involves severe shocks or jolts [12]. The inevitable prolonged sitting and possible other contributions to not applying ergonomics behavior are factors that are associated with whole-body vibration increasing the risk of musculoskeletal disorders.

In addition to possible work-related illness and traumas, whole-body vibration has a direct and indirect impact on occupational safety and health in terms of contributing to increased stress and fatigue, as well as reducing concentration. The appearance of such effects not only endangers the safety of bus drivers but also passengers. Of course, the effects of whole-body vibration on these phenomena should not be overestimated, but given their importance and possible consequences, they should be taken into account when designing a drivers vibration exposure management program.

Compared to other groups of professionally exposed persons (machine operators in the mining, construction, agriculture etc.), bus drivers are usually exposed to lower values of vibration magnitude. A review of the literature related to field studies of bus drivers whole-body vibration exposure [2,4-7] indicates that exposure values are generally below the limit but near or above the action and recommended values. Such results indicate the need for regular monitoring of WBV exposure, as well as monitoring bus drivers health status regarding the risk of WBV.

BASIC PARAMETERS OF EXPOSURE EVALUATION TO WBV

The influencing factors that determine how the vibration is transmitted and how they affect on humans are: vibration magnitude, vibration frequency, vibration direction and vibration exposure duration.

Vibration magnitude in the field of human vibrations is expressed by r.m.s (root-mean-square) value of acceletation (in m/s^2 for translational acceleration). This value is generally the most useful because it is directly related to the energy content of the vibration profile and thus the destructive capability of the vibration and also takes into account the time history of the wave form.

From the point of view of the adverse effect of vibration on health, not all frequencies have the same effect. Therefore, frequency weighting curves are introduced, which have the function of weighting the significance of frequency ranges in accordance with the harmfulness to the human body or in accordance with the sensitivity of the human body to them. They are defined by ISO 2631-1 [13]. As the vibration direction has an impact on the manifestation of the WBV effect, certain weighting curves for the vertical direction (z direction, frequency weighting curve W_k) and for horizontal directions (x and y directions, frequency weighting curve W_d) are determined. Frequency weighting curve for vertical direction gives utmost importance to frequencies between 4 Hz and 13 Hz, while frequency weighting curve for vertical direction gives utmost importance to frequencies between 0.5 Hz and 2 Hz. These curves are for principal frequency weightings, and there are also curves for additional weightings. There are specific additional multiplying factors for each of the directions (axes), which will be discussed in a later section of the paper.

In the European Union, the area of vibration occupational exposure management is governed by Directive 2002/44/EC [11], which defines the minimum requirements for safety and health at work caused by vibration. The daily exposure value depends on the frequency-weighted r.m.s (root mean square) value of the vibration acceleration and the actual time of the daily exposure. A supplementary parameter that can be used in assessing WBV exposure is the vibration dose value (VDV). The VDV calculation performs the duration weights as it is accumulated and automatically incorporates a method of giving more weight to occasional peaks (shocks) in the motion. The Directive relies on the ISO 2631-1 standard, both in terms of WBV exposure parameters and in the evaluation of exposure to WBV.

The daily exposure limit value of WBV and the daily action value of exposure to WBV, standardized to the eight-hour reference period, are respectively 1.15 m/s^2 and $0.5/s^2$. VDV limit and action values are 21 $m/s^{1.75}$ and 9.1 $m/s^{1.75}$, respectively. The exposure action value (EAV) is a daily amount of vibration exposure above

which employers are required to take an action to control exposure, and the exposure limit value (ELV) is the maximum amount of vibration an employee may be exposed to on any single day.

ISO 2631-1, on the other hand, defines the two health guidance zones (HGZ) shown in Figure 1 with respect to a combination of weighted r.m.s acceleration values and exposure duration, which almost coincide when the WBV exposure time is between 4 and 8 hours. For exposures below the zone, health effects have not been clearly documented and/or objectively observed; in the zone, caution with respect to potential health risks is indicated and above the zone health risks are likely [13]. From the foregoing, it is clear that the standard does not define safe whole-body vibration exposure values. It can be seen in Figure 1 that the vibration exposure values for a period of 8 hours are somewhat more rigorously set than in Directive 2002/44, since the upper limit of HGZ is lower than ELV. As stated by Griffin [14] while excessive magnitudes at short durations when using r.m.s. evaluation were avoided in ISO 2631, they are "allowed" in the Directive. In the Directive, these high magnitudes at short durations are controlled when using the VDV evaluation method (that is, 9.1 $m/s^{1.75}$ and 21 $m/s^{1.75}$) but not when using r.m.s. measures (that is 0.5 and m/s^2 and 1.15 m/s^2).

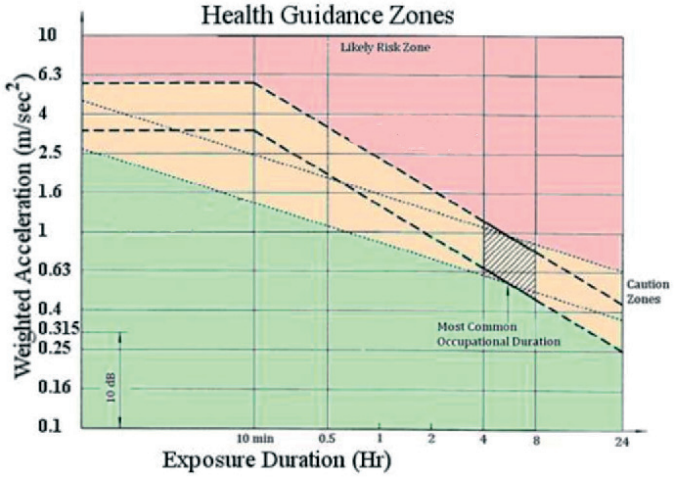

Figure 1. Health guidence zones according to ISO 2631-1 [15]

Apart from the health guidance zones, the standard provides ranges of daily exposure values relative to comfort (Table 1), noting that these values give approximate indications of likely reactions to various magnitudes of overall vibrations total values in public transportation [13]. Principal frequency weightings are applied to the seated persons and therefore the bus drivers, the same as when assessing the health effects of WBV, with the difference that each axis is considered equally influential.

Table 1. Comfort reactions to whole-body vibration environment according to ISO 2631-1

Daily WBV exposure value	Comfort experience
Less than 0,315 m/s^2	not uncomfortable
0,315 m/s^2 to 0,63 m/s^2	a little uncomfortable
0,5 m/s^2 to 1 m/s^2	fairly uncomfortable
0,8 m/s^2 to 1,6 m/s^2	uncomfortable
1,25 m/s^2 to 2,5 m/s^2	very uncomfortable
Greater than 2 m/s^2	extremely uncomfortable

WBV EXPOSURE EVALUATION PROCEDURE

The assesment of the level of exposure may be carried out on the basis of the information provided by the manufacturers regarding the emission level of the work equipment used, and based on the observation of specific work practices or measurement [11]. However, in the process of assessing the WBV exposure of a bus driver, the only justifiable procedure is based on field measurements, since vehicle vibration emission data (if any) do not represent a sufficient source of information. Other very important parameters (driving style, type and condition of the road, etc.) also influence the level of vibration magnitude, so only with the results obtained from the measurements can the WBV exposure assessment of the bus driver be considered relevant. Accordingly, as well as Directive 2002/44 and ISO 2631-1, the procedure should include the following basic methodological steps: bus driver whole-body vibration analysis, vibration measurement and daily vibration exposure calculations.

Exposure analysis should cover operations, sources and modes of vibration exposure, as well as typical actual exposure time. Also, depending on the mode of operation, the required measurement time will depend. Daily vibration exposure does not match daily working hours, as it should exclude all periods (breaks) when vibration exposure is absent. Certain job cycles (and their contribution to exposure time) need to be identified, such as driving between public bus terminals, driving to different intercity bus stops, etc. In this way, during the subsequent analysis of the results, it may be possible to identify characteristic exposures related to, for example, the type and condition of the road.

Instrumentation that meets the requirements of *ISO 8041-1 Human response to vibration - Measuring instrumentation - Part 1: General purpose vibration meters* is used for measurements, since this instrumentation integrates all the necessary functions, such as r.m.s. averaging vibration magnitude and frequency weighting. Also, modern instruments equipped with triaxle accelerometers allow simultaneous measurements in all three directions.

Vibration magnitude is measured simultaneously in defined orthogonal directions (Figure 2), by placing accelerometers at the point where it is estimated that there are vibration transmission to a person. In order to evaluate the vibration exposure of the whole body of the sitting person, in Figure 2 the measurement axes are shown, i.e. the required orientation of the accelerometer.

Figure 2. Direction of measurement [12]

The measurement point, or accelerometer position, can be on the seat pan, on the backrest or next to the seat, i.e. on the floor of the bus. The most reliable results of the vibration exposure of the bus driver are obtained by measurements on the seat pan. For this purpose, manufacturers provide specially designed accelerometers, which are built into the rubber pad. In order to determine seat transmissibility, measurements are made with two accelerometers simultaneously on the seat pan and on the floor of the bus near the driver's seat. This makes it possible to determine the SEAT (Seat Effective Amplitude Transmissibility) parameter. This value is the ratio of the frequency-weighted acceleration on the driver's seat and the frequency-weighted acceleration on the bus floor. SEAT value below 1 (or 100%) implies that the seat is attenuating vibration. The measurement duration may cover the entire working day, but from a previous adequate exposure analysis, this period can be minimized.

