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EuroS@P
EUROPEAN ROAD SAFETY PARTNERSHIP

WP3. Teaching materials development related to the road infrastructure safety inspection

IO.7 - Practical implementation of RSI methodology on the selected road sections in Croatia

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1 ABOUT THE EUROS@P PROJECT

The main objective of the EuroS@P project is to promote the best education solutions in the area of RISM directive, with an increase of awareness and knowledge of road safety, by:

1) Developing an e-learning platform with access to project products,
2) The development of teaching and training materials dedicated to conducting classes at universities and training courses for RISM staff,
3) Raising competencies and skills in RISM, by changing curricula at universities and equipping students and staff with didactic materials based on innovative RISM methods and tools,
4) Creating the foundations for Road Safety Professional Certification (RSP),
5) The development of a lasting relationship and the continuation of active international cooperation between project partners with the possibility of its extension to other institutions.

The EuroS@P project targets the following groups:

1) Students, researchers, and academic teachers at universities.
2) Road authority staff at national, regional and local levels.
3) Experts, specialists, and practitioners involved in RS activities, including staff who conduct training in various RS courses.
4) All users of road infrastructure, as an indirect target group, for whom the risk of road accidents will ultimately be reduced by increasing the effectiveness and efficiency of RISM activities.

The project is also supported by a group of associates who will cooperate with project partners to consult and evaluate the results. They will implement final products and promote the dissemination and accessibility of the project results.

ABOUT OUTPUT IO.6

- **Objective:** Practical implementation of RSI methodology on the selected road sections in Croatia
- **Work package:** The task falls under WP3 Teaching materials development related to the road infrastructure safety inspection.
- Target Groups:
- Research and teaching staff from institutions involved in the project.
- Students of civil engineering and transportation engineering.

As part of the task, the following elements have been conducted included:

- Preparatory work related to the selection of research sections, collecting data on these sections and organisation of field tests.
- Field work involving the inspection, so far assessed according to the methodology in force and other road sections that have not yet been assessed. As part of the inspection, attention was paid primarily to the distinctive problems of road safety in Croatia.
- The essential scope of remedial actions is necessary to improve road safety on selected road sections.

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2 INTRODUCTION

The road inspection and subsequent results for selected roads in Rovinj was performed based on standardised iRAP methodology in order to determine critical road sections on which developed EuroS@P road safety inspection can be applied to. To assess the road safety of the selected roads, the team has perform coding of relevant road infrastructure elements that are related to road safety and have a proven influence on the possibility of an accident occurrence or its severity. Coding process has been performed based on georeferenced video files of project roads which are going to be recorded during road survey phase. After an iRAP coding process, datasets have been imported into ViDA software in order to identify Star Rating results of observed road sections.

After the Star Rating analysis had been completed, the most critical road segment was identified for the implementation of the EuroS@P RSI (Road Safety Inspection) methodology, which stands for an ordinary periodical verification of the infrastructure characteristics and defects that require maintenance work for reasons of safety. The developed safety inspection procedures reflect the scope of the project and give some quantitative safety evaluation to the best extent compatible with a methodology mainly based on subjective evaluations.

By using video files recorded previously for the purposes of iRAP Star Rating, a virtual drive trough was conducted on inspected roads, and the IASP checklists were filled in order to identify any critical infrastructure road elements in order to determine if a road is safe and which has to be reconstructed.

3 Didactic workshop in Croatia and its connection with IO.7

During the workshop in Croatia, consortium members (Bauhaus Universität Weimar, Universita Degli Studi di Catania, Gdansk University of Technology, University of Zagreb, Faculty of Transport and Traffic Sciences and EIRA, European Institute of Road Assessment) came together to pool their road safety expertise, share insights, and synergise their efforts towards the project's objectives of developing EuroS@P road safety methodology. The main objective of the workshop was to demonstrate Croatian RSI and RSA procedures and test the applicability of the iRAP Star Rating methodology in determining dangerous sections for targeted RSI inspection developed within EuroS@P. This document represents a report of results from both Star Rating and EuroS@P methodology.

Workshop participation and main activities are shown within the next few figures (Survey preparation, iRAP coding and analysis).

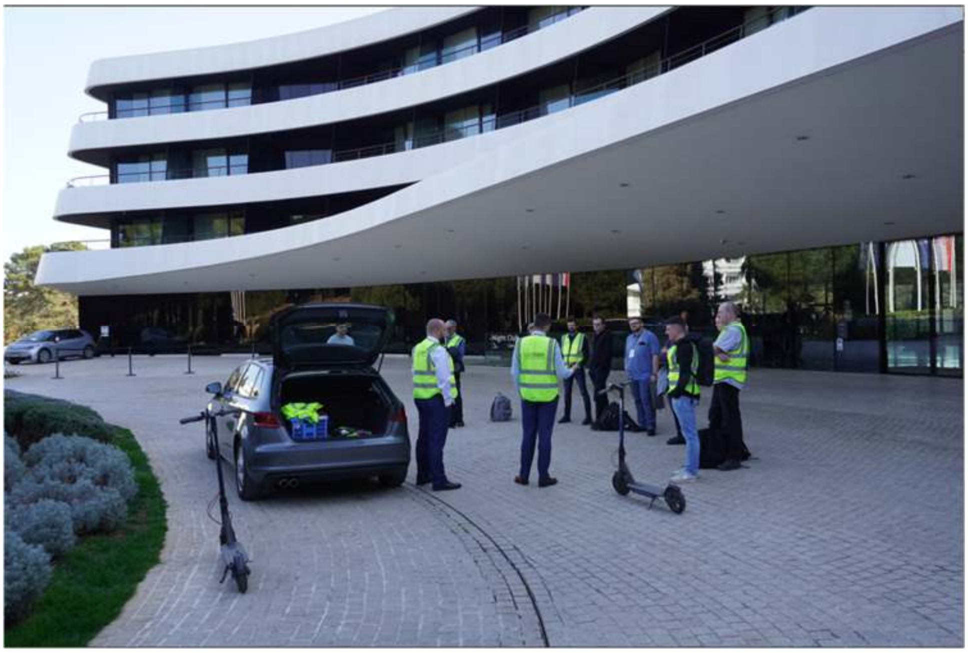

Figure 1 Survey preparation

Figure 2 Survey preparation

Figure 3 iRAP coding and analysis

4 CONTEXT

The key factor in road safety is the condition of the roads. Vehicle damage and harm to other road users can result from poorly built infrastructure, or poor quality of traffic management systems. Roads designed to only ensure better traffic flow and to minimize bottlenecks can have a significant negative impact on road safety. Infrastructure has a key role to play in ensuring road safety, and continued targeted investments in existing and new technologies will be vital for road safety.[1]

