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# O.T.3.1.a
# Pilot Actions on 4(6) Road Safety Thematic Areas

**TA1 SRIP – BIH**

**RADAR – Risk Assessment on Danube Area Roads**

**https://www.interreg-danube.eu/radar**

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# Abbreviation list

| | |
|---|---|
| AADT | Average Annual Daily Traffic |
| BCR | Benefit to Cost Ratio |
| BIHAMK | Bosnia and Herzegovina Automobile Club(BIHAMK) |
| EuroRAP | European Road Assessment Programme |
| EU | European Union |
| iRAP | International Road Assessment Programme |
| RADAR | Risk Assessment on Danube Area Roads |
| RAP | Road Assessment Programme |
| RIA | Road Infrastructure Agency |
| RSEG | Road Safety Expert Group |
| SRIP | Safer Roads Investment Plan |
| SARS | State Agency Road Safety |
| ToR | Terms of Reference |
| TA | Thematic Area |
| TEN-T | Trans-European Transport Network |
| WHO | World Health Organization |
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# 1. Executive Summary

Bosnia and Herzegovina Automobile Club(BIHAMK)is Project Partner in the RADAR Project – Risk Assessment on Danube Area Roads. As part of the activities set out in Work Package 5 of the Project – Pilot actions, BIHAMK is responsible for performing Pilot Actions on Thematic Area 1 of the Project – Safer Road Investment Plans (SRIP). The main goal of SRIPs is to improve the overall road safety quality by implementing different types of specific measures, like for example installing roadside barriers and shoulder treatment for reducing run-off barriers.

Different stakeholders were involved in the process. Bosnia and Herzegovina Automobile Club (BIHAMK) performed the Pilot Action with the supervision and participation of its Road Safety Experts. For best results, the well-established procedures and practices of the international Road Assessment Programme (iRAP) were followed and implemented according to Bosnia-Herzegovina's national specifics and for the purposes of the road safety in Bosnia-Herzegovina.

The main objective of the RAP method is the improvement of the road users' safety by proposing cost-effective investment plans. The most crucial point of the RAP methodology is that engineers and planners in developed countries have for over twenty years adopted an underlying philosophy of designing a forgiving road system to minimize the chances of injuries when road users make mistakes that result in crashes. The method indicates that the severity of a road accident can be reduced through the intervention at the sequence of events happening during this accident.

The initial step for the implementation of the RAP method is the inspection and record of the infrastructure elements of a road network, which relate to the road safety. The record leads to the quantification of the safety provided by a road section to its users by awarding safety scores (Star Rating Scores). The Star Rating Scores express the safety capacity of a road section in a 5-Star scale. This quantification aims at identifying the most appropriate countermeasures, which will increase the infrastructure's road safety score. The Safer Roads Investment Plan (SRIP) includes all the countermeasures proved able to provide the greater safety capacity and maximize the benefit over spent cost of the planned investments. Thus, the SRIPs are considered as a valuable tool for the authorities, stakeholders and investors in order to decide for the most cost-effective and efficient road infrastructure investments.



The Pilot project, implemented by BIHAMK, consists of three main parts:

1. Road Sections Selection for further road survey – road accidents statistics analysis of the Bosnia-Herzegovina's National Road Network according to National protocols and procedures in order to select appropriate road sections for the survey;

2. Road survey of the preliminary selected road sections as per iRAP methodology, including coding using the iRAP online road safety software platform – VIDA, Star Rating and Safer Roads Investment Plan Analysis and Reporting;

3. Preparing of implementation ready road layout concept based on the SRIP measures and results.

The objective of the pilot was to assess the safety of about 227 km of roads in Bosnia and Herzegovina and build capacity for a sustainable road safety, in the field of road safety inspection and maintenance and network safety management.

The objectives included the following tasks which were performed byiRap accredited Automobile and Motorcycle Association of Serbia - AMSS-CMV. The selected road sections were inspected and the video survey data was coded according to the iRAP Survey and Coding specification. Objectives:

- Survey 227 km of roads and code the video survey data according to the International Road Assessment Programme (iRAP) Survey and Coding specification.
- Collect crash data, traffic flow and speed data for the 227 km according to the iRAP Data Analysis and Reporting specification.
- Produce an iRAP input file which includes all road attributes and collected data. Produce Star Rating results and Safer Roads Investment Plan to identify areas of high risk and to shape future road safety investment.
- Produce a Concept Design plan of selected location
- Produce a detailed report in accordance with iRAP Data Analysis and Reporting specification

The report from AMSS-CMV – Serbia describes the road assessment project in Bosnia-Herzegovina and includes details on data collection, methodology used and a summary of results in a form of Star Ratings, showing the level of risk on the road network. It also offers Safer Roads Investment Plans which have enormous potential to reduce road deaths and injuries on the inspected roads. iRAP results are available to the project stakeholders who can learn about precise locations where countermeasures should be considered for implementation.

There were 2 main road sections inspected. The surveyed network is 217 km long, but some divided roads are surveyed in both directions, the survey length is 227 carriageway kilometers. The sections were selected on the basis of high number of accidents and black spots registered on them over the years, as well as the intense traffic flow.

• Part of the main road M18 Sarajevo - Tuzla - Priboj (border with Republika Srpska); total length = 148.08 km

• Part of the main road M4 Doboj - Tuzla - Caparde (border with Republika Srpska); total length = 83.09 km

The selected road sections were assessed according to the Rap methodology, a Star rating was made and an investment plan (SRIP) with specific countermeasures was prepared.

The results show that no road on the 228 km long surveyed network was awarded 5 stars for vehicle occupants. Only 4% of the roads scored 4 stars for the car occupant safety. 76 % of the network was awarded 3 stars, while 20% of the roads scored only 1 star or 2 stars.

The rated road sections for the vulnerable road users were awarded poor rating, especially in terms of pedestrian safety, which turned out to be very low.

Sources of deaths or serious injuries on the inspected network are likely to include:

- lack of run-off protection and hazardous objects close to the road
- inadequate intersection layout, control and marking
- lack of head-on protection

- lack of pedestrian facilities

The most efficient and cost-effective countermeasures include shoulder rumble strips, roadside barriers on both driver and passenger side, shoulder sealing etc. It is expected that after implementing these measures the star ratings for both roadsections is expected to be 4 stars or better .

As a final result and example of an implementation ready design plan two road sections were prepared with the prescribed measures and the needed drawings. The two roadsections are Road M18, Section Simin Han – Priboj and Road M4/M18, Section Sicki Brod - Simin Han.

The outputs of this work give support to the decision-makers as well as engineers in the process of identifying the areas of high risk and help them decide how to address these locations. The methodology of measuring the relative risk of various types of accidents based on coded attributes and collected data about the traffic flow proved to be effective in many countries of the world in the framework of the RAP programme.

## 2. Introduction

RADAR (Risk Assessment on Danube Area Roads) aims to improve the road infrastructure safety in the Danube region by raising capacity and enhancing transnational cooperation for all road users, including vulnerable road users on Danube major, secondary and tertiary road networks. One of RADAR's main tasks is to identify risk on road networks and offer plans to systematically reduce that risk by improving infrastructure and road layout. Pilot action on SRIP (Safer roads investment plan) in Bosnia and Herzegovina on Safer roads investments follows the broadest approach of targeting all road users and implement countermeasures based on what is most financially effective benefit-cost ratio.

### 2.1 Objectives

The objective of the project is to assess the safety of about 227 km of roads in Bosnia and Herzegovina and build capacity for a sustainable road safety, in the field of road safety inspection and maintenance and network safety management.

The objectives include the following tasks:

- Survey 227 km of roads and code the video survey data according to the International Road Assessment Programme (iRAP) Survey and Coding specification.
- Collect crash data, traffic flow and speed data for the 227 km according to the iRAP Data Analysis and Reporting specification.
- Produce an iRAP input file which includes all road attributes and collected data. Produce Star Rating results and Safer Roads Investment Plan to identify areas of high risk and to shape future road safety investment.
- Produce a concept design plan of selected locations.
- Produce a detailed report in accordance with iRAP Data Analysis and Reporting specification



### *2.2 Methodology*

The protocols used here were developed by the International Road Assessment Programme (iRAP). iRAP is a registered charity dedicated to saving lives through safer roads.

iRAP provides tools and training to help countries make roads safe. Its activities include:

- inspecting high-risk roads and developing Star Ratings, Safer Roads Investment Plans and Risk Maps,
- providing training, technology and support that will build and sustain national, regional and local capability,
- tracking the road safety performance so that funding agencies can assess the benefits of their investments.

The programme is the umbrella organisation for EuroRAP, AusRAP, usRAP, KiwiRAP and ChinaRAP. Road Assessment Programmes (RAP) are now active in more than 70 countries throughout Europe, Asia Pacific, North, Central and South America and Africa.

iRAP is financially supported by the FIA Foundation for the Automobile and Society. Projects receive support from the World Bank Global Road Safety Facility, automobile associations, regional development banks and donors.

National governments, automobile clubs and associations, charities, automotive industry and institutions, such as the European Commission, also support RAPs in the developed world and encourage the transfer of research and technology to iRAP. In addition, many individuals donate their time and expertise to support iRAP. iRAP is a member of the United Nations Road Safety Collaboration.

The main objective of the RAP method is the improvement of the road users safety by proposing cost-effective investment plans. The most crucial point of the RAP methodology is that engineers and planners in developed countries have for over twenty years adopted an underlying philosophy of designing a forgiving road system to minimize the chances of injuries when road users make mistakes that result in crashes. The method indicates that the severity of a road accident can be reduced through the intervention at the sequence of events happening during this accident. As it is known, an injury accident results from a chain of events, starting with an initial event, probably resulting from several factors, which leads to a dangerous situation. The basic idea is to intervene at any point of this chain, in order to reduce the kinetic energy of all road users involved in the accident to a tolerable level. Such an intervention may not only reduce the number of accidents, but also the severity of injuries.

The initial step for the implementation of the RAP method is the inspection and record of the infrastructure elements of a road network, which relate to the road safety. The record leads to the quantification of the safety provided by a road sections its users by awarding safety scores (Star Rating Scores). The Star Rating Scores express the safety capacity of a road section in a 5-Star scale. This quantification aims at identifying the most appropriate countermeasures, which will increase the infrastructure's road safety score. The Safer Roads Investment Plan (SRIP) includes all the countermeasures proved able to provide the greater safety capacity and maximize the benefit over spent cost of the planned investments. Thus, the SRIPs are considered as a valuable tool for the authorities, stakeholders, and investors in order to decide for the most cost-effective and efficient road infrastructure investments.

### 2.2.1 Measuring the road infrastructure safety

The assessment of the road safety requires Road Safety Inspections of the road network sections and the assignment of a safety score to them. The inspection is conducted by visual observation and recording of the road infrastructure elements which are related -directly or not- to road safety and have a proven influence on the likelihood of an accident or its severity. The RAP uses two types of inspection: drive-through and video-based inspection. During the first one, recording of the infrastructure's elements is performed manually, with the help of the specialized software, while during the second type of inspection; a specially equipped vehicle is used, so that the recorded video could be used for a virtual drive-through of the network and an automated identification of the infrastructure's elements.

Following the survey, the Road Protection Score (RPS) is calculated. The RPS is a unit-less indicator, which depicts the infrastructure's safety capacity for each road user type and it is calculated for 100m road segments. Road user types include the following vulnerable road users: car occupants, motorcyclists, bicyclists and pedestrians, who may be involved in road accidents. The respective RPS is calculated for each road user type and each of the 100m road segmentation, in the following way:

$$RPS_{n,u} = \sum_{c} RPS_{n,u,c} = \sum_{c} L_{n,u,c} * S_{n,u,c} * OS_{n,u,c} * EFI_{n,u,c} * MT_{n,u,c}$$

where “n” is the number of 100m road segment, “u” the type of road user and “c” the crash type that the road user type “u” may be involved in. The following variables are taken into consideration: L: Likelihood that the “i” crash may be initiated, S: Severity of the “i” crash, OS: Degree to which risk changes with the Operating Speed for the specific “i” crash type, EFL: Degree to which a person’s risk of being involved in the “i” type of crash is a function of another person’s use of the road (External Flow Influence), MT: Potential that an errant vehicle will cross a median (Median Travers ability).

### 2.2.2 The Star Rating process

The aim of the Star Rating process is awarding the “n” 100m road segments with Stars, depicting the safety offered to each of the “u” road user types. The Star Rating system uses the typical international practice of recognising the best performing category as 5-star and the worst as 1-star (5-star scale), so that a 5-star road means that the probability of a crash occurrence, which may lead to death or serious injury, is very low. The Star Rate is determined by assigning each RPS calculated to the Star Rating bands. The thresholds of each band are different for each road user and were set following the significant sensitivity testing to determine how RPS varies with changes in road infrastructure elements. The assignment procedure leads to the development of a risk-worm chart, which depicts the variation of the RPS score in relation to the position (distance from the beginning) of the road under consideration. The final output of the Star Rating is the Star Rating Maps, in which the “n” road sections are shown with different colour, depending on their Star award (5-star green and 1-star black).



### 2.2.3 Developing the Safer Roads Investment Plans (SRIPs)

The development of the most appropriate SRIP presupposes the assessment of the number of fatalities and serious injuries that could be prevented for each 100m road segment, on an annual basis, if a set of countermeasures is applied. The number of fatalities is calculated as follows:

$$F_n = \sum_{u} \sum_{c} F_{n,u,c}$$

where “n” is the number of the 100m road segment, “u” the type of road user, “c” the crash type that the road user “u” may be involved in and F the number of fatalities that can be prevented in a time period of 20 years, given that a specific set of countermeasures is applied.

The number is related to four main factors: (1) the safety score of the specific road segment, (2) the “u” road users flow, (3) the fatality growth, which indicates the underlying trend in road fatalities and (4) the calibration factor, which inserts the actual number of fatalities that occur on the specific road section. The calculation of this factor presupposes the existence of similar crash data.

The assessment of the number of serious injuries that could be prevented in a 100m road segment is the function of the Fn, u, c value and the ratio of the actual number of serious injuries to the actual number of fatalities to the relevant number of fatalities. In case the appropriate data are missing, the competent authorities should estimate this actual number as previously, or the ratio of 10 serious injuries to 1 death is used, which is proposed by McMahon and Dahdah (2008)[1].

The next step in establishing the SRIPs is the identification of the most appropriate countermeasures. Countermeasures are the engineering improvements that the road authorities should take in order to reduce the rate of fatalities and serious injuries. Each countermeasure is characterized by its trigger sets and its effectiveness for each of the 100m road segments. Each trigger set describes all the cases in which this certain countermeasure can be used. The effectiveness is calculated according to the number of fatalities and serious injuries that can be prevented in this segment and the RPS of this segment before and after the application of the countermeasure. It is important to mention that in the case that multiple countermeasures act on a certain road segment, the total effectiveness is not the simple sum of each countermeasure's effectiveness. Instead, a reduction factor should act, which calibrates the total effectiveness.

The procedure of selecting the most appropriate countermeasures is the basis for the techno-economic analysis of the investment plan, with the aim of calculating the Benefit-Cost ratio (BCR) for each countermeasure. The economic benefit is considered as the benefit of preventing a death or a serious injury. The calculations are conducted following the assumption that the cost of a human life is 70 times the GDP per capita, the cost of a serious injury is the 25% of the cost of a human life and the ratio of 10 serious injuries for 1 death, if more accurate information is not available. The countermeasure cost includes all the construction costs, the maintenance costs over a 20 year period and/or probable reconstruction costs. All the benefits/costs should reflect the actual local prices, taking into account the economic life of each countermeasure and the discount rate. The outcome of this procedure is the BCR calculation for each countermeasure applied to a specific road segment.

The SRIP is conducted for a period of 20 years and shows the list of the most cost effective improvements that are able to reduce the crash risk for all road user types. In that way the SRIP enables the road authorities to set the priorities properly when developing infrastructure's maintenance and/or rehabilitation plans.

# 3. Road network

The roads inspected were selected by the, Bosanskohercegovački auto-moto klub (BIHAMK). There are nine road sections inspected, which are shown in Figure 1. The surveyed network is 219km long, but as some divided roads are surveyed in both directions, the survey length is 228 carriageway kilometres.

**Table 1 Road network**

| Road name | Description | Survey Length (km) | Divided length (km) | Undivided length (km) |
|---|---|---|---|---|
| M18 | Sarajevo - Semizovac | 13 | 0 | 13 |
| M18 | Semizovac - Olovo | 40 | 0 | 40 |
| M18 | Olovo - Vitalj | 20 | 0 | 20 |
| M18 | Vitalj - Živinice | 30 | 0 | 30 |
| M18 | Živinice – Šićki Brod | 13 | 0 | 13 |
| M18 | Simin Han – Priboj (gr.RS) | 16 | 0 | 16 |
| M4 | Doboj (gr.RS) – Šićki Brod | 47 | 0 | 47 |
| M4 / M18 | Šićki Brod – Simin Han | 25 | 10 | 15 |
| M4 | Simin Han - Ceparde | 23 | 0 | 23 |


**Figure 1** **Road networkmap**

# 4.Crash Risk Mapping

In regions where crash data is available, Crash Risk Maps represent the actual number of deaths and injuries on a road network. The maps provide objective view of where people are dying and where their crash risk is highest.

## *4.1 Risk types*

- Individual risk

  The public is often most interested in their risk on the road as individual user. The simplest way to represent this is in terms of crash risk in relation to exposure. Rates per vehicle kilometre travelled can show the likelihood of a particular type of road user (e.g. car driver, motorcyclist, pedestrian or cyclist), on average, of being involved in road crash.

- Collective risk

  Collective risk is used by road providers to reflect more broadly how the total risk to all road users is distributed across a network. At the simplest level collective risk maps show the density or total number of crashes on a road over a given length. Rates expressed in this way are largely influenced by the number of vehicles using a particular road section, given the positive correlation between fatal and serious crashes with traffic flow.

## *4.2 Risk bandings*

In order to show the varying levels of risk across network, individual sections are allocated into five colour coded risk bandings (Figure 2). The standardization of colours provides an internationally recognized system allowing comparisons across borders.




**Figure 2. Colour coded risk bandings**

## 4.3 Types of Crash Risk Mapping

### 4.3.1 Crash risk per vehicle km travelled – Individual risk

Aimed to individual road users, this map shows the risk to individual road users of being involved in fatal or serious crash while using a specific road length. It is useful in showing how and where behaviour needs to be modified to minimise risk. Basis of rating is risk rate expressed as fatal and serious injury crashes per billion vehicle km.

