

# Safety of Cyclists in Belgrade

Milija Radović<sup>1</sup>, Danislav Drašković<sup>2</sup>, Vedran Vukšić<sup>3</sup>, Tijana Ivanišević<sup>4</sup>

<sup>1</sup>BSc.TE, Road Safety Agency of the Republic of Srpska, Banja Luka, Republic of Srpska, m.radovic@absrs.org

<sup>2</sup>PhD, BSc.TE, Republic Administration for Inspection Activities, Republic of Srpska, Banja Luka, Republic of Srpska, d.draskovic@inspektorat.vladars.net

<sup>3</sup>BSc.TE, Road Safety Center, Belgrade, Republic of Serbia, vedran.vuksic@centarbs.com

<sup>4</sup>BSc.TE, Road Safety Center, Belgrade, Republic of Serbia, tijana.ivanisevic@centarbs.com

Received: January 30, 2016

Accepted: November 4, 2016

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

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

## INTRODUCTION

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

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

Danger for cyclists in traffic, along with insufficient protection compared to other participants in the traffic (lack of adequate and suitable traffic infrastructure, busy existing traffic infrastructure, improper education, etc.), can also be observed from the aspect of specific behaviour of cyclists themselves. Because of their heterogeneous structure in terms of age, physical and mental capabilities to participate in traffic, level of traffic culture and the fact that by engaging in traffic, regardless of their traffic

education, they become equal participants in traffic with others, most of all with motor vehicles, the cyclists are more exposed to risk of fatal or severe injuries in traffic accidents [3]. Also, there are no medical requirements for cyclists or tests of their traffic training, i.e. whether they are familiar with necessary traffic regulations and signs, or whether they have the necessary skill to ride the bicycle [4]. Bearing all this in mind, cyclists, as a vulnerable category of participants in traffic need to be given special attention, considering their specific movement and need to provide adequate and suitable infrastructure.

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

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

The aim of the research is to, based on results of survey on attitudes and behaviour of cyclists on traffic safety and based on results of analysis of traffic acci-

dents, reach the most accurate data that would be used to accurately define problems in traffic safety of cyclists within the territory of the city of Belgrade.

---

## RESEARCH METHODOLOGY

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

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

**The second method is survey research of attitudes and behaviour of cyclists within the territory of the city of Belgrade as well as the use of protective equipment.** The survey was conducted from 1 to 22 August, 2014. year from 8 am to 7 pm at ten locations within the territory of the city of Belgrade, on a sample of total 320 cyclists. The respondents were members of Belgrade cycling clubs, professional cyclists, but also amateurs who cycle every day for recreational or some other purposes. The survey form had 15 questions, 10 of them of closed type, while 5 were of open type. The concept of the survey form was such that it led respondents to give concrete answers, based on which one can get quality perception of their view of the issue of cycling traffic in the city of Belgrade. A special attention was given to the set of questions referring to the safety of cyclists and where they were expected to point out concrete problems (situations) in traffic, and point out direct locations or parts of the road for which the surveyed cyclists thought to be "dangerous". The survey was divided into two parts. In

the first part of the survey there were questions dedicated to overview of general data on the surveyed cyclists, such as gender, age, how many years had they been riding the bicycle, during which part of the day, for what purpose, which streets they usually ride through and how much time a day they spend cycling. In the second part, the questions were predominantly aimed at over viewing the safety of surveyed cyclists in traffic. In the second part the cyclists were asked to point out the most significant risks in traffic, and to rank them. During the development of questions a special attention was given to the attempt to acquire data on concrete types of risks and their location in the road network. In order to give a simple overview of the location with increased risks for cyclists, the survey form had a map of Belgrade where the surveyed cyclist would mark the locations with increased risk. A database was prepared in order to analyse and process the survey. The aim of this survey was to observe the attitude and knowledge of cyclists, as well as determining subjectively dangerous and unsafe behaviour in traffic.

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

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

---

## RESULTS OF RESEARCH

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

### **Analysis of traffic accidents involving cyclists**

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

with material damages (208 TAs – 22%) and traffic accidents with fatalities (27 TAs – 3%).