4.1 ROAD INFRASTRUCTURE IMPACT ON ROAD SAFETY

Road safety is essential to the well-being of people and communities, and vital for economic growth and prosperity. Many countries around the world (Croatia included) have adopted a Safe System approach as the guiding paradigm to address road safety. The Safe System Approach has been embraced by the transportation community as an effective way to address and mitigate the risk inherent in our complex transportation system. It works by building and reinforcing multiple layers of protection to prevent crashes from happening and to minimise the harm caused to people. A Safe System Approach incorporates the following principles: prioritises the elimination of crashes that result in death and serious injuries, designs and operates to accommodate certain types and levels of human mistakes and avoid death and serious injuries when a crash occurs, to use proactive tools to identify and address safety issues in the transportation system and also to strengthen all parts of the transportation system, so if one part fails, the other parts still protect road users.[2] Road infrastructure includes physical assets such as the road carriageway and roadsides, as well as other infrastructural objects, for example, bus stops, bridges and tunnels. Properly built road infrastructure will make a positive impact on global road safety, as it has the potential to save many lives. On the opposite side, if the infrastructure isn't built well enough, it can also make road and roadside objects unsafe. It is imperative to plan the infrastructure in a way that can reduce the number of crashes. [3]

4.1.1 Global context

According to the World Health Organisation's Global Status Report On Road Safety report, 1,2 million people die each year on the world's roads, and between 20 and 50 million suffer non-fatal injuries. Road traffic injuries are one of the top three causes of death for people aged between 5 and 44 years. In most regions of the world, this epidemic of road traffic injuries is still increasing. Over 90% of the world's fatalities on the road occur in low-income and middle-income countries, which have only 48% of the world's registered vehicles. Almost half of those who die in road traffic crashes are pedestrians, cyclists or users of motorised two-wheelers (commonly known as Vulnerable Road Users), and this proportion is higher in the developing economies of the world. [4]

[1] https://www.acea.auto/fact/safe-infrastructure/
[2] https://www.transportation.gov/NRSS/SafeSystem
[3] https://apps.who.int/iris/bitstream/handle/10665/44122/9789241563840_eng.pdf
[4] https://apps.who.int/iris/bitstream/handle/10665/44122/9789241563840_eng.pdf

4.1.2 Context in Croatia

According to the National Road Safety of the Republic of Croatia for the period 2021 – 2030, analysed data showed the number of 57% of fatal and serious injury road traffic accidents in the Republic of Croatia potentially caused by road users. In fact, 35% of fatal and serious injury road traffic accidents are potentially attributed to road users including the road, and 6% to road users including vehicle. This can be seen in the figure 1.

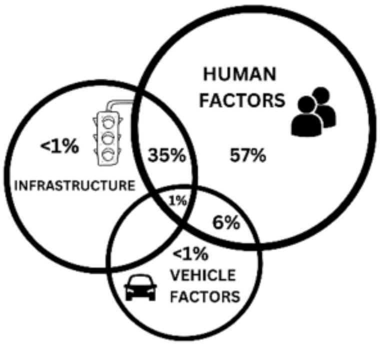

Figure 4 - Road accident distribution per user, vehicle and infrastructure categories

Regarding causality of road traffic accidents, speed as the only potential cause was recorded in about 17% of fatal and serious injury road traffic accidents. In 8% of fatal and serious injury road traffic accidents, speed was combined with alcohol and in 10% of cases, with reckless driving. Alcohol as the potential cause was recorded in 23% of fatal and serious injury road traffic accidents, where it can be assumed that driving under the influence of alcohol is the cause of about 4% of fatal and serious injury accidents. Likewise, the analysis of circumstances indicated reckless driving as one of the potential causes of as many as 59% of serious road traffic accidents or the potential main cause of 38% of serious road traffic accidents, which is a slightly higher percentage compared to more developed European countries, [5] as it is shown in the figure 2.