### 4.3.2 Crash density – Collective risk

Shows the actual observed number of crashes per unit length and therefore where the highest and lowest numbers of crashes occur on the network. Basis of rating is risk rate expressed as the number of fatal and serious injury crashes per km per year

### 4.3.3 Crash risk by road type –Collective risk

Risk rates related to group averages highlight road sections with higher or lower crash rates after the expected variability between different road groups are taken into account. Basis of rating is risk rate expressed as fatal and serious injury crashes per billion vehicle km, relative to the average rate of roads with a similar traffic flow.

### 4.3.4 Potential accident savings – Collective risk

Indicate the magnitude of opportunity to reduce crashes. Used with cost information, this map can indicate locations where the largest return on investment can be expected.

## *4.4 Risk Mapping results*

### 4.4.1 MAP 1 Crash risk per kilometre travelled

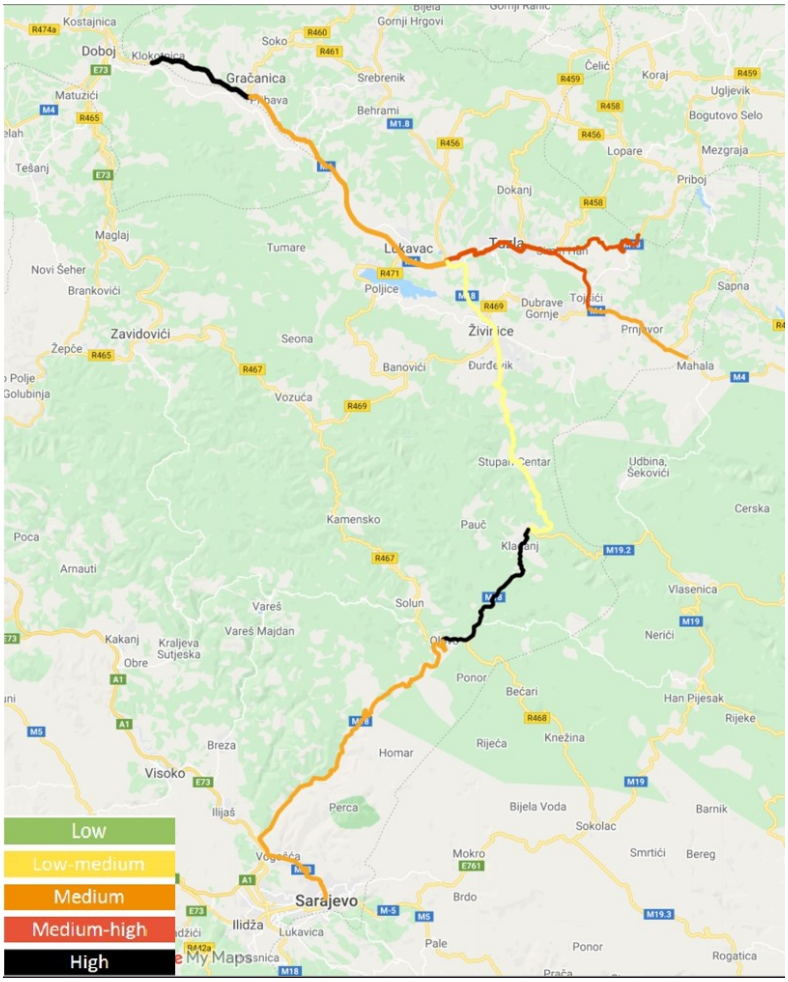



**Figure 3** **Individual crash risk per km travelled**

| Road No. | Description of section's start and end points | RRM results (map 1) |
|---|---|---|
| M4/M18 | ŠIĆKI BROD - SIMIN HAN | Medium-high risk |
| M4 | DOBOJ(raskršće RS) - JOHOVAC | High risk |
| M4 | JOHOVAC - LUKAVAC | Medium risk |
| M4 | LUKAVAC - ŠIĆKI BROD | Medium risk |
| M4 | SIMIN HAN - MEĐAŠ | Medium-high risk |
| M4 | MEĐAŠ - (DR.rs) CEPARDE | Medium risk |
| M18 | PRIBOJ (gr. RS) - SIMIN HAN | Medium-high risk |
| M18 | ŠIĆKI BROD - ŽIVINICE | Low-medium risk |
| M18 | ŽIVINICE - VITALJ | Low-medium risk |
| M18 | VITALJ - (granica ZDK) BJELIŠ | High risk |
| M18 | OLOVO (gr. ZDK) - SEMIZOVAC | Medium risk |
| M18 | SEMIZOVAC - SARAJEVO | Medium risk |

**Table 2** **Individual crash risk per km travelled**

### 4.4.2 MAP 2 Crash density

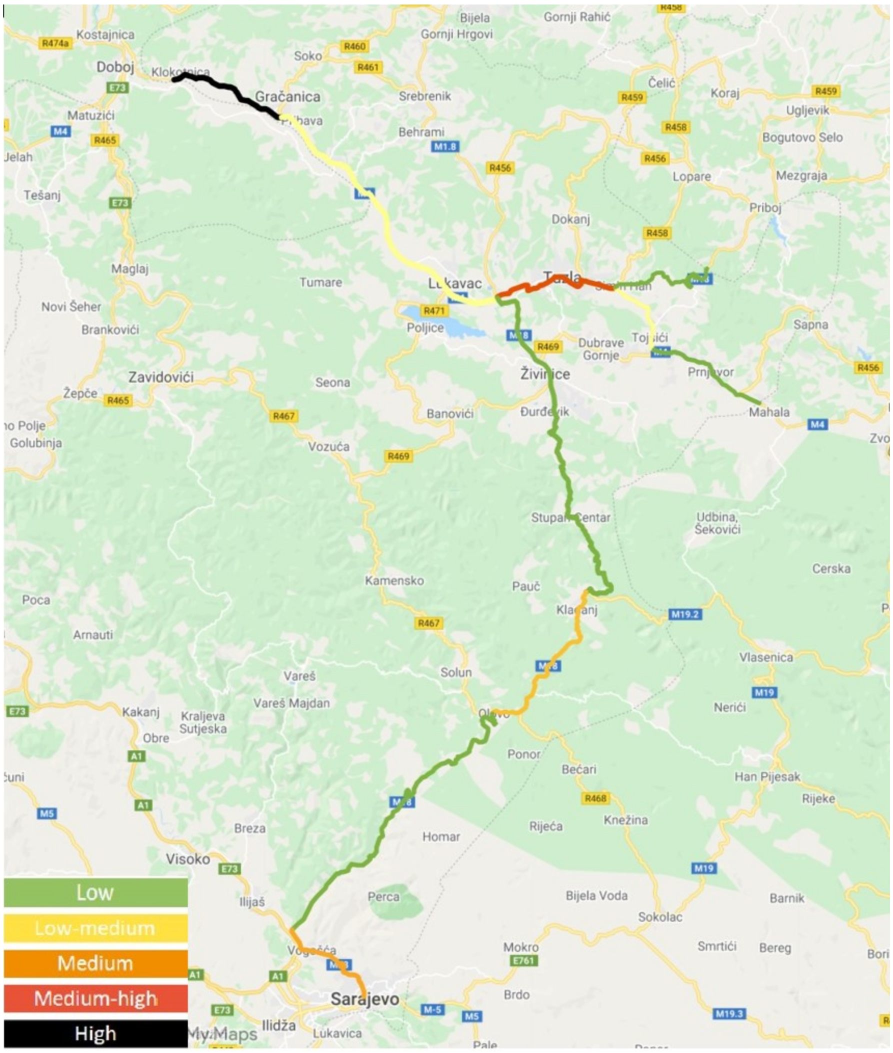



**Figure 4** **Crash density – Collective risk**

| Road No. | Description of section's start and end points | RRM results (map 2) |
|---|---|---|
| M4/M18 | ŠIĆKI BROD - SIMIN HAN | Medium-high risk |
| M4 | DOBOJ(raskršće RS) - JOHOVAC | High risk |
| M4 | JOHOVAC - LUKAVAC | Low-medium risk |
| M4 | LUKAVAC - ŠIĆKI BROD | Low-medium risk |
| M4 | SIMIN HAN - MEĐAŠ | Low-medium risk |
| M4 | MEĐAŠ - (DR.rs) CEPARDE | Low risk |
| M18 | PRIBOJ (gr. RS) - SIMIN HAN | Low risk |
| M18 | ŠIĆKI BROD - ŽIVINICE | Low risk |
| M18 | ŽIVINICE - VITALJ | Low risk |
| M18 | VITALJ - (granica ZDK) BJELIŠ | Medium risk |
| M18 | OLOVO (gr. ZDK) - SEMIZOVAC | Low risk |
| M18 | SEMIZOVAC - SARAJEVO | Medium risk |

**Table 3** **Crash density – Collective risk**

### 4.4.3 MAP 3 Crash risk by road type

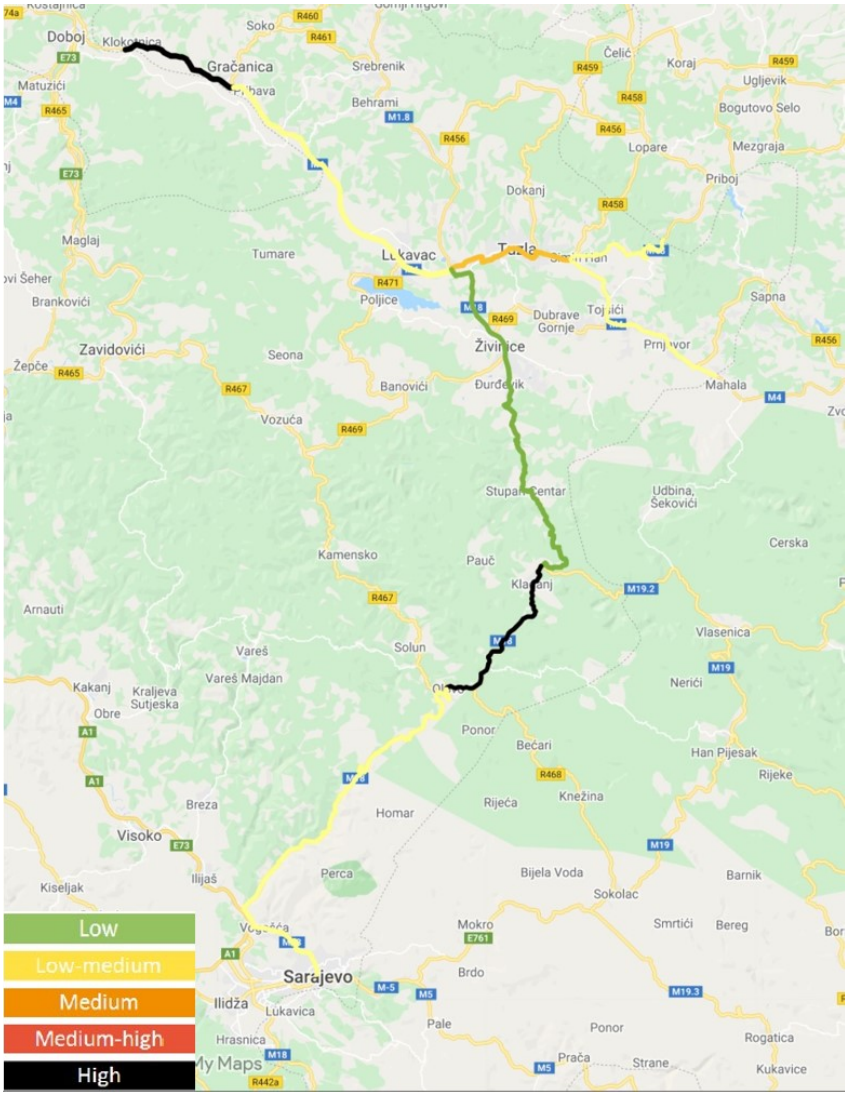



**Figure 5 Crash risk by road type**

| Road No. | Description of section's start and end points | RRM results (map 3) |
|---|---|---|
| M4/M18 | ŠIĆKI BROD - SIMIN HAN | Medium risk |
| M4 | DOBOJ(raskršće RS) - JOHOVAC | High risk |
| M4 | JOHOVAC - LUKAVAC | Low-medium risk |
| M4 | LUKAVAC - ŠIĆKI BROD | Low-medium risk |
| M4 | SIMIN HAN - MEĐAŠ | Low-medium risk |
| M4 | MEĐAŠ - (DR.rs) CEPARDE | Low-medium risk |
| M18 | PRIBOJ (gr. RS) - SIMIN HAN | Low-medium risk |
| M18 | ŠIĆKI BROD - ŽIVINICE | Low risk |
| M18 | ŽIVINICE - VITALJ | Low risk |
| M18 | VITALJ - (granica ZDK) BJELIŠ | High risk |
| M18 | OLOVO (gr. ZDK) - SEMIZOVAC | Low-medium risk |
| M18 | SEMIZOVAC - SARAJEVO | Low-medium risk |

**Table 4 Crash risk by road type**

### 4.4.4 MAP 4 Potential accident savings

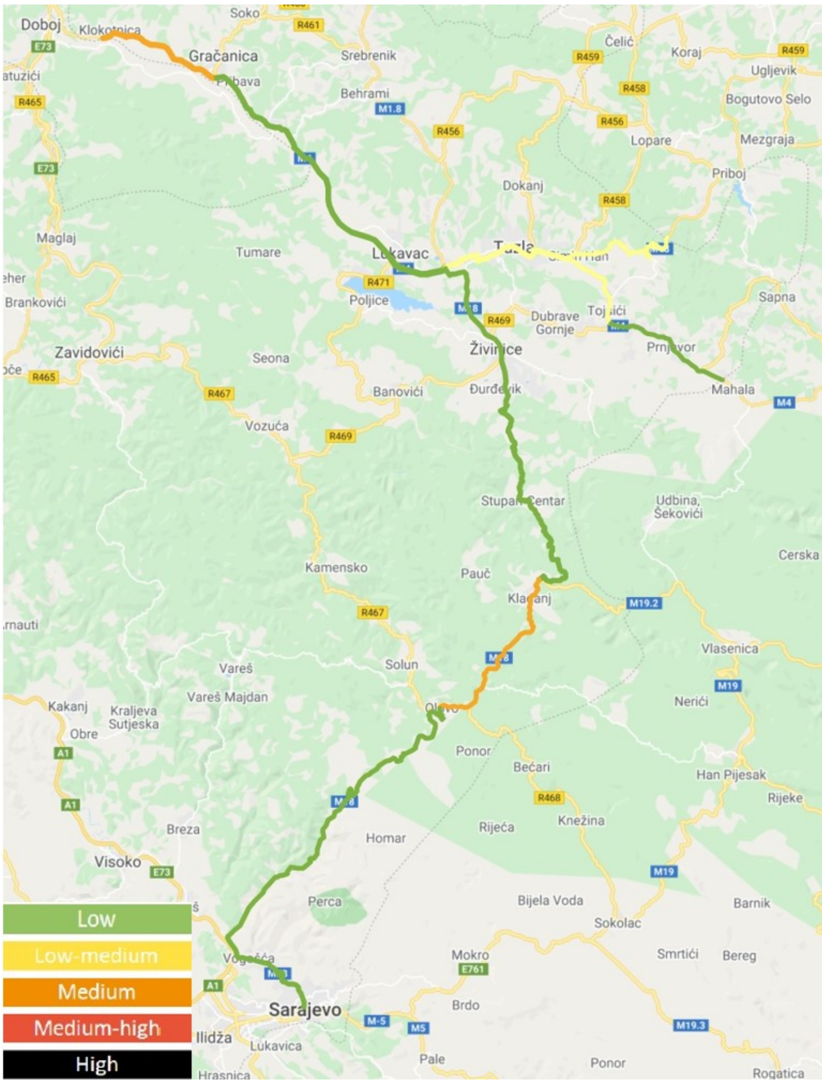



**Figure 6 Potential crash savings**

| Road No. | Description of section's start and end points | RRM results (map 4) |
|---|---|---|
| M4/M18 | ŠIĆKI BROD - SIMIN HAN | Low-medium potential |
| M4 | DOBOJ(raskršće RS) - JOHOVAC | Medium potential |
| M4 | JOHOVAC - LUKAVAC | Low potential |
| M4 | LUKAVAC - ŠIĆKI BROD | Low potential |
| M4 | SIMIN HAN - MEĐAŠ | Low-medium potential |
| M4 | MEĐAŠ - (DR.rs) CEPARDE | Low potential |
| M18 | PRIBOJ (gr. RS) - SIMIN HAN | Low-medium potential |
| M18 | ŠIĆKI BROD - ŽIVINICE | Low potential |
| M18 | ŽIVINICE - VITALJ | Low potential |
| M18 | VITALJ - (granica ZDK) BJELIŠ | Medium potential |
| M18 | OLOVO (gr. ZDK) - SEMIZOVAC | Low potential |
| M18 | SEMIZOVAC - SARAJEVO | Low potential |

**Table 5 Potential crash savings**

# 5.Data Collection

## 5.1Road Survey

**Figure 7 The survey vehicle**

The survey was carried out using the CAMSS digital imaging system with three high resolution cameras (1280 x 960 pixels), manufactured by the AMSS-CMV. Together, the three cameras recorded a panoramic view of the road and roadside verges in front of the vehicle. The image was sufficiently wide to identify intersections, roadside usage and also roadside hazards. These images were collected every 10 meters of travel.

The cameras were also calibrated to allow the measurement of particular features of the road, such as lane and shoulder widths and distance to roadside hazards which are important components in the safety assessment of the road.

## 5.2 Coding the data

After the completion of the road inspection phase, the process of coding of video material took place. The coding of the roads was undertaken by the AMSS-CMV.

The coding of the recorded video material was carried out on the basis of the iRAP Star Rating Coding Manual. The coding staff used the coding software to rate road infrastructure features at 100 meter intervals along the road.