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

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

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

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

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

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

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

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

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

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

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



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

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

The junctions with the most traffic accidents involving cyclists are:

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

### Results of cyclists survey

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

The third question was an open type and the respondents had the opportunity to name more than one

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

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

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

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

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

For the eighth question 39.32% of surveyed people stated that they ride the bicycle from 1 to 2 hours on average, while 23.73% of them spend 1 hour. In 18.31% of

cases the respondents spend from 2 to 3 hours riding the bicycle, while the cyclists who ride from 3 to 5 hours represent 14.92% of the total number of the surveyed cyclists. The time riding a bicycle up to 1 hour corresponds to trips for shopping or to the market, while the average daily riding time from 1 to 2 hours corresponds to trips to work, possible to university, while the trips lasting from 2 to 3 and 3 to 5 hours can be interpreted as recreational rides.

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

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

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

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

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

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

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

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

#### Results of field research

The field research involved visiting the location of subjectively and objectively increased danger for cyclists in traffic, which had been identified in previous parts of the research. The conclusions related for the analysis of

traffic accidents involving cyclists and conclusions related to the analysis of cyclists attitude were used as a basis for choosing the locations. The behaviour of cyclists and drivers of motor vehicles was observed on these subjectively and objectively “dangerous” locations in order to determine the problems in traffic safety.

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

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

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



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



Figure 2. Example of lack of continuity of cycling tracks

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



Figure 3. Examples of cycling track being occupied



Figure 4. Example of inadequate traffic infrastructure

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



## PROPOSED MEASURES FOR IMPROVING CYCLIST SAFETY IN TRAFFIC

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

### 1. Legal and other normative and regulative measures:

- Developing rulebooks or instructions for identifying locations of increased vulnerability of cyclists in traffic (based on available data, e.g. analyses of traffic accidents, analyses of conflicts, analyses of cyclists attitude, field research, etc.);
- Developing rulebooks or instructions to define necessary visibility on locations that have been proclaimed highly unsafe for cyclists by an expert independent body.
- Separately regulating obligations of public communal companies in the areas unsafe for cyclists in traffic, which refer to:
  - number and quality of public lighting fixtures;
  - clearing cycling track and lanes from snow, leaves, dust and mud;
  - control and penalties for illegally parked vehicles, locations and improvement of bus stops;
  - restrict licenses for advertising boards;
  - arranging plants who could influence visibility (for drivers and cyclists); visibility of vertical signals, etc.(periodical pruning of trees that could hinder visibility in junctions, visibility of cyclists);
  - setting up, maintenance and quality check of traffic signals;
  - separating from the existing and introducing new sources of financing for concrete measures to increase safety of cyclists in traffic at the most endangered locations;
  - forming a special section of the local authority that would oversee, direct and coordinate the work of utility services at the locations with increased danger for cyclists in traffic.
- Discuss the possibility to introduce the rule of "opposite direction" in one-way streets (regulated with the sign "except for cyclists");
- Formulate a legal concept for mixed pedestrian and cyclist surfaces. Current legislation regulates the existence of pedestrian area, but not joint mixed pedestrian - cycling surface or area;
- Harmonize legal definitions (e.g. different definition of the cycling track in the Law on Road Traffic Safety and the Law on Public Roads);
- Define the cycling protective equipment and bicycle equipment in the law;
- Consider the possibility to introduce "cycling streets" (Belgian example). A cycling street is a

street in which there is not enough room to build a cycling track, so the cyclists are given advantage over motor vehicle traffic. Motor vehicles are allowed to use the street, but they are not allowed to overtake cyclists. Speed in cycling streets must not be over 30 km/h.

### 2. Construction measures

- Construction measures aimed at drivers in order to decrease the movement speed:
  - decreasing the width of road at the entry of the slow traffic zone, at the level of pedestrian crossings, cycling tracks crossings over the road and other locations with increased number of cyclists. In this way the drivers are "forced" to decrease their speed due to the narrowing of road, i.e. decreased profile of the road that was previously available to them;
  - use of physical obstacles for force drivers to change the direction of movement in the zones of slow traffic, zones of pedestrian crossings and other zones with increased number of cyclists. Using this solution forces the drivers to constantly change their trajectory, which requires them to decrease speed. In this way, beside clearly letting the drivers know they are in a special zone, their speed is decreased in a direct way;
  - upon entering the streets or parts of streets that are primarily intended for vulnerable participants in traffic, a "gate" effect can be used which would clearly let drivers know they are in zones with special traffic regime;
  - physical obstacles on the road are very successful and efficient construction measures. One of the cheapest and highly effective ways to physically decrease the speed of motor vehicles is installing speed ramps ("sleeping policemen"). By installing different models it is possible to give priority to some categories of traffic participants, e.g. cyclists, and to discourage others to drive fast. Also, installing rubber speed ramps slows down the motor vehicle traffic, and on the other side gives cyclists a better sense of safety;
  - raising cycling track crossing over the road by using a platform, so that drivers would be "forced" to decrease their speed. Placing platforms that require vehicles to slow down even more, warns the drivers that they are entering a zone with increased number of cyclists and that it is necessary to decrease their speed. The platform itself, as well as any other physical obstacle, forces drivers to decrease their speed.
- Construction measures aimed at cyclists in order to prevent unsafe behaviour:
  - one of the construction measures to increase the safety of all participants in traffic, not only cyclists, can be a reconstruction of the road by