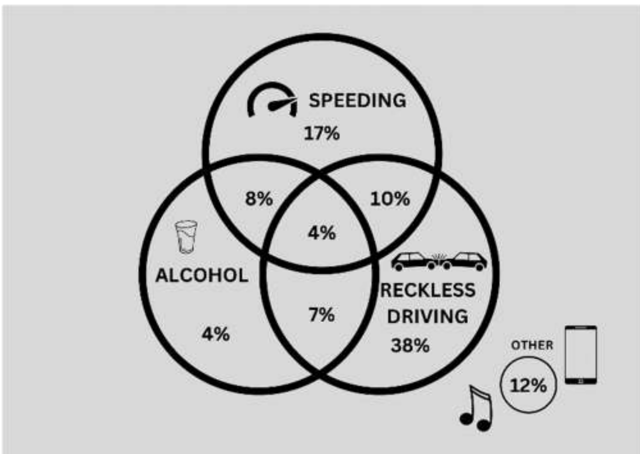

Figure 5 - Causes of Road Accidents

[5] https://mup.gov.hr/UserDocsImages//2022/06//NPSCP%2021-30_engl.pdf

4.2 ROAD SAFETY POLICIES

Infrastructure is defined as the basic physical system of a business, region, or nation and often involves the production of public goods or production processes.[6] A question which can often occur during international and regional discussions is how can targeted infrastructure investment be used most effectively in order to improve road safety. Infrastructure elements, if wrongly designed or unmaintained, can be significantly dangerous if they confuse drivers or do not adequately provide the minimal level of defined standards.[7] The Road Safety Policy Framework of the European Union for the upcoming period 2021–2030 is based on the 'safe system approach' of 2020. Over the past decade, the safe system approach has emerged from best safety practice. Globally recommended by the World Health Organisation, the safe concept approach represents a holistic view of the road transport system and the interaction between the roads, users and vehicles. It addresses all groups using the road system, including drivers, motorcyclists, passengers, pedestrians, cyclists and drivers of commercial and heavy-duty vehicles. The safe system approach recognises the fact that people will always be prone to mistakes and reshapes road safety policy by focusing on the prevention of deaths and injuries. According to the principle underpinning the safe system approach, the system is to be 'forgiving', and road traffic accidents, regardless of their immediate cause, shall not result in death or serious injury. The safe system is based on the fact that the deaths and injuries resulting from road traffic accidents are not the price that road users inevitably have to pay for the increasing demand for mobility. Key factors, including the previously identified and established safe system factors, are: safe infrastructure, safe road use, safe vehicles, and fast and efficient emergency services. The safe system approach involves multisectoral and multidisciplinary action by different actors to increase the level of road safety. It is based on the division of responsibilities towards road safety. In order to function, all actors need to perform the planned tasks in a coordinated manner.[8]

4.3 Global context

Usually traffic deaths and severe injuries are considered as inevitable side effects of modern life. The reality is that by taking a proactive, preventative approach that prioritizes traffic safety as a public health issue, tragedies can be prevented. Vision Zero is a strategy to eliminate all traffic fatalities and severe injuries, while increasing safe, heathy, equitable mobility for all.

In two key ways, Vision Zero represents a significant departure from the status quo:

1) Vision Zero recognizes that people will sometimes make mistakes, so the road system and related policies should be designed to ensure those inevitable mistakes do not result in severe injuries or fatalities. This means that system designers and policymakers are expected to improve the roadway environment, policies (such as speed management), and other related systems to lessen the severity of crashes.

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6 https://www.investopedia.com/terms/i/infrastructure.asp

7 https://roadsafetyfacts.eu/active-safety-systems-what-are-they-and-how-do-they-work/

8 https://mup.gov.hr/UserDocsImages//2022/06//NPSCP%2021-30_engl.pdf

2) Vision Zero is a multidisciplinary approach, bringing together diverse and necessary stakeholders to address this complex problem. In the past, meaningful, cross-disciplinary collaboration among local traffic planners and engineers, policymakers, and public health professionals has not been the norm. Vision Zero acknowledges that many factors contribute to safe mobility — including roadway design, speeds, behaviour, technology, and policies — and sets clear goals to achieve the shared goal of zero fatalities and severe injuries.[9]

4.4 Context in Croatia

The National Road Safety Plan of the Republic of Croatia for the period 2021. – 2030. defines a need to invest in road infrastructure, defining that all new roads should have a safety standard for all road users of at least 3 stars. Additionally, the program aims to strengthen the human and technical potential of the police and inspectors to the services in charge of road traffic control by 100%. For the purposes of reducing the number of people killed in road traffic accidents, as well as the consequences of serious road traffic accidents with infrastructure as a potential contributing factor, 33 activities were defined and divided into 15 measures:

- implementation of preventive-educational and promotional activities;
- training of people working in road transport;
- remedial treatment of black spots;
- road safety inspection (RSI), safety analysis of new and existing roads;
- safety analysis of new and existing roads (RSIA, RSA);
- design of a safe transport system;
- road infrastructure maintenance;
- technical solutions for driving in the opposite direction;
- research;
- investigation of road traffic accidents;
- implementation of the system of 'forgiving roads';
- deployment and improvement of ITS;
- addressing of railway level crossings used by vehicles and pedestrians;
- road safety audit;
- amendments to legislation.

The implementation of the defined measures provides for the compliance of all new roads with the required safety standards for all road users or a three-star or better rating. On the other hand, the existing roads carrying 75% of traffic should have a minimum three-star rating for all road user groups, depending on the road category and the planned traffic load by road user groups.[10]

4.5 RISM Directive

Directive 2008/96/EC requires the establishment and implementation of processes relating to road safety evaluations, road safety audits, road safety audits, road safety inspections and network – wide road safety assessments by the Member States. This Directive applies to

[9] https://visionzeronetwork.org/about/what-is-vision-zero/

[10] https://mup.gov.hr/UserDocsImages//2022/06//NPSCP%2021-30_engl.pdf

roads which are part of the trans-European road network, to motorways and to other primary roads, whether they are at the design stage, under construction or in operation. Directive 2019/1936 is an amendment on Directive 2008/96/EC. 11 The amendment also prescribes a targeted road safety inspection once the network wide safety assessment has been performed on the national main road network and potentially dangerous locations have been identified.[12]

4.5.1 About RISM directive

In order to improve the road safety status, the European parliament and the council of the European Union adopted the Directive on road infrastructure safety management (RISM) in 2008. RISM directive provided a legal framework under which all member states had to put in place mechanisms which mandated the RSIA (Road Safety Impact Assessment), RSA (Road Safety Audit), RSI (Road Safety Inspection) assessments as well as NSM (Network Safety Management).[13] 23. October 2019 Directive 2019/1936 has been adopted as an amendment to Directive 2008/96/EC on road infrastructure safety management. The procedures defined within road infrastructure safety management ('RISM') directive - DIRECTIVE (EU) 2019/1936, which were implemented on the road network in some countries, have helped reduce fatalities and serious injuries in the Union. It is clear from the evaluation of the effects of this directive of the European Parliament and of the Council that Member States which have been applying RISM principles on a voluntary basis to their national roads beyond the TEN-T network have achieved much better road safety performance than Member States which did not do so.[14] The National Highway Traffic Safety Administration has released that 31,785 people died in traffic crashes in the first nine months in year 2022. This is a 0.2% decrease as compared to the 31,850 estimated fatalities during the same time in 2021.