The features coded by the team include:

1. Carriageway label
2. Upgrade cost
3. Motorcycle flow observed
4. Bicycle flow observed
5. Pedestrian flow observed across the road
6. Pedestrian flow observed along the road
7. Land use
8. Area type
9. Speed limits
10. Median type
11. Roadside severity – objects
12. Roadside severity – distance
13. Paved shoulder
14. Intersection type, quality and volume
15. Property access points
16. Number of lanes
17. Lane width
18. Curvature
19. Quality of curve
20. Grade
21. Road condition
22. Skid resistance/grip
23. Delineation
24. Street lighting
25. Pedestrian crossing facilities, quality
26. Speed management/traffic calming
27. Vehicle parking
28. Sidewalk provision
29. Facilities for motorcycles
30. Facilities for bicycles

More details on the features coded are available in the *iRAP Inspection Manual*

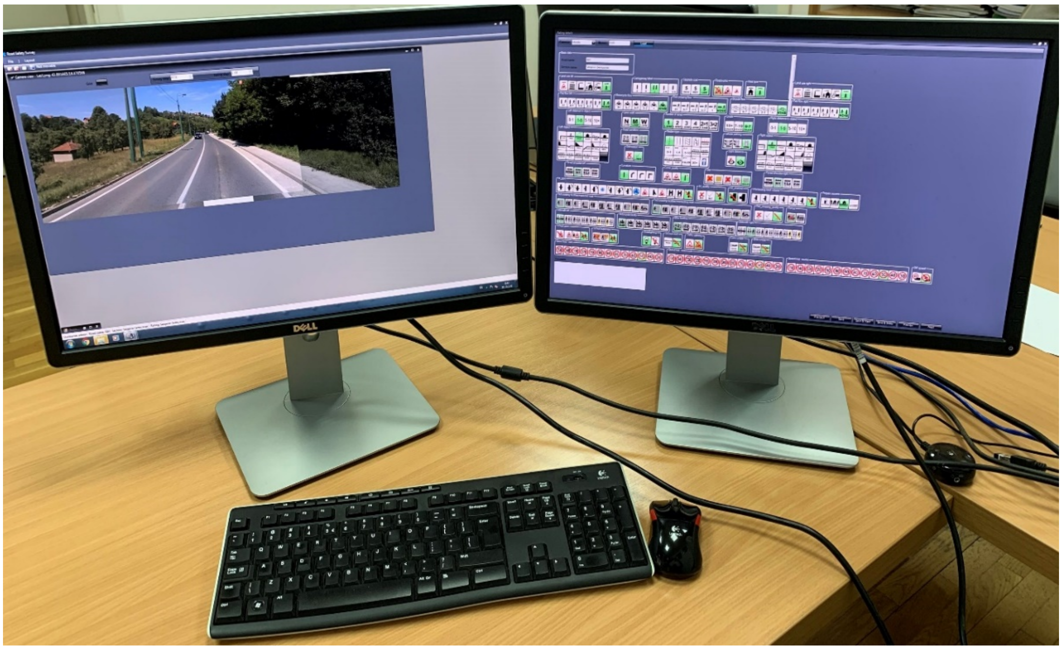


**Figure 8** **Coding software**

## 5.3 Traffic volumes

Traffic volume data are used in the iRAP model as a multiplier for the estimation of the number of deaths and serious injuries that could be prevented on the roads.



Traffic volume data have been provided by the BIHAMK staff.

Following the results of the traffic flow data collection, the sections identified as having the highest traffic volumes are shown in Table 6.

**Table 6** **Sections having the highest traffic volumes**

| Section | AADT(V) |
|---|---|
| M18 Sarajevio - Semizovac | 20,010 |
| M18/M4 Šićki Brod – Simin Han | 19,731 |
| M18 Živinice – Šićki Brod | 15,366 |

Traffic flow data for all sections can be found in Appendix 1.

## 5.4 Pedestrian and bicycle volume

The ViDA (iRAP online software) model also requires the inputs on four types of flows for each 100m section of the surveyed network:

- Pedestrian peak hour flow across the road
- Pedestrian peak hour flow along the driver-side
- Pedestrian peak hour flow along the passenger-side

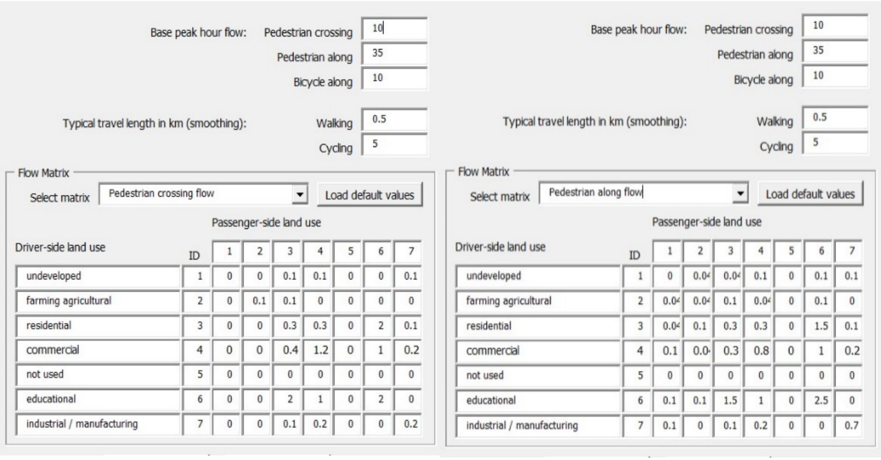
- Bicyclist peak hour flow along the road

These types of data are difficult to obtain as there are no relevant measurements. To overcome this issue, appropriate estimations were made. The estimations of the flows of pedestrians and bicyclists based on the coded attributes such as Land use, Area type, Pedestrian crossing facilities, Sidewalk provision, etc.

In addition, number of conditions was applied to better estimate the real pedestrian and bicyclist flows. In particular:

- In sections where pedestrians/bicyclists were observed, the minimum base flow multiplier was set to 1. Where more than 8 pedestrians/bicyclists were observed, the minimum base flow multiplier was set to 1.5.
- On dual carriageway roads with a median barrier (without pedestrian crossing facility) the pedestrian crossing flow was set to 0.
- Where pedestrian crossing facility is present, the minimum base flow was set to 1, and the pedestrian crossing flow is multiplied by 1.5.
- Where an intersection is present, the base pedestrian crossing flow is multiplied by 1.25.
- It is assumed that pedestrians do not walk in medians on dual carriageway roads.
- Where a sidewalk facility is present, the minimum pedestrian base flow multiplier along the road is set to 1.
- Where vehicles park either on one or both sides of the road (including bus stops), the minimum pedestrian base flow multiplier is set to 1.
- In all rural areas, the values are multiplied by 0.1 for the passengers along, and bicyclists along flows. The pedestrian crossing flow is multiplied by 0.2.
- On rural dual carriageway roads all flows are set to 0.

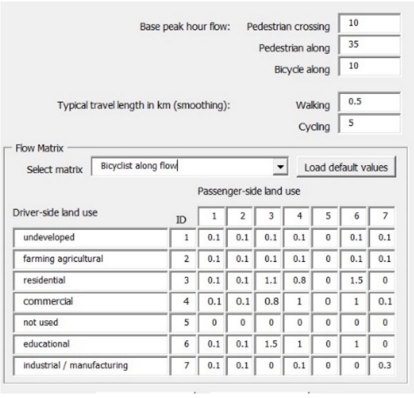
The basic flows and the multiplier matrix for various land use along the road are displayed in the following Figures.




| Driver-side land use | ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| undeveloped | 1 | 0 | 0 | 0.1 | 0.1 | 0 | 0 | 0.1 |
| farming agricultural | 2 | 0 | 0.1 | 0.1 | 0 | 0 | 0 | 0 |
| residential | 3 | 0 | 0 | 0.3 | 0.3 | 0 | 2 | 0.1 |
| commercial | 4 | 0 | 0 | 0.4 | 1.2 | 0 | 1 | 0.2 |
| not used | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| educational | 6 | 0 | 0 | 2 | 1 | 0 | 2 | 0 |
| industrial / manufacturing | 7 | 0 | 0 | 0.1 | 0.2 | 0 | 0 | 0.2 |

| Driver-side land use | ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| undeveloped | 1 | 0 | 0.04 | 0.04 | 0.1 | 0 | 0.1 | 0.1 |
| farming agricultural | 2 | 0.04 | 0.04 | 0.1 | 0.04 | 0 | 0.1 | 0 |
| residential | 3 | 0.04 | 0.1 | 0.3 | 0.3 | 0 | 1.5 | 0.1 |
| commercial | 4 | 0.1 | 0.04 | 0.3 | 0.8 | 0 | 1 | 0.2 |
| not used | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| educational | 6 | 0.1 | 0.1 | 1.5 | 1 | 0 | 2.5 | 0 |
| industrial / manufacturing | 7 | 0.1 | 0 | 0.1 | 0.2 | 0 | 0 | 0.7 |

*Figure 9 – Basic pedestrian flows*




| Driver-side land use | ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| undeveloped | 1 | 0.1 | 0.1 | 0.1 | 0.1 | 0 | 0.1 | 0.1 |
| farming agricultural | 2 | 0.1 | 0.1 | 0.1 | 0.1 | 0 | 0.1 | 0.1 |
| residential | 3 | 0.1 | 0.1 | 1.1 | 0.8 | 0 | 1.5 | 0 |
| commercial | 4 | 0.1 | 0.1 | 0.8 | 1 | 0 | 1 | 0.1 |
| not used | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| educational | 6 | 0.1 | 0.1 | 1.5 | 1 | 0 | 1 | 0 |
| industrial / manufacturing | 7 | 0.1 | 0.1 | 0 | 0.1 | 0 | 0 | 0.3 |

*Figure 10 – Basic bicyclists' flows*

## 5.5 Operating speed

The level of risk of death or serious injury on a road section is highly dependent on the speed at which the traffic travels. The RAP method indicates that risk assessments must be performed using the 'operating speed' on the road. Operating sped is defined as being the greater of the legislated speed limit or the measured 85$^{th}$ percentile speed. The operating speed is one of 52 variables used in generating the Star Rating.

Speed data are not usually available for every individual road or section at frequent intervals and in absence of detailed information, it is necessary to make assumptions about general speeds over the network based on the available data and local knowledge. Many EuroRAP and iRAP speed surveys have found that it is not uncommon for 85$^{th}$ percentile speeds to exceed the speed limit by about 10 km/h over a range of speeds.

## 5.6 Crash data

The crash number as well as, the number of fatalities and serious injuries for all roads are used to support the countermeasure selection and economic analysis.

In consultation with BIHAMK and relating traffic crash data for surveyed road network for the year 2016 to 2018,it was estimated that an average of 22 deaths per annum occur on the surveyed network, distributed as shown below.

**Table 7** **Road accident fatalities on surveyed network**

| | 2016 | 2017 | 2018 |
|---|---|---|---|
| Total deaths in road accidents | 12 | 18 | 8 |

**Table 8** **Number of fatalities on the surveyed road network**

| | |
|---|---|
| Survey length | 228 km |
| Total number of deaths | 38 |



**Table 9** **Distribution of deaths by road user type (per year, on the surveyed network)**

| Road user type | No. of deaths | % |
|---|---|---|
| Vehicles Occupants | 15 | 68 |
| Motorcyclists | 2.42 | 11 |
| Pedestrians | 4.19 | 19 |
| Bicycles | 0.44 | 2 |

**Table 10 Distribution of deaths by crash type (per year, on the surveyed network)**

| Vehicles Occupant crash type % | | Totals |
|---|---|---|
| Car Run-Off LOC Driver side | 19 % | 2.85 |
| Car Run-Off LOC Passenger side | 25 % | 3.75 |
| Car Head-On LOC | 6% | 0.9 |
| Car Head- On Overtaking | 11 % | 1.65 |
| Car Intersection | 33% | 4.95 |
| Car Property Access | 6 % | 0.9 |
| | 100% | 15 |

| Pedestrian crash type % | | Totals |
|---|---|---|
| Pedestrian Along | 30 % | 1.26 |
| Pedestrian Crossing Side-Road | 35 % | 1.47 |
| Pedestrian Crossing Through-Road | 35 % | 1.47 |
| | 100 % | 4.2 |



| Bicycle crash type % | | Totals |
|---|---|---|
| Bicycle Along | 34 % | 0.15 |
| Bicycle Intersection | 33% | 0.15 |
| Bicycle Run–Off | 33 % | 0.15 |
| | 100 % | 0.45 |

| Motorcycle crash type % | | Totals |
|---|---|---|
| Motorcycle Run-Off LOC Driver side | 19 % | 0.45 |
| Motorcycle Run-Off LOC Passenger side | 25 % | 0.61 |
| Motorcycle Head-On LOC | 6 % | 0.15 |
| Motorcycle Head- On Overtaking | 11 % | 0.27 |
| Motorcycle Intersection | 33 % | 0.8 |
| Motorcycle Property Access | 5 % | 0.12 |
| Motorcycle along | 1 % | 0.024 |
| | 100 % | 2.42 |

The following tables contain the number of fatalities calibration that are needed and used to support the selection of countermeasures, economic analysis, and the predicted casualty reduction plan, over 20 years.



**Table 11 Fatality estimations – Car occupants, pedestrians, bicyclists**

Fatality estimation – Car

| Variable | Calibration factor | AADT Multiplier | AADT Power |
|---|---|---|---|
| Car Run-Off LOC Driver side | 2.04 | 1 | 1 |
| Car Run-Off LOC Passenger side | 2.76 | 1 | 1 |
| Car Head-On LOC | 0.83 | 1 | 1 |
| Car Head- On Overtaking | 12.33 | 1 | 1 |
| Car Intersection | 20.18 | 1 | 1 |
| Car Property Access | 35.67 | 1 | 1 |

Fatality estimation – Pedestrian

| Variable | Calibration factor | AADT Multiplier | AADT Power |
|---|---|---|---|
| Pedestrian Along | 0.06 | 1 | 1 |
| Pedestrian Crossing Side-Road | 9.54 | 1 | 1 |
| Pedestrian Crossing Through-Road | 0.56 | 1 | 1 |

Fatality estimation – Bicycle

| Variable | Calibration factor | AADT Multiplier | AADT Power |
|---|---|---|---|
| Bicycle Along | 0.01 | 1 | 1 |
| Bicycle Intersection | 1 | 1 | 1 |
| Bicycle Run - Off | 10.36 | 1 | 1 |

## *5.7 Countermeasure cost*



The iRAP model requires inputs concerning local construction and maintenance costs for the 70 potential countermeasures that are considered when developing the Safer Roads Investment Plans. The costs are categorised by area type (urban, semi-urban and rural) and upper and lower costs (low, medium and high). The costs will enable the determination of the benefit-cost ratio of each proposed countermeasure.

## 5.8 Economic data

RAP uses a standard approach globally to estimate the economic cost of deaths and serious injuries. The economic data were collected from the IMF and other websites in the prescribed manner.

**Table 12** **Economic data**

| Category | Units / Description | Data |
|---|---|---|
| Current year | | 2020 |
| Assessment Year | Year in which the analysis was carried out. | 2020 |
| Side of the road driven on | Left or right | right |
| Analysis period | Years - default 20 years | 20 |
| GDP per capita | In local currency (current prices) | 9,536 |
| Discount rate (%) | % | 5 |
| Minimum attractive Rate of Return | Discount Rate / 100 or user defined | 0.05 |
| Internal Rate of Return | % | 0.12 |
| Value of Life Multiplier | Default 70 | 70 |
| Value of Life | In local currency – Official National Figure or (GDP per capita * Value of Life Multiplier) | 667,520 |
| Value of Serious Injury Multiplier | Default 0.25 | 0.25 |
| Value of Serious Injury | In local currency – Official National Figure or (Value of Life x Value of Serious Injury Multiplier) | 166,880 |
| Serious injuries to fatalities ratio | | 12 |

# 6. Detailed Road Condition Report

A detailed condition report is a constituent part of any road assessment survey and report and is therefore important for all the stakeholders. The attributes obtained on the basis of survey data are listed in Table 13.

**Table 13** **Detailed information about the road**

Roadside

| Roadside severity-driver side distance | km | % |
|---|---|---|
| 0 to < 1m | 91.5 | 40 |
| 1 to < 5m | 129.5 | 57 |
| 5 to < 10m | 6.4 | 3 |
| >= 10m | 0.4 | 0 |

| Roadside severity-driver side object | km | % |
|---|---|---|
| Safety barrier – metal | 10.6 | 5 |
| Safety barrier –concrete | 0.5 | 0 |
| Aggressive vertical face | 17.6 | 8 |
| Upwards slope – rollover gradient | 18.3 | 8 |
| Upwards slope – no rollover gradient | 0.9 | 0 |
| Deep drainage ditch | 21.9 | 10 |
| Downwards slope | 9.6 | 4 |
| Tree>= 10cm dia. | 31.4 | 14 |
| Sign, post or pole >= 10cm dia. | 48.3 | 21 |
| Rigid structure/bridge or building | 15.9 | 7 |
| Semi-rigid structure or building | 10.3 | 5 |
| Unprotected safety barrier end | 41.4 | 18 |
| Large boulders>= 20cm high | 1 | 0 |
| None | 0.1 | 0 |

| Roadside severity-passenger side distance | km | % |
|---|---|---|
| 0 to < 1m | 79.9 | 35 |
| 1 to < 5m | 136.9 | 60 |
| 5 to < 10m | 10.4 | 5 |
| >= 10m | 0.6 | 0 |

| Roadside severity- passenger side object | km | % |
|---|---|---|
| Safety barrier - metal | 13.1 | 6 |
| Safety barrier –concrete | 0.7 | 0 |
| Aggressive vertical face | 10 | 4 |
| Upwards slope – rollover gradient | 10.3 | 5 |
| Upwards slope – no rollover gradient | 0.4 | 0 |
| Deep drainage ditch | 14.6 | 6 |
| Downwards slope | 16.4 | 7 |
| Cliff | 0.1 | 0 |
| Tree>= 10cm dia. | 31.8 | 14 |
| Sign, post or pole >= 10cm dia. | 49.8 | 22 |
| Rigid structure/bridge or building | 12.3 | 5 |
| Semi-rigid structure or building | 14.2 | 6 |
| Unprotected safety barrier end | 52 | 23 |
| Large boulders>= 20cm high | 2 | 1 |
| None | 0.1 | 0 |
| **Shoulder rumble strips** | km | % |
| Not present | 227.8 | 100 |



| Paved shoulder – driver side | km | % |
|---|---|---|
| Narrow (>=0m to <1m) | 212 | 93 |
| None | 15.8 | 7 |

| Paved shoulder – passenger side | km | % |
|---|---|---|
| Narrow (>=0m to <1m) | 212 | 93 |
| None | 15.8 | 7 |

