SENSOR
South East Neighbourhood Safe Routes

SOUTH EAST EUROPE
Jointly for our common future

Programme co-funded by the EUROPEAN UNION

Pilot Project
IBARSKA MAGISTRALA
SERBIA

Star Rating and Risk Mapping according to iRAP/EuroRAP methodologies

iRAP/EuroRAP

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AMCC

Република Србија
Агенција за безбедност саобраћаја

Република Србија
МИНИСТАРСТВО УНУТРАШЊИХ ПОСЛОВА

ЈАВНО ПРЕДУЗЕЋЕ
ПУТЕВИ СРБИЈЕ

EuroRAP
EUROPEAN ROAD ASSESSMENT PROGRAMME

iRAP

AMSS
CMV

John Dawson,
iRAP Chairman
EuroRAP Chairman and Managing Director

Every year 1.3 million people are killed and more than 50 million people are injured or disabled in road crashes worldwide. Globally, road crashes are the leading cause of death for young people and now kill on the scale of malaria or tuberculosis. These social costs have an economic cost of 2% of GDP.

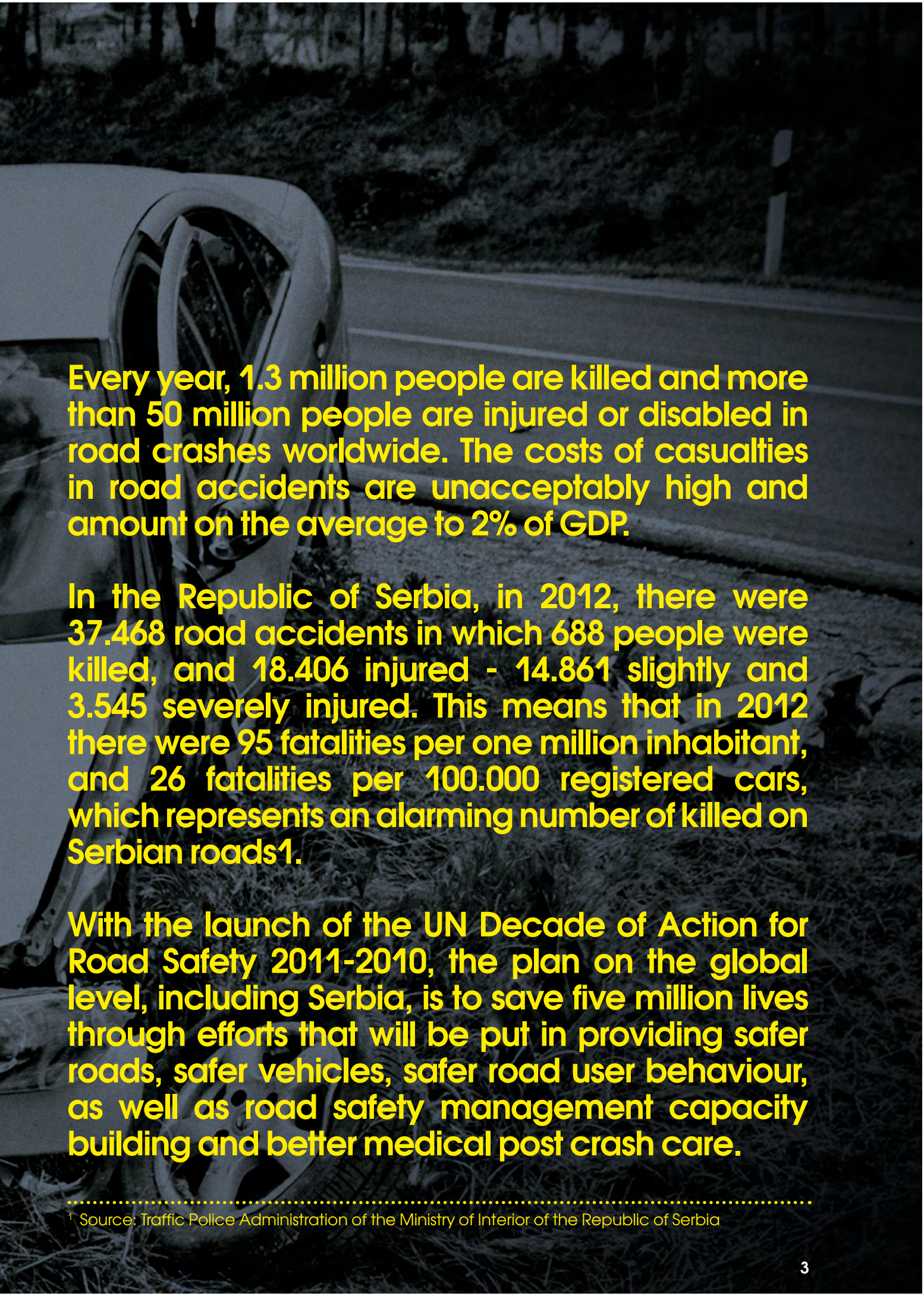
The scale of the social and economic loss has led to a UN Decade of Action for Road Safety 2011-2020. The global action endorsed by the EU and development banks focuses on pillars for action with pillars for each of safe roads, safe vehicles and safe road users.

The International Road Assessment Programme (iRAP) is a charity formed to help implement action for the Decade on safe road infrastructure. Already, some 80 countries have implemented projects or programmes. By 2015, some 0.5m million kms of the world's roads will be assessed and high return, cost effective programmes to save lives through safer roads will have been developed with many programmes implemented.

In Europe, the European Road Assessment Programme (EuroRAP AISBL) has led the world in piloting techniques to measure the safety of roads. At the heart of the European programme has been the contribution from Serbia. iRAP's first cooperative programme with the World Bank's Global Road Safety Facility chose Serbia as the country to pathfind new techniques in Europe. Since that time, the capability in Serbia through auto-moto association AMSS, has undertaken inspection work from the Netherlands to Ukraine.

The first recommendations from its initial RAP programme have already been implemented in Serbia despite the impact of the Global Financial Crisis on programmes throughout Europe. The work in Serbia has helped build momentum in the south east Europe region as a whole. AMSS is a key partner with the European Commission in the SENSoR programme covering 14 countries. SENSoR is the largest transnational Road Assessment Programme in the world.

I am deeply grateful to AMSS, the Road Traffic Safety Agency, the Government of Serbia and Public Enterprise „Roads of Serbia" for its innovative pathfinding work focusing on the network where the majority of road deaths take place in the country. I welcome the willingness of these organisations to share the results of their Road Assessment Programme openly in order that lessons learnt in Serbia can be used across the region and the rest of the world.



Every year, 1.3 million people are killed and more than 50 million people are injured or disabled in road crashes worldwide. The costs of casualties in road accidents are unacceptably high and amount on the average to 2% of GDP.

In the Republic of Serbia, in 2012, there were 37.468 road accidents in which 688 people were killed, and 18.406 injured - 14.861 slightly and 3.545 severely injured. This means that in 2012 there were 95 fatalities per one million inhabitant, and 26 fatalities per 100.000 registered cars, which represents an alarming number of killed on Serbian roads[1].

With the launch of the UN Decade of Action for Road Safety 2011-2010, the plan on the global level, including Serbia, is to save five million lives through efforts that will be put in providing safer roads, safer vehicles, safer road user behaviour, as well as road safety management capacity building and better medical post crash care.

[1] Source: Traffic Police Administration of the Ministry of Interior of the Republic of Serbia

Pilot Project Ibarska Magistrala Belgrade (Zarkovo) – Cacak (Preljina)

STAR RATING PILOT PROJECT **IBARSKA MAGISTRALA** USING iRAP METHODOLOGY

iRAP/ EuroRAP

The Auto-Moto Association of Serbia (AMSS) is a member of European (EuroRAP) and International (iRAP) Road Assessment Programmes. The objective of these programmes is to provide independent, consistent ratings of the safety characteristics of roads. This is happening in more than 30 European countries, and in 80 countries worldwide, including high income countries (USA, Australia, New Zealand, etc), and those classified as low and middle income countries (Malaysia, Mexico, Paraguay, the Philippines, Uganda, Vietnam, etc.).

In cooperation with the international financial institutions (IFI), FIA Foundation and the national road safety stakeholders, and using iRAP methodology, 3.000 km of roads of all categories were inspected and star rated in Serbia, in 2008. The report with the project results and recommended engineering countermeasures to be implemented, was published in May 2009 and can be found at the link http://www.eurorap.org/media/134145/irap_serbia_09_eng.pdf

In June 2013, AMSS-Motor Vehicle Centre carried out a star rating and risk mapping pilot project of the road IA-2 - Ibarska magistrala, on the section from Belgrade (Zarkovo) to Cacak (Preljina). The project was completed in cooperation with the Ministry of Interior-Traffic Police Administration, PE „Roads of Serbia" and iRAP team, using iRAP/EuroRAP methodology. It is also a part of the SENSoR project – South East Neighbourhood Safe Routes, whose aim is improvement of road safety in South-East Europe. The programme involves 14 countries, including Serbia, and is financially supported by the funds from the European Commission.

V*i*DA

V*i*DA is the new software that has been developed within the iRAP programme. It contributes to a higher quality of analysis than was available previously and a more comprehensive processing of data for the roads that have been surveyed and coded. It is a vital part of making a world free of high risk roads.

V*i*DA software has been used for the star rating and risk mapping pilot project of the road Belgrade (Zarkovo) – Cacak (Preljina), whose details are presented in the text below.

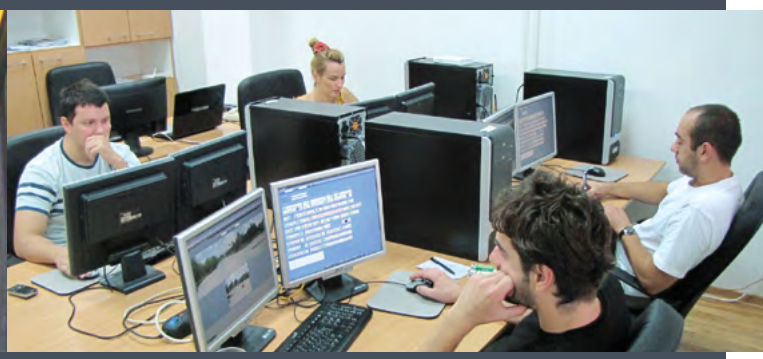
Road inspection vehicle

AMSS - CMV road inspection vehicle has been used for this project.

The vehicle is equipped with high-resolution cameras (three cameras in the front, one camera at the rear of the vehicle). Digital images of minimum resolution 1280x960 pixels have been collected in 10 m intervals while driving at the normal speed. The inspection system has a compatible software for coding from digital images, at 100 m intervals. Geo-referenced data have been provided for each digital image, including the distance along the road (from the determined start point), longitude and latitude, date and time.