RISM directive defines indicative elements of targeted road safety inspections (RSI) as follows: [15]

1. Road alignment and cross-section:
   (a) Visibility and sight distances;
   (b) Speed limit and speed zoning;
   (c) Self-explaining alignment;
   (d) Access to adjacent property and developments;
   (e) Access of emergency and service vehicles;
   (f) Treatments at bridges and culverts;
   (g) Roadside layout
2. Intersections and interchanges:
   (a) appropriateness of intersection/interchange type;
   (b) geometry of intersection/interchange layout;
   (c) visibility and readability (perception of intersections;
   (d) visibility at the intersection;
   (e) layout of auxiliary lanes at intersections;
   (f) intersection traffic control (stop controlled, traffic signals)

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11 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L1936&from=LV
12 https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/50/d2618cbe1b0f956c65ef7aebb7274bd9e43a9e37.pdf
13 https://www.interreg danube.eu/uploads/media/approved_project_output/0001/50/d2618cbe1b0f956c65ef7aebb7274bd9e43a9e37.pdf
14 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019L1936
15 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L1936&from=LV

   (g) existence of pedestrian and cycling crossings.
3. Provision for vulnerable road users:
   (a) Provision for pedestrians;
   (b) Provision for cyclists;
   (c) Provision for powered-two-wheelers;
   (d) Public transport and infrastructures;
   (e) Level crossings (noting, particularly, the type of crossing and if they are manned, unmanned, manual, automated).
4. Lighting, signs and markings:
   (a) Coherent road signs, not obscuring visibility;
   (b) Readability of road signs (position, size, colour);
   (c) Sign posts;
   (d) Coherent road markings and delineation;
   (e) Readability of road markings (position, dimensions and retro reflectivity under dry and wet conditions);
   (f) Appropriate contrast of road markings;
   (g) Lightning of lit roads and intersections;
   (h) Appropriate roadside equipment.
5. Traffic signals:
   (a) Operation;
   (b) Visibility;
6. Objects, clear zones and road restraint systems:
   (a) Roadside environment including vegetation;
   (b) Roadside hazard and distance from carriageway or cycle path edge;
   (c) User-friendly adaptation of road restraint systems (central reservations and crash barriers to prevent hazards to vulnerable road users);
   (d) End treatments of crash barriers;
   (e) Appropriate road restraint systems at bridges and culverts;
   (f) Fences (in roads with restricted access)
7. Pavement:
   (a) Pavement defects;
   (b) Skid resistance
   (c) Loose material/gravel/stones
   (d) Ponding, water drainage.
8. Bridges and tunnels:
   (a) Presence and number of bridges;
   (b) Presence and number of tunnels;
   (c) Visual elements representing hazards for the safety of the infrastructure.
9. Other issues:
   (a) Provision of safe parking areas and rest areas;
   (b) Provision for heavy vehicles;
   (c) Headlight glare;
   (d) Roadworks;
   (e) Unsafe roadside activities;
   (f) Appropriate information in ITS equipment (variable message signs);
   (g) Wildlife and animals;
   (h) School zone warnings (if applicable);

4.5.2 Context in Croatia

Regarding the RISM implementation in Croatia, four procedures are currently under the implementation process:

- Prescribing transparency and directing further action based on the results of road infrastructure safety management procedures.
- Incorporating a network – wide road safety assessment, a process of systematic and proactive risk mapping to assess the “in-built”, or inherent, road safety in the European Union.
- Extending the scope of the Directive beyond the Trans-European Transport Network (TEN-T) to include motorways and primary roads outside TEN-T network and all roads outside urban areas that are wholly or partly built with EU funds.
- Introduction of an obligation for vulnerable road users to be systematically taken into account within all road safety management procedures.

In Croatia, there are two major legislative documents which have been adapted in accordance to RISM directive:

- Amendments to the Roads Act
- Ordinance for road safety audit and training of road safety auditors

Key actors involved in the EU 2019/1936 RISM Directive implementation are: Ministry of the Sea, Transport and Infrastructure, Ministry of the Interior, Road authorities, Croatian Motorways Ltd and Croatian Roads Ltd.

- Challenges which were encountered were the following:
- Unclear definition of the “primary” network. There was a discussion on how many road selections to include, and ultimately, all highways and state roads were included into the primary road network.
- Problems with distinguishing the difference between targeted and periodical road safety, inspections, and how it relates to RSI, as defined in the old directive (responsibilities, financing etc…)[16]

4.6 Network wide road safety inspection approach

The Network wide road safety Assessment Methodology is applicable for existing EU roads within scope of Directive 2008/96/EC, as amended by Directive 2019/1936/EC, and specifically roads which are part of the trans – European road network, motorways both rural and urban, roads outside urban areas that are right below motorways in Member States’ road functional classification system and other roads situated outside urban areas, which do not serve properties bordering on them and which are completed using Union funding.[17]

The Network – wide assessment methodology comprises two methodological approaches: one for the assessment of the in-built safety roads (proactive methodology) and one for the assessment of road on the basis of crash occurrence analysis (reactive methodology). The two methodologies are both applied over the same network and the resulting assessment

[16] https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/48/e135439fcd8a88a077de3249a04ed9c751d645f2.pdf
[17] https://road-safety.transport.ec.europa.eu/system/files/2023-01/NWA-Handbook7.pdf

outcome are combined via an integration methodology to provide the final road network rating and ranking. The NWA-reactive methodology (or simply the reactive methodology) aims to assign a section or junction to one safety class on the basis of statistical analyses of crash data. The methodology differentiates between the road type, i.e., rural or urban motorway, divided rural road or undivided rural road. The crashes which are considered are those that involve at least one casualty (i.e., fatality or injury) and must refer to a period of at least three years. The implementation of the reactive methodology involves the segmentation of the network which can be performed using three alternative segmentation approaches; the network is divided in a set of sections or a set of sections and a set of junctions. Using the Poisson method, upper and lower thresholds are defined for the observed number of crashes of each section (and junction). Then, these thresholds are converted to crash density and crash rate thresholds for each section. For the final ranking of the section it is recommended to rely on the crash rate comparison, if they are available. Otherwise, the ranking relies on the crash density comparison. Each section is classified as "low risk", "unsure" or "high risk". The methodology differentiates between the road type, i.e., rural or urban motorway, divided rural road or undivided rural road. The network also needs to be segmented for the implementation of the proactive methodology. Sections are formed by segments and junctions, and are not necessarily identical to the segments of the reactive methodology, as segmentation criteria are different. [18]

The iRAP Methodology fact sheets answer many of questions people have about iRAP approach, covering topics such as crush types, Star Rating Score equations, model calibration and estimation of economic benefits and costs.

iRAP was created to assist address the severe social and economic costs of car accidents. Without action, the global yearly number of road deaths is expected to rise to 2.4 million by 2030. The bulk of fatalities will occur in low- and middle-income nations, which currently account for nine out of every 10 road deaths worldwide. Almost half of those killed will be vulnerable road users, such as cyclists, pedestrians, and motorcyclists.