Mid-block

| Carriageway label | km | % |
|---|---|---|
| Carriageway A of a divided carriageway road | 9.3 | 4 |
| Carriageway B of a divided carriageway road | 9.2 | 4 |
| Undivided road | 209.3 | 92 |

| Upgrade cost | km | % |
|---|---|---|
| Low | 70.9 | 31 |
| Medium | 63.8 | 28 |
| High | 93.1 | 41 |

| Median type | km | % |
|---|---|---|
| Safety barrier - metal | 6 | 3 |
| Physical median width>= 1m to <5m | 12.5 | 5 |
| Physical median width>= 0m to <1m | 0.2 | 0 |
| Centre line | 207.5 | 91 |
| One way | 1.1 | 0 |
| Wide centre line (0.3m to 1m) | 0.5 | 0 |



| Centre line rumble strips | km | % |
|---|---|---|
| Not present | 227.8 | 100 |

| Number of lanes | km | % |
|---|---|---|
| One | 202.8 | 89 |
| Two | 18.9 | 8 |
| Three | 2.5 | 1 |
| Two and one | 3.6 | 2 |

| **Lane width** | km | % |
|---|---|---|
| Wide (>=3.25m) | 58.1 | 26 |
| Medium (>=2.75m to <3.25m) | 169.1 | 74 |
| Narrow (>=0m to <2.75m) | 0.6 | 0 |

| **Curvature** | km | % |
|---|---|---|
| Straight or gently curving | 163.6 | 72 |
| Moderate | 52 | 23 |
| Sharp | 12 | 5 |
| Very sharp | 0.2 | 0 |

| **Quality of curve** | **km** | **%** |
|---|---|---|
| Adequate | 45.8 | 20 |
| Poor | 18.4 | 8 |
| Not applicable | 163.6 | 72 |



| **Grade** | km | % |
|---|---|---|
| >= 0% to < 7.5% | 219.4 | 96 |
| >= 7.5% to < 10% | 8.4 | 4 |

| **Road condition** | km | % |
|---|---|---|
| Good | 225.8 | 99 |
| Medium | 1.4 | 1 |
| Poor | 0.6 | 0 |

| **Skid resistance / grip** | km | % |
|---|---|---|
| Sealed - adequate | 227.8 | 100 |

| Delineation | km | % |
|---|---|---|
| Adequate | 182.5 | 80 |
| Poor | 45.3 | 20 |

| Street lighting | km | % |
|---|---|---|
| Not present | 153.4 | 67 |
| Present | 74.4 | 33 |

| Vehicle parking | km | % |
|---|---|---|
| None | 215.3 | 95 |
| One side | 10.5 | 5 |
| Two sides | 2 | 1 |

| Service road | km | % |
|---|---|---|
| Not present | 226.8 | 100 |
| Present | 1 | 0 |



| Road works | km | % |
|---|---|---|
| No road works | 226 | 99 |
| Minor road works in progress | 1 | 0 |
| Major road works in progress | 0.8 | 0 |
| **Sight distance** | km | % |
| Adequate | 227.8 | 100 |

Intersections

| Intersection type | km | % |
|---|---|---|
| Merge lane | 1 | 0 |
| Roundabout | 0.5 | 0 |
| 3-leg (unsignalised) with protected turn lane | 3.3 | 1 |
| 3-leg (unsignalised) with no protected turn lane | 16.7 | 7 |
| 3-leg (signalised) with protected turn lane | 1.6 | 1 |

| | | |
|---|---|---|
| 3-leg (signalised) with no protected turn lane | 0.5 | 0 |
| 4-leg (unsignalised) with protected turn lane | 1.2 | 1 |
| 4-leg (unsignalised) with no protected turn lane | 2.2 | 1 |
| 4-leg (signalised) with protected turn lane | 1.7 | 1 |
| 4-leg (signalised) with no protected turn lane | 0.3 | 0 |
| None | 198.5 | 87 |
| Railway Crossing – active (flashing lights / boom gates) | 0.3 | 0 |

| **Intersection channel station** | km | % |
|---|---|---|
| Not present | 224 | 98 |
| Present | 3.8 | 2 |

| **Intersection road volume** | km | % |
|---|---|---|
| 10000 to 15000 vehicles | 0.2 | 0 |
| 5000 to 10000 vehicles | 0.2 | 0 |
| 1000 to 5000 vehicles | 4.1 | 2 |
| 100 to 1000 vehicles | 10.8 | 5 |
| 1 to 100 vehicles | 14 | 6 |
| None | 198.5 | 87 |
| **Intersection quality** | km | % |
| Adequate | 13.3 | 6 |
| Poor | 16 | 7 |
| Not applicable | 198.5 | 87 |

| **Property access points** | km | % |
|---|---|---|
| Commercial Access 1+ | 34.1 | 15 |
| Residential Access 3+ | 47.2 | 21 |
| Residential Access 1 or 2 | 45.6 | 20 |
| None | 100.9 | 44 |

Flow

| Vehicle flow (AADT) | km | % |
|---|---|---|
| 1000 – 5000 | 36.6 | 16 |
| 5000 - 10000 | 69.9 | 31 |
| 10000 - 15000 | 70.6 | 31 |
| 15000 - 20000 | 37.9 | 17 |
| 20000 - 40000 | 12.8 | 6 |

| Motorcyclist observed flow | km | % |
|---|---|---|
| None | 226.4 | 99 |
| 1 motorcyclist observed | 1.4 | 1 |

| Bicyclist observed flow | km | % |
|---|---|---|
| None | 225.4 | 99 |
| 1 bicycle observed | 1.9 | 1 |
| 2 to 3 bicycle observed | 0.4 | 0 |
| 4 to 5 bicycle observed | 0.1 | 0 |

| Pedestrian observed flow across the road | km | % |
|---|---|---|
| None | 225.2 | 99 |
| 1 pedestrian crossing observed | 1.5 | 1 |
| 2 to 3 pedestrians crossing observed | 0.9 | 0 |
| 4 to 5 pedestrians crossing observed | 0.2 | 0 |

| **Pedestrian observed flow along road driver - side** | km | % |
|---|---|---|
| None | 221.5 | 97 |
| 1 pedestrian along driver – side observed | 3.9 | 2 |
| 2 to 3 pedestrians along driver – side observed | 1.4 | 1 |
| 4 to 5 pedestrians along driver – side observed | 0.5 | 0 |
| 6 to 7pedestrians along driver – side observed | 0.2 | 0 |
| 8+pedestrians along driver – side observed | 0.3 | 0 |

| **Pedestrian observed flow along road passenger - side** | km | % |
|---|---|---|
| None | 215 | 94 |
| 1pedestrian along passenger – side observed | 6.9 | 3 |
| 2 to 3 pedestrians along passenger – side observed | 3.6 | 2 |
| 4 to 5 pedestrians along passenger – side observed | 1.5 | 1 |
| 6 to 7pedestrians along passenger – side observed | 0.4 | 0 |
| 8+pedestriansalongpassenger – side observed | 0.4 | 0 |



| **Motorcyclist %** | km | % |
|---|---|---|
| 1% - 5% | 227.8 | 100 |

| **Pedestrian peak hour flow across the road** | km | % |
|---|---|---|
| 0 | 131.2 | 58 |
| 1 to 5 | 76.1 | 33 |
| 6 to 25 | 12.3 | 5 |
| 26 to 50 | 8.2 | 4 |

| **Pedestrian peak hour flow along the road driver - side** | km | % |
|---|---|---|
| 0 | 35.7 | 16 |
| 1 to 5 | 42.2 | 19 |
| 6 to 25 | 57.1 | 25 |
| 26 to 50 | 92.5 | 41 |

| Pedestrian peak hour flow along the road passenger - side | km | % |
|---|---|---|
| 0 | 31.8 | 14 |
| 1 to 5 | 41.3 | 18 |
| 6 to 25 | 60.9 | 27 |
| 26 to 50 | 93.8 | 41 |

| Bicyclist peak hour flow | km | % |
|---|---|---|
| 1 to 5 | 9 | 4 |
| 6 to 25 | 218.8 | 96 |

VRU facilities and land use

| Land use - driver side | km | % |
|---|---|---|
| Undeveloped areas | 147.7 | 65 |
| Residential | 57.8 | 25 |
| Commercial | 19.2 | 8 |
| Educational | 0.9 | 0 |
| Industrial land manufacturing | 2.2 | 1 |



| Land use – passenger side | km | % |
|---|---|---|
| Undeveloped areas | 129.3 | 57 |
| Framing and agricultural | 0.1 | 0 |
| Residential | 64.3 | 28 |
| Commercial | 28.2 | 12 |
| Educational | 3 | 1 |
| Industrial and manufacturing | 2.9 | 1 |

| Area type | km | % |
|---|---|---|
| Rural / open areas | 201 | 88 |
| Urban / rural town or village | 26.8 | 12 |
| **Pedestrian crossing facilities – inspected road** | km | % |
| Grade separated facility | 0.4 | 0 |
| Signalised with refuge | 2 | 1 |
| Signalised without refuge | 1.7 | 1 |
| Unsignalised marked crossing with refuge | 2.2 | 1 |
| Unsignalised marked crossing without a refuge | 7.6 | 3 |
| No facility | 213.7 | 94 |
| Raised marked crossing without refuge | 0.2 | 0 |

| Pedestrian crossing quality | km | % |
|---|---|---|
| Adequate | 9.1 | 4 |
| Poor | 5.3 | 2 |
| Not applicable | 213.4 | 94 |



| Pedestrian crossing facilities – intersecting road | km | % |
|---|---|---|
| Signalised with refuge | 1.5 | 1 |
| Signalised without refuge | 2 | 1 |
| Unsignalised marked crossing without a refuge | 1.2 | 1 |
| No facility | 223.1 | 98 |

| Pedestrian fencing | km | % |
|---|---|---|
| Not present | 227.8 | 100 |

| Sidewalk – driver side | km | % |
|---|---|---|
| Non-physical separation>= 3m | 1.2 | 1 |
| Non-physical separation 1m to < 3m | 5.7 | 3 |
| Non-physical separation 0m to < 1m | 19.1 | 8 |
| None | 191.4 | 84 |
| Informalpath0m to <1m | 10.4 | 5 |

| Sidewalk – passenger side | km | % |
|---|---|---|
| Physical barrier | 0.6 | 0 |
| Non-physical separation>= 3m | 1.9 | 1 |
| Non-physical separation 1m to < 3m | 4.5 | 2 |
| Non-physical separation 0m to < 1m | 31.1 | 14 |
| None | 173.7 | 76 |
| Informal path>= 1m | 0.2 | 0 |
| Informal path 0m to < 1m | 15.8 | 7 |



| Facilities for motorised two wheelers | km | % |
|---|---|---|
| None | 227.8 | 100 |

| Facilities for bicycles | km | % |
|---|---|---|
| Off road path | 0.9 | 0 |
| None | 234.4 | 100 |

| School zone warning | km | % |
|---|---|---|
| School zone static signs or road markings | 3.3 | 1 |
| No school zone warning | 2.5 | 1 |
| Not applicable (no school at the location) | 222.2 | 98 |

| **School zone crossing supervisor** | km | % |
|---|---|---|
| School zone crossing supervisor not present | 3.8 | 2 |
| Not applicable (no school at the location) | 224 | 98 |

Speeds

| **Speed limit** | km | % |
|---|---|---|
| < 30 km/h | 1.7 | 1 |
| 40 km/h | 9.3 | 4 |
| 50 km/h | 101.3 | 44 |
| 60 km/h | 64.8 | 28 |
| 70 km/h | 39.2 | 17 |
| 80 km/h | 11.5 | 5 |

| **Motorcyclist speed limit** | km | % |
|---|---|---|
| < 30 km/h | 1.7 | 1 |
| 40 km/h | 9.3 | 4 |
| 50 km/h | 101.3 | 44 |
| 60 km/h | 64.8 | 28 |
| 70 km/h | 39.2 | 17 |
| 80 km/h | 11.5 | 5 |

| **Truck speed limit** | km | % |
|---|---|---|
| < 30 km/h | 1.7 | 1 |
| 40 km/h | 9.3 | 4 |
| 50 km/h | 101.3 | 44 |
| 60 km/h | 64.8 | 28 |
| 70 km/h | 39.2 | 17 |
| 80 km/h | 11.5 | 5 |

| Differential speed limits | km | % |
|---|---|---|
| Not present | 227.8 | 100 |

| Speed management / traffic calming | km | % |
|---|---|---|
| Not present | 227.8 | 100 |

| Operating Speed (85th percentile) | km | % |
|---|---|---|
| 40 km/h | 1.1 | 0 |
| 50 km/h | 9.2 | 4 |
| 60 km/h | 101.9 | 45 |
| 65 km/h | 0.4 | 0 |
| 70 km/h | 64.5 | 28 |
| 80 km/h | 39.8 | 17 |
| 90 km/h | 10.9 | 5 |

| Operating Speed (mean) | km | % |
|---|---|---|
| < 30 km/h | 1.7 | 1 |
| 40 km/h | 9.3 | 4 |
| 50 km/h | 101.3 | 44 |
| 60 km/h | 64.8 | 28 |
| 70 km/h | 39.2 | 17 |
| 80 km/h | 11.5 | 5 |

Policy targets

| Roads that cars can read | km | % |
|---|---|---|
| Does not meet specification | 227.8 | 100 |
| **Vehicle Occupant Star Rating Policy Target** | km | % |
| Not applicable | 227.8 | 100 |

| Motorcyclist Star Rating Policy Target | km | % |
|---|---|---|
| Not applicable | 227.8 | 100 |



| Pedestrian Star Rating Policy Target | km | % |
|---|---|---|
| Not applicable | 227.8 | 100 |

| Bicyclist Star Rating Policy Target | km | % |
|---|---|---|
| Not applicable | 227.8 | 100 |

As it was discussed in Section 3.2 of this Report, the coding team assessed the condition of more than 30 road infrastructure elements, at 100-meter intervals throughout the network. This assessment shows that the network mainly consists of single carriageway roads (92%) and another 8% with divided lanes, traversing mainly rural/open areas (88%).

Throughout the network, lanes are wider than 2.75 metres. Shoulders are paved (93%) and sealed and are 0 to 1 m wide (narrow), on the passenger's side (92%).

Many of the roads traverse rural terrain, which is reflected by the fact that (72%) of the roads have straight or gentle curves. The majority of the road network length has unprotected fixed objects close to the travelling lanes.

The most common type of intersections is 3 and 4-leg.

The maximum posted speed limits are mostly 80 km/h (5%), whereas the speed of the remaining roads is generally posted at 50 km/h and 60km/h.

As for the pedestrian facilities, they do not exist in 94% of the inspected roads, i.e. there is a very small number of unsignalised and signalized pedestrian crossings, with or without refuges and grade separated facilities. The same goes for bicyclist facilities.

When it comes to hazardous objects, such objects are recorded in about 90% of the surveyed road network. These objects include poles of a diameter greater than 10cm, unprotected barrier ends, steep slopes and trees,

# 7. Road safety assessment results

Based on the analysis of the coded survey data and safety indicators, i.e. background data, the roads are Star Rated for safety using the iRAP methodology. Star ratings are given for the following road user categories: vehicle occupants, motorcyclists, pedestrians and bicyclists.

## *7.1 Overall Star Ratings Results*

The overall Star Ratings for the road sections assessed are shown below in Table 14.

1-star roads are those with the highest risk and 5-star roads have the least risk.



**Table 14 Star Rating results of the inspected network**

| | Vehicle Occupant | | Motorcycle | | Pedestrian | | Bicycle | |
|---|---|---|---|---|---|---|---|---|
| Star Ratings | Length (km) | Percent | Length (km) | Percent | Length (km) | Percent | Length (km) | Percent |
| 5 Stars | 0.0 | 0.00% | 0.0 | 0.00% | 0.0 | 0.00% | 0.3 | 0.13% |
| 4 Stars | 9.7 | 4.26% | 1.8 | 0.79% | 3.3 | 1.45% | 3.1 | 1.36% |
| 3 Stars | 173.3 | 76.08% | 125.8 | 55.22% | 13.9 | 6.10% | 70 | 30.73% |
| 2 Stars | 41.0 | 18.00% | 92.1 | 40.43% | 59.4 | 26.08% | 117 | 51.36% |
| 1 Star | 3.0 | 1.32% | 7.3 | 3.20% | 118.6 | 52.06% | 36.6 | 16.07% |
| Not applicable* | 0.8 | 0.35% | 0.8 | 0.35% | 32.6 | 14.31% | 0.8 | 0.35% |
| Totals | 227.8 | 100.00% | 227.8 | 100.00% | 227.8 | 100.00% | 227.8 | 100.00% |

The results show that no section on the 228 km long surveyed network was awarded 5 stars for vehicle occupants. Only 4% of the sections scored 4 stars for the car occupant safety. 76 % of the network was awarded 3 stars, while 20% of the roads scored only 1 or 2 stars.

It is evident that the rated road sections for the vulnerable road users were awarded a poor rating, especially in terms of pedestrian safety which turned out to be very low.

The Star Rating results from the table above are also shown on following the Star Rating maps.