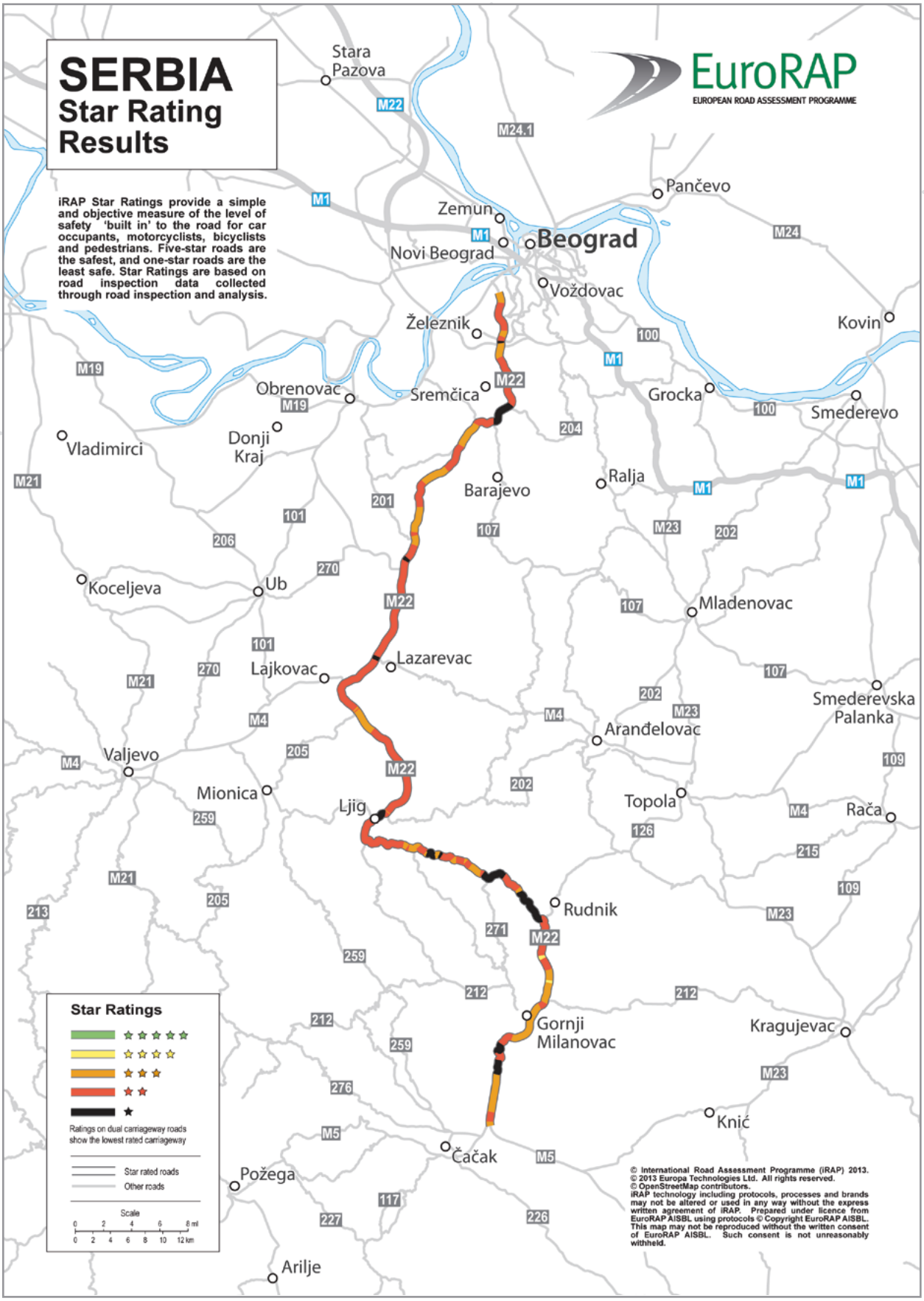
Coding of the recorded material

After the completion of the road inspection phase, the process of coding of video material took place. Coding represents the process of determining road attributes, at each 100 meters of the inspected road. Road characteristics are grouped into more than 30 attributes. Each attribute has its own set of categories. When the coding process is completed, a detailed road condition report is made containing characteristics, i.e. attributes of the road in question. This detailed condition report represents the basis for the making of the star rating assessment, as well as the proposal for the engineering countermeasures for the improvement of the existing state of the inspected road.

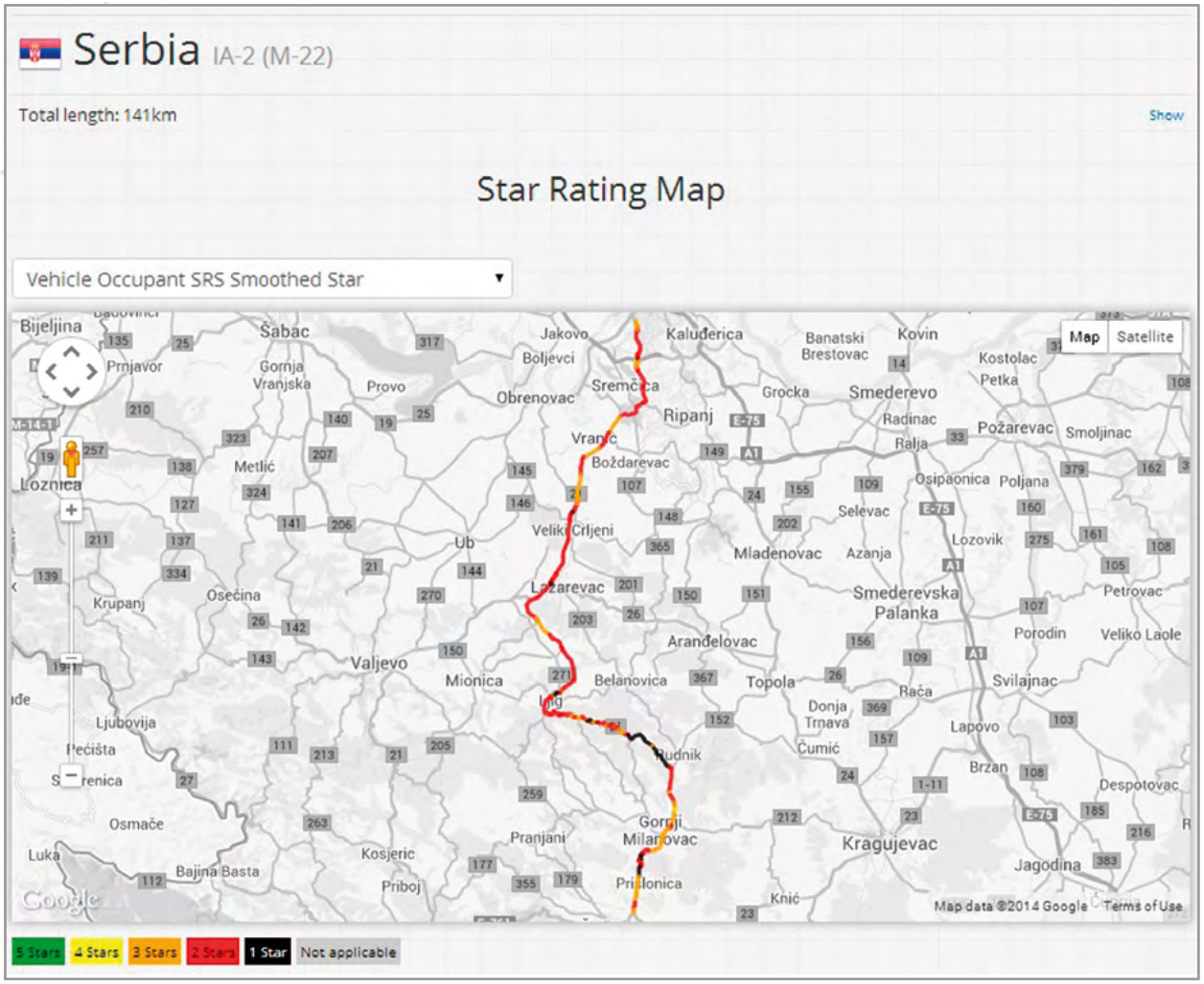


CHARACTER AND CONDITION OF THE INSPECTED ROAD IA-2 (M-22), BELGRADE-CACAK

The inspected road from Belgrade to Cacak is a part of the international road IA-2, i.e. M-22 road. It includes 13 sections, in the total length of 131,1 km.



Map 1. Star rating results of the road IA-2 (M-22) Belgrade (Zarkovo) – Cacak (Preljina)



Map 1A. Star rating results of the road IA-2 (M-22) Belgrade (Zarkovo) – Cacak (Preljina), taken from ViDA

The largest portion of the road is a single carriageway.

The lane width is over 3,25 m, in the length[2] of 138 km. Concerning physical separation between opposing traffic flows, the centreline separating traffic is present in the length of 126,8 km, and a wide centreline (0,3 to 1 m wide) – in the length of 7,1 km. Metal median barrier separating traffic lanes by directions, is placed in the length of 3,7 km. Hard shoulders are mainly paved, and are mostly 0 to 1 m wide.

As for the pedestrian facilities, they do not exist at the 99% of the inspected road, i.e. there is a very small number of signalized pedestrian crossings, with or without traffic lights, refuges and grade separated facilities.

Regarding hazardous objects at the side of a driver or passenger in the front seat, such objects are recorded in the length of 85,3 km (61%), at the distance of 1 to 5 m from the edge line. These objects include in the first place deep canals, steep slopes, trees and poles of a diameter greater than 10 cm, etc. However, the most common hazardous objects are safety barriers with their unsafe start and end points.

[2] Given kilometres include sections that have been inspected in both directions, because of physically separated traffic lanes.

Examples of hazardous objects along the road

The following figures contain some of the hazardous objects in the roadside area, as well as unsafe engineering measures:

Figures 1 and 2: Unsafe ends of safety barriers

Figure 3: Unsafe ends of safety barriers, canal, electric pole in the roadside area

Figure 4: Unsafe curve

Figure 5: A steep slope, trees and electric pole in the roadside area

Figure 6: Trees with a diameter greater than 10 cm in the roadside area

Traffic flow

Ibarska magistrala, i.e. the road IA-2 (M-22) accounts for one of the busiest roads in the Republic of Serbia. The road carries large volumes of traffic throughout the year, especially during the summer season when a lot of tourists are using this road towards the Montenegrin coast.