As large as the problem is, keeping roads safe is far from insurmountable; the necessary knowledge, technology, and skill to save lives already exist. Road safety engineering directly contributes to the reduction of traffic fatalities and injuries. Well-designed junctions, safe roadside features, and proper road cross-sections can dramatically reduce the likelihood and severity of motor vehicle collisions. Footpaths, pedestrian crossings, and bicycle routes can significantly reduce the danger of walkers and bicyclists being killed or injured by removing the need for them to interact with motorized vehicles. Motorcycle lanes can reduce the danger of death and injury for riders. [19]

The iRAP methodology can significantly assist in the selection of road traffic accidents which were probably caused by the driver's fatigue, because by using the iRAP methodology the static safety of road infrastructure elements can be quickly and objectively evaluated, and then excluded as s possible cause of a traffic accident.[20]

[18] https://road-safety.transport.ec.europa.eu/system/files/2023-01/NWA-Handbook7.pdf
[19] https://irap.org/methodology/
[20] https://hrcak.srce.hr/clanak/355200

4.6.1 Global context

The Network Wide Road Safety Assessment Methodology is envisioned for existing EU roads within scope of Directive 2008/96/EC, as amended by Directive 2019/1936/EC, and specifically:

- roads which are part of the trans-European road network,
- motorways (rural and urban),
- other primary roads (i.e. roads outside urban areas that are right below motorways in Member States' road functional classification system), and
- other roads situated outside urban areas, which do not serve properties bordering on them and which are completed using Union funding.

The methodology may also be used by Member States to assess roads outside urban areas outside scope of the Directive, on a voluntary basis.

According to the relevant requirements for network wide road safety assessment defined in Directive 2008/96/EC (as amended by Directive 2019/1936/EC), the objective of the network wide road safety assessment methodology is to provide a cost-effective safety assessment of the road network within the scope of the Directive and ranking in at least three classes. The safety assessment is to be based on the evaluation of both the design characteristics of the road (in-built safety) and historic crash data (if available), and serves a screening purpose in order to prioritise in an efficient way either targeted road safety inspections or direct remedial actions.[21]

4.6.2 Context in Croatia

EuroRAP/iRAP methodology has been occasionally used in Croatia as a network wide safety assessment methodology. Furthermore, Croatia utilises a country specific accident occurrence analysis which is used in order to identify hazardous locations across the road network. Methodology is not estimating the "in-built" road safety, and is reactive in its nature. RSA has been adopted as a standard for all new planned sections by the Croatian Motorways and other motorway operators on TEN-T network, as well as all new planned sections on state roads managed by the Croatian Roads (All of TEN-T and all major projects co-financed by the EU). RSI in Croatia is currently performed by the Sector for Road Safety and Roads Inspection of the Ministry of the Sea, Transport and Infrastructure, however, to this date a very insignificant part of the network was inspected, due to the late adoption of the 2008/96/EC Directive requirements and lack of capacity.[22]

In Croatia, iRAP has been employed on a large number of various local and international projects. Some examples of this include:

- Project Sensor
  - https://eurorap.org/sensor/
  - Raising the safety standards of the networks inspected can be achieved with on-going maintenance, specific accident reduction programmes and road rehabilitation.

[21] https://road-safety.transport.ec.europa.eu/system/files/2023-01/NWA-Handbook7.pdf

[22] https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/48/e135439fcd8a88a077de3249a04ed9c751d645f2.pdf

Within SENSoR project the Safer Roads Investments Plans for each country surveyed had been developed based on the cost/benefit ration.

- Project SLAIN
  - https://eurorap.org/slain-project/
  - SLAIN (Saving Lives Assessing and Improving TEN-T Road Network Safety)
  - Enhancing road safety and minimizing the occurrence of road accidents necessities a persistent effort that relies on well-established and tested risk assessment techniques. There are two primary approaches to evaluating risks: reactive, which draws on historical crash data, and proative, which involves anticipating risks through expert judgment or empirical correlations between road design elements and the likelihood or severity or accidents. Both these methods play a vital role in creating a safer road environment.
- Project Sabrina
  - https://www.interreg-danube.eu/approved-projects/SABRINA
  - SABRINA (Safer Bicycle Routes in Danube Area) project focuses on road infrastructure safety for cyclists as one of the most vulnerable users. It tackles cycling infrastructure safety issues on existing, planned and missing cycling corridors crossing nine countries in the Danube region. The goal of the project was to improve bicycle infrastructure in a safe and sustainable way. Within the project, extensive iRAP assessment of 4 EuroVelo cycling routes in Croatia, amongst other countries of the Danube region, was conducted.[23]

[23] https://irap.org/2021/12/sabrina-project-training-irap-model-in-the-context-of-safer-bicycle-infrastructure/

5 PROJECT SCOPE

Following subchapters will presented the scope of the intended road safety assessment within Croatia. As a summary, iRAP Star Rating methodology will be used in order to identify critical road sections, and iRAP tools will be utilised in order to generate Star Ratings for all road user groups, generation of countermeasures and determining the best value of network safety upgrading programmes through economic appraisal.

5.1 Area of observation

Map layout of the roads which we will analyse for safety can be seen in the figure 3. The analysed roads are located in Croatia in Istria, city Rovinj. Two parts of roads are in rural part and one in urban.

Figure 6 - Legend of analysed roads

The total length is about 5 kilometres divided into three parts. Each road is explained in detail in the following table (name, length, urban/rural, average annual daily traffic).

Table 1 - Road explanation

ROAD	PROJECT NAME	ROAD LENGTH (KM)	RURAL/ URBAN	AADT	SPEED (KM/H)
UL. LUJE ADAMOVIĆA - UL. BRAĆE BOŽIĆ	Rovinj part 1 1	1,77	Urban	6775	50
PULSKA CESTA (ŽC 5096)	Rovinj part 1 2	1,66	Urban	9500	50
PULSKA CESTA (ŽC 5096)	Rovinj part 2	2	Urban	8400	60

5.2 Road safety statistics for observed roads

According to the available databases, analysed traffic accidents in the area of the Istria county in the period since 2016 till 2020, can be found in the figure 3. In the figure 4 can be seen that the most of the vehicle accidents in Istria happen on unclassified roads with more than 74 000 accidents within the observed period. Furthermore, roads falling within State road classification have more than 15 000 accidents, County roads have more than 6 000 accidents, highways have around 5 000, and local roads have more than 1 000 accidents in the period since 2016 till 2020.