The calculation of daily exposure to whole-body vibration is based on the measurements results. According to the directions of vibration propagation, the daily exposure is calculated by the equation:

$$A_j(8) = k \times a_{w,j} \times \sqrt{\frac{T_{exp}}{T_o}} \quad (1)$$

where $A_j(8)$ is daily exposure in direction x, y or z, k is multiplying factor (for x-axis and y-axis: $k = 1.4$; for z-axis: $k = 1.0$), $a_{w,j}$ is frequency-weighted r.m.s. accelerations by axe x, y or z, T_{exp} is daily duration of exposure and T_0 is reference duration of eight hours.

When partial observation is made in the measurement against different conditions having different contribution to vibration exposure (e.g. different road type) during working hours, it is possible to determine partial daily vibration exposure $A_{x,i}(8)$, $A_{y,i}(8)$, $A_{z,i}(8)$ for each i task:

$$A_{j,i}(8) = k \times a_{w,j,i} \times \sqrt{\frac{T_{exp,i}}{T_o}} \quad (2)$$

where $a_{w,j,i}$ is frequency-weighted r.m.s. accelerations by axe x, y or z, $T_{exp,i}$ is daily duration of exposure for task i and T_0 is reference duration of eight hours. The multiplying factors are equal as in the equatation (1). Total vibration exposure by single axe j for tasks i to N is:

$$A_j(8) = \sqrt{A_{j,1}^2(8) + A_{j,2}^2(8) + \cdots + A_{j,N}^2} \quad (3)$$

Finally, daily whole-body vibration for bus operater is the highest value of daily exposures by each direction:

$$A(8) = \max\{A_x(8), A_y(8), A_z(8)\} \quad (4)$$

Vibration dose value (VDV) is a cumulative dose, based on the fourth root of the fourth power of the acceleration signal. VDV determination method is more sensitive to peaks than previously described A(8) method. It's value depends on measurement time:

$$VDV = \left\{ \int_0^T [a_w(t)]^4 dt \right\}^{1/4} \quad (5)$$

where $a_w(t)$ is instanteneous frequency-weighted acceleration, and T is duration of measurement. Sum of VDVs when there are i tasks (for example, task 1 driving on freeway, task 2 driving on city streets, etc. or some other criteria for tasks analyzes) is:

$$VDV_{total} = \sqrt[4]{\sum_i VDV_i^4} \quad (6)$$

The parameters described are necessary to evaluate the vibration exposure in accordance with the Directive 2002/44. For other additional daily exposure determination methods as well as vibration comfort evaluation see ISO 2631-1.

The International Standards Organization developed one more standard for the evaluation of WBV exposure and it offers a method for the evaluation of vibration containing multiple shocks (ISO 2631-5: 2018). New parameters are the daily compressive dose of the lumbar spine and risk factor. As Bovenzi states, "the derived metrics for the risk assessment of the lumbar spine are expressed in terms of daily compressive dose S_{ed} (MPa) and risk factor R (non-dimensional units) calculated from the static gravitational force acting on the vertebral endplates , the vibration related peaks of the

dynamic compressive vertebral forces, and other factors such as the individual characteristics (age, body mass, body mass index, the size of the bony vertebral endplates), the duration of vibration exposures and the postures of the drivers [16]. " These parameters take into account the cumulative exposure of WBV and its effect on the lumbar spine and allow estimation of the probability of low back disorders [16,17]. Frequent and intense multiple shocks are unlikely to be expected under normal bus driver working conditions. Previous studies on bus drivers WBV exposure therefore largely did not take into account these parameters, i.e. methods of determining them. Nevertheless, Lewis and Johnson [5] suggest that for a more comprehensive understanding of the vibration exposure of bus drivers, the methods of both ISO standards, 2631-1 and 2631-5, should be used.

MANAGING RISKS OF BUS DRIVERS WBV EXPOSURE

Considering all the limitations and specifics when it comes to the exposure of bus drivers, risk management methods should necessarily include the choice of seats that effectively reduce whole-body vibration, vehicle maintenance programs, providing relevant information and training for drivers, appropriate organization of work with the necessary rest time as well as health surveillance. Although limiting exposure time is one of the most effective measures when it comes to vibration exposure, its applicability in the workplace in question is difficult in practice. Of course, this measure would be necessary if exposure exceeded ELV, but no such cases were expected.

Adequate choice of seats is affected by vehicle suspension, road type [2], noting that poor maintenance and years of operation can reduce the degree of seat attenuation. The bus driver seats also have the primary function of supporting the occupant in a comfortable seated posture [4], which must be taken into account when selecting a seat, which should be adjustable. Drivers' awareness of the risks should be accompanied by appropriate training, which would primarily indicate ergonomic principles for reducing the risk of musculoskeletal disorders.

By Directive 2002/44 provisions all bus drivers found to have a daily WBV exposure level greater than EAV, must undergo medical examinations, which should be specific to the possible degenerative changes that are caused or contributed by WBV. When hiring new workers, particular attention should be paid to their possible exposure to WBV in an earlier period and/or the existence of another risk factor for low back disorders [16]. Periodic medical examinations are desirable, regardless of the intensity of the exposure, especially bearing in mind that bus drivers are at risk of musculoskeletal disorders due to the full range of factors, primarily the non-ergonomic position of the body.

CONCLUSION

Whole-body vibration which drivers in all forms of bus transport are exposed to require attention. Epidemiological studies imply that there is a wide range of adverse health effects, which development can occur due to WBV exposure. The possible development of musculoskeletal disorders is the most important aspect when it comes to preserving the health of the driver, but it is not the only topic that matters.

Achieving oscillatory comfort gives drivers the opportunity to reach full work productivity, with slow development of fatigue and concentration over long driving hours. For bus companies, it is vital not only the comfort of the drivers, but also of the users i.e. the passengers.

Previous studies has evolved in two basic, interconnected, directions. One is related to epidemiological studies that attempt to establish a dose-response relationship, i.e. the health outcome produced by whole-body vibration exposure. Another direction is finding the best technical, organizational and other ways for prevention and control of whole-body exposure risk.

The prospect of future research could move toward modeling the prediction of WBV bus driver exposure, based on a multi-criteria evaluation of the impact attributes of WBV exposure. In this way, bus companies could more easily manage vibration exposure through the selection of the most effective risk control methods. Certainly, like any other model, it would be necessary to perform the verification and possible modifications before the final application. The main activities are the establishment of the model, its iterations and verification supported by vibration measurements and evaluation in accordance with the international standards.

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PRELIMINARY COMMUNICATIONS

Problem of Organized Transport for Employees with Physical Disabilities in the Republic of Serbia

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Abstract: Protection of the rights of persons with disabilities is one of the most delicate elements of socio-development, economic and above all social policy, which aims to remove negative consequences, both on the quality of life and work of these people, and members of their families. One of the key problems facing persons with disabilities in the Republic of Serbia is a (non)organized transportation. Therefore, it becomes more difficult to ignore members of this population while using the public transport capacities and the problems they face at the opportunity. The main goal of this paper is to point to the legal barriers that are present in the national legislation of the Republic of Serbia, which affects the long-lasting maintenance of this population's high unemployment rate. The results of the research indicate a very small number of vehicles that are given to the use of people with disabilities in the Republic of Serbia, of which 1/3 owns the mechanical ramp, and 2/3 hydraulic ramp. Finally, the paper zoned the map of the Republic of Serbia, in order to indicate through the graphical representation of the (non)existence of transportation in certain parts of our country to persons who are immobile in the lower extremities.

Keywords: (non)organized transport, zoning map of RS, unemployment rate.

INTRODUCTION

Disability is a complex social phenomenon that practically strands in all areas of modern life and requires multisector access and cooperation of various authorities, local self-governments, civil sector and persons with disabilities and their Organization [2]. The existence of disability has always withdrawn and elevated the risk that persons with disabilities (PWDs) and their family members to face some form of social isolation. The described situation leaves many of negative consequences on family members who provide long-term care for people with disabilities, especially if it prevents them from working, which increases the risk of coping with burn-out syndrome or material deprivation [3]. Convention number 159/83 *Vocational Rehabilitation and Employment (Disabled Persons)* restates the idea that persons with disabilities should be fully integrated into the world of labor and society, without loss of fignity [1].

The estimated number of PWDs in the Republic of Serbia is about 700,000, of which between 215,000 and 300,000 is a category of potentially working engagement population aged 15 to 65 years [4]. Research made on the topic of determining the cause of the high unemployment rate PWDs in the Republic of Serbia, shows that people with phisical disabilities as the largest employment barrier see the problem of accessibility for the facilities [3]. Inefficiency in access to facilities, both because of architectural deficiencies, and due to the lack of specialized transport for the PWDs, has led to a failure to fulfil the basic requirements for members of this population and to prevent many immovable persons from move. According to Henry, T. (2009), inaccessibility to the built phisical environment is one of the significant barriers to the full participation of persons with phisical disabilities in the society [5]. Therefore, the intention of the study was conducted in this paper to point to the current situation and the representation of the organized transportation to person with phisical disabilities in the Republic of Serbia.