The following traffic flow has been recorded on the road: 5000-10000 vehicles on 64,6 km of the road length (46%), 10000-15000 vehicles on 44,7 km (32%), 15000-20000 vehicles on 12,6 km (9%), and 20000-40000 vehicles on 19,00 km (13%).

Speed

The analysis of the speed measurement data[3] has led to the conclusion that 85% of vehicles do not exceed the speed of 90 km/h. The average speed on the road in question exceeds the speed limit by 10-20 km/h.

Types of road accidents

Since the inspected road is mainly a single carriageway, where traffic in opposing directions has not been physically divided (in the length of 133,8 km), there were 130 fatal and serious road accidents recorded on this road in the period 2010-2012. The characteristics of the road influenced in majority of cases the occurrence of the following types of road accidents:

- head-on crashes – 47 accidents
- accidents involving vulnerable road users - pedestrians and bicyclists – 27 accidents
- run-off crashes - 26 accidents

[3] Source: PE "Roads of Serbia"

STAR RATINGS

Star ratings are given for the various categories of road users: vehicle occupants, motorcyclists, pedestrians and bicyclists.

Serbia IA-2 (M-22)

Total length: 141km Show

Star Ratings (Smoothed)

	Vehicle Occupant		Motorcycle		Pedestrian		Bicycle	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.0	0%	0.0	0%	0.0	0%	1.6	1%
4 Stars	0.9	1%	0.3	0%	0.0	0%	0.0	0%
3 Stars	41.3	29%	11.8	8%	0.9	1%	3.8	3%
2 Stars	82.0	58%	77.5	55%	11.2	8%	32.0	23%
1 Star	16.7	12%	51.3	36%	120.4	85%	89.5	64%
Not applicable	0.0	0%	0.0	0%	8.4	6%	14.0	10%
Totals	140.9	100%	140.9	100%	140.9	100%	140.9	100%

Table 1: Star ratings for the categories of road users

The following ratings have been awarded:

5 stars - 1% of the road length (1,6 km) for bicyclists' safety.

4 stars - 1% of the road length for vehicle occupants' (0,9 km) and motorcyclists' safety (0,3 km).

3 stars - 29% of the road length (41,3 km) for vehicle occupants' safety, 8% (11,8 km) for motorcyclists' safety, 3% of the road length (3,8 km) for bicyclists' safety and only 1% (0,9 km) for pedestrians' safety.

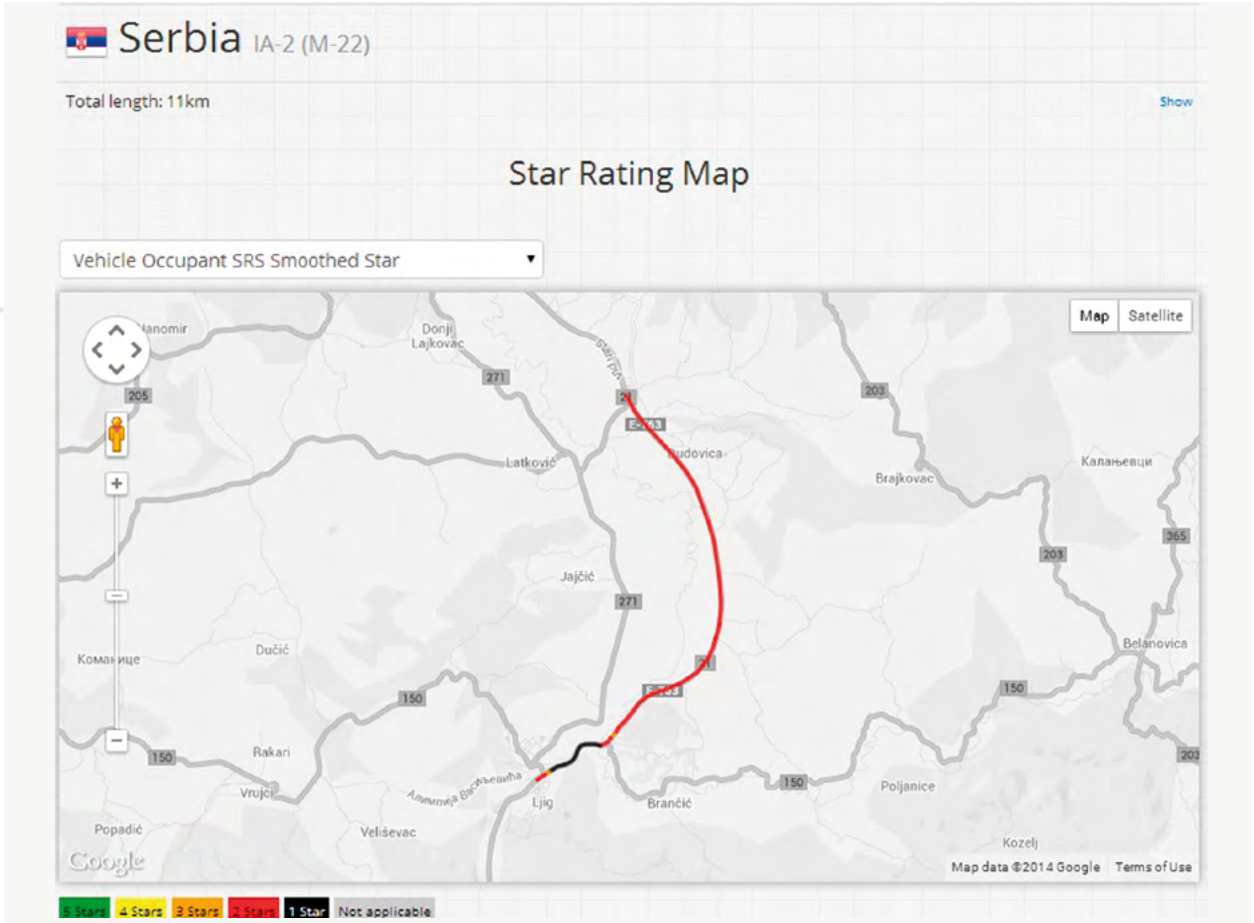
2 stars - 58% (82 km) for vehicle occupants' safety, 55% (77,5 km) for motorcyclists' safety. Due to the lack of facilities, 23% of the road length (32 km) was 2-star rated for the safety of bicyclists, while 8% (11,2 km) was 2-star rated for pedestrians' safety.

1 star – 16,7 km (12%) for vehicle occupants' safety, 51,3 km (36%) for motorcyclists' safety. Also, 120,4 km (85%) has been rated as unsafe for pedestrians, and 89,5 km (64%) for safety of bicyclists using this road.

Example of one of the risky sections

Based on the analysis of the recorded video material and safety indicators, the sections in question have been identified as portions of road with a significant risk level.

The section Dudovica-Ljig, which has been characterized mainly as a 2-star section, is presented below.



Map 2: Star rated section Dudovica-Ljig

The safety of this section is presented in a form of a chart, for all four categories of vulnerable road users.

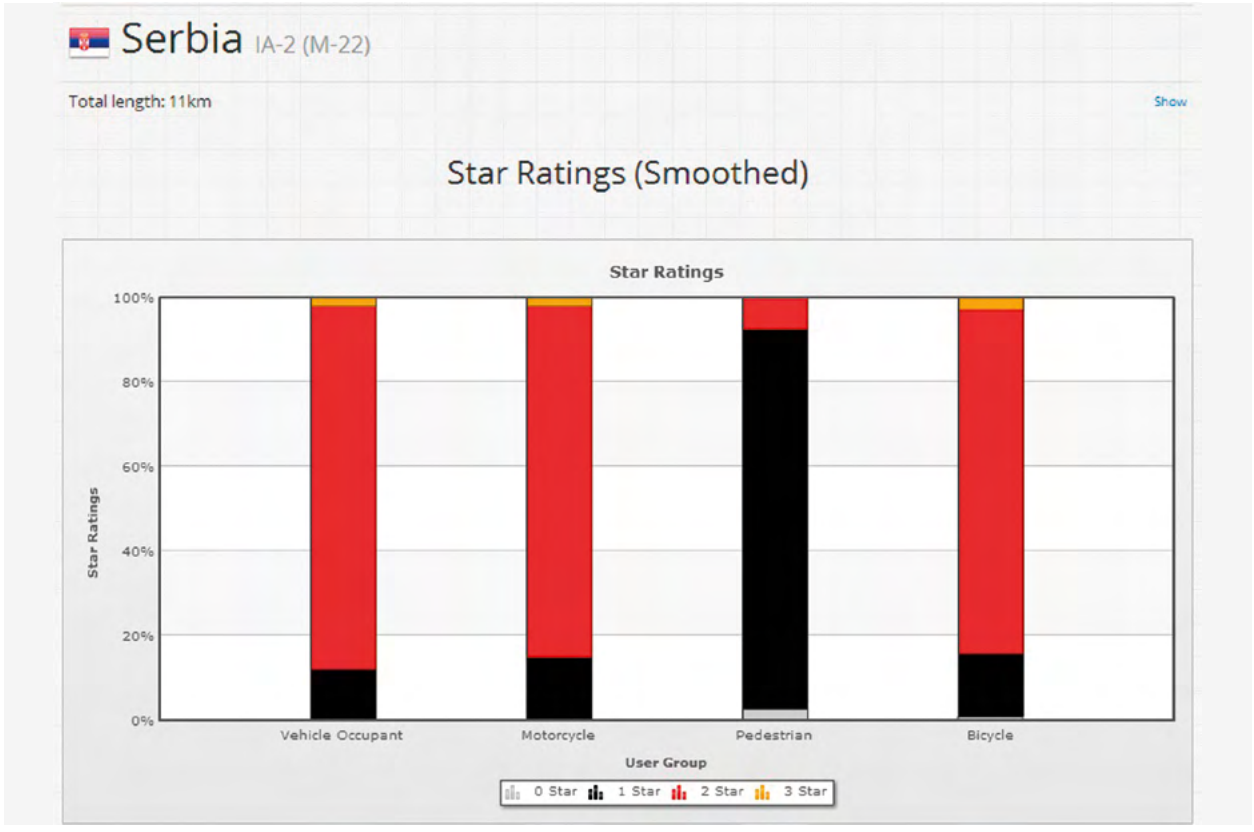


Chart 1: Section Dudovica-Ljig

Adequate engineering countermeasures, if implemented, would help improve significantly the safety of the section in question, for all categories of road users, which would look like as follows:

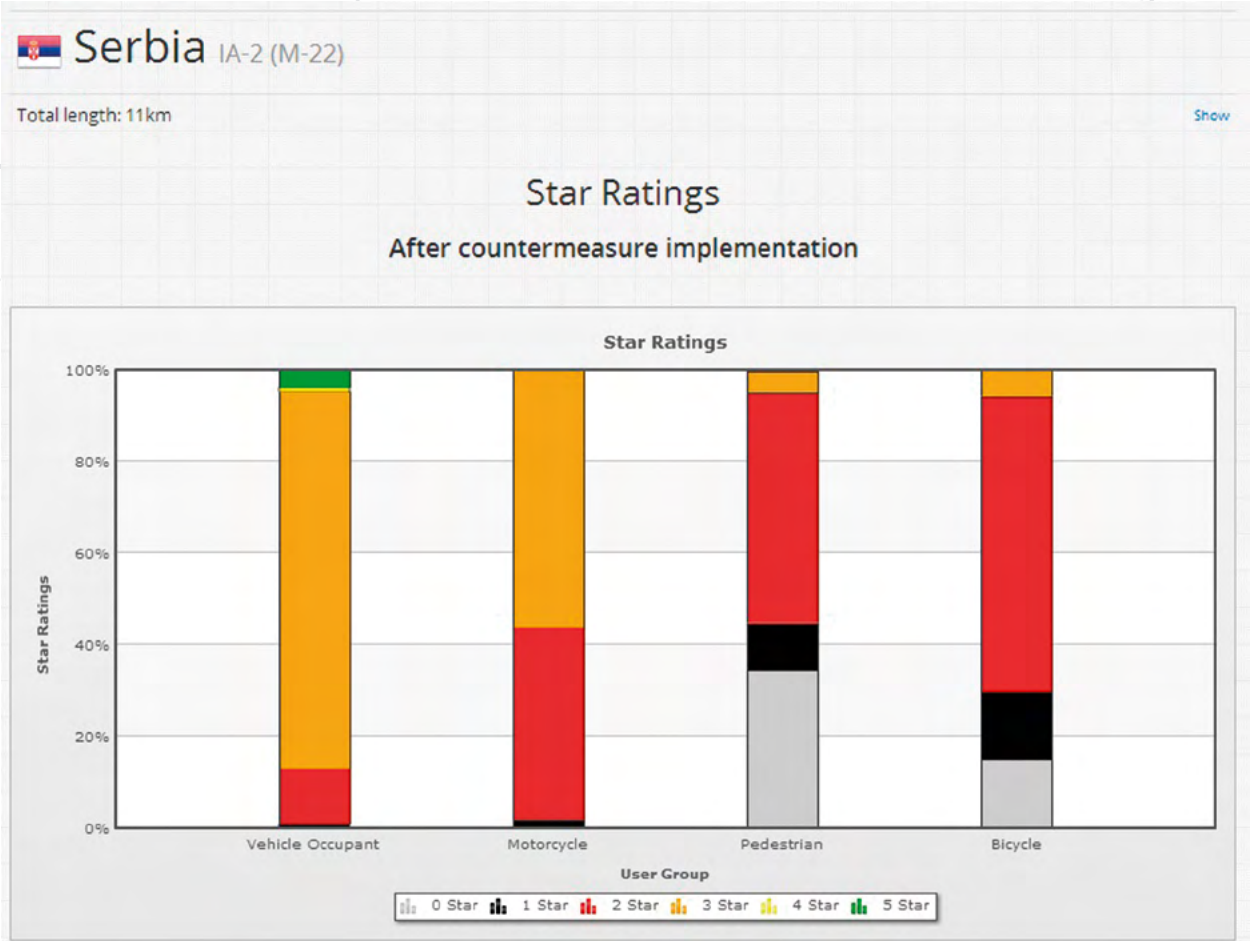


Chart 2: Section Dudovica-Ljig after the implementation of engineering countermeasures

Software ViDA offers more detailed analysis options for displaying risk levels. One of them is the Risk Worm illustration.

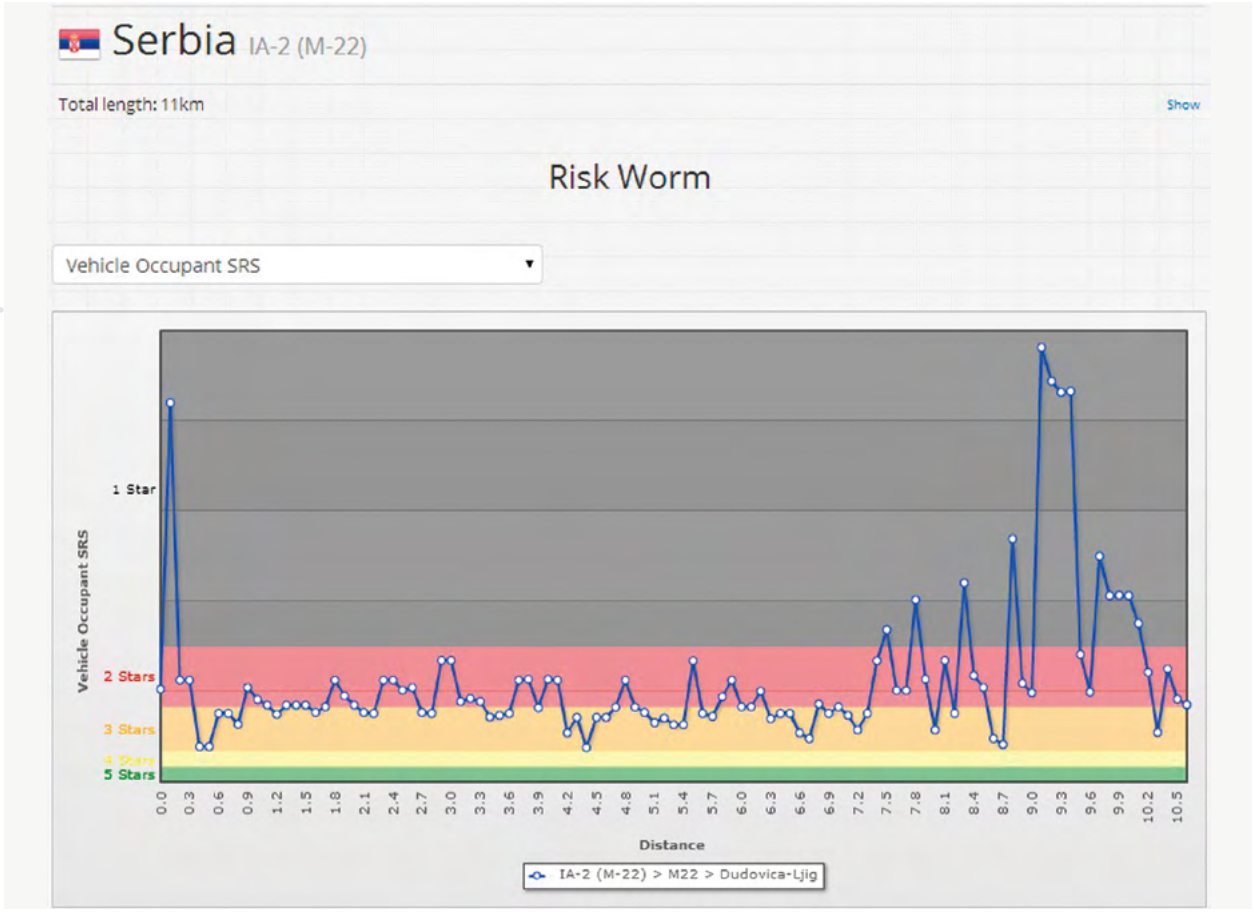


Chart 3. *Risk Worm* illustration of the section Dudovica-Ljig

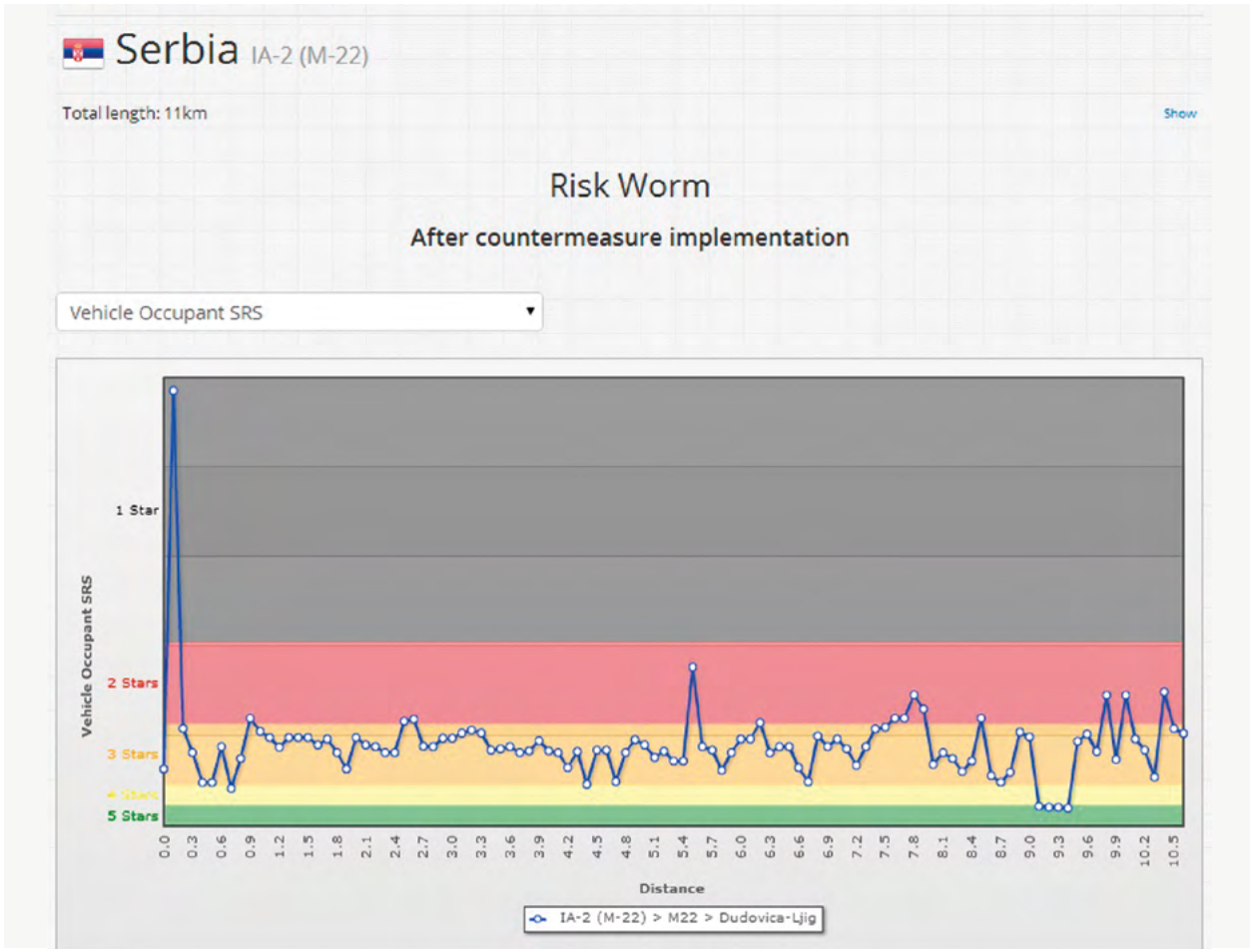


Chart 4: *Risk Worm* illustration of the section Dudovica-Ljig, after the implementation of engineering countermeasures

Engineering countermeasures

Road inspections and processing of obtained data lead to countermeasures that should be implemented by road authorities in order to improve the state of road safety on the inspected road or road section. In 99% of cases (139,8 km), the costs of upgrading the state of the inspected road would be cost-effective in the long run (20 years).