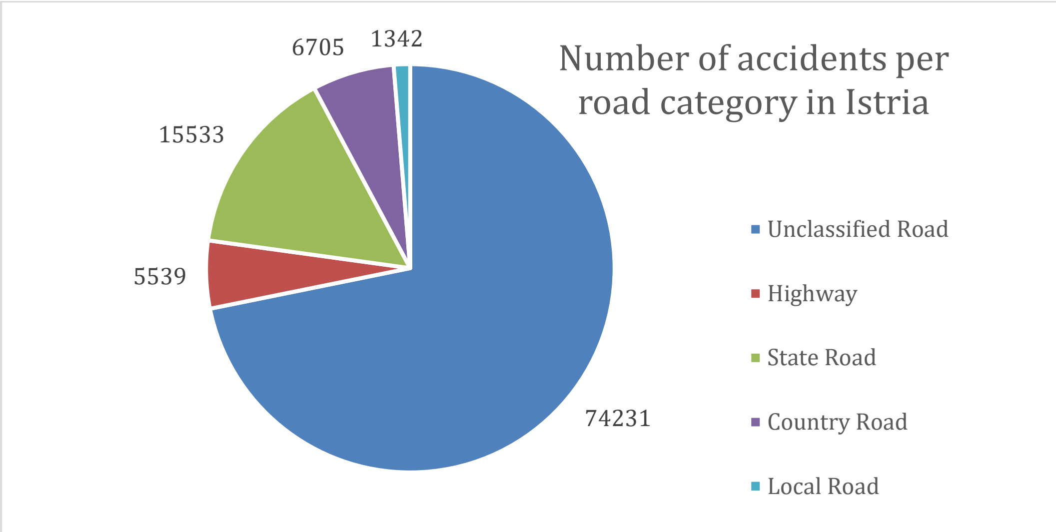

Figure 7 - Number of accidents per road category in Istria (2016-2020)

In figure 5, it can be seen that the higher number of accidents is also for unclassified roads with little more than 600 accidents. At the second highest place are a county road class type roads with 146 accidents, then state roads with 139 accidents. The lowest number of accidents has happened on local roads for the observed period.

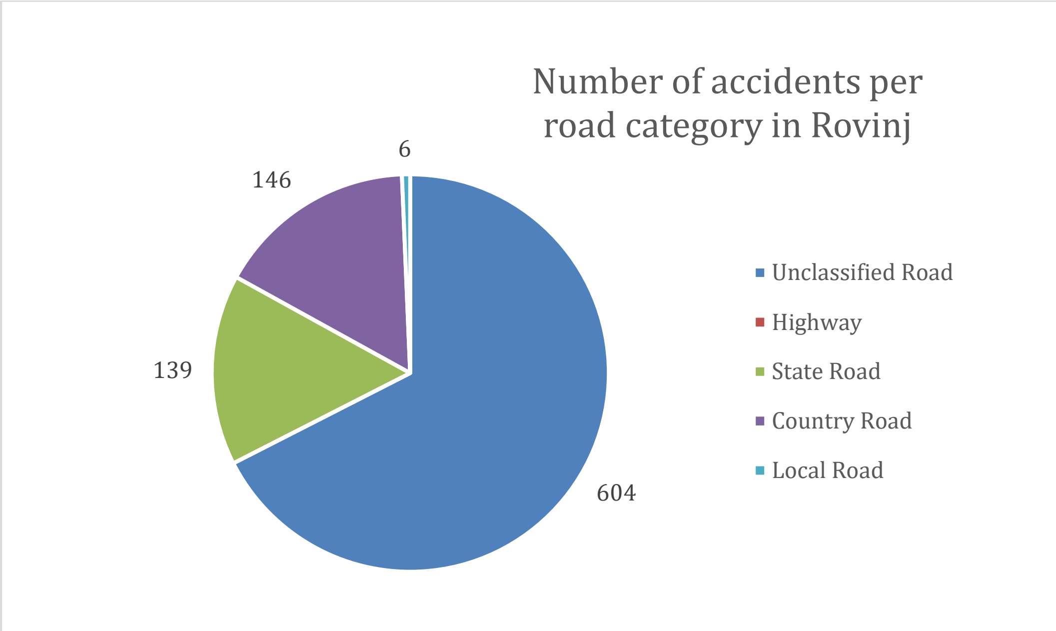

Figure 8 - Number of accidents per road category in Rovinj (2016-2020)

Figure 6 shows what are the causes of accidents in Rovinj. It can be seen that the most accidents happen because of the drivers and their behaviour in traffic.