*Figure 11 Star Rating map for vehicle occupants*

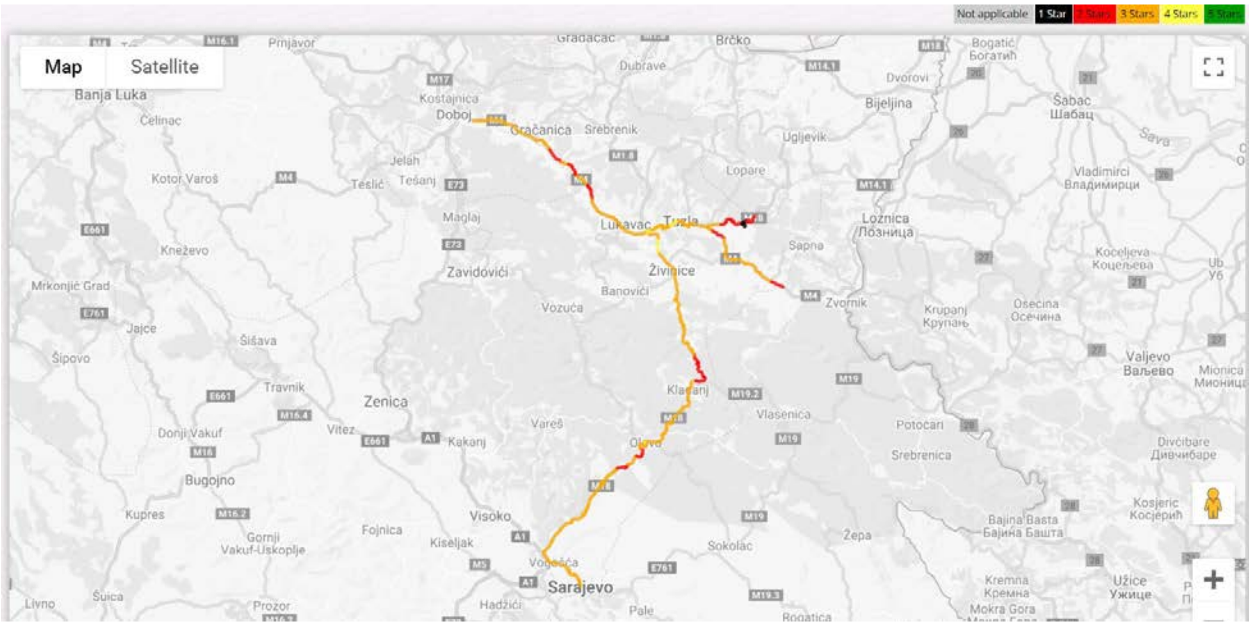



*Figure 12 Star Rating map for pedestrian occupants*



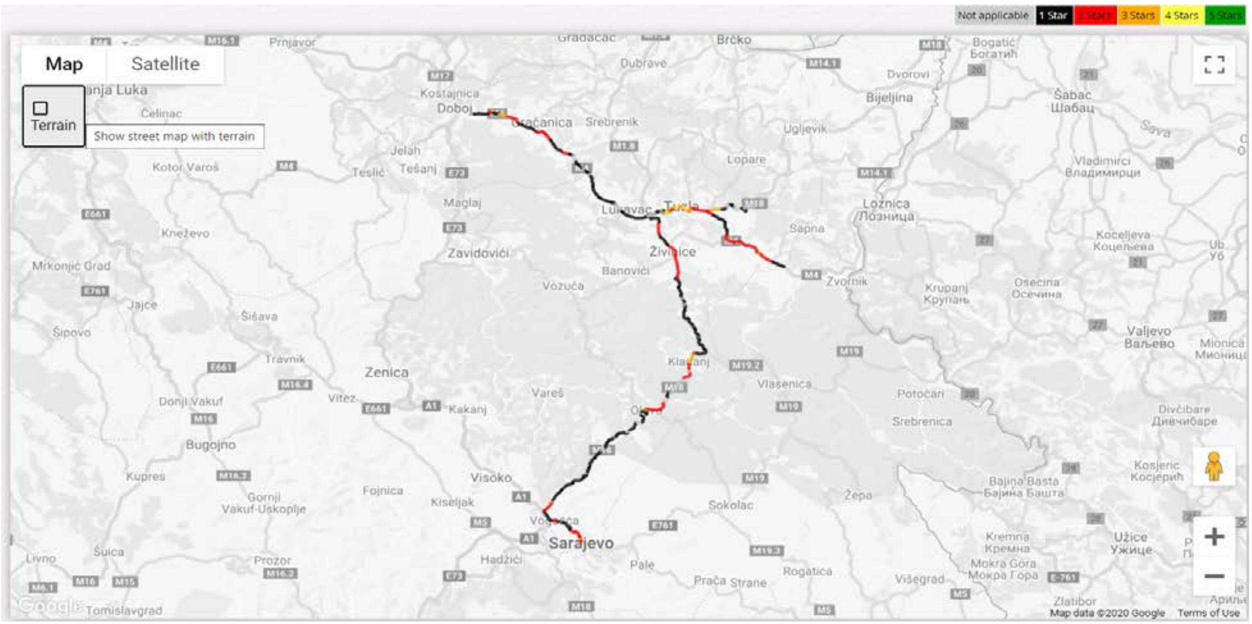
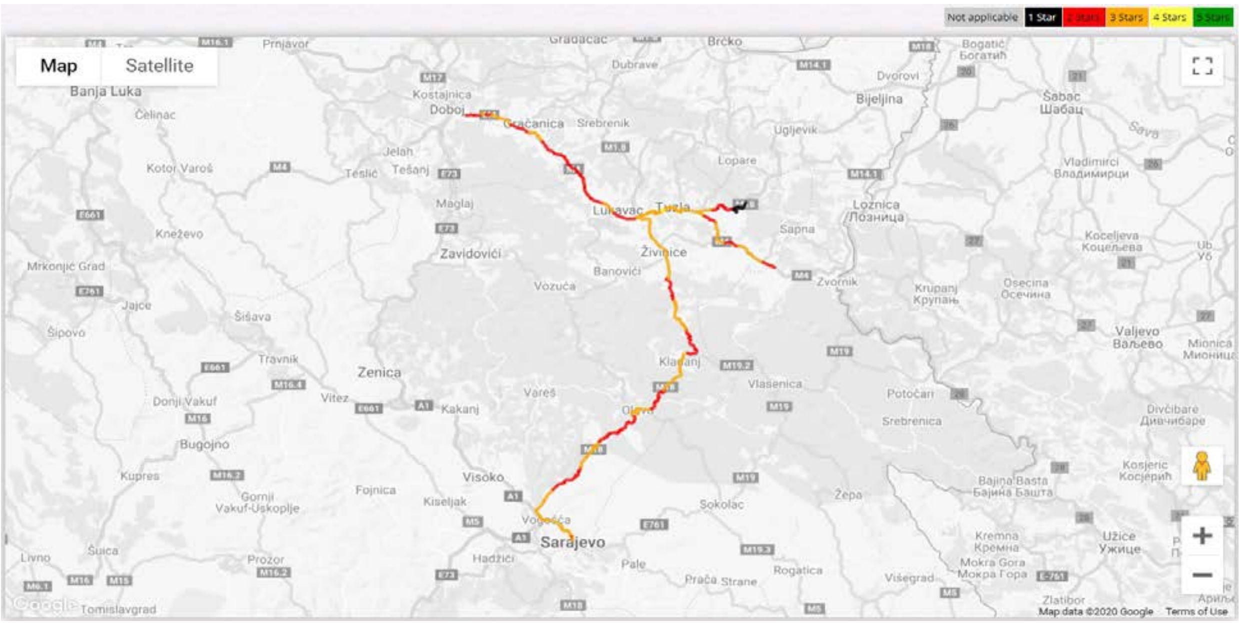


*Figure 13 Star Rating map for bicycle occupants*


*Figure 14 Star Rating map for motorcycle occupants*



# 8. Safer Roads Investment Plan

## 8.1 Overview of the method

The making of a SRIP is preceded by the following actions, as summarized below.

### 8.1.1 Estimating the number of deaths and serious injuries

To enable economic evaluation of various countermeasure options, an estimate of the number of deaths and serious injuries under existing conditions on each 100 m section of road was made. As discussed earlier, it is estimated that 29 deaths occur each year on the surveyed roads in Bosnia and Herzegovina. Since the number of deaths was available only in aggregate form the deaths and serious injuries needed to be distributed among the 100m sections of road, the number distributed to each section was a function of the product of each section's Star Rating Score and exposure (in the case of vehicle occupants, exposure is measured as the annual average daily traffic). Hence, it is feasible that a road with a 1-star rating (indicating high risk) can still experience very few deaths if its traffic volume is low, and vice versa.

### 8.1.2 Selecting countermeasures

For each 100m section of road, a series of countermeasures that could be feasibly implemented were identified. This was achieved by considering each countermeasure's ability to reduce risk (using a series of 'triggers') and 'hierarchy' rules.



The following are examples of triggers:

- A section of road that has a poor pedestrian Star Rating Score and high pedestrian activity would 'trigger' installation of a pedestrian refuge, pedestrian crossing or signalised pedestrian crossing.
- A section of road with poor delineation and a high vehicle occupant Star Rating Score would 'trigger' delineation improvements.

'Hierarchy' rules were used to ensure that more comprehensive countermeasures 'override' less comprehensive countermeasures. For example:

- If a grade separated pedestrian facility was feasible, then it took precedent over other pedestrian measures (such as a pedestrian refuge or signalised crossing).
- If a horizontal realignment was feasible, then redundant countermeasures were not considered (for example, curve delineation and shoulder widening).
- If a segregated motorcycle lane was feasible, then other motorcycle lanes (such as an on-road motorcycle lane) were removed from the plan.

### 8.1.3 Economic analysis

Each countermeasure option identified was then subject to a BCR (Benefit-Cost Ratio) analysis. Countermeasures that failed to achieve a BCR that met a prescribed threshold for a given 100m segment were excluded from the analysis. The benefit of a countermeasure was determined by calculating the net present value of deaths and serious injuries that would be avoided over twenty years if the countermeasure was installed (a discount rate of 5% was used). The cost of a countermeasure was determined by calculating the net present cost of constructing and replacing it (based on its service life) over 20 years.

## 8.2 Investment plan

The basic output of the RAP method is the Safer Roads Investment Plan. The SRIP presents all the countermeasures that proved to be able to provide the greater safety capacity and maximize the benefit over spent cost of the planned investments. The cost of each countermeasure is compared to the value of life and serious injuries that could be saved. The Benefit to Cost Ratio (BCR) is calculated for each countermeasure proposed. It has to be mentioned that the countermeasures listed are indicative and will need to be assessed and sense-checked with local engineers.

*Table 15 The Safer Roads Investment Plan*



Currency: KM BAM – Analysis Period: 20 years

| Total FSIs Saved | Total PV of Safety Benefits | Estimated Cost | Cost per FSI saved | Program BCR |
|---|---|---|---|---|
| 2,008 | 256,943,846 | 50,216,174 | 25,012 | 5 |

| Countermeasure | Lenght/ Sites | FSIs saved | PV of safety benefit | Estimated Cost | Cost per FSI saved | BCR |
|---|---|---|---|---|---|---|
| Roadside barriers – passenger side | 75.00 km | 417 | 53,377,465 | 12,251,205 | 29,374 | 4 |
| Roadside barriers – driver side | 52.90 km | 258 | 33,009,078 | 8,599,997 | 33,343 | 4 |
| Road Shoulder rumble strips | 91.50 km | 202 | 25,803,227 | 4,571,528 | 22,674 | 6 |
| Central hatching | 89.50 km | 137 | 17,596,255 | 2,649,270 | 19,269 | 7 |
| Shoulder sealing passenger side (>1m) | 98.30 km | 124 | 15,923,144 | 3,115,961 | 25,044 | 5 |
| Traffic calming | 5.80 km | 103 | 13,223,633 | 823,564 | 7,971 | 16 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Roundabout | 10 sites | 90 | 11,500,070 | 3,775,560 | 42,017 | 3 |
| Shoulder sealing driver side (>1m) | 74.40 km | 81 | 10,388,890 | 2,246,637 | 27,676 | 5 |
| Pedestrian fencing | 7.20 km | 80 | 10,237,767 | 477,042 | 5,963 | 21 |
| Street lighting (intersection) | 13 sites | 66 | 8,501,529 | 1,480,617 | 22,289 | 6 |
| Delineation and signing (intersection) | 23 sites | 59 | 7,533,696 | 1,552,497 | 26,374 | 5 |
| Clear road side hazards - driver side | 25.40 km | 58 | 7,436,560 | 345,437 | 5,945 | 22 |
| Improve curve delineation | 14.70 km | 56 | 7,180,430 | 1,193,041 | 21,264 | 6 |
| Clear road side hazards - passenger side | 15.50 km | 44 | 5,596,445 | 207,514 | 4,745 | 27 |
| Street lightning (mid-block) | 1.80 km | 29 | 3,762,515 | 923,061 | 31,398 | 4 |
| Additional lane (2+1 road with barrier) | 0.60 km | 28 | 3,588,625 | 565,942 | 20,183 | 6 |
| Improve delineation | 7.60 km | 21 | 2,751,020 | 747,563 | 34,778 | 4 |
| Side road unsignalised pedestrian crossing | 11 sites | 19 | 2,440,542 | 169,561 | 8,892 | 14 |
| Side slope improvement – passenger side | 8.10 km | 19 | 2,393,959 | 239,686 | 12,814 | 10 |
| Protected turn provision at existing signalised site(4leg | 1 site | 13 | 1,693,035 | 58,777 | 4,443 | 29 |
| Protected turn lane (unsignalised 3 leg) | 5sites | 12 | 1,495,056 | 532,809 | 45,610 | 3 |
| Footpath provision passenger side ( >3m from road) | 4.90 km | 9 | 1,179,310 | 511,809 | 55,543 | 2 |
| Side slope improvement – passenger side | 4.10 km | 9 | 1,103,112 | 118,376 | 13,734 | 9 |
| Footpath provision passenger side (informal path>1m) | 7.70km | 9 | 1,163,214 | 488,411 | 53,737 | 2 |
| Footpath provision driver side (informal path>1m) | 7.70km | 9 | 1,171,777 | 488,411 | 53,344 | 2 |
| Upgrade pedestrian facility quality | 7sites | 9 | 1,104,885 | 291,775 | 33,797 | 4 |
| Footpath provision driver side ( >3m from road) | 4.10km | 7 | 948,071 | 433,206 | 58,479 | 2 |
| Footpath provision passenger side (adjacent to road) | 3.20 km | 7 | 867,842 | 345,146 | 50,899 | 3 |
| Footpath provision driver side (adjacent to road) | 3.20 km | 7 | 867,842 | 345,146 | 50,899 | 3 |
| Unsignalised crossing | 18sites | 7 | 945,191 | 276,964 | 37,502 | 3 |
| Parking improvements | 2.50 km | 6 | 723,251 | 68,542 | 12,129 | 11 |
| Central rumble strip / flexi-post | 0.90 km | 4 | 450,333 | 68,884 | 19,576 | 7 |
| Street lighting (ped crossing) | 4sites | 4 | 496,446 | 100,612 | 25,937 | 5 |
| Protected turn lane (unsignalised 4 leg) | 1 sites | 3 | 399,293 | 106,562 | 34,155 | 4 |
| Signalised crossing | 1 sites | 1 | 90,289 | 45,066 | 63,879 | 2 |
| | | 2,008 | 256,943,846 | 50,216,174 | 25,012 | 5 |

| Deaths and serious injuries | Deaths (per year) | Deaths and serious injuries (per year) | Deaths and serious injuries (20 years) |
|---|---|---|---|
| Before Countermeasures | 22 | 286,5 | 5.427 |
| After Countermeasures | 14 | 179,6 | 3.419 |
| Prevented | 8 | 106,9 | 2.008 |
| FSI reduction | 37 % | | |
| Program BCR | 5 | | |
| Cost per death and serious injuries prevented | 25.012 | | |

According to the investment plan, the total cost of the engineering measures is 50.216.174KM BAM, while the present value of safety benefits amounts to 256.943.846KM BAM. If the SRIP is implemented, the estimated number of FSI saved will be 2.008 in the next 20 years, i.e. 25.012KM BAM per FSI saved.

The top five most efficient and cost-effective measures that could help save the greatest number of lives include the following identified solutions: Roadside barriers – driver side, Roadside barriers – passenger side, Shoulder rumble strips, Central hatching, Shoulder sealing (>1m).



The Star Rating results after adopting all the proposed countermeasures are presented in the next figures.

*Table 16 Star Rating after implementing the SRIP*

| | Vehicle Occupant | | Motorcycle | | Pedestrian | | Bicycle | |
|---|---|---|---|---|---|---|---|---|
| Star Ratings | Length (km) | Percent | Length (km) | Percent | Length (km) | Percent | Length (km) | Percent |
| 5 Stars | 3.3 | 1.45% | 0.0 | 0.00% | 0.0 | 0.00% | 0.3 | 0.00% |
| 4 Stars | 70.4 | 30.90% | 9.7 | 4.26% | 3.3 | 1.45% | 6.1 | 2.68% |
| 3 Stars | 153.3 | 67.30% | 217.3 | 95.39% | 18.1 | 7.95% | 110.7 | 48.60% |
| 2 Stars | 0.0 | 0.00% | 0.0 | 0.00% | 80.6 | 35.38% | 109.9 | 48.24% |
| 1 Star | 0.0 | 0.00% | 0.0 | 0.00% | 93.2 | 40.91% | 0.0 | 0.00% |
| Not applicable* | 0.8 | 0.35% | 0.8 | 0.35% | 32.6 | 14.31% | 0.8 | 0.35% |
| Totals | 227.8 | 100.00% | 227.8 | 100.00% | 227.8 | 100.00% | 227.8 | 100.00% |

It is clear that the SRIP would improve the road network safety significantly. For vehicle occupants, the number of 1 and 2-Star high-risk roads would decrease to a great extent, whereas the 4-Star roads would be present in 30% of the network. Practically all road networks will be minimum 3-star. There are improvements in the bicycles and pedestrians safety as well. However, the effect of the SRIP on these user groups is relatively lower than on vehicle occupants.