The most efficient and cost-effective measures that could help save the greatest number of lives include the following identified solutions for the inspected road Belgrade (Zarkovo)-Cacak (Preljina):

- **roadside barriers – driver and passenger side**
- **improve delineation**
- **shoulder rumble strips**
- **shoulder sealing (>1 m)**
- **footpath provision**

Serbia IA-2 (M-22)

Total length: 141km Show

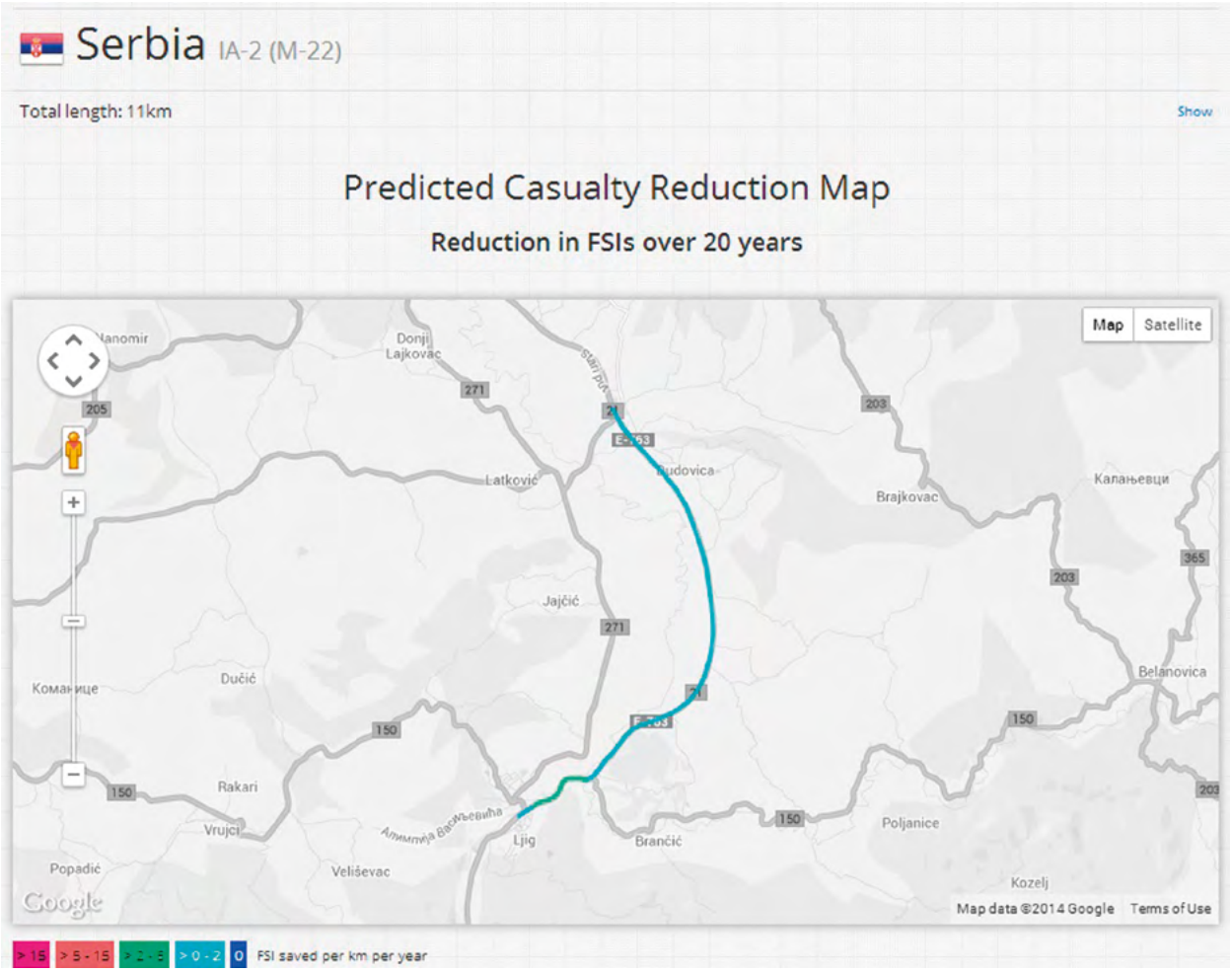
Safer Roads Investment Plan

Total FSIs Saved	Total PV of Safety Benefits	Estimated Cost	Cost per FSI saved	Program BCR
1,100	4,915,198,131	3,067,039,650	2,679,149	2

Countermeasure	Length / Sites	FSIs saved	PV of safety benefit	Estimated Cost	Cost per FSI saved	Program BCR
Roadside barriers - driver side	52.1 km	200	1,028,664,552	802,845,000	3,351,015	1
Shoulder rumble strips	131.6 km	200	891,786,208	178,660,700	860,175	5
Central median barrier (1+1)	14.1 km	100	513,222,243	290,244,000	2,428,154	2
Additional lane (2 + 1 road with barrier)	1.5 km	60	268,820,044	234,270,000	3,741,739	1
Footpath provision passenger side (>3m from road)	16.1 km	60	259,651,677	210,777,300	3,485,389	1
Footpath provision driver side (>3m from road)	16.5 km	50	246,705,689	216,014,000	3,759,424	1
Improve Delineation	24.5 km	40	182,777,993	54,701,200	1,284,966	3
Central median barrier (no duplication)	5.7 km	40	212,488,963	153,266,900	3,096,924	1
Roadside barriers - passenger side	12.0 km	40	212,002,468	185,364,000	3,754,075	1

Table 2: Recommended engineering countermeasures for improving safety of the inspected road

Illustrated by a map and on condition that the recommended engineering countermeasures have been implemented, the illustration of the number of saved lives (fatalities and seriously injured) per km, for the period of 20 years, will be as follows:



Map 3: Casualty savings per km in 20 years

Instead of a conclusion

The findings in this paper indicate that, in total, 70% of the inspected road length has been 2- and 1-star rated for car occupants' safety, 86% for bicyclists, 91% for motorcyclists and 93% for pedestrian's safety.
This is an unacceptable state of safety for one of the busiest roads in the country.
If implemented on this road, efficient and cost-effective engineering countermeasures from the proposed Safer Road Investment Plan will contribute considerably to improving the road safety situation and reducing the number of around 1100 fatalities and serious casualties, over 20 years.
The road inspection project was carried out by AMSS - Motor Vehicles Centre in cooperation with iRAP team. The work on improving the road network in Serbia will continue and will include all Serbian road safety stakeholders.

RISK MAPPING PILOT PROJECT *IBARSKA MAGISTRALA* USING EURORAP METHODOLOGY

In cooperation with AMSS-Motor Vehicles Centre, Traffic Police Administration of the Ministry of Interior of the Republic of Serbia, and the Public Enterprise "Roads of Serbia", the Road Traffic Safety Agency has carried out the risk mapping pilot project of the IA-2 Ibarska magistrala, on the section Belgrade (Zarkovo) – Cacak (Preljina), in the length of 131,1 km. Risk mapping has been made on the basis of the number and consequences of road accidents in the period 2010-2012, using EuroRAP methodology (EuroRAP – European Road Assessment Programme).

The first activity during the execution of the pilot project included division of existing sections of the IA-2 road from Zarkovo to Preljina. Aggregation has been made for the sections defined, i.e. joining certain section together in order to obtain portion of roads not shorter than 5 km, according to the EuroRAP protocol. After the aggregation has been made, required parameters have been determined for the new, so called EuroRAP sections. These parameters included values of AADT, start and end points with their coordinates, kilometre distance along the road length, number and consequences of road accidents, calculation of the correctional factor, calculation of the risk values, etc.

After having collected the data on the number and consequences of road accidents per sections of the IA-2 road from Zarkovo to Preljina, the Road Traffic Safety Agency has made the EuroRAP risk mapping analysis. Making of maps with various risks is also a constituent part of this protocol.

No	Sections of the IA-2 road from Belgrade to Cacak, start-end knot	Section length (km)
01	Žarkovo – Kružni put (Kneževac)	5,40
02	Kružni put (Kneževac) – Rušanj	8,00
03	Rušanj – Vranić	8,20
04	Vranić – Stepojevac (Veliki Crljeni)	13,70
05	Stepojevac (Veliki Crljeni) – Lazarevac 1	13,80
06	Lazarevac 1 – Županjac	8,60
07	Županjac – Dudovica	6,40
08	Dudovica – Ljig (Mionica)	10,40
09	Ljig (Mionica) – Dići	8,70
10	Dići – Ugrinovci	9,60
11	Ugrinovci – Bućin Grob	10,80
12	Bućin Grob – Gornji Milanovac	12,30
13	Gornji Milanovac – Preljina	15,20