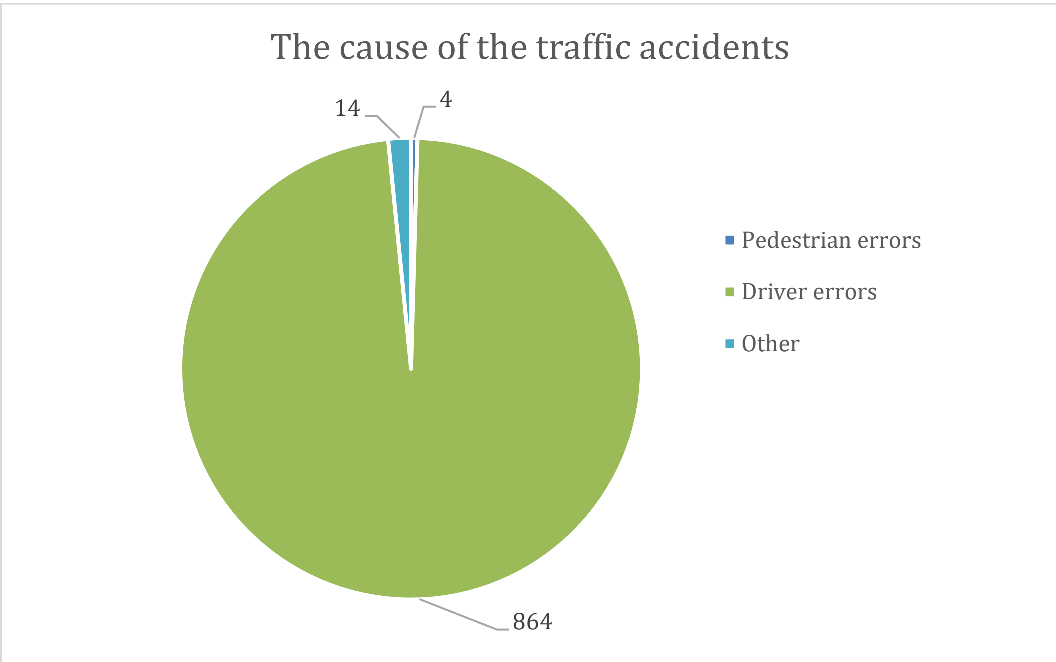

Figure 9 - The cause of the traffic accidents (2016-2020)

Within the following figures (figure 7 and figure 8), locations of accidents within observed road segment are displayed. It can be seen that there were 12 accidents on the analysed roads for the observed period, out of which 10 happened on urban area of the observed road, while 2 happened on the rural area of the observed road.

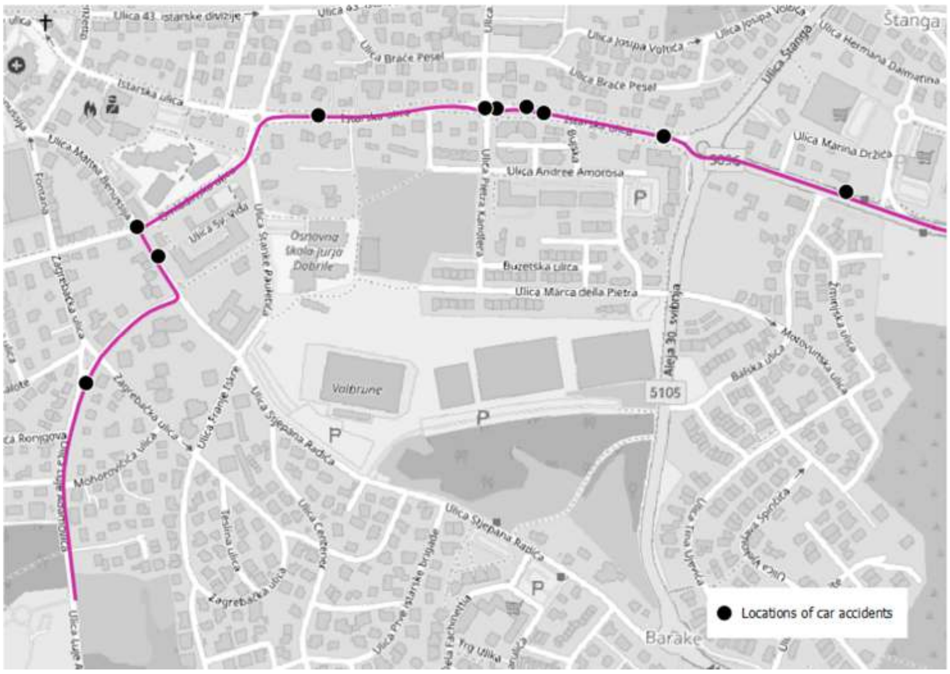

Figure 10 – Locations of vehicle accidents within urban areas of observed roads

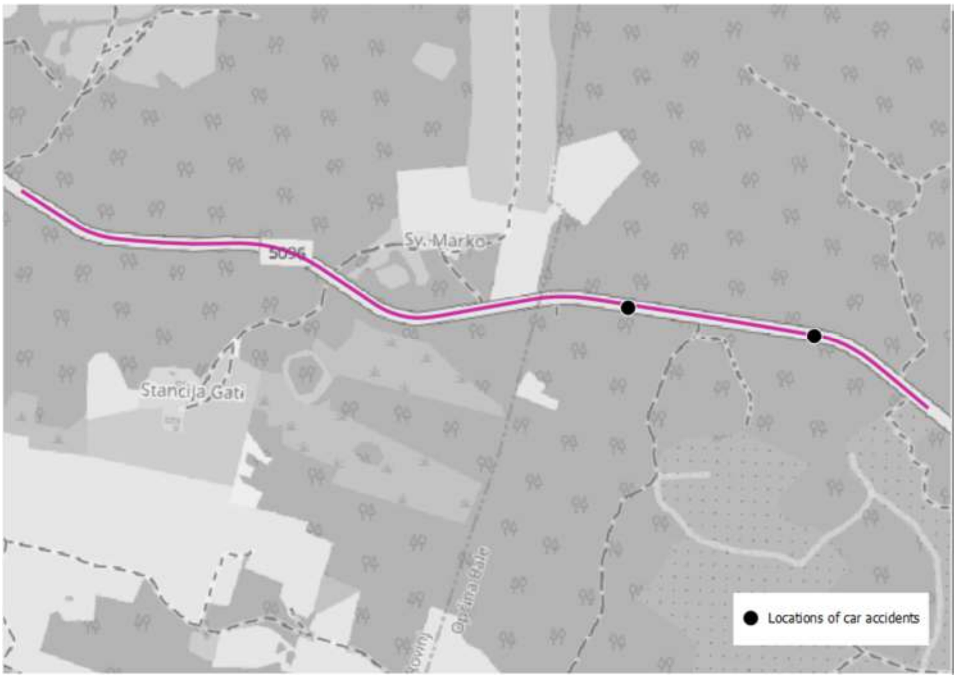

Figure 11 - Locations of vehicle accidents within rural areas of observed roads

5.3 About iRAP Star Rating protocol

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.

In this project, the iRAP model version v3.02 was used to calculate the Star ratings, Fatality estimations and prepare the SRIP.

iRAP provides specialized 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 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, ChinaRAP, IndiaRAP, BrazilRAP, SARAP, ThaiRAP and MyRAP. Road Assessment Programmes (RAP) are now active in more than 100 countries throughout Europe, Asia Pacific, Australia, New Zealand, as well as North, Central and South America and Africa.