Also, the goal of the research is to show the impact of the momente law of the legislation on the accessibility of persons with bodily disabilities to and from jobs. The following tasks are set with this:

- Identifying entities that possess specialized vehicle for transportation of PWDs;
- Identifying the entities that possess these vehicles for the purposes of transport of the PWDs to and from work;
- Determining the purpose of these vehicles, i.e. priorities in use;
- Determine how access to these vehicles in accessed by an PWDs.

LEGISLATION IN SERBIA

The position of persons with disabilities in the Republic of Serbia is regulated by a many of legal and sub-legal acts, and such provisions relating to the rights of persons with disabilities meet in all important laws adopted by the National Assembly. Almost every legal act in at least one of it's member talks about a persons disabilities right. In addition to the positive regulations adopted by the National Assembly, the position of persons with disabilities is regulated by the international conventions ratified by the Republic of Serbia, which became part of the internal law of internal positive regulations and as such can be immediately apply. The most important document of International public Law is the *Convention on the Rights of Persons with disabilities*, as the first instrument on human rights adopted by the UN in the new millennium. From regional and european documents, it's particularly significant to the revised *European Social Charter*, which guarantees to persons with disabilities the right to independence, social integration and community involvement [2].

Although the position of persons with disabilities in the Republic of Serbia is through in many of normative acts, of which the most important *Law on professional rehabilitation and employment of persons with disabilities*, the research shows that the number of employed persons who have disability, including and persons with phisical disabilities, has not increased significantly after ten years since the application of the aforementioned law. There are a number of causes that highlight this problem, and an increase in the unemployment rate of PWDs. Some of the most important problems facing the PWDs are architectural barriers and the organized transport. Architectural barriers in the Republic of Serbia were recognized two decades ago, when it was created and legal grounds for its resolution, which resulted in the adoption of the *Law on Planning and Construction*, 2009. year. This Act defines that all objects must be designed, constructed and maintained so that all users, especially persons with phisical disabilities, provide a access, movement, stay, or use of the [6]. Also, the organised transportation has not yet found its place in the Republic of Serbia legislation, but it has been left as a free choice and goodwill by units of local governments, city administrations, municipalities, associations, etc. The lack of organised transport for persons with phisical disabilities, which would function by the ,,door to door'' principle, combined with architectural barriers (inadequate access to the building, lack of platforms, elevators, etc.), makes it much harder access to a number of organizations in which potentially these people could base a working relationship, inevitably affecting their unemployment.

According to United Nations (2007), accessibility is about giving equal access to everyone and without being able to access the facilities and services, person with phisical disabilities will never be fully included into social flows [7]. In this regard, these people must first be allowed access to the facilities, which would achieve a lower unemployment rate for members of this population. Numerous regulations concerning the position of the PWDs cannot be fully applied precisely due to the aforementioned barriers.

LITERATURE REVIEW

There are many definitions that determine the meaning of "*people with disabilities*" in the same ways. One of the more approximate definitions that corresponds to the work subject is provided by Oregon Department of Transportation which defines people with disability as ,,individuals of all ages who are unable to transport themselves without special equipment or outside assistance due to a phisical impairment'' [8].

Griffin, K. W. (2004) further added that the simplest way of increasing the use of public transportation facilities is to establish an environment where pedestrian access is safe, convenient, and comfortable [9]. Habert and Blank (1992) reported that there is increasing awareness, particularly in the developed and industrialized countries, pertaining to the disabled, but that the present provisions are inadequate and not disabled friendly. [10]. Kennedy, M. K. and B. Hesla (2008) too, supported attitude that people with disabilities have not been treated as equals like other citizens. They pointed that, the disabled is a unique category of people, and have a limitation in accessibility in use of built environment needs further attention in a society as compared to a normal people. [11].

Zajac A. (2016) also considered that in the recent years more attention has been paid to accessibility of public transport and space. This growing interest is also visible in The European Union transport policy, aiming at securing rights of passengers with reduced mobility [12]. The European Conference of Ministers of Transport announced in 2006. *,,Guide to good practice – Improving Transport Accessibility for All''*, which insists that the national and local government should have a responsibility for the development of affordable transport and infrastructure. In this regard, national government is responsible for national laws and regulations defining access in the environment [13].

In the study, which was conducted 2017. in regard with to the position of the person with disabilities in Republic of Serbia, the recognized obstacles to employment of PWDs are presented (Figure 1) [4].

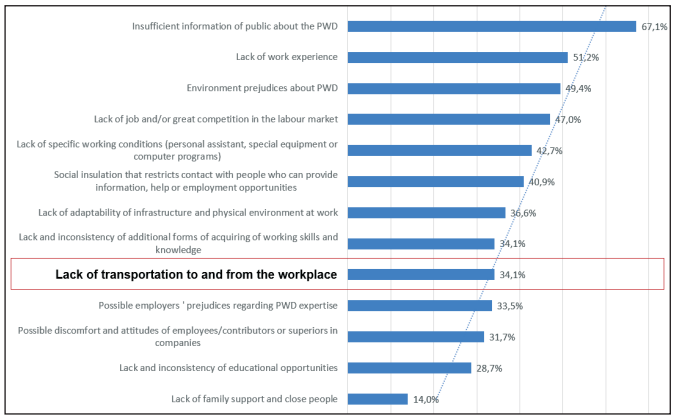

Figure 1. Total recognized obstacles to employment of PWDs (N=164)

This results suggest that one third of the PWDs recognizes as a lack of unaccessibility of the workplace, where is among other things and the lack of transportation to and from the workplace (34.1%). This data have the weight of meaning if in considering that the research is covered by persons with different disability forms (persons disrupated in intellectual development, blind and visually impaired persons, hearing impaired persons, etd.), and not just persons with phisical disabilities.

Figure 2 present the latest research of Dimitrijevic (2016), performed in the Republic of Serbia, on the topic of social integration of the PWDs and the problem of hiring members of this population, which also indicates problems of accessibility and lack of service specialized transport. This research included 117 people with some kind of disabilities of upper and/or lower extremities, where 39 people use a wheelchair (manual or electric motor) [3].

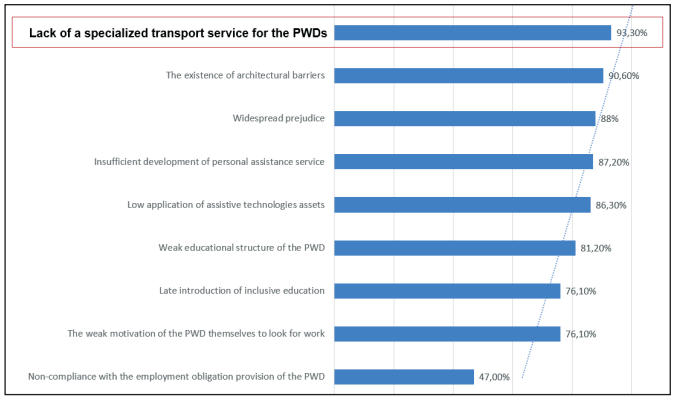

Figure 2. Respondents ' opinions on the most significant obstacles regarding hiring persons with phisical disabilities (N=117)

Based on the entire state of the described situation, it is inevitable that the person with phisical disabilities, especially those who use the wheelchair, enables adequate access to work. In this regard, Korsu i Wenglenski (2010) belive that low access to jobs is related to increased risks of unemployment, especially in low-income areas. [14].

METHODOLOGY

The research was conducted through the collection of data on the existence of specialized vehicles for persons with phisical disabilities in the Republic of Serbia and refers to the transport that works by the principle ,,door to door''. The main objective was to determine the existence of this type of transportation that is free for users and do not constitute an additional cost to PWDs, while commercially transport of PWDs was not part of the research.

The main data sources, used in this study, were collected from the City Administration, Municipalities and various Associations that bring together persons with disabilities throughout the Republic of Serbia. Data processing and analysis were done using a online software ,,ColorMaps'', which made zoning map of the Republic of Serbia on the existence of specialized transportation for persons with phisical disabilities.

RESULTS AND DISCUSSION

The development of a specialized transport service for persons with phisical disabilities based on the universal principles of the design is an important task, primarily for the members of this population, but also for that State, especially with regard to the employment. According to research by Dimitrijevic's (2016), persons with phisical disabilities have no motive to look for job, because of the architectural barriers, and because of the lack of transportation that would work ,,to and from the workplace''. For these reasons, the largest number of unemployed members of this population is relying on information they receive from the representatives of the National Employment Service, through relatives, friends or acquaintances. [3].

Analysis of data on possession and provision serices of specialized transport for persons with phisical disabilities, collected from different state administrations and associations, it depicted in table 1 below.