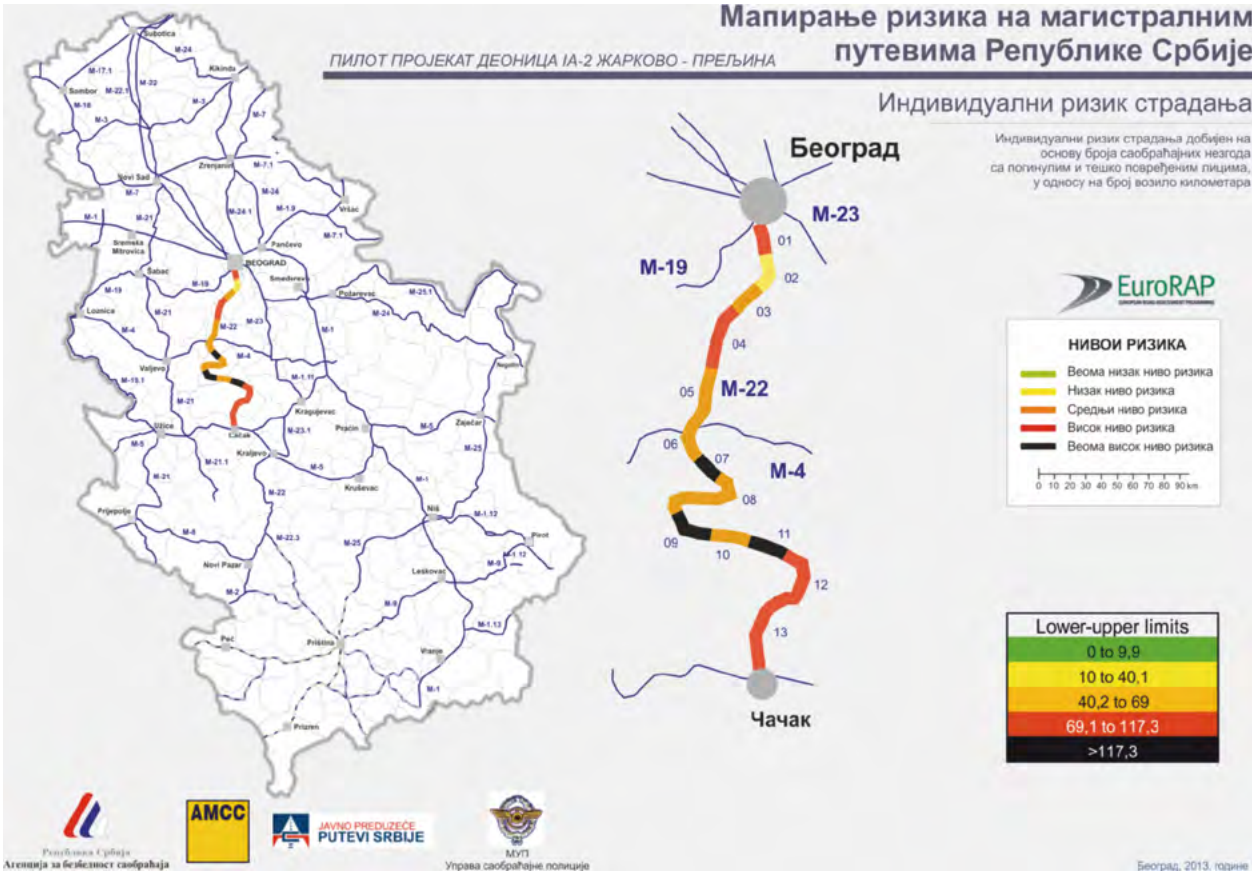
Table 3. Sections of the IA-2 road included in the pilot project

Risk mapping has been done on the basis of data on road accidents with fatalities and road accidents with seriously injured. There were 40 accidents with fatal outcomes and 90 accidents with seriously injured recorded on the IA-2 road section from Zarkovo (Belgrade) to Preljina (Cacak). The largest number of accidents with fatalities occurred on the section Vranic-Stepojevac (Veliki Crljeni), while most accidents with severe bodily injuries were recorded on the section Ljig (Mionica)-Dic.

With regard to the type of accidents, head-ons account for the prevailing type of accidents on the Belgrade-Cacak road. There were 47 head-on accidents with fatalities and severe injuries in the observed period. Also, 27 road accidents involving pedestrians and bicyclists, i.e. vulnerable road users, were recorded on this section in the same period. There were 26 accidents involving one vehicle, i.e. run-off accidents, on the same road, in the same observed period.

Three types of risk have been analyzed using EuroRAP standard: 1) Crash risk per kilometer travelled (individual risk), 2) Crash density (collective risk), and 3) Crash risk by road type. Apart from these risks, RAP standard foresees mapping of potentials for the reduction of the number of road accidents on the observed sections.

CRASH RISK PER KILOMETRE TRAVELLED - INDIVIDUAL RISK



Map 4. Crash risk per kilometre travelled - Individual risk (particularly important for road users)

Based on the results of the individual risk, the largest number of „black-banded" sections have been singled out in relation to other analyzed risks. **Many of the higher risk (black and red) sections on this map also rate poorly on the star rating**. Sections with the highest value of risk are sections number 7, 9 and 11. Head-ons account for the largest number of road accidents on these sections. Apart from this type of accidents, run-off crashes have been also identified on the high risk sections according to the analysis of the individual risk.

No sections on the road from Belgrade to Cacak have been characterized as a low-risk, in relation to the individual risk calculated according to EuroRAP methodology.

Figures 7 and 8. Details of the high risk section Ugrinovci-Bucin Grob

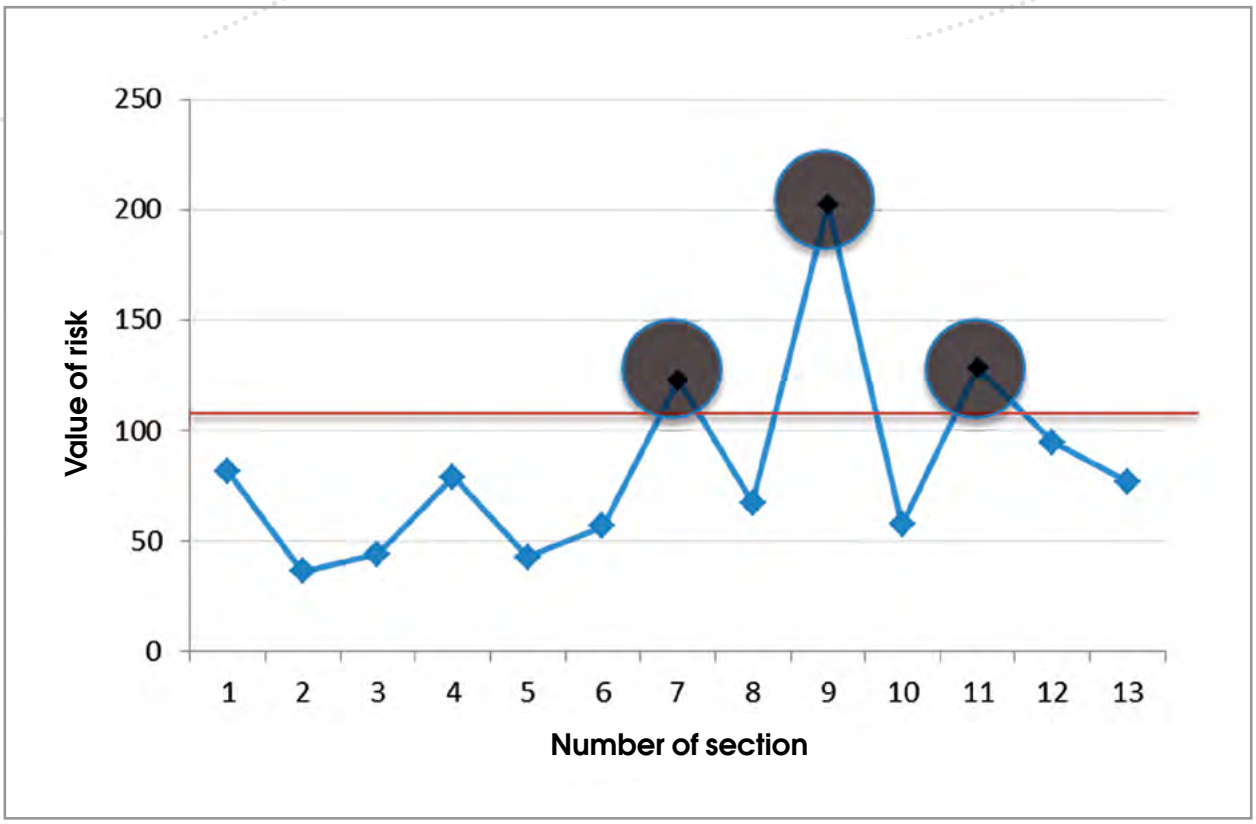


Chart 5. Values of individual risk per sections

Редни број	Деоница, почетни - завршни чвор	Дужина деонице (km)	Ризик
01	Жарково - Кружни пут (Кнежевац)	5,40	81,4
02	Кружни пут (Кнежевац) - Рушањ	8,00	36,2
03	Рушањ - Вранић	8,20	44,0
04	Вранић - Степојевац (Велики Црљени)	13,70	78,8
05	Степојевац (Велики Црљени) - Лазаревац	13,80	42,7
06	Лазаревац 1 - Жупањац	8,60	56,8
07	Жупањац - Дудовица	6,40	122,9
08	Дудовица - Љиг (Мионица)	10,40	67,5
09	Љиг (Мионица) - Дићи	8,70	202,5
10	Дићи - Угриновци	9,60	57,3
11	Угриновци - Бућин Гроб	10,80	128,6
12	Бућин Гроб - Горњи Милановац	12,30	94,6
13	Горњи Милановац - Прељина	15,20	76,9

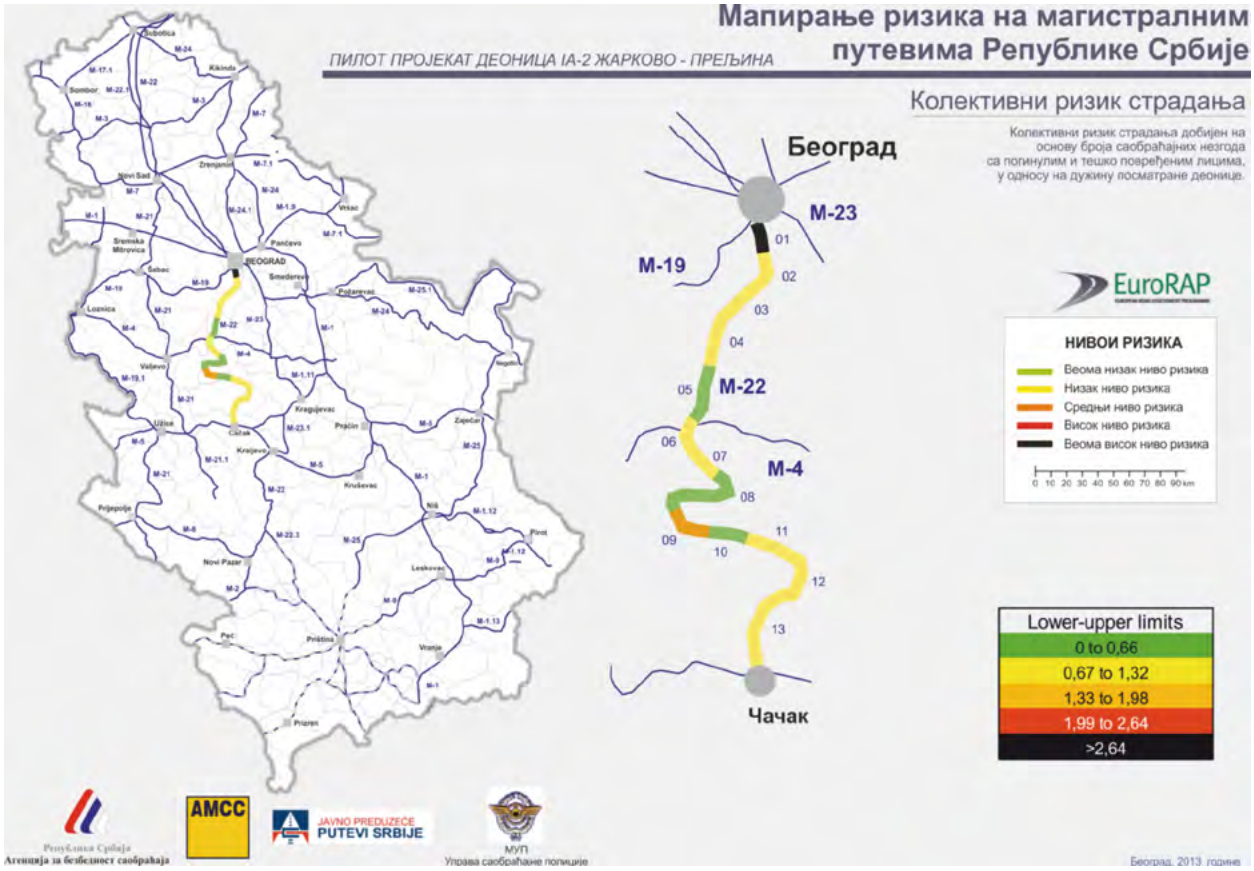
Table 4. Values of individual risk per sections