*Figure 15 Star Rating map for vehicle occupants after implementing the SRIP*

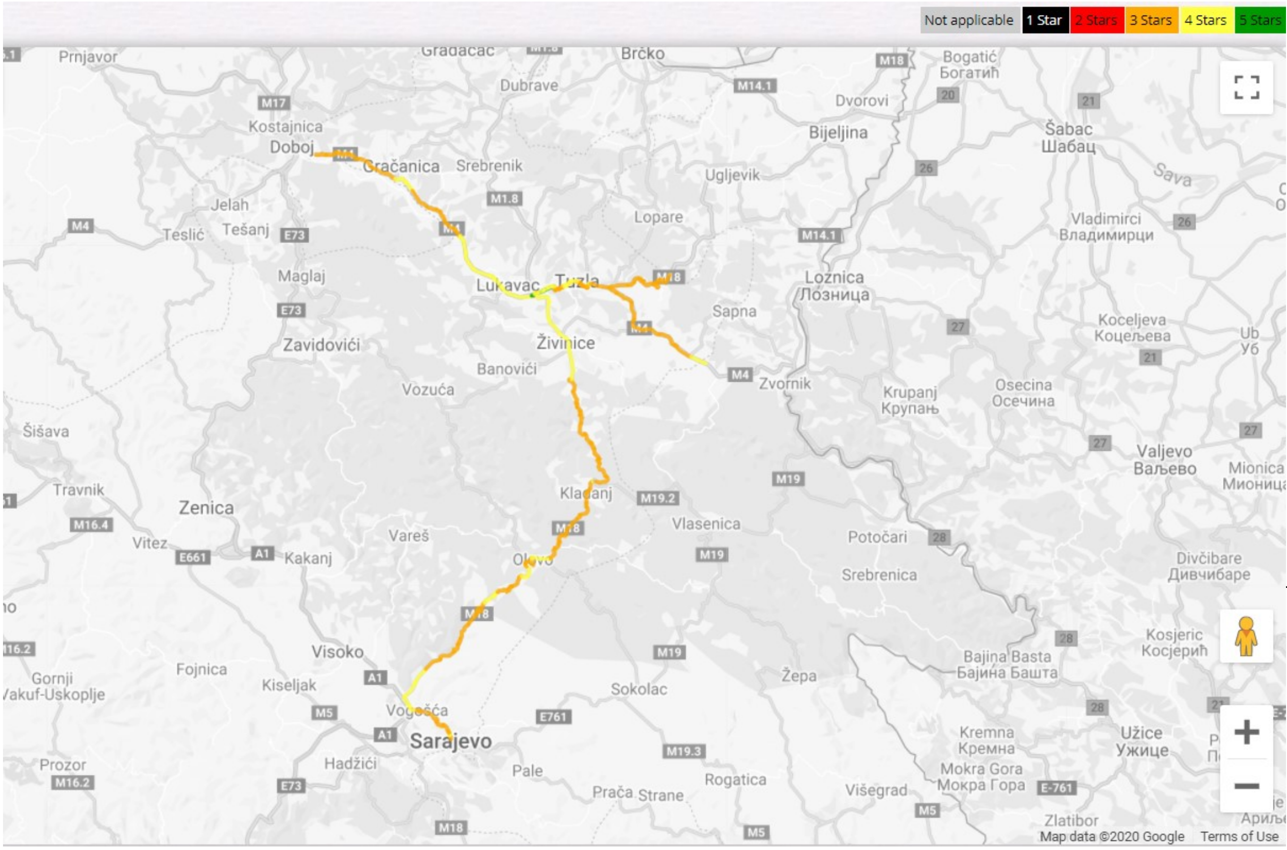


**Figure 16 Star Rating map for pedestrian occupants after implementing the SRIP**

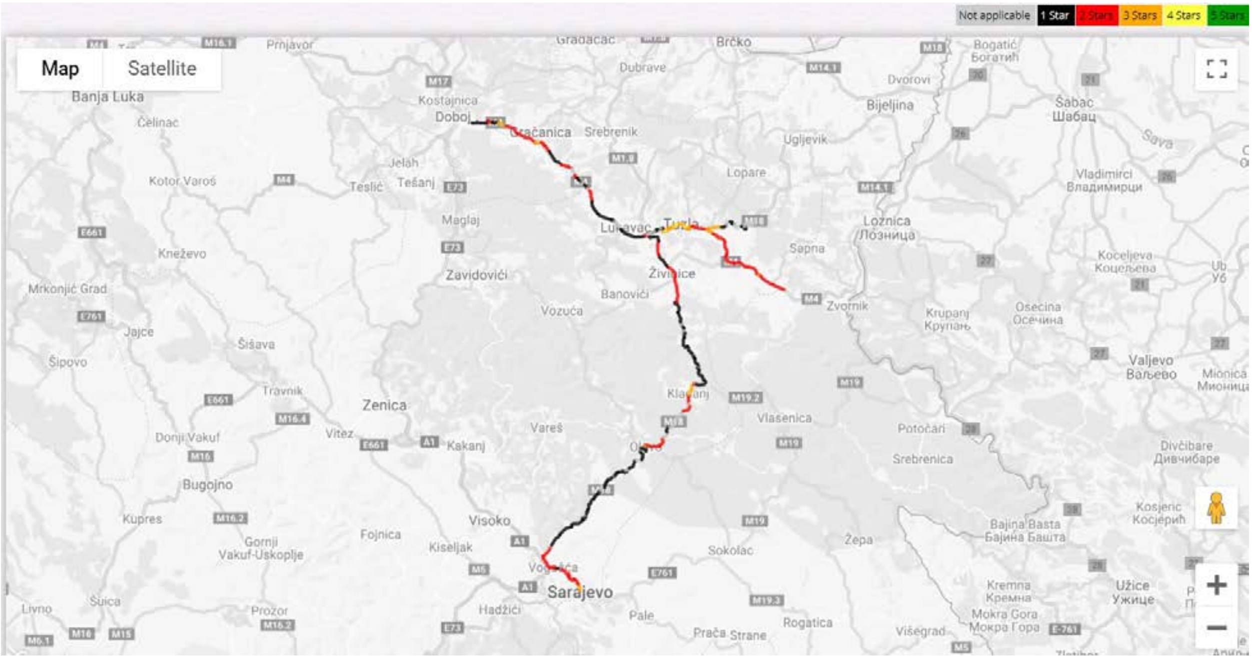



*Figure 17 Star Rating map for bicycle occupants after implementing the SRIP*



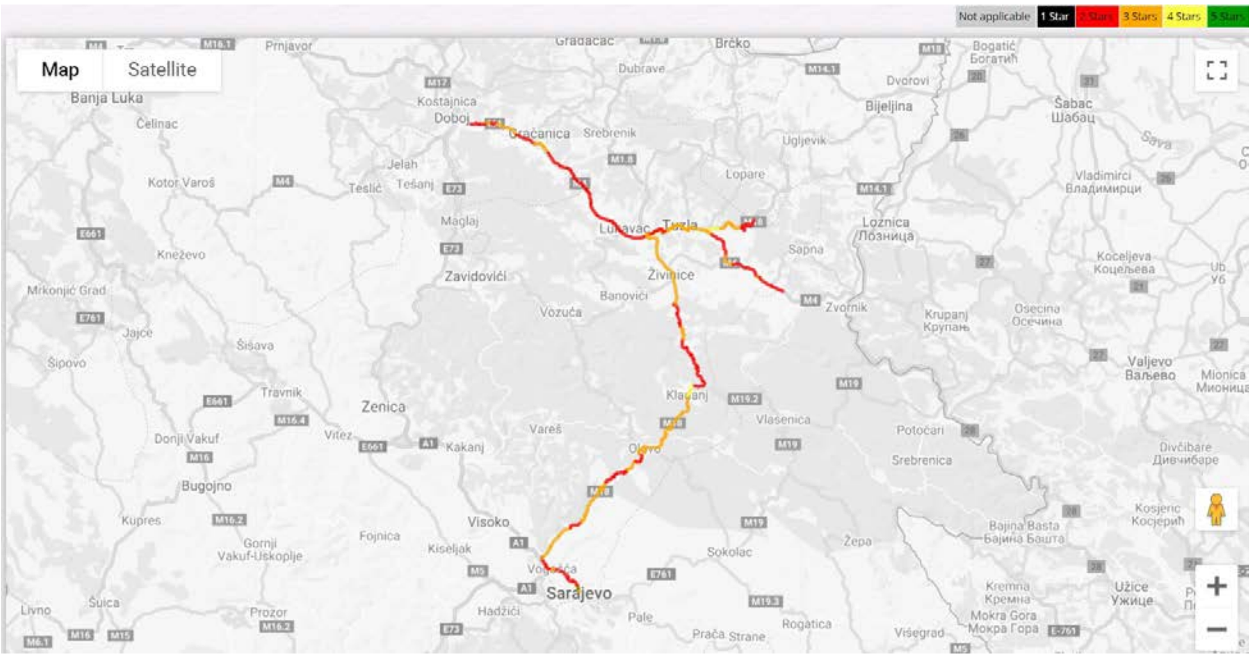
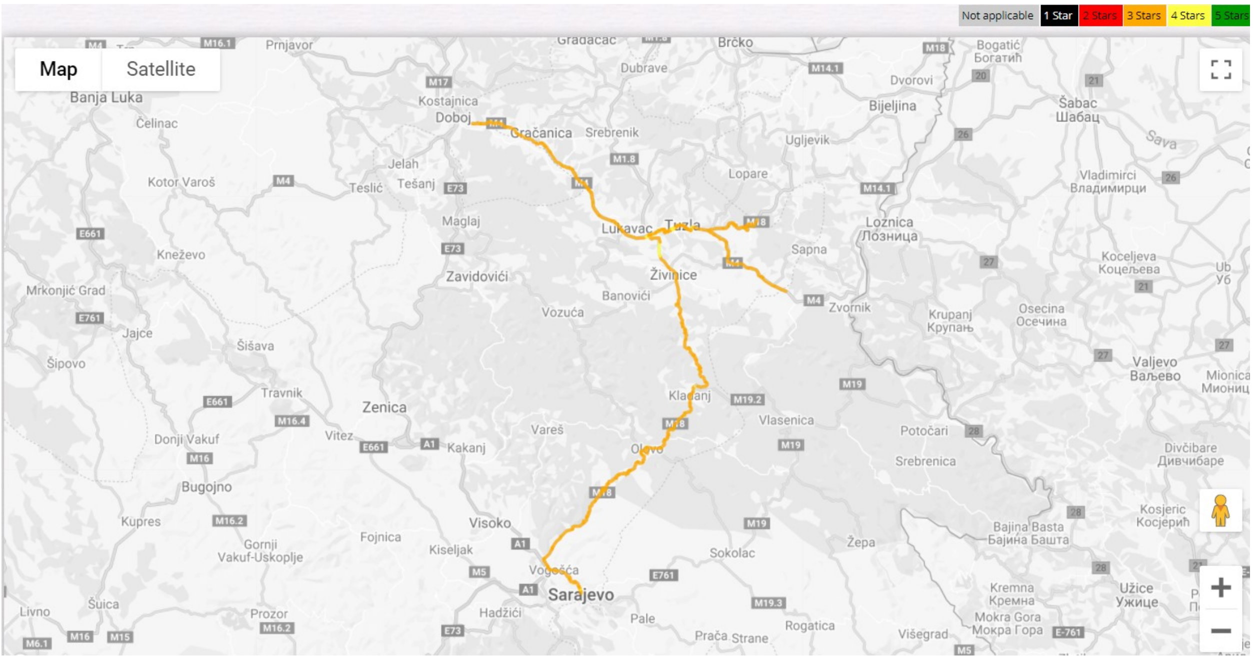


**Figure 18 Star Rating map for motorcycle occupants after implementing the SRIP**

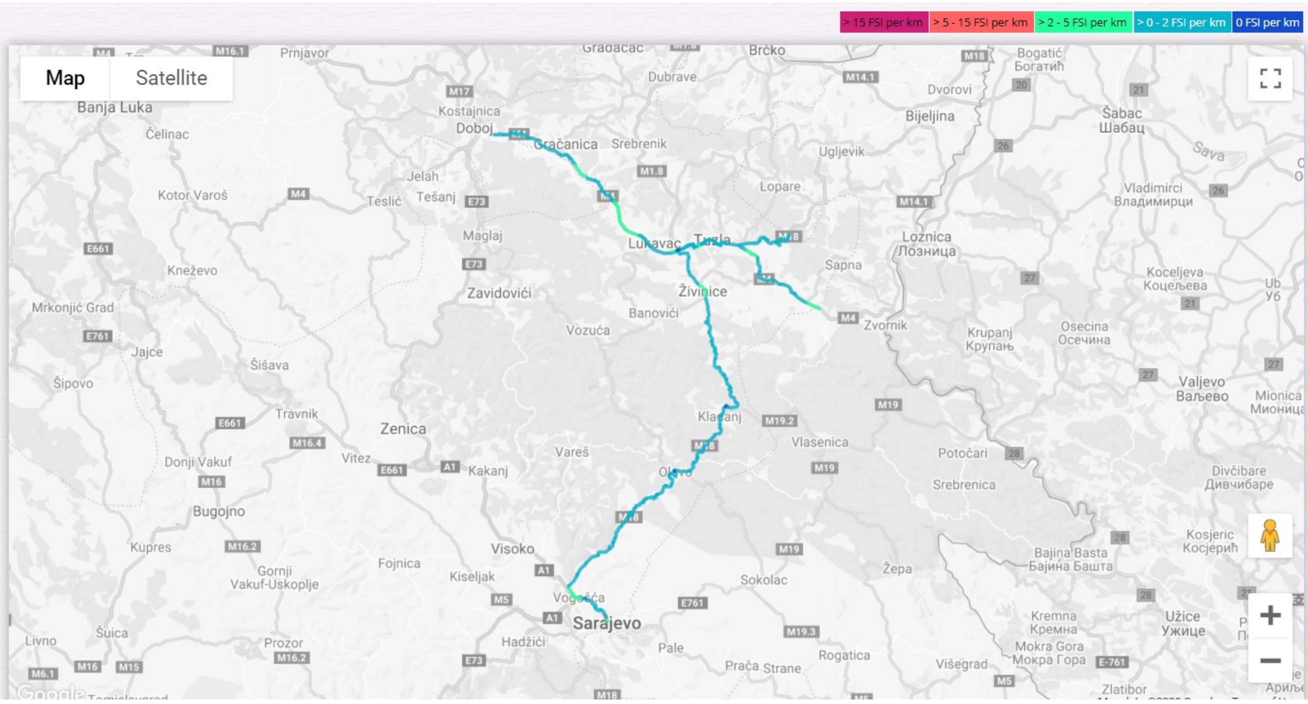





## *8.3 Implementation of Countermeasures*

If the recommended countermeasures have been implemented, the predicted casualty reduction map with the reduced FSI over 20 years will be as follows:

*Figure 19 Predicted casualty reduction map*



This map illustrates the numbers of fatalities and serious injuries that could be prevented per kilometre, per year, if the countermeasures identified in the Safer Roads Investment Plan (SRIP) were implemented.

The SRIP contains extensive planning and engineering information such as road attribute records, countermeasure proposals and economic assessments for 100- meter sections of road network. They are supported by theViDA online software which makes this information highly accessible. Each countermeasure proposed in a SRIP is backed by strong evidence. If implemented, it will prevent deaths and serious injuries in a cost-effective way. Nevertheless, in interpreting the results of this report, it is important to recognize that iRAP method is designed to provide a network-level assessment of risk and cost-effective countermeasures. As such, a SRIP should be considered just the first step in building a safe road.

# 9.Implementation ready design plans

Some road sections have been selected in the text below to demonstrate the implementation ready design plan. Engineering studies involve interpretation of the SRIP and having identified a priority location or a section of road, it is possible to further tailor the countermeasure plan to suit specific circumstances. This is especially useful if budget constraints have changed. Cost-effectiveness may be used to generate a list of priority countermeasures within a limited budget.

## *9.1 Road M18, Section Simin Han – Priboj (gr.RS)*



This particular section starts at Simin Han and goes towards Priboj to the border with Republic of Srpska. The main terrain of this section is a rural undeveloped area. It is a single carriageway road with a total length of about 16 km. The traffic flow on this section is approximately 1,000 - 5,000 vehicles per day. Median type on the whole section is the central line only, number of lanes is one and lane width is mainly over 2.75 m up to 3.25 m.

**Figure20 Vehicle Occupant Star Rating map – before countermeasures implementation**

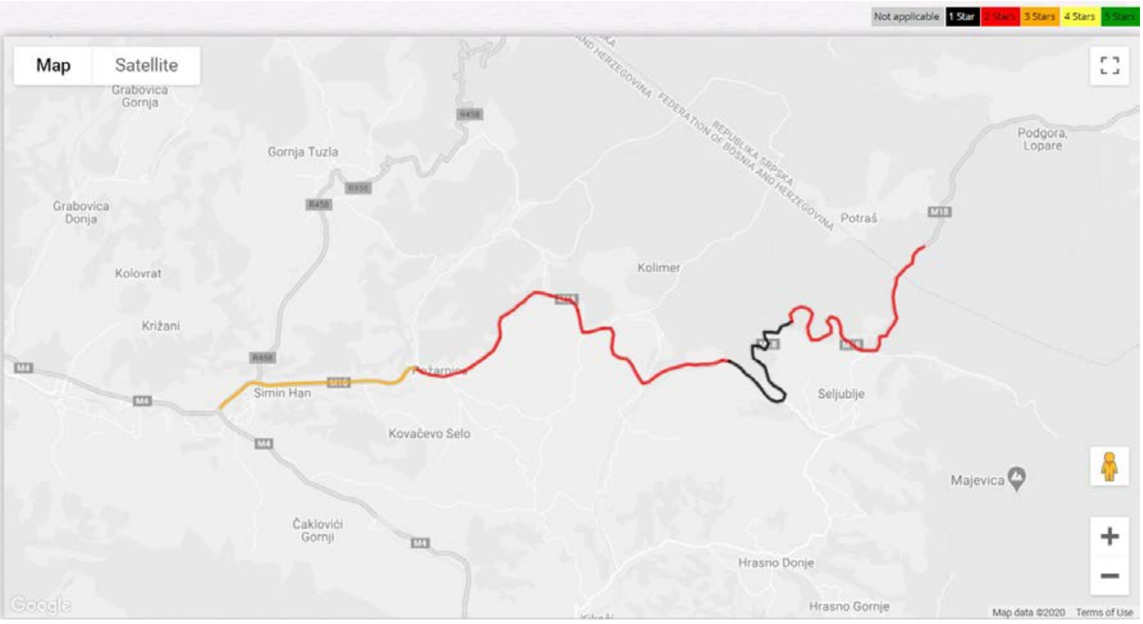


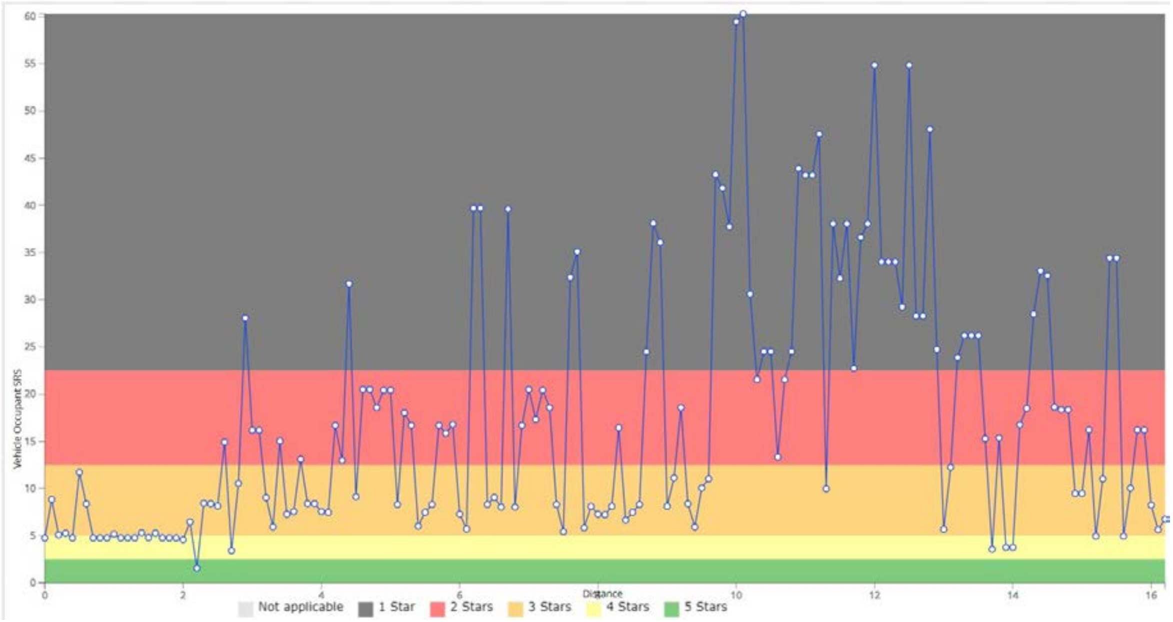

**Table 17 Vehicle Occupant Star Rating – before countermeasures are implemented**



| | Vehicle Occupant | |
|---|---|---|
| Star Ratings | Length (km) | Percent |
| 5 Stars | 0,0 | 0.0% |
| 4 Stars | 0,0 | 0.0% |
| 3 Stars | 3,0 | 18,4% |
| 2 Stars | 10,3 | 63,2% |
| 1 Star | 3,0 | 18,4% |
| Not applicable* | 0,0 | 0.0% |
| Totals | 16,3 | 100.0% |