Table. 1. Total number of specialized transportation for PWD's in Republic of Serbia and way of access to vehicles

Subjects	Total number of vehicles	Percentage	Mechanical Ramp	Hydraulic Ramp
City administration	9	21,95%	0	9
Municipalities	5	12,20%	2	3
PWD's Associations	8	19,51%	3	5
Organization	19	46,34%	9	10
TOTAL	**41**	**100%**	**14**	**27**

The described results shown in the table indicates a very small number of vehicles on the territory of the Republic of Serbia, which are intended for free transport to person with disabilities. These are emphasized the insurmountable barriers to members of this population, which is why it is difficult to expect that the unemployment rate of persons with phisical disabilities can be reduced without minimum initial conditions for their daily functioning. The positive side of the data shown in the table is the fact that 2/3 vehicles possess a hydraulic ramp, intended for entering and exiting persons with phisical disabilities, which reduces the phisical effort of these persons, but also their assistants.

In addition, the research also enables determining the various priorities of using these vehicles, which differ from the subject to the subject that provides the transport service to the PWDs. Some of the recognized priorities fefer to the:

- Transport PWDs to hospital, treatment, rehabilitation;
- Transport PWDs to school and back;
- Transport PWDs to various competitions, excursions, manifestations, etc.;
- Transport PWDs to various educations etc.;
- Transportation for children, youth and adults of impeded development;
- Transport PWDs to work and back.

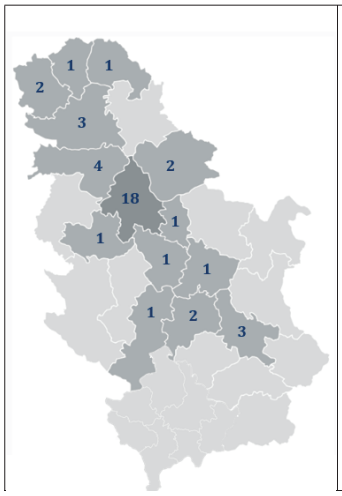

Figure 3. Zoned map of RS and identified number of vehicles per districts for transport PWDs without priority

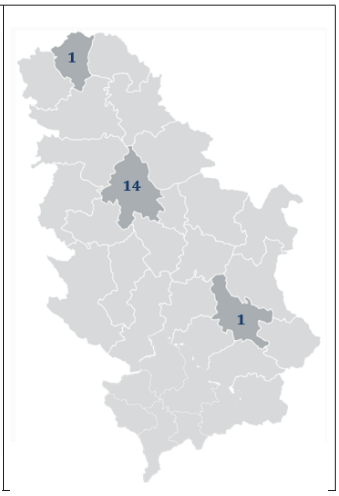

Figure 4. Zoned map of RS and identified number of vehicles per districts for transport PWDs to and from the workplace

From the described can be seen that great attention is given to transportation, primarily a persons with phisical disabilities to examinations, rehabilitation, different manifestations and various excursions. The research showed that there is almost no subject on the territory of the Republic of Serbia, which for the use of its specialized vehicle as priority sets the transport of PWDs to and from the workplace. This fact clearly points to the necessary assistance of the State, in order to provide equal labour rights for PWDs, as to citizens without phisical disability.

Also, this study zoned the map of the Republic of Serbia, according to two separate criteria. On the first map, figure 3, it was done zoning of all identified specialized vehicles, intended for free transportation of the PWDs, regradless of the priorities set. On the other map, figure 4, it was done the zoning of the map of all identified specialized vehicles, intended for free transportation of the PWDs where, among other things, the possibility of transportation to and from the workplace is a priority.

This study indicates a problem of availability of job opportunities for users of the wheelchair in the Republic of Serbia, indicating the need for interventions to increase and facilitate access to persons with phisical disabilities to objects of organizations, using specialized transport.

Richard K., Scotch i Charles E. McConnel (2017) indicate that accelerated technological changes, including automation and increasingly sophisticated infrastructure that used by computers and telecommunications, are very changing the nature of the work that requires less phisical effort, but higher levels of education and improvements flexibility in task performance [15]. So, persons with phisical disabilities are in the category of people who are worth investing in and who, with proper and necessary education and training, they can provide answers to all requirements that modern society and technology dictate.

CONCLUSION

The problem of Accesibility to objects for PWDs should be treated as a multidimensional phenomenon. In basic terms, accessibility can be ensured by appropriate specialized vehicles, with universal ergonomic design, customized for users with phisical disabilities. By introducing these vehicles, the state would show the care of belonging to PWDs society, which would achieve one of the most basic international human rights, in accordance with the *Universal Declaration of Human Rights*, which is that all persons are treate equally with equal conditions of work. From another aspect, the development of transportation service for PWDs to and from the workplace, with appropriate legal support, it would inevitably affect of reducing the unemployment rate of members of this population, which is of interest to each country.

The research shown in the paper was aimed at providing to facts at one of the problems that persons with phisical disabilities face off in the Republic of Serbia. The study identified the gap between efforts of the state to ensure a lower unemployment rate of PWDs and real problems of this PWDs face when looking for job.

The main contribution of this research is to encourage a better relationship between members of the general population according to persons with phisical disabili-

ties, as their equalization from an aspect of achieving the right to work and working conditions.

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PRELIMINARY COMMUNICATIONS

Improvement of the Traffic Safety in the Local Community by Upgrading of the Planning Documentation Through the Annex of the Law on Planning and Construction

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Abstract: By reviewing The Act on planning and construction we can make a note that traffic as well as the safety does not have the appropriate place in the same act. Being unjustifiably disregarded in comparison to the other areas, traffic and its safety were respectively not given the clear definitions by this frame act as well. On the other hand, the existing legal regulations that directly define the area of traffic: The Act on traffic safety on the roads and the Act on Roads do not likewise provide clear definitions , conditions and the way of making planning documentation predominately. This condition allows and brings to the following: making of the bad planning and technical documentation respectively, surpassing of traffication engineers in the process of making planning and technical documentation, difficulties in the work of the local community units which eventually bring to the degradation of the traffic science resulting in the decrease of the traffic safety in the local community unit. In order to execute the systematic solution to the problem as well as the establishing the traffic science to the appropriate, leading position in the mission of the traffic development of the local community unit it is necessary to clearly define the way of making and implementation of the planning and technical documentation with the obligation of engagement of traffic engineers. After all the necessary actions being taken together with the agreement with the Ministry in charge it is necessary to make an annex to the Act on planning and construction in the purpose of enhancing the safety of the traffic. This way of solving this problem is the only right way for traffic and its safety to be placed to the belonging position in The Act on planning and construction and the way for the local community units to get the appropriate and usable planning and technical documentation.

Key words: traffic, traffic safety, documentation improvement, roads.

INTRODUCTION

The aim of any local community and the significant institutions in charge with the area of traffic should by all means be the maintenance of the satisfactory level of the traffic safety as well as the constant work on and investment in the existing traffic safety.

Reaching of the set goal can be achieved in a quality manner by solving the elementary problems first. They represent the making of the according and quality legal regulations in all the areas that are directly or indirectly connected to the traffic safety and appropriate conduction of the above mentioned.

By working in the area of space planning, urbanism and construction as well as the traffic in the frames of the legal regulations of The Republic of Serbia, I have noticed numerous problems connected to their conduction and implementation in the everyday practice.

Regarding the large amount of the noticed problems it is impossible to dedicate them the equal amount of time in this paperwork; therefore for the purpose of this paperwork I have chosen single problems that have the equal importance in many areas.

This work gives the short survey of the acts that directly or indirectly influence the traffic safety are in the scope of its jurisdictions; a comparative presentation and analysis of the legal regulations were done; certain examples from the practice were given with given guidelines for the solution of the recognized problems finally.

The problems of technical documentation is important as well as from the point of view of the urban planning and projection but also from the point of view of construction of objects and the area of the traffic projection. By all means there is a huge dependence between the mentioned areas and the most significant problem that is necessary to be solved is the safety of the traffic.

The disadvantages of the technical documentation are seen in the sense of its content, type and the scope of quality and the skilled workers who deal with it, making, controlling and conducting it.

METHODOLGY OF THE WORK

In order to be able to give the retrospective of the afore mentioned problems and to reach to the right conclusions it is necessary to make the analysis of the existing state of the planning and technical documentation, as well as the analyses of the local community units and traffic safety.

For the purpose of this work the following has been conducted:

- Retrospective and the analysis of the legal un sub-legal regulations
- Retrospective of the state and the analysis of the planning and the project documentation within the local community units
- Analysis and the retrospective presentation of the state of the traffic safety in the local community units, as well as the
- Comparative analysis of the state of the planning documentation as well as the state of the traffic safety.

Retrospective and the analysis of the legal and sub-legal regulations

In the frame of the analysis of the legal and sub-legal regulations for the purposes of this work the adequate articles of the legal and sub-legal documents of The Republic of Serbia are included:

- The Law on planning and construction
- The Law on Roads
- The Law on traffic safety on roads
- The book of regulations on traffic signalization

The Law on planning and construction

The Law on planning and construction is defined in the way that its basic role is definition of conditions and manners of a urban space arrangement, arrangement and usage of a plot and construction of the object; surveillance over the implementation of the articles of this act as well as the inspection surveillance; as well as the other significant questions important for the urban space arrangement and the exploitation of the plot and construction of the objects.