CRASH DENSITY OR COLLECTIVE RISK

Collective risk shows the density, or total number, of crashes on a road over a given length of a section expressed in kilometres. This risk is of particular interest for road authorities so that they could have an overview of how the total risk for all road users is distributed across the network. The information obtained on the basis of calculation of collective risk are crucial in determining how to spend available budgets effectively for improving road safety.

In any case, values obtained for collective risk depend to a great extent on the number of vehicles using the observed road section, given the positive correlation between the number of severe road accidents and traffic flow.

In order to reduce the collective risk rate on the observed section, it is necessary to understand not only the presented risk level, but also to which extent the lower risk level can be achieved on the observed section, at a reasonable cost. Information presented in collective risk maps can be used as the basis for considering investment decisions by road authorities and policy makers, since these maps can serve as valuable tools for estimating the reductions in the total number of road crashes that occur on the observed section, if certain funds are invested in order to improve safety of this road.



Map 5. Crash density – Collective risk (particularly important for road authorities)

Based on the collective risk results on the IA-2 section from Belgrade to Cacak, only one section belongs to a high-risk category of sections, i.e. Zarkovo-Kruzni put (Knezevac). A part of this section is an urban section at the exit from Belgrade towards the city of Cacak. The presence of a large number of vulnerable road users in traffic caused road accidents involving pedestrians and bicyclists to be the most frequent type of severe road accident occurring on this road section.

Except from the section Zarkovo-Kruzni put (Knezevac), the values of collective risk on other sections from Belgrade to Cacak represent the best assessed values in relation to other observed risks – individual risk and crash risk by road category.

Figures 9 and 10. Details of the high-risk section Zarkovo-Kruzni put (Knezevac)

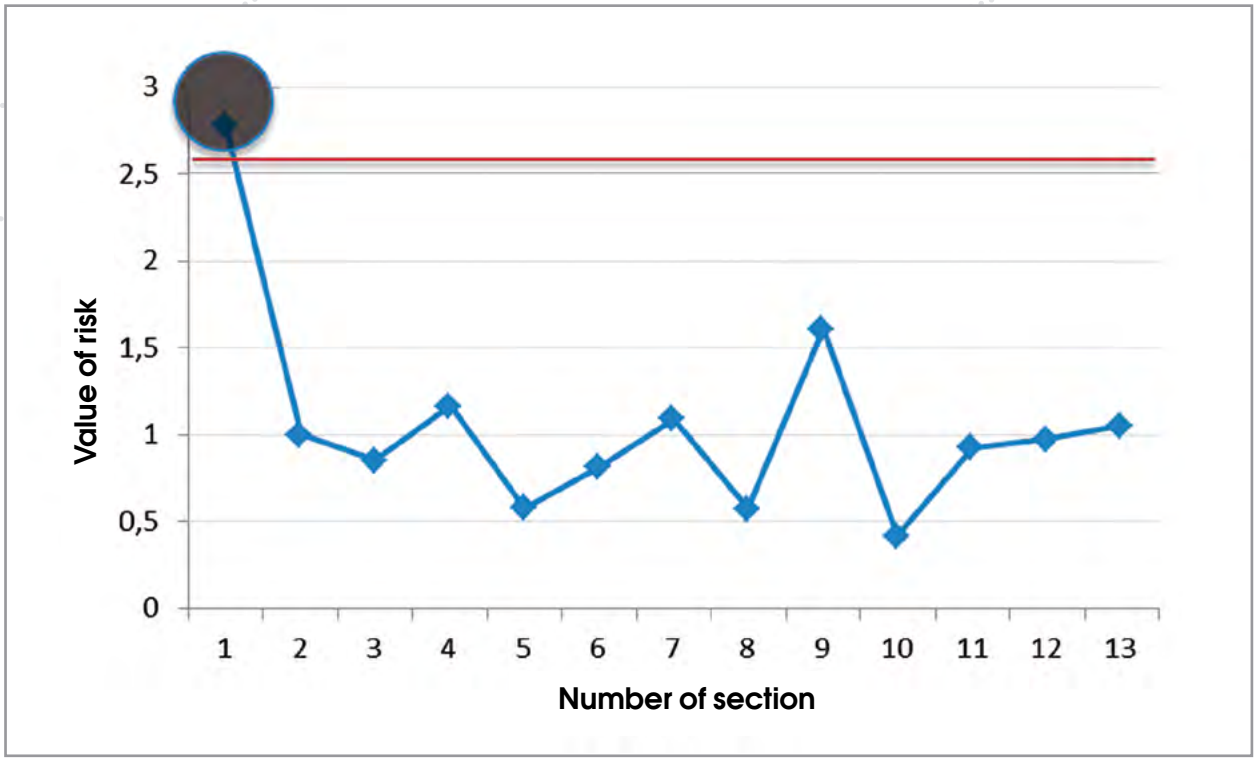
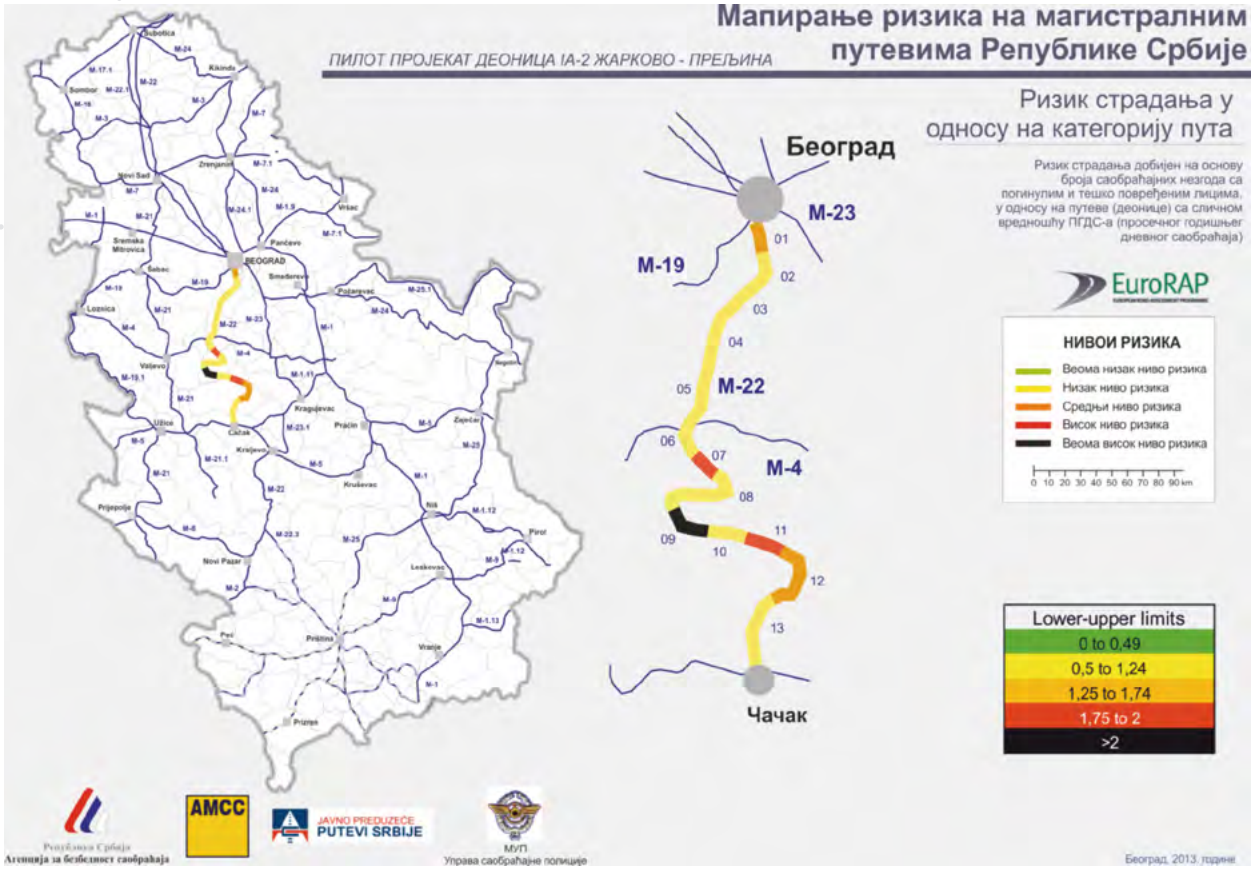


Chart 6. Values of individual risk per sections

Редни број	Деоница, почетни - завршни чвор	Дужина деонице (km)	Ризик
01	Жарково - Кружни пут (Кнежевац)	5,40	2,78
02	Кружни пут (Кнежевац) - Рушањ	8,00	1,00
03	Рушањ - Вранић	8,20	0,85
04	Вранић - Степојевац (Велики Црљени)	13,70	1,17
05	Степојевац (Велики Црљени) - Лазаревац '	13,80	0,58
06	Лазаревац 1 - Жупањац	8,60	0,81
07	Жупањац - Дудовица	6,40	1,09
08	Дудовица - Љиг (Мионица)	10,40	0,58
09	Љиг (Мионица) - Дићи	8,70	1,61
10	Дићи - Угриновци	9,60	0,42
11	Угриновци - Буђин Гроб	10,80	0,93
12	Буђин Гроб - Горњи Милановац	12,30	0,98
13	Горњи Милановац - Прељина	15,20	1,05

Table 5. Values of collective risk per sections and the length of sections

CRASH RISK BY ROAD TYPE



Map 6. Crash risk by road type – (particularly important for the road authorities in charge of certain road categories, if division of the road network management system is organized in this way)

Crash risk by road type compares the crash risk with the average risk for roads of that type. It is of great help to road safety engineers who, using the values of the calculated risk, can illustrate whether certain road sections have been adjusted to certain categories of road users, i.e. whether the observed road sections have been well designed for a certain category of road. Values are compared with average values of other categories of roads of a similar type.