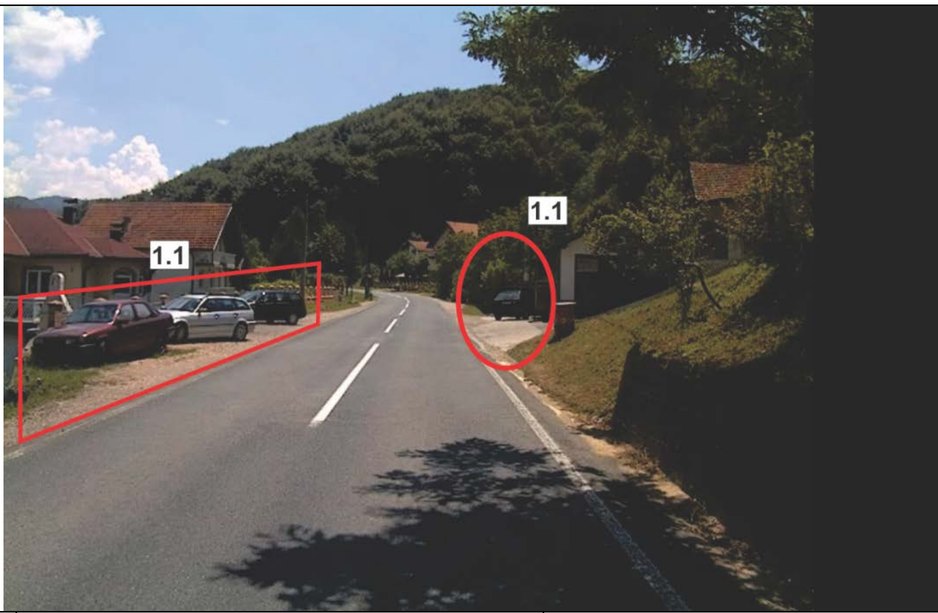
The Star Rating results for this particular road are quite poor. Almost 18% of the section are rated as 1-star, 63% is rated as 2-star and only 18% are rated as 3-star for vehicle occupants. To illustrate the risk distribution along the road, a specific V*i*DA tool can be used – the Risk Worm. The Risk Worm helps identify quickly the locations of high risk. The “spikes” in the graph usually relate to intersections, sharp curves, or similar single factors which increase the risk significantly.

*Chart 1 Risk Worm of the section Simin Han –Priboj (gr.RS), raw data*

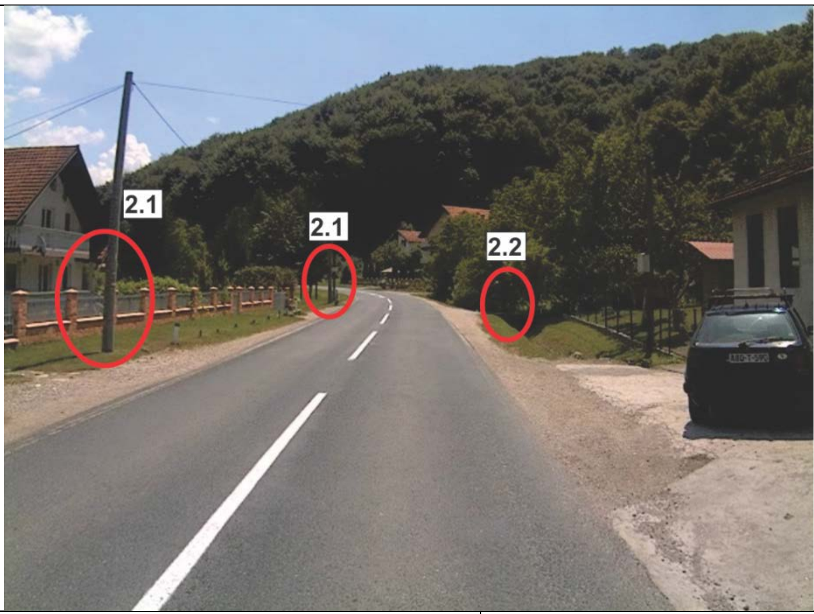



Looking at the statistics of the coded attributes along this section, the reason for the overall low safety rating can be identified. Almost 50% of the section contains poor quality curvatures. The roadside severity distance on both sides of the road is up to 1m, on almost 50% of the section. On almost 60% of both sides of the section, dangerous objects (trees, unprotected barrier ends, poles, rigid structures) have been recorded.

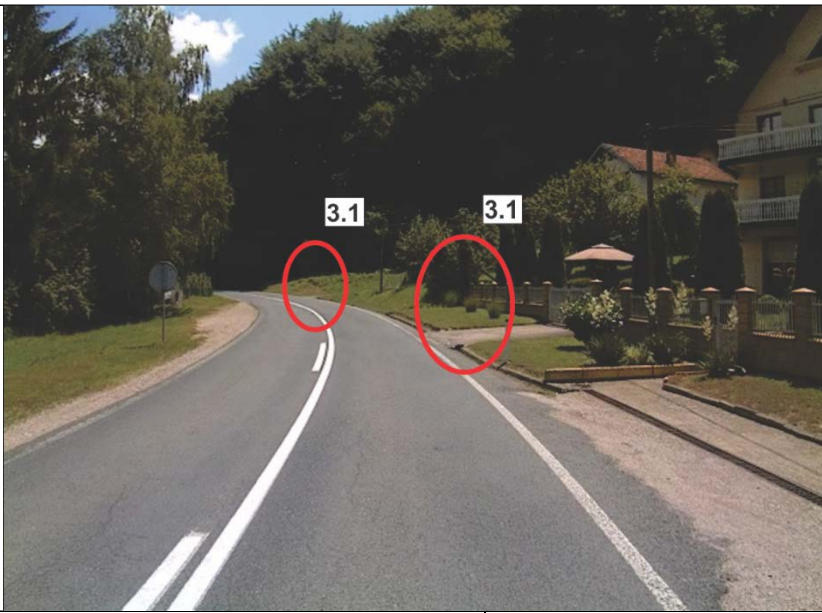
One of the locations with high risk distribution (1 star) is shown on the examples below. Posted speed limit on this location is 60km/h and the traffic flow is 3,085 vehicles per day.



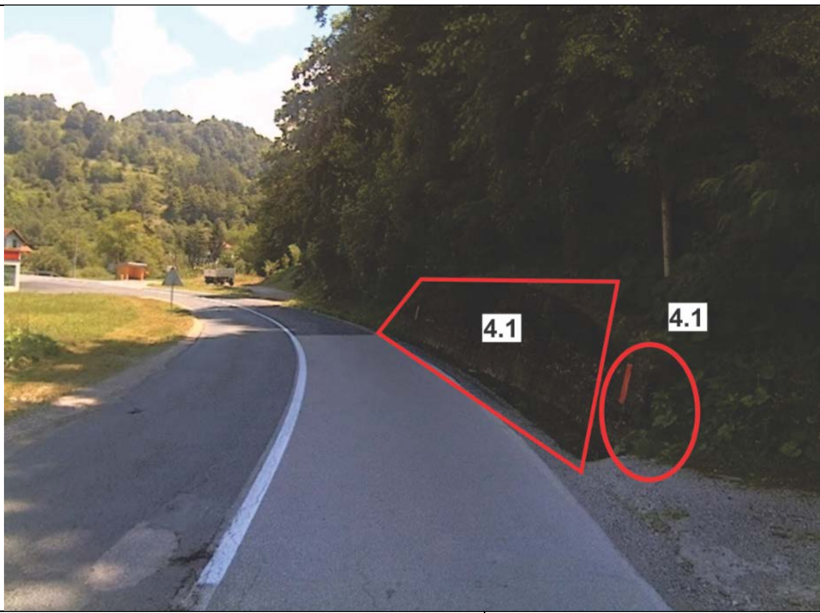

| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.529549 Long. 18.838817 | **1.1**<br>There have been observed many vehicles parked on both sides, and entering the traffic is a high-risk manoeuvre.<br>Vehicles moving on the main road are travelling at higher speeds, while vehicle is entering the traffic, accelerating, and connecting to the continuous traffic flow on the main road is a potential hazard for all road users. | **Mid-term measure:**<br>Building protective, deflectable safety barriers, to prevent direct access to the road. Consideration should be given to the provision of the owners of facilities in the immediate vicinity with the access to the point of entering the main road, using a limited number of accesses. An alternative solution would be to build a service road that would connect two or more objects and reduce them to one access road. |
| | The road in question is a higher-class road where the access to this road is not regulated, with many locations observed along the road that serve as parking space for stopping and parking the vehicles or as accesses to residential objects in the immediate vicinity of the road. | |



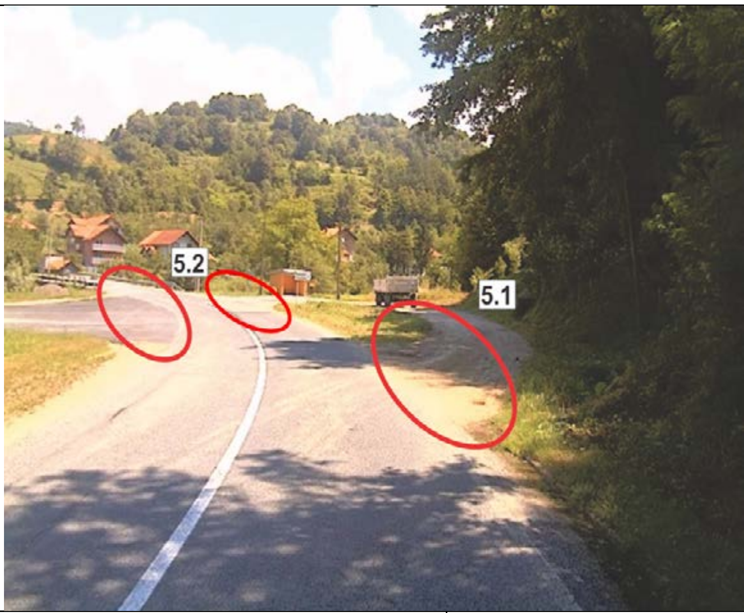

| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.529394 Long. 18.838982 | **2.1**<br>Presence of reinforced concrete poles of the electro-energy network in the immediate vicinity of the road is a potential hazardous location in the case of vehicle's running off the road, when taking into account assumed vehicle speeds and fixing of the obstacles. It is necessary to secure these fixed obstacles from potential vehicle's crash and conflict. | **Mid-term measure:**<br>All the fixed obstacles, especially those having a constructive stability, such as reinforced concrete poles, must be secured by placing safety barriers. Placing a safety barrier, as well as choosing its type and function, or its working width (W), depends on specific circumstances on the field, spatial possibilities and needed/desired level of protection. |
| | **2.2**<br>Presence of unsecured driveways whose lateral sides are sometimes built from reinforced concrete constructions, also represent a potential hazardous location in the case of vehicle's running off the road. | **Mid-term measure:**<br>Placing deflectable safety barriers of an appropriate type that depends on the desired level of protection. All driveways, or their construction, must be also secured by arched safety barrier within the turning zone. |




| Location | Description | Suggested measures |
|---|---|---|
| Lat.<br>44.528717<br>Long.<br>18.839828 | **3.1**<br>Presence of a high number of property accesses is a potential point of conflict or hazard. | **Mid-term measure:**<br>Placing safety barriers that are preventing direct entering onto the roadway of the main road, with potential building of a service road, parallel to the main road and reducing many accesses to one access. |
| | | **Long-term measure:**<br>Whenever possible, urban planning documents need to envisage building secondary roads as a countermeasure. |

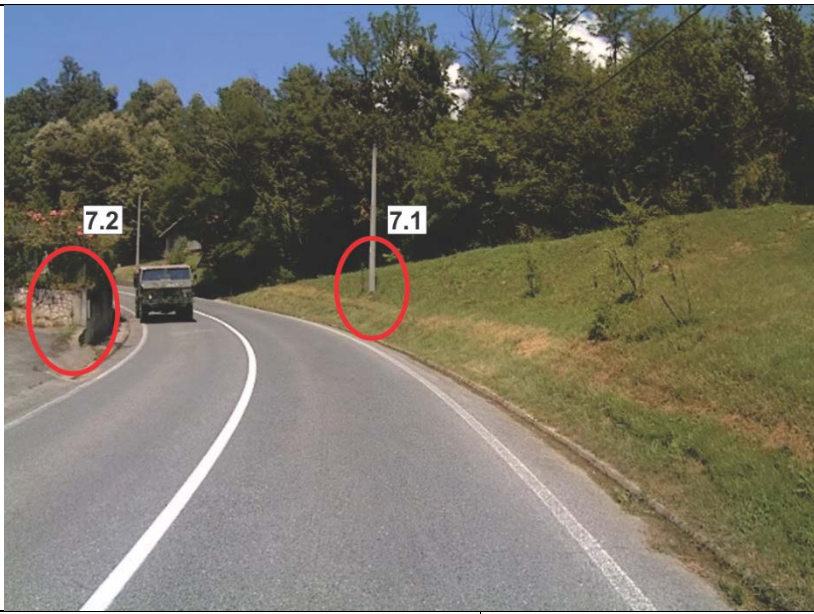



| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.52841 Long. 18.840858 | **4.1**<br>Reinforced concrete construction (retaining wall – stabilisation of a landslide) alongside the main road as potentially dangerous locations for vehicle's run off collisions. Special hazard is posed by the elements at the beginnings and ends of these constructions. | **Short-term measure:**<br>Constantly marking the radius of the curve by chevrons, on the shoulder and on the object<br><br>**Mid-term measure:**<br>Securing such locations by safety barriers with a high level of protection, as well as with envisaged shock absorbers/deflectors, as part of passive safety elements, in cases when construction solutions and circumstances on the road require so. |




| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.528425 Long. 18.841351 | **5.1** Informal access roads are an additional hazard for a safe traffic flow on the main road, as they bring about an increase in the number of conflict points due to potential manoeuvring activities (for example, turning manoeuvres of agricultural machines, etc.). | **Short-term measure:** Constantly marking the radius of the curve by chevrons, on the shoulder and on the object |
| | | **Mid-term measure:** Securing these locations by safety barriers, installed on the shoulder |
| | **5.2** Non-channelized flows of the access roads, with huge manoeuvring surfaces and over-dimensioned turning radii, increase the conflict nature of surfaces carrying main traffic flow. | **Short-term measure:** Constantly marking the radius of the curve by chevrons, on the shoulder and on the object |
| | | **Mid-term measure:** Securing these locations by safety barriers, installed on the shoulder |
| | | **Long-term measure:** Reconstructing the intersection with channelization of traffic flows by separating left-turn lanes, using adequate road signs to indicate more important intersecting point. |


| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.528425 Long. 18.841351 | **6.1**<br>Unsecured reinforced concrete elements at the outer part of the curve (the impact of the centrifugal force and possibility of vehicles to run off the road into direction of force's action) are a direct hazardous location | **Short-term measure:**<br>Constantly marking the radius of the curve by chevrons, on the shoulder and on the object |
| | | **Mid-term measure:**<br>Securing such locations by safety barriers on the shoulder, and placing safety barriers in the turning radii of access roads |
| | | **Long-term measure:**<br>Reconstructing the intersection with channelization of traffic flows and defining cross falls (warping) of the main road, so that the impact of centrifugal forces could be reduced and provide better adherence of pneumatics |
| | **6.2**<br>Grade-separated terrain (valley, cut slope, waterway) is not protected by a safety barrier and can increase the severity of a road accident with potentially fatal outcomes, in cases of vehicle's running off the road. | **Mid-term measure:**<br>Securing such locations by safety barriers on the shoulder and placing safety barriers in the turning radii of slip roads. |
| | | **Long-term measure:**<br>Reconstructing the intersection with channelization of traffic flows by separating left-turn lanes, using adequate road signs to indicate intersecting of traffic flows. |




| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.529566 Long. 18.842325 | **7.1**<br>Poor sight distance in the curve along with the presence of various fixed obstacles, reinforced concrete constructions, is a directly hazardous location.<br>Concrete pole of the electro-energy network is a directly hazardous location. | **Short-term measure:**<br>Constantly marking the radius of the curve by signs for directing the traffic, on the shoulder and on the object.<br>Cutting and maintaining the greenery. |
| | | **Mid-term measure:**<br>Securing such locations by safety barriers on the shoulder |
| | **7.2**<br>Reinforced concrete construction of the retaining wall and its frontal part (beginning of the retaining wall) is a directly hazardous location. | **Mid-term measure:**<br>Securing such locations by safety barriers on the road object |

### 9.1.1 Design plan suggestions and recommendations

1. **Short-term measures**
    - Cutting and maintaining low and high greenery (by cutting, mowing, and trimming) within the cross-section of the main and access roads
    - Placing chevron signs on tables with the higher grade of retro reflection, with fluorescent foliage.
    - Placing transverse rumble strips at several indication levels in order to highlight the hazard and raise driver's attention due to the presence of a continuous curve and conflict points.
    - Securing informal (illegal) access roads by placing safety barriers with the aim to reduce the number of conflict points.
    - Channelize junctions with access roads, using asphalt colour paint for marking. Recommended radius for marking is from 9 to 12 m, depending on the needs of vehicular traffic.