Through the principles of the arrangement and usage of the space it has been defined that the planning, arrangement and usage of the space is based on the principles of: sustainable development through integral approach in planning; equal territorial development; rational exploitation of the site by subvention of urban and rural restoration and reconstruction measures; rational and sustainable usage of the non-renewable resources and optimal usage of the renewable resources; protection and sustainable usage of the natural wealth and immobile cultural wealth; prevention of the technical-technology accidents; protection from fire and explosions, protection from the natural accidents, removal of the climatic changes causes; planning and arrangement of the space for the needs of country's defense; adjustments to the European regulations and standards in the area of planning and space arrangement; improvement and usage of the information technologies that contribute to the better efficiency and economy of the public management work at the construction affairs; public participation; preservation of the cultural heritage and tradition; preservation of the specificity of the area; horizontal and vertical coordination.

The Law also defined documents of space and urban planning which are: planning documents, conduction of the aerial planning documents; urban-technical documents, Strategy of the sustainable urban development of The Republic of Serbia, and National architectural strategy.

In the part of planning documents The Law on planning and construction recognizes the aerial and urban plans such as:

- The Regulation plan of the Republic of Serbia
- Regional aerial plan
- Aerial plan of the local municipality unit
- Aerial plan of the special purpose area

While the urban plans are:

- General urban plan
- General Regulation plan (GRP)
- Detailed regulation plan (DRP)

According to the Law, the GPRs and DRPs elaborate the traffic conception from the planning documentation of the higher rank through the more detailed representation and description of the solution with the defined regulations of construction and arrangement. By the rules within plans it has been defined that besides regulations on construction of the objects, the arrangement rules and demarcation of the public urban areas through pre-plotting and plotting to determine corridors and capacities of the traffic infrastructure.

This Law also defines the content and the type of technical documentation such as:

- Technical documentation is the set of projects that are made in the purpose of: establishing the concept of the object, elaboration of the conditions, the manner of objects construction and for the needs of objects maintenance.
- Technical documentation contains measures providing that the object in the whole, or in its every single part is to be appropriate for the specified purpose and also, that in the economically acceptable time of usage satisfies the following basic demands: capacity and stability; fire protection; hygiene; health and the environ-

ment; safety and acceptability in usage; noise protection, economical usage of the energy and heat conservation and sustainable usage of the resources.

- Types of the technical documentation are: general project (GP), preliminary solution (PS), preliminary project (PP), construction permit project (CPP), conduction project (CP) and the project of the made object (PMO).
- As the part of this Law another important document has been defined, and these are location conditions which by definition are granted on the basis of: insight to the planning document, or separate, or by the side of the proprietors of the public authorities.

Analysis of the Law on planning and construction

As it can be noticed from the quotation of the principle of the Law on planning and construction in the area of traffic and traffic safety it is not given to the importance as in the case of the area of the preservation of the immobile cultural wealth, protection of the environment, fire protection etc. even though those areas have also been defined by the special acts as well as the safety in traffic.

If we go into the further analysis of the planning and project documents, as well as of the technical documentation of the lower rank we can also see that traffic and its safety is mentioned nowhere.

For the making of the planning documents there is no condition of obligation in participation of the traffic engineer. Also, making of the planning documents and the remaining technical documentation is not conditioned by the making of the necessary analyses, studies and strategies in the area of traffic.

When issuing the conditions for the construction permits and making of the planning and project documentation the local municipality unit guides itself on the basis of the Law on planning and construction and issues all the condition permits based on the planning document or based on the conditions of the Controller of the road. In this case, the Controller of the road mainly does not possess the planning document, and in the case it possess it, it is inadequate from the point of view of the traffic, meaning the Controller of the Road is forced to regulate its own traffic area conditions according to the Law on Roads and the Law on safety of the traffic on the roads.

The Law on roads

The Law on Roads gives clear definitions such as:

- The Controller of the road is trusted with the execution of the public authorizations that are related to: issuing the condition permits for the making of the technical documentation for the construction and reconstruction of the traffic connections, setting up the linear and infrastructural object, issuing the approval for maintenance of the sport and other exhibitions of the road, emergency traffic permits, issuing approval for redirecting of the traffic to the public road in case of making construction, reconstruction work, maintenance and protection of the public road.
- Traffic-technical conditions contain: mark and number of the main road; name or number of the section of the public road; starting and ending stationary of the section of the public road traffic-technical conditions are issued for; general terms, special conditions, cadaster sections of the part of the public road the traffic-technical condition permits are issued for.
- Planning, projection and construction of the public roads is made in the manner that planning and technical solutions are adjusted to the latest know-how of the projection and construction of the public roads to the demands of the traffic safety, demographic and economic principles and standards for the justifiable assessment of their construction, regulations on environment protection and regulations that set up the agricultural fields.
- Within regular maintaining of public roads of the controller of the road it is necessary to make the traffic project that contains the instruments of the security of the working zones at the regular maintenance of the public road; in the case of rehabilitation of the public road the controller of the public road needs to file for a demand for decision on technical regulation of the traffic that has a traffic project as the constituent part, and in the occasion of the urgent maintenance, the controller of the public road has the obligation to provide a traffic project that contains the instruments of securing the zones of the work on the urgent maintenance of the public road.
- The regime of traffic during the time of the construction work at the maintenance by definition is the constituent part of the solution of the traffic project if the work is done in the manner that the traffic on the public road is stopped.
- At the special conditions of the construction and reconstruction of public roads when constructing and reconstructing public roads it is defined that the construction and reconstruction of public road is performed in the accordance to the Law that arranges planning and construction in the accordance to the Law on roads.

Analysis of the Law on roads

From the above mentioned it can be seen that the Law on Roads, as well as the Law on planning and con-

struction do not define the type of the technical documentation but state the need for the making of the traffic project and calls themselves upon the Law on planning and construction where it is stated that construction and reconstruction is performed in the accordance to the Law that sets the planning and construction and in the accordance to the Law on Roads.

The Law on roads traffic safety

The Law on road traffic safety states that:

- Enterprises, some other legal entity, or an entrepreneur that projects, constructs, reconstructs, maintain and control roads has the obligation to perform so in a manner that provides safe flow of the traffic
- Sports and other exhibitions on the road can be performed when the territorial organizational unit of The Ministry of Internal Affairs in charge issues a permit for the same exhibitions, and in the case the exhibition is taking place on the territory that has two or more organizational units in charge, the permit is issued by the Ministry of Internal Affairs.
- The surveillance over the traffic on roads, the direct control over the participants and vehicles in the traffic, the control over the suspense traffic signalization at the site of the work or where the occurring road embarkments that jeopardize the continual and safe traffic in the manner of respect of this Law and regulations that are brought based on it, is by rule done by The Ministry of Internal Affairs.
- Technical regulation of the traffic includes all the measures and actions that set the regime of the traffic in regular conditions and in the conditions of the work on roads, specifically redirecting and conducting of the traffic in regular conditions and in the conditions on the work on roads, and specifically directing and conducting of the traffic , conducting of velocities in the function of density of the traffic continuity, speed limit in the function of the state of the road and weather conditions, determination of the one-way roads and streets, determination of the roads and streets where the traffic is not allowed or it is allowed to the certain type of vehicles, speed limits to the all or certain categories of vehicles, determination of the space for parking and stopping of the vehicles, supply, directing and redirecting of the beneficiaries, determination of the safe and efficient way of traffic regulation at crossroads, bus stop locations, allowed axis loads for the protection of the environment and similar.
- Traffic-technical measures in settlements set the regime of traffic in the regular conditions and during the work on roads and especially in directing transit, traffic, bicycle, and pedestrian traffic, setting up roads and streets specified for the public transport of passengers, the manner of usage traffic lanes for the public transport vehicles, speed limit for all or certain categories of vehicles, determination of one-way streets, pedestrian zones, zones of the slow traffic, "30" zones, zones of schools, environment protection zones, determination of the safe and efficient way of traffic regulation at crossroads, determination of the parking and stopping space, supply, directing and redirecting of the beneficiaries and similar.
- For the conduction of the set regime of traffic the traffic a project must be made and traffic signalization must be put on the road according to the project.

Analysis of the Law on roads traffic safety

The Law on Road Traffic Safety –ARTS as the founding law that gives the best definition of traffic safety in fact defines that all the actions that are connected to the projecting, construction, reconstruction, and maintenance and controlling of roads of traffic are performed in the manner of safe providing of the continuity of the traffic. From that matter, ARTS has provided a good definition that conditions traffic safety at first place.

On the other hand, neither ARTS, nor other laws contain clear definitions of both planning and technical documents in the area of traffic thus having non-existing accordance to the remaining technical documentation, nor do they provide the manner of conduct and implementation.

I would like to give a special review on a term Technical regulation of traffic that has no clear definition. Technical regulation of traffic by existing definition can be a planning document, but can also be a type of technical-project documentation and therefore in the practice one can come across the terms of Technical traffic regulation plan, Technical regulation of traffic project and Technical regulation of traffic.