The section number 9, from Ljig (Mionica) to Dici, is carrying the highest risk and has been obtained on the basis of the crash risk by road type. Section 9 proved to be a high-risk section in the analysis of two out of three observed risks. Apart from the crash risk by road type, this section has been also assessed to be of high risk in relation to the assessment of individual risk.

Figures 11 and 12. Details of the high-risk section Ljig-Dici, with obvious heterogeneity

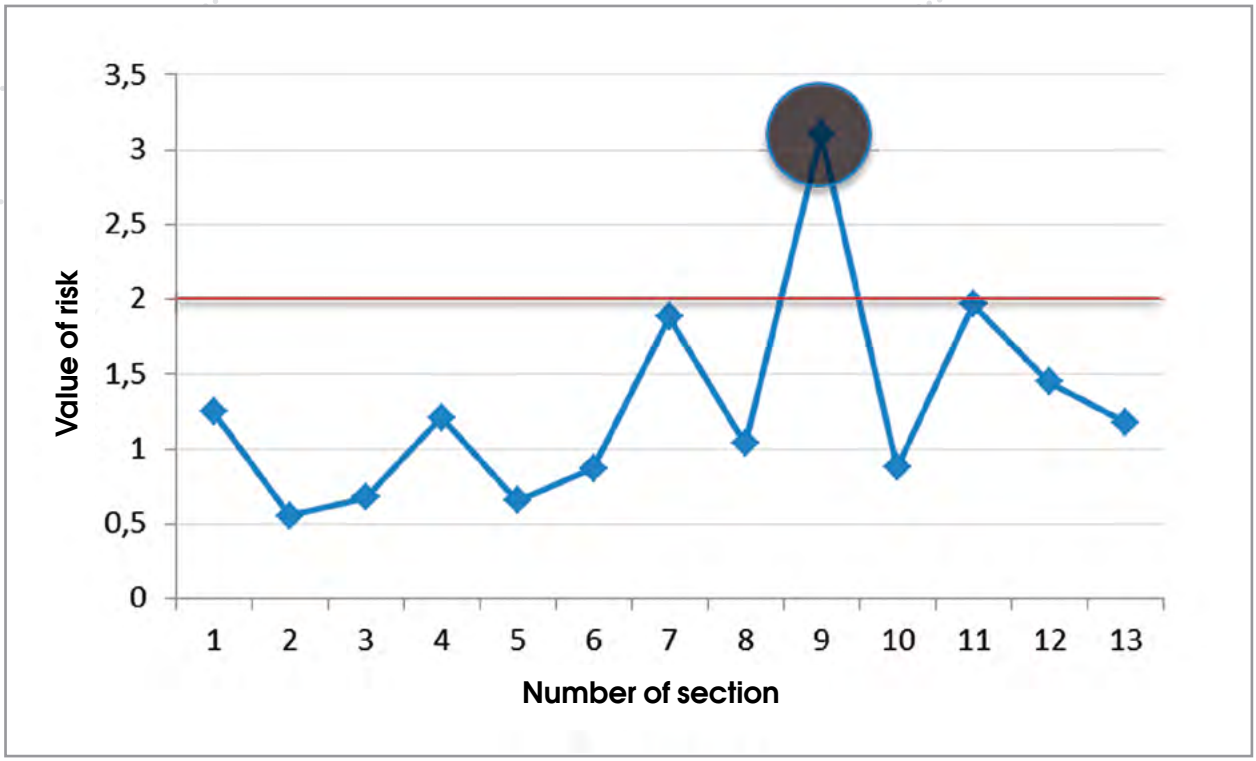


Chart 7. Values of crash risk by road type per sections

Редни број	Деоница, почетни - завршни чвор	Дужина деонице (km)	Ризик
01	Жарково - Кружни пут (Кнежевац)	5,40	1,25
02	Кружни пут (Кнежевац) - Рушањ	8,00	0,55
03	Рушањ - Вранић	8,20	0,67
04	Вранић - Степојевац (Велики Црљени)	13,70	1,21
05	Степојевац (Велики Црљени) - Лазаревац	13,80	0,65
06	Лазаревац 1 - Жупањац	8,60	0,87
07	Жупањац - Дудовица	6,40	1,88
08	Дудовица - Љиг (Мионица)	10,40	1,03
09	Љиг (Мионица) - Дићи	8,70	3,10
10	Дићи - Угриновци	9,60	0,88
11	Угриновци - Бућин Гроб	10,80	1,97
12	Бућин Гроб - Горњи Милановац	12,30	1,45
13	Горњи Милановац - Прељина	15,20	1,18

Table 6. Values of crash risk by road type per sections and the length of sections

Section 9 starts at the place of Dici, representing at that point the passage of the state road through a settlement, i.e. urban area. Heterogeneity of traffic is dominant, as it passes through the urban settlement of Ljig. This is reflected in the types of road accidents. The severest road accidents that occur on the observed section belong to all indicated road accident types, according to EuroRAP standard. The greatest number of severe accidents is classified as head-ons, followed by accidents involving pedestrians and collisions with bicyclists. One severe road accident involving a motorcyclist was recorded in the observed three-year period. Also, another three crashes have been recorded on the same section, but can not be classified as any of the indicated road accident types, according to EuroRAP methodology.

Based on the risk mapping results of the IA-2 road section from Belgrade to Cacak, the worst rated sections have been obtained using the analysis of individual risk. On the other hand, the best rated sections are those obtained on the basis of collective risk. All three analyzed risks indicate the results with at least one high-risk section.

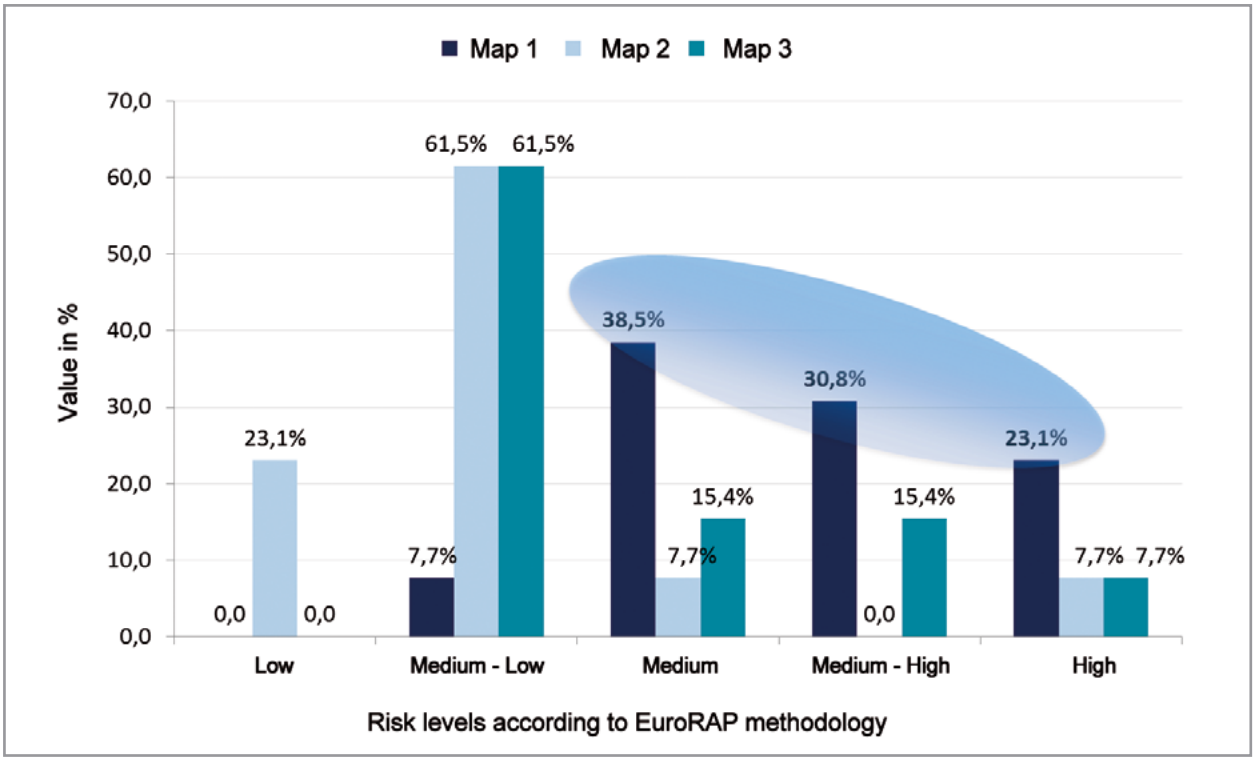


Chart 8. Statistical overview of the risk mapping results

CONCLUSION AND RECOMMENDATION

Data from this study have been given for the purpose of determining priority engineering countermeasures aimed at improving road safety on this road, for all categories of road users, as it concerns the road whereon a large number of road accidents and casualties are concentrated. iRAP/ EuroRAP tools have been used for this purpose, as they represent valuable instruments for all road safety stakeholders contributing to identifying road safety deficiencies and making of the adequate, efficient and cost-effective measures so that road safety can be improved on all the road network, for all categories of road users.

The application of these star rating and risk mapping tools provides benefits for: **the state of Serbia**, as it will join the group of countries that monitor the road safety situation and changes in the state of road safety on their roads, using common methods for that; **road authorities**, because of the identification of dangerous sections where the implementation of infrastructure measures and impact on the road and the roadside will help reduce the risk on all sections, and on the high-risk sections in particular; **road users**, who will be made familiar with the size of risk on the road they use even before the road safety improvement measures have been implemented on the section in question; **traffic police**, which would be able to continually monitor and adjust its response and improve its work in order to increase activities on low-to-high risk sections, in accordance with the recognized problems; **local self-governments**, whose aim will be to implement measures and actions in order to reduce the crash risk on the sections falling under their jurisdictions.

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