introducing a clear border between the surfaces intended for pedestrians, cyclists and motor vehicles. During the reconstruction of streets with higher intensity of cycling traffic, a special attention should be given to separating the motor vehicle and cycling traffic;

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

### 3. Technical and regulatory measures

- Regulating the intersections between cycling streams with other traffic streams by painting and marking surfaces intended for movement of cyclists;
- Separation of cycling tracks from the motor traffic by using rumble strips (in combination with dyeing the surfaces intended for cyclists) or rubber fenders;
- Measures intended to discourage drivers of motor vehicles to use roads close to areas attractive to cyclists, which is achieved by artificially extending the road by using regime measures (chicanes, road narrowing, etc.), with the aim to maximally decrease the speed of vehicles, or give up using those roads in the attraction zones in order to arrive to desired destination.

### 4. Preventive measures

- Educational measures (Educational measures are the corner stone of preventive actions aimed at all

participants in traffic, children as well. A special attention within educational measures must be given to children. Children need to be adequately prepared for their safe participation in traffic as pedestrians, but also as cyclists. This was confirmed in practice in the countries with world's most developed cycling traffic. For example, in 97% of elementary schools in Amsterdam students go through certain cycling tests (theory), while in 66% of them there is also a practical test. In practice it was proven that children prepared to be cyclists (not only as pedestrians), are much more familiar with the rules and behaviour in motor traffic, which is logical and clear considering the fact that according to the standing Law on Traffic Safety a cyclist is treated as a driver, and the bicycle is treated as a vehicle);

- Campaigns (Potential topics of campaigns aimed at promoting cycling and safety of cyclists in traffic within the territory of the city of Belgrade, could be: comprehensive promotion of cycling; promotion of using the bicycle to go to work, school, cultural events, etc.; promoting modern, socially and environmentally acceptable local mobility in towns at short distances up to 5 km; promotional campaign for big events; "Code of Conduct in cycling" – educational campaign aimed at the most frequent accidents that cyclists have with proposed measures to decrease the number of accidents; campaign to stimulate use of protective helmets (use data from research that the cycling helmet offers the protection for the head at speeds up to 20 km/h and decrease the risk of head injury by 42%, risk from brain injury 53%, and risk of face injury by 17%); campaign to increase the visibility of cyclists in traffic in conditions of low light or during the night; an awareness raising campaign for other participants in traffic on what is specific about cyclists and what is their "vulnerability").
- ### 5. Measures to improve the road/street infrastructure
- Review (RSI) and evaluation (RSA) of traffic safety;
  - Depth analysis of traffic accidents with fatalities (cyclists);
  - Management of dangerous locations (black spots).
- ### 6. Repressive measures
- ### 7. Measures for improving research of cyclist safety in traffic
- Organize international expert seminars on cycling traffic in order to exchange knowledge on this mode of transport;
  - Encourage private organizations and citizens action groups to cooperate with city authorities and find common solutions to increase participation and safety of cyclists in traffic within the territory of the city of Belgrade;



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

---

## CONCLUSION

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

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

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

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

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

---

## LITERATURE

- [1] Vukšić, B., Petrović, T. Cycling strategy in function of road safety in the Republic of Serbia, *Traffic Accidents 2013 – VII Counselling with international participation, proceedings*, Zlatibor, 2013, 552-567.
- [2] Drašković, D., Kulović, M., Vuksić, V. and Ivanisević, T. Sustainable development and cyclist's safety in the city of Belgrade, *Towards a Humane City 2015 – V international conference, proceedings*, Novi Sad, 2015.
- [3] Ivanišević, T. and Vukšić, V. Analysis of the circumstances of the traffic accidents with the participation of cyclists, *Road Safety in Local Communities 2014 – III International Conference, proceedings*, Banja Luka, 2014, 343-350.
- [4] Miljković, A., Luković, B. and Marković, I. Cyclists as vulnerable category of participants in traffic in the city of Pancevo, *Road Safety in Local Communities 2013 - VIII International Conference, proceedings*, Valjevo, 2013, 113-118.