By Law the Ministry of Internal Affairs (MIA) was given the obligation of issuing a permit for performing sports and other exhibitions on the road as well as controlling the temporary traffic signalization. The manner of solving this problem can certainly not give the maximum results because the MIA would certainly need to have additional capacities.

The Rule book on traffic signalization

The Rule book on traffic signalization states that:

- Traffic signalization is set and marked on the road based on the traffic project in the accordance to the regulations of the Rule book and regulations that set the area of traffic

- Traffic project is a project of traffic and traffic signalization in the accordance to the regulations set by technical documentation
- Traffic project contains: the front page, the content of the project documentation, the general documentation in the accordance to the regulations; project task verified by the seal and signature of the investor; technical report; bill of quantities and estimates of traffic signalization for the appropriate level of making and setting the traffic signalization, for the appropriate level of making it in the accordance to the regulations set by the technical documentation, the appendix on work and environment protection related to the project for the appropriate level of making it in the accordance to the regulations set by the technical documentation, graphic part of the project and details of the traffic signalization.

Analysis of the Rule book on traffic signalization

The Rule Book on traffic signalization is the only sub-legal document in the area of traffic that defines the term and the content of the traffic project.

The deficiency with this definition of the traffic project is that it only quotes that it is "a project of traffic and traffic signalization in the accordance to the regulations set by the technical documentation" which represents the only, and in the practice, bad connection to The Law on planning and construction.

1. State and the analyses of the planning and project documentation at the Local municipalities units

Project documentation

Based on the accessible information of the local municipality units the survey has been conducted as well as the analysis of the part of the planning documentation at the sample of 152 municipalities at the territory of The Republic of Serbia where traffic engineers were engaged.

In order for comparative data to be analyzed and to retrospect easily the territory of The Republic of Serbia will be sorted according to Nomenclature of Territorial Units for Statistics 1(NUTS 1): Serbia-North (Vojvodina and Belgrade) and Serbia-South (Sumadija and Western Serbia, Southern and Eastern Serbia, Kosovo and Metohia). The data from Kosovo and Metohia are not available and therefore were not included in the analysis.

At the observed sample at the territory of The Republic of Serbia (without Autonomous Province of Kosovo and Metohia) it has been established that out of the 152 observed municipalities 72 of them (47%) made the planning documentation without the engagement of the traffic engineers, while for the 18 municipalities (12%) the data were not available (Figure 1).

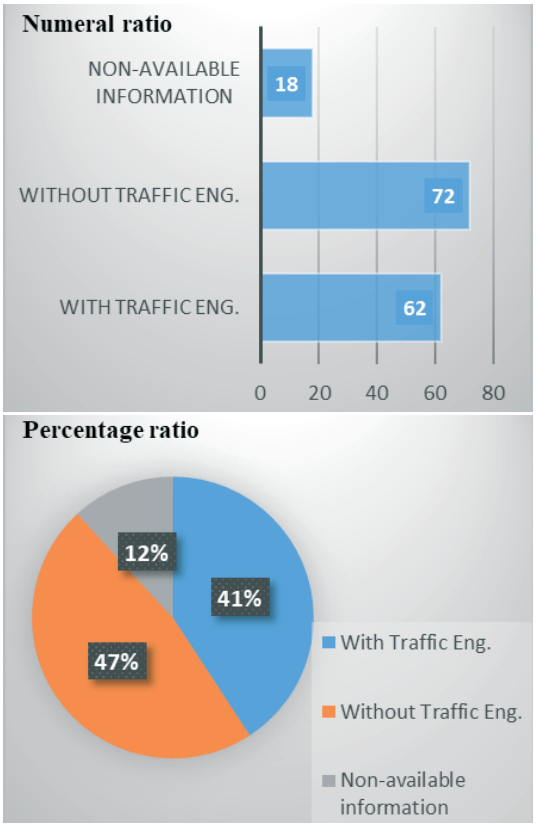

Figure 1. Presentation of the made planning documentation at the area of The Republic of Serbia

By further analysis of the received data it has been established that 45 municipalities is situated in the region of Serbia-North, while 107 municipalities is situated in the region of Serbia-South.

If we analyze the data from the region of Serbia-North we can see that 10 municipalities (22%) possess the adopted planning documentation where the traffic engineers were engaged, 31 municipalities (69%) possesses planning documentation where traffic engineer participated in the work, while 4 municipalities (9%) represent municipalities with no available data. (Figure 2)

The situation in the region Serbia-South is somewhat different. At the observed sample comprised of 107 municipalities, we can see that 62 municipalities (58%) possess the planning documentation that has been done without participation of a traffic engineer, 31 municipality (29%) possess planning documentation that has been done by engaging a traffic engineer, and 14 municipalities (9%) has no available information. (Figure 3)

Based on the analyzed data we can come to a conclusion that in the manner of made planning documentation the disadvantageous situation is in the region of Serbia-South because this region has the higher percentage of planning documentation that has been made without engaging of traffic engineers.

If we compare the data between the observed regions we can see that in the overall number of municipalities that have done the planning documentation with-

out engaging a traffic engineer (72 of them), the region of Serbia-North has only 10 municipalities, or 14%, while in the region of Serbia-South there are 62 municipalities, or 86% of the overall number. (Figure 4).

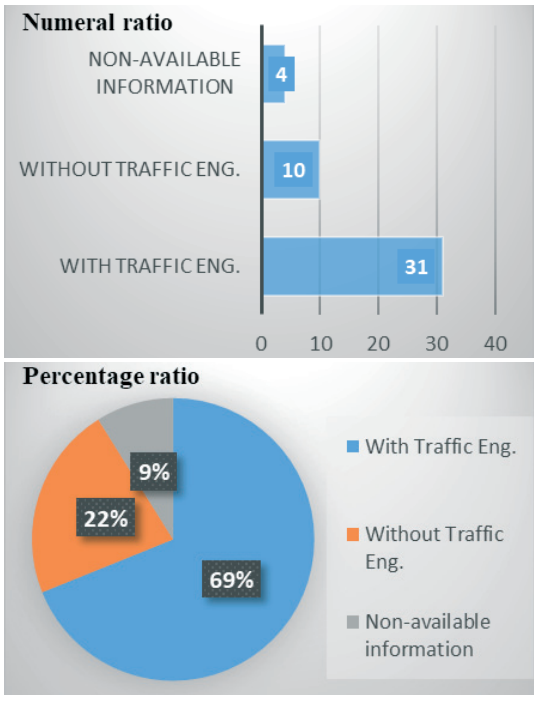

Figure 2. The representation of the made planning documentation at the region of Serbia-North

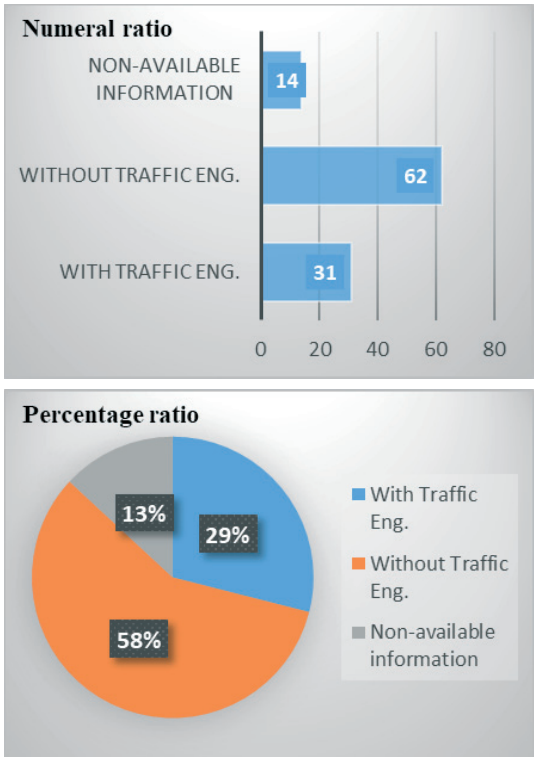

Figure 3. The representation of the made planning documentation at the region of Serbia-South (without Kosovo and Methia)

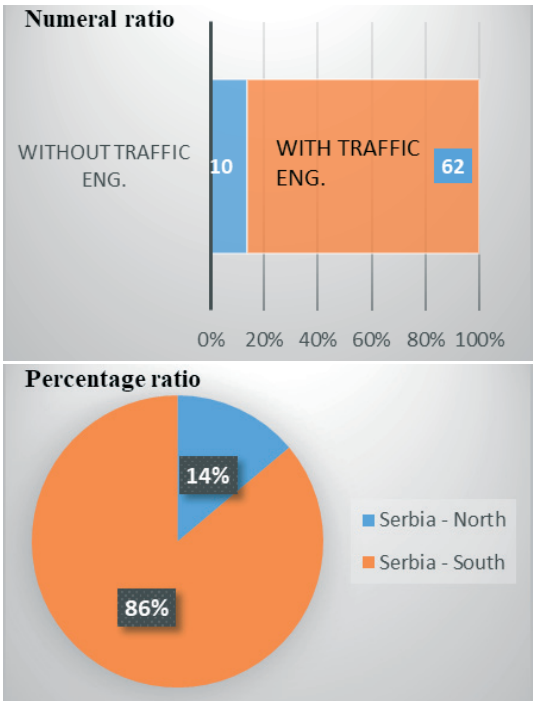

Figure 4. The representation of the ratio in the planning documentation without the participation of a traffic engineer between the region of Serbia-North and Serbia-South

All the received data should be taken with a amount of reservation because the analysis of the work did not include the overall planning documentation.