2. **Mid-term measures**
    - Placing safety barriers along the curve, and securing in particular the entry inlets of slip roads
    - Placing road signs on tables with the higher grade of retro reflection, with fluorescent foliage of better conspicuity in order to highlight potential hazard. Adequate placement of the road signs indicating and informing the drivers of all circumstances and conditions of traffic operation within the curve zone (curve warning signs, 50km/h speed limit signs)
    - Limiting speeds of vehicular traffic

3. **Long-term measures**
    - Reconstructing intersection with access roads by channelizing traffic flows and separating left-turn lanes.
    - Reducing the number of driveways by building secondary access roads with the aim to reduce the number of intersecting locations or conflict points.

**Figure21 Short-term measures design plan**

**Figure 22 Mid-term measures design plan**

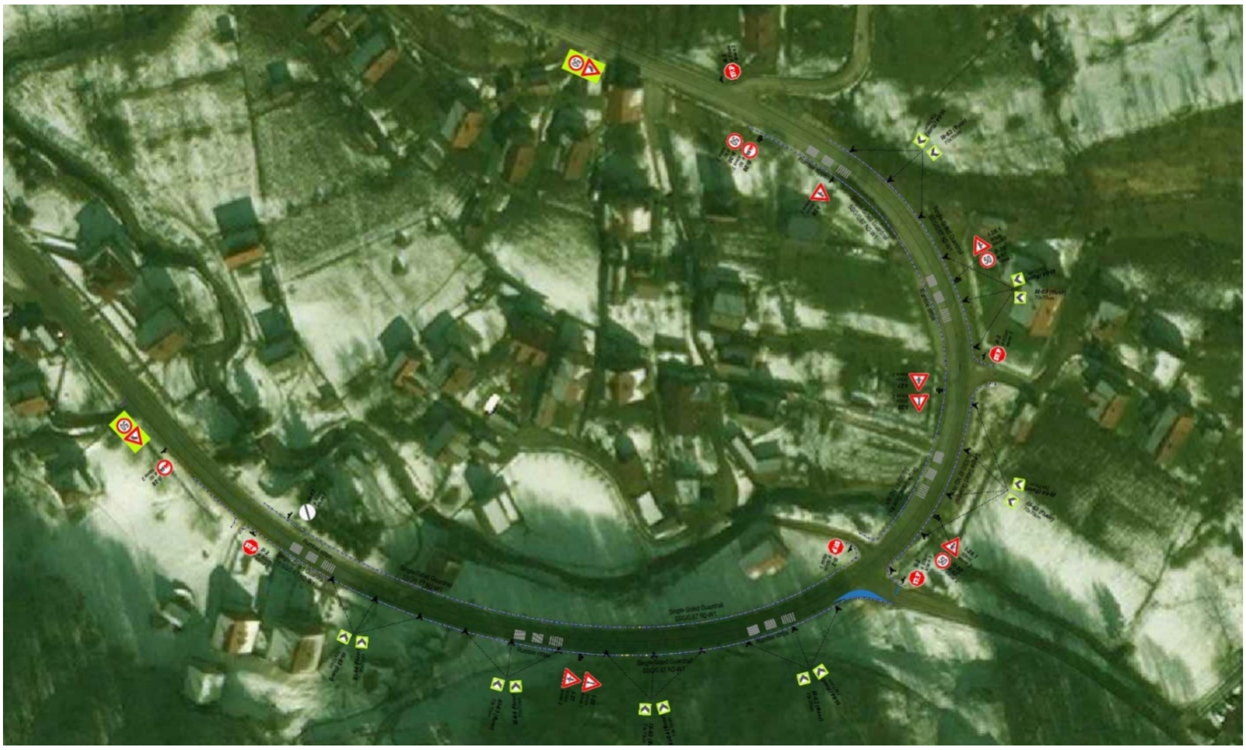


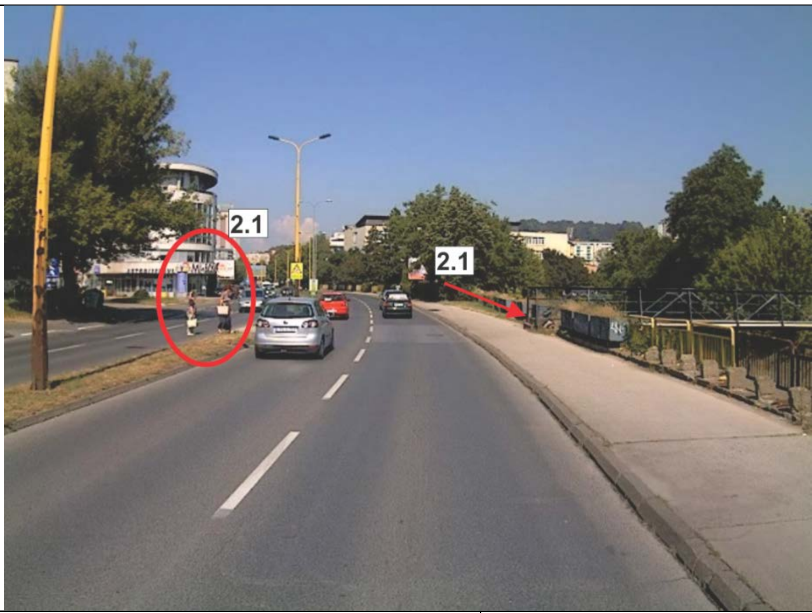


**Figure23 Long-term measures design plan**

## 9.2 Road M4/M18, Section Šićki Brod - Simin Han, Tuzla-School zone

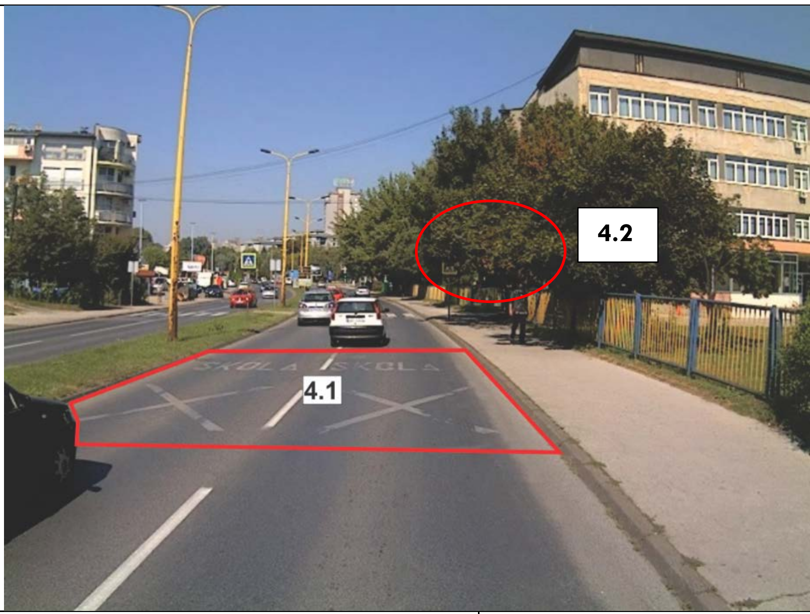
This particular section starts at Šićki Brod and goes towards Simin Han through town of Tuzla. The main terrain of this section is an urban area. It is a mainly dual carriageway road whit a total length of about 15 km. The traffic flow on this section is 19,731 vehicles per day. Posted speed limit is 50km/h. This road section has been selected to demonstrate the implementation ready design plan of school zone area.


| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.537473 Long. 18.67041 | **1.1**<br>A vehicle parked on the sidewalk, or pedestrian path, has been noticed. In such situations, pedestrians may be forced to walk on the roadway in order to pass by that vehicle, given that they come across a lateral obstacle on the opposite side of the vehicle. | **Short-term measure:**<br>Building physical obstacles on a portion of the sidewalk (safety barriers or bollards in order to prevent the access of motor vehicles). |
| | **1.2**<br>Current signage of presence of children on the road, and speed limit of 50 km/h, given in the form of road signs, are placed too far from school zone area. | **Short-term measure:**<br>Replacing the existing road signs closer to area of entering the school zone and reducing speed limit to 30 km/h. |

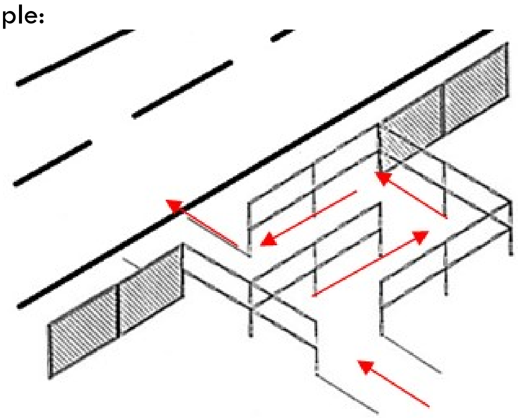
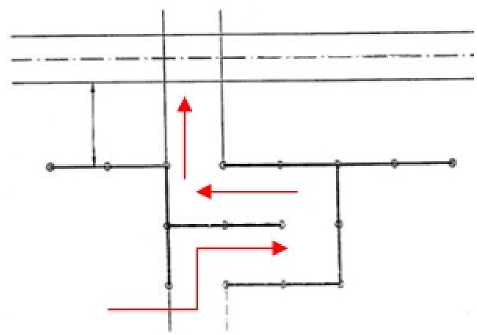



| Location | Description | Suggested measures |
|---|---|---|
| Lat.<br>44.537752<br>Long.<br>18.66916 | **2.1**<br>Pedestrian's crossing the roadway at an unsafe place, outside a marked pedestrian crossing.<br>Such illegal and unsafe behaviour in road traffic pose a direct risk for the occurrence of a road accident. | **Mid-term measure:**<br>Placing a median barrier of the height not less than 1, 8 m, in the green median so that crossing the roadway outside pedestrian crossings could be prevented. Marking a pedestrian crossing in the immediate vicinity of the pedestrian footbridge if the frequency of pedestrian movement, and accessibility envisaged by urban planning, are likely to allow for that. |


| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.537928 Long. 18.668112 | **3.1**<br>Presence of a billboard in the central part of the median island has an adverse effect on driver's attention | **Short-term measure:**<br>Removing all types of billboards and messages from the median or from the street lighting poles placed in the immediate vicinity of the "school zone" so that driver's attention could be directed on the traffic flow and traffic situation in the vicinity of school. |

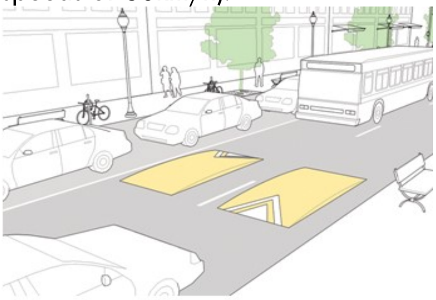



| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.537985 Long. 18.667595 | **4.1**<br>Hardly conspicuous horizontal road markings indicating a „school zone “ | **Short-term measure:**<br>Using horizontal markings to mark the „school zone “. It is recommended to build these markings by using applicative materials or by applying warm or cold plastic material containing retro reflective materials that provide better conspicuity and longer duration of the marking. |
| | | **Mid-term measure:**<br>Using „rumble strips “immediately before the horizontal road marking and road sign used for marking the „school zone “. Rumble strips should be built across the full width of the roadway, individually, for each driving direction. |
| | **4.2**<br>Road sign indicating pedestrian crossing is obstructed by greenery. Such a situation reduces forward visibility of drivers in the right traffic lane and conspicuity of a pedestrian crossing | **Short-term measure:**<br>Cutting high plants in order to provide visibility of road signs |

| Location | Description | Suggested measures |
|---|---|---|
| Lat. 44.537985 Long. 18.667595 | Lack of a protective pedestrian fence along the sidewalk, in the length of school facility. | **Short-term measure:**<br>Putting a pedestrian fence as a fixed obstacle to prevent direct access from the sidewalk onto the roadway. The fence should be minimum 1 m high and clearly conspicuous to drivers of motor vehicles, by being marked alternatively by means of colours or fields (for example, yellow / black). The fence should be placed on both sides of the roadway.<br>Such a principle should be adopted for a wider territory of the city/state so that the solutions could be unified and be recognizable to road users. |
| | | **Mid-term measure:**<br>Placing “chicanes” at the access to a pedestrian crossing by directing pedestrians view to the oncoming traffic.<br>Example:<br><br> |
| | | Consideration should be given here to passage widths, meaning that they should be able to allow for smooth movement of disabled persons or persons using auxiliary vehicles for movement (wheelchairs). Also, such design features understand pedestrian crossings with flow redirection so that pedestrian attention should always be focused on the oncoming |

traffic, or at any moment a pedestrian is approaching the roadway.

In order to reduce the speed of vehicular traffic before the pedestrian crossing, building vertical plateaus of the height depending on desired level of deceleration of vehicular traffic should be envisaged (for example, h=5cm for 40km/h or h=7cm for speeds of 30km/h).

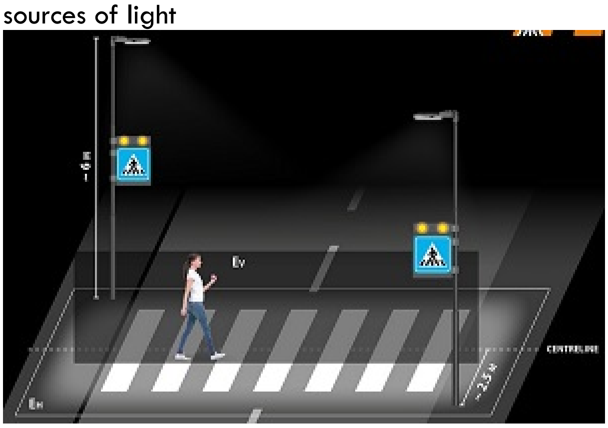


Consideration should be given in such a solution to the width of a plateau to ensure smooth movement of Public transport vehicles.

**Long term measure:**

Reconstructing the pedestrian crossing by raising it onto the plateau as a measure of physical traffic calming of vehicular traffic, with predefined measures of channelizing pedestrian flows by placing protective pedestrian fences within the school zone", both at access sidewalks and along a central median island. Such crossings should allow and meet all the requirements for smooth and safe spatial movement of persons with special needs.

Reconstructing or upgrading the street lighting so that pedestrian crossing could be directly lit with LED sources of light




Building a traffic lights device with the announcement of pedestrian movement when the frequency of pedestrian movement or road safety indicator (statistical data on the number and severity of road accidents) require so.

### 9.2.1 Design plan suggestions and recommendations

4. **Short-term measures**
    - More frequent and regular renewal of road markings if they are implemented using asphalt colour paint. More permanent solution of road markings to be made of plastic or applicative materials.
    - Placing road signs on both sides of the roadway, at regular distance defined by legal provisions, when there are two or more traffic lanes per driving direction.
    - Removing (by cutting, mowing, trimming) the greenery overhanging the road's free cross-section and the greenery overhanging the cross-section of sidewalks.
    - Securing the improper crossing of the roadway outside pedestrian crossings by placing protective pedestrian fences.

5. **Mid-term measures**
    - Securing pedestrians approach to crossings within the „school zone „by building „chicanes "or channelizing pedestrian movement by construction solutions that help direct pedestrian's view to the oncoming vehicular traffic, at any time.
    - Reinforcing the indication of approach to the „school zone "by using rumble strips in the zones in which the vicinity of residential buildings and traffic volumes will not affect the increase of noise and negative vibrations on surrounding objects.
      Reinforcing the road signs and markings by providing several levels of indication so that drivers could adjust their behaviour to sites that require increased attention.

6. **Long-term measures**
    - Reconstructing pedestrian crossings by placing them onto raised plateaus.
    - Reconstructing street lighting by lighting all the pedestrian crossings in periods of reduced visibility.
    - Building a traffic lights device with the indication of pedestrian movement

**Figure 24** **Short term measures design plan**

**Figure25** **Mid term measures design plan**

**Figure26** **Long term measures design plan**

# 10. Conclusion

This report describes the road assessment pilot project in Bosnia and Herzegovina and includes details on data collection, methodology used and a summary of results in a form of Star Ratings, showing the level of risk on the road network. It also offers Safer Roads Investment Plans which have enormous potential to reduce road deaths and injuries on the inspected roads as well as implementation ready design plans of selected locations. iRAP results are available to the project stakeholders who can learn about precise locations where countermeasures should be considered for implementation.

The star rating showed that no road was rated as 5-star for vehicle occupants. Only 4% of the roads scored 4 stars for the car occupant safety. 13% of the network was awarded 3 stars, while 73% of the roads scored only 1 star or 2 stars.

Rating for pedestrians and bicyclists was worse. Only 10% of the network scored better than 1-star for pedestrians and only 8% for bicyclists.

Sources of deaths or serious injuries on the inspected network are likely to include:

- lack of run-off protection and hazardous objects close to the road
- inadequate intersection layout, control and marking
- lack of head-on protection
- lack of pedestrian facilities



The most efficient and cost-effective countermeasures include improved delineation, road side barriers on both driver and passenger side, protected turn lanes, footpath provision adjacent to road etc.

The results showed that the current state of roads needs improvements in order to achieve the desired level of safety, and to climb higher in the international rating of safety level on roads.

The outputs of this work give support to the decision-makers as well as engineers in the process of identifying the areas of high risk and help them decide how to address these locations. The methodology of measuring the relative risk of various types of accidents based on coded attributes and collected data about the traffic flow proved to be effective in many countries of the world in the framework of the RAP programme.

# Appendix 1 – Traffic flows

| Road name | Description | AADT |
|---|---|---|
| M18 | Sarajevo - Semizovac | 20,010 |
| M18 | Semizovac - Olovo | 5,408 |
| M18 | Olovo - Vitalj | 3,930 |
| M18 | Vitalj - Živinice | 8,035 |
| M18 | Živinice – Šićki Brod | 15,366 |
| M18 | Simin Han – Priboj (gr.RS) | 3,085 |
| M4 | Doboj (gr.RS) – Šićki Brod | 10,514 |
| M4 / M18 | Šićki Brod – Simin Han | 19,731 |
| M4 | Simin Han - Ceparde | 11,005 |