Planning documentation

Unlike the planning documentation, the project documentation is not publicly available so the analysis of the project documentation is not possible to conduct in this way, and the very approach to the analysis of the project documentation needs to be different, which surpasses the borderlines of this work.

2. Analysis and presentation of the state of safety at the local municipalities units

By analyzing the number of people killed in road accidents at local municipalities in The Republic of Serbia in the period of 2011-2015 observed by regions Serbia-North and Serbia-South without regarding the facts for Belgrade and Autonomous Province of Kosovo and Metohia, we can established that the number of dead people in the region of Serbia-North is 1324, while the number of killed in the Region of Serbia-South is 2900. The analysis has been done without the data from Autonomous province of Kosovo and Metohia because the previous analyses have been made without the data from that autonomous province, and the data for the city of Belgrade were not taken into the consideration because the city of Belgrade represents the whole for itself.

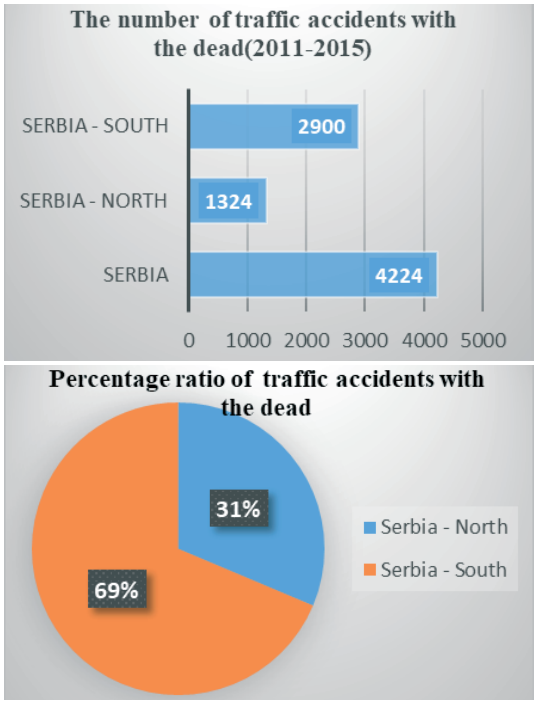

Figure 5. Presentation of the ratio of people killed in road accidents by regions of Serbia-North and Serbia-South for the period of 2011-2015

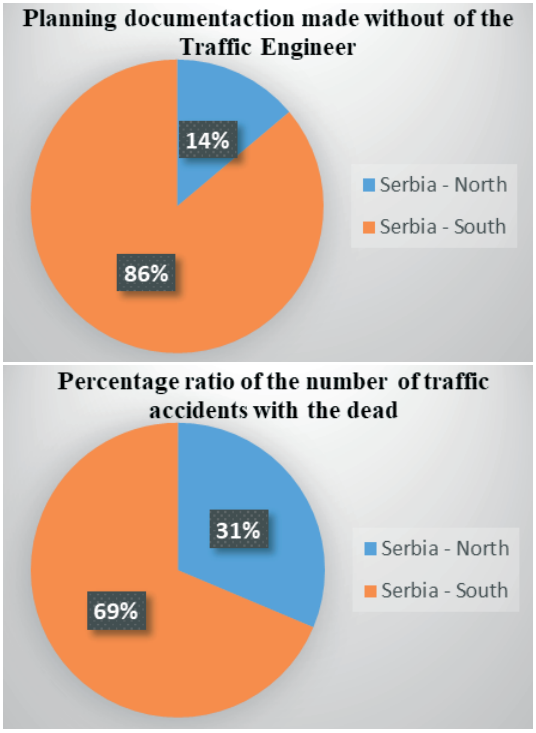

Figure 6. Comparative percentage presentation of the made planning documentation without engaging a traffic engineer in its making and the number of dead by regions Serbia-North and Serbia-South

By comparing these ratios we can see that the region of Serbia-North takes occupies 31% in this analysis, while the region of Serbia-South occupies 69% in the overall number of people killed in road accidents. (Figure 5)

3. Comparative analysis of planning documentation made without engaging traffic engineers and the state of traffic safety at local municipalities

If we comparably observe the received results of the planning documentation that has been made without traffic engineer (Figure 4) and results on the number of traffic accidents with the dead by regions (Figure 6) then we can see that the region of Serbia-North has the larger percentage of planning documentation that has been done by engaging of traffic engineers, and the lower number of traffic accidents, while the region of Serbia-South has the larger percentage of planning documentation that has been done without engaging of the traffic engineers and the larger number of accidents. (Figure 7)

Based on this data we can conclude that a connection can be set between traffic accidents (the number of dead) and the quality of making of the planning documentation which brings to the clear conclusion that the lower number of traffic accidents is accomplished by engaging traffication engineers in the process of planning and making the planning documentation.

CONCLUSION

By overall analysis of the previously mentioned we can conclude that:

- The Law on planning and construction as the ground law does not recognize the area of traffic sufficiently
- Strategy of the traffic safety is not included within the law
- There are no necessary and clear definitions about the obligation of engaging traffic engineers on the making and implementation of the planning and project documentation
- There is no obligation in engaging traffic engineers at the appropriate working positions

The consequences of this state most usually are:

- Not engaging the traffic education area and traffic engineers on making of the planning and technical documentation
- Making of the bad planning and technical education that from the aspect of traffic provides unrealistic solutions, economically unjustified, hardly conductive, and sometimes non-conductive
- Difficulty of implementation of the planning and technical documentation at the local municipalities units and usage of the existing documentation in an inadequate manner
- Slow economic development of local municipality units because of the spending of the financial assets on solving the same problems

- Bad condition of the traffic safety

If we observe the safety of the traffic and economic development at the country's level we can see that the attitudes are notably changed as well as relationships towards traffic infrastructure. The Republic of Serbia in the previous period invested and it is further investing the significant assets in the traffic infrastructure by building highways, reconstruction, building of the fast roads etc. which are all in the purpose of economic development and enlargement of the traffic safety. In order to continue the trend of the state politics we have to continue the projection of the traffic safety and economic development also at the local municipalities' level.

Enlargement of the traffic safety as well as the economic development at the local municipality units can be made by improvement of the planning and project documentation through the upgrading of the Law on planning and construction but also through other laws and sub-legal acts. This is necessary to be done because the planning represents the starting point of the traffic safety and only with the good planning many of the problems and accidents in traffic can be anticipated.

In order execute the adequate improvement of the planning and project documentation the skilled public needs to be engaged when making legal and sub-legal acts with the cooperation and support of the Ministry in charge.

Improvement of the planning and project documentation can be executed only by making of the necessary and clear definitions, by defining of the clear legal procedures and conditioning in the engagement of traffic engineers in making and conducting of the planning and project documentation in the frame of the appropriate laws and sub-legal acts.

The consequence of the improvement of the planning and project documentation should by all means be the larger number of traffic engineers engaged in the making and conduction of the planning and technical documentation which should bring to the making of the adequate and quality planning and project documentation, which should again have the consequence the improvement of traffic safety and economic development of the local community.

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PROFESSIONAL PAPER

Video Conferencing and its Application in Education

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Abstract: In many countries, the demand for jobs in the conventional education system far exceeds the available job offers. Under the right circumstances, open and distance learning systems have proven that they can provide quality education and training to many people at lower unit costs than conventional education systems. In remote or sparsely populated areas, it is not economically feasible to provide the full range of educational opportunities and vocational training through the conventional institutions. Video conferencing as a method of distance education enables learning and training to be delivered in a more efficient and economical way. Due to the rapid development of technology, the idea that a student is trained as a young person for the same life-long job is becoming less viable. Most people are likely to change the profession for at least two or three times throughout their careers. This paper provides some technologies and standards used in video conferencing. In addition, it outlines some basic types of video conferencing and equipment requirements.

Key words: e-learning, information technology, students, standards.

INTRODUCTION

Professional training is undergoing radical change. In the second half of the last century, according to [1], there were three main methods of vocational training: on-the-job training (essentially on-the-job training provided at the workplace); classroom teaching in the public sector or institutions (either as day or evening classes); and organized, internal training (seminars or courses). These three methods are primarily based on personal contact between the teacher and the student, and they are therefore time and place dependent. All three methods are also expensive for employers, especially if there are travel and accommodation costs, or if employees are far from regular work during training. Such methods are also inflexible from the perspective of students.

Concepts of open and distance learning provide the necessary flexibility for adults to continue their education or training even though they work and have families. Some governments and employers have emphasized the importance of lifelong learning and distance education for increased economic productivity. Businesses appreciate especially when employees continue to learn and improve. Individuals see the value of flexibility and access to learning without sacrificing time outside the home. Lastly, the rapid growth of knowledge in areas such as healthcare, technology and management requires from people working in these fields to continue learning in order to keep up with the new findings in the context of their work. E-learning and distance education are ideal methods of lifelong learning. A period of ten years is an eternity in the field of education. For example, in the first edition of the book [1] on technology and the concept of open and distance learning, there are no references to the *World Wide Web*. According to [2], from this time distance, it is difficult to believe that by 1996 there were no educational programs using the *Web*.

As reported in [3], there are three generations of distance learning. The first generation of distance learning was characterized by the predominant use of one technology and the lack of direct interaction between the student and the institution that provides education or awards certificates of successful completion of a particular course. Although educational television and radio were used in the first generation, the main form of first generation distance education was correspondence based on printed learning materials. Distance education of the second generation is characterized by access to multiple types of learning materials (printed material and broadcast), where learning materials are specifically designed for distance learning. Communication with students is mediated by a third party or a tutor, not by the original author of the learning material used in the teaching process. The third generation of distance education is based on two-way communication through media, such

as the Internet or video conferencing, which enables interaction between the teacher and the student using the distance learning system. And maybe more importantly, communication between students, either individually or as groups, is facilitated, but it takes place remotely. Third-generation technologies have led to a more even distribution of communication between students and teachers (as well as between students).

According to [4-5], third-generation systems are sometimes described as knowledge-based systems. Small, relatively autonomous teams manage the design, development, and delivery of a particular course.

According to [5], third-generation distance education is characterized by tailor-made courses, which are rapidly produced and require relatively small initial investment (although operating costs can be significant). Examples of third-generation distance education can often be found in conventional distance-learning universities (dual-mode institutions) and in some smaller training organizations.

According to [6], the main reason for the growth of third-generation distance education is the rapid expansion of the Internet, and especially of the *Web*. The *Web* is a special component of the Internet, which enables the creation of digital materials, then storing and accessing them, and ultimately communication through the Internet. The Internet also includes email, bulletin boards and digital video conferencing, separate or combined with the *Web*. The terms *e-learning* and *online learning* are often used interchangeably, although e-learning can encompass any form of telecommunications and computer-based learning, while online learning involves the use of the Internet and the *Web*. Figure 1 shows an overview of technology-based learning categories.

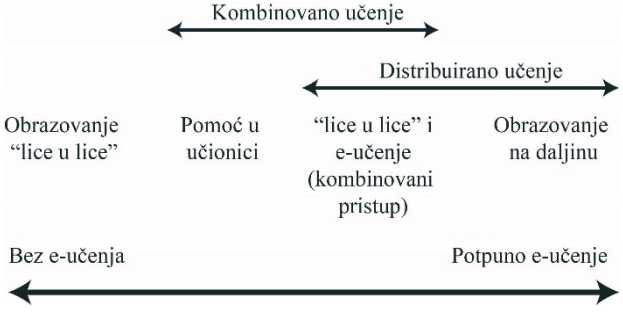

Figure 1. Overview of technology-based learning categories
Source: Bates & Poole, 2003, p. 127

Kombinovano učenje: Combined learning
Distribuirano učenje: Distributed learning
Obrazovanje "licem u lice": "Face-to-face" education
Pomoć u učionici: Help in the classroom
"Lice u lice" i e-učenje (kombinovani pristup): "Face-to-face" and e-learning (combined approach)
Obrazovanje na daljinu: Distance learning
Bez e-učenja: Without e-learning
Potpuno e-učenje: Full e-learning

According to research [7], despite the benefits, the success of video conferencing depends on various factors, such as teachers, students, but also on their attitudes towards educational technology. In the study [8], it was concluded that over 80% of students responded positively to video conferences. However, 80% of students stated that it would be more comfortable in a classic classroom. In accordance with the findings of studies conducted in educational institutions [7-8], students generally tend to have a positive attitude towards video conferences.

The paper [9] explored the possibility of using free *ooVoo* and *Skype* software in foreign language learning through video conferencing. *OoVoo* and *Skype* are free chat and video communication tools that allow users to send previously recorded video messages, chat with other users synchronously, and participate in video conferences with up to three users at a time.

VIDEO CONFERENCING TECHNOLOGIES AND STANDARDS

The following section provides a brief overview of the standards used for video conferencing. In addition to the standards listed in Table 1 in accordance with [10-11], special standards refer to internet standards related to video conferencing. Particular attention is also paid to standards related to security and encryption, multimedia control, etc.

Table 1. Names of standards for video conferencing technologies

Technology	Name of the standard
Signal transmission	H.310, H.320 (ISDN Networks) H.321, H.323 (since 1996) H.324 (PSTN) H.324m (3G or UMTS) SIP (VoIP and Video Calls)
Video codecs	H.261 (introduced in 1988) H.261 Annex D H.263 H.264 (MPEG 4 AVC)
Audio codecs	G.711, G.722 and modifications G722.1 G.722.1 Annex C G.723.1, G.725 G.728, G.729, G.703

Notes: PSTN- Public Switched Telephone Network,
UMTS - Universal Mobile Telecommunications System,
SIP - Session Initiation Protocol,
VoIP - Voice over Internet Protocol.
Source: Andberg, 2008, pp. 119-126.

Based on the literature review, the paper [10] makes recommendations for basic equipment:

- Camera. Particular attention should be paid to the positioning of the camera (cameras). Another aspect is related to the quality and functionality of the camera (the existence of the zoom option and resizing).

- Sound. Audio quality is immensely important in video conferencing. A delay in sound transmission of only *0.5 seconds* [12] leads to a discrepancy between speech and body movement, which impedes teacher-student interaction. According to [13], a delay of only *0.15 seconds* results in interference with the natural flow of communication.
- Lighting and background. Particular attention should be paid both to the place from which it is aired and the place where the listeners are.

Many video conferencing features are algorithms that have been ratified by the *ITU-T (International Telecommunication Union, Telecommunication Standardization Sector)* standards. This allows seamless connectivity between different products or networks, eliminating thus any interoperability issues.

VIDEO CONFERENCING TYPES

According to the report [14], compressed video conferencing can take place in point-to-point configuration (2 locations) or multiple points (3 locations or more). All video conferencing sites require a proper codec.

All locations participating in a multiple call must be "bridged" by using the built-in multipoint capability or the *Multipoint Control Unit (MCU).* Many codecs have the built-in ability to "bridge" up to 4 locations, i.e. 3 other locations and their own.

The codec initiates a multipoint call, which may also require additional network bandwidth to make or "host" the call. Using an *MCU* is usually a requirement in conferences with 4 or more points. The *MCU* is a hardware solution that allows you to connect multiple locations to video, audio and the *Web*. During a multipoint conference, all participants can hear each other at any time (Figure 2).

What participants see, depends on how the conference is set up through the *MCU* [14]:

- *Voice Activated*: Participants see the current or the last spoken location.
- *Continuous Presence:* Participants see all locations in different window layouts on the monitor screen. Examples of possible multiple window layouts are given in the following figure.

CONCLUSION

Video conferencing has become an essential component not only of the business world, but also of the world of education, health, and many other fields. Nowadays, video conferencing is also present in classrooms and it is accepted as a way of teaching. New technologies, such as video conferencing, have given teachers new ways of presenting materials, working with students, and thus they are stimulating the development of strategies that are consistent with new technology. Video conferencing uses synchronous two-way audio and two-way compressed video through the Internet.

Video conferencing students use special cameras, look at monitors and use the microphone of a computer or mobile device at any location. In doing so, students can communicate with each other and with teachers, as if they were in an educational institution. Students receive instructions and information on any topic through video conferencing, and are able to ask questions to participants from all locations involved in the video conference. The use of digital images, videos and video conferencing in the classroom puts teaching beyond textbooks and connects students with the world they live in. Video conferencing, as a form of distance education, illustrates well the relationship between the use of technology and the need for reorganization in order to maximize their benefits. Distance education, when properly organized and structured, also illustrates the ability to reach new target groups and to expand the range of educational offerings through technology.

Video conferencing has flourished with the development of various services on the Internet. Video conferencing, as a way of open and distance learning, provides education and training in a more flexible way than the regular ones. Technology is an essential component of this e-learning technology.

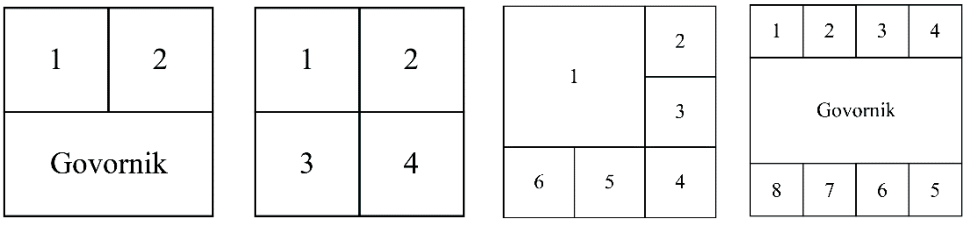

Figure 2. Possible multiple window layouts

Source: VSGI, 2005, p. 6.
Govornik: speaker

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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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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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