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

National governments, automobile clubs and associations, charities, the motor 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 in the RAP 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 of 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 who are 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 road safety. The record leads to the quantification of the safety that a road section provides 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-Stars scale (the risk level is signified by a star rating from 1 to 5 stars, 1 star rating represents the highest level of risk, while 5 star rating indicates the lowest level of risk). This quantification aims to identify 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 greater safety capacity and maximize the benefit over the 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.

5.3.1 Measuring the road infrastructure safety

The assessment of the road safety requires the Road Safety Inspections of the road network sections and the assignment of a safety score to them. After the completion of the coding process, each individual segment of the road network is assigned an SRS (Star Rating Score) rating indicating the identified level of risk. The inspection is conducted by visual observation and record 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 methodology uses two types of inspection; the drive-through and the video-based inspection. During the first one, the record of the infrastructure's elements is performed manually, with the help of specialized software, while during the second inspection, a specially equipped vehicle is used, so as the recorded video to be used for a virtual drive-through of the network and the characteristics of the road infrastructure elements are written in the appropriate code form into a numerical matrix of attribute values.

Following the RSI, the Star Rating Score (SRS) is calculated. The SRS is a unit-less indicator which depicts the infrastructure's safety capacity for each road user type, and it is calculated for 100-m road segments. Road user types are considered the car occupants, the motorcyclists, the bicyclists and the pedestrians who may be involved in road accidents. For each road user type and for 100-m road segmentation, the respective SRS is calculated as follows:

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

where "n" is the number of 100-m 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 - the Likelihood that the "i" crash may be initiated, S - the Severity of the "i" crash, OS - the degree to which risk changes with the Operating Speed for the specific "i" crash type, EFI - the 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 - the potential that an errant vehicle will cross a median (Median Traversability).

5.3.2 The Star Rating process

The aim of the Star Rating process is the award of the "n" 100-m road segments with Stars, depicting the safety offered to each of the "u" road users' types. The Star Rating system uses the typical international practice of recognizing the best performing category as 5-star and the worst as 1-star (5 stars 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 SRS calculated to the Star Rating bands. The thresholds of each band are different for each road user and were set following significant sensitivity testing to determine how SRS 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 SRS score in relation to the position (distance from the beginning) on the road under consideration. The final output of the Star Rating are the Star Rating Maps in which the "n" road sections are shown with different colour depending on their Star award (Figure 12).

5 Stars	★★★★★
4 Stars	★★★★☆
3 Stars	★★★☆☆
2 Stars	★★☆☆☆
1 Star	★☆☆☆☆

Figure 12 - iRAP Star Ratings

5.3.3 Developing the Safer Road 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 100-m road segment on an annual basis when 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 100-m 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 in 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 for a 100-m road segment is a 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 of lack of appropriate data, 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 10/1 ratio.

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 so as to reduce the fatalities and serious injury rates, for example the reconstruction of critical elements of the observed road network, reconstruction of dangerous intersections and curves, carriageway and lane widening, removal of roadside hazards, installation of appropriate protection systems (roadside barriers, shock-absorbent safety barriers), delineation improvement and the installation of vertical signalling and other similar activities. Each countermeasure is characterized by its trigger sets and its effectiveness for each of the 100.m 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 SRS 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 and aims to the calculation of the Benefit-Cost ratio (BCR) for each countermeasure. The economic benefit is considered the benefit of preventing a death or 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 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 maintenance and/or rehabilitation plans.

6 CURRENT STATE RESULTS

Based on the coded and supporting data, the ViDA online software produces Star Rating of the surveyed network. The star rating is based on individual relative risk for four user groups – vehicle occupants, pedestrians, motorcyclists and bicyclists. Therefore, four different star ratings were produced. The software is also capable of smoothing the data in order to eliminate random star rating differences over short sections of road.

The next Figures (Figure 10 – Figure 17) display Star Rating maps for the observed roads in Rovinj, per user category.

Figure 13 - Star Rating map for the vehicle occupants, Road part 1 1 and Road part 1 2

Figure 14 - Star Rating map for the vehicle occupants, Road part 2

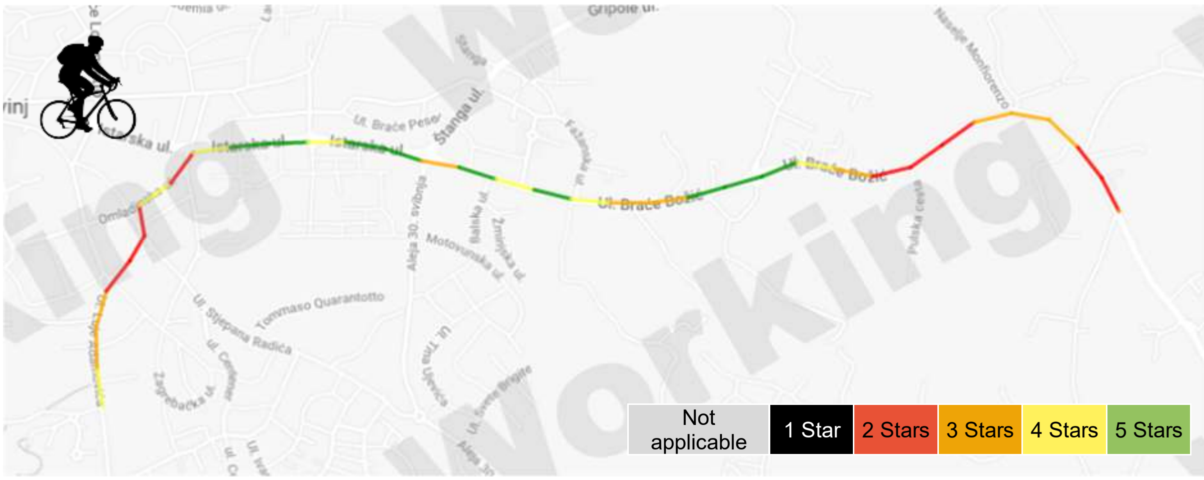

Figure 15 - Star Rating map for bicyclists, Road part 1 1 and Road part 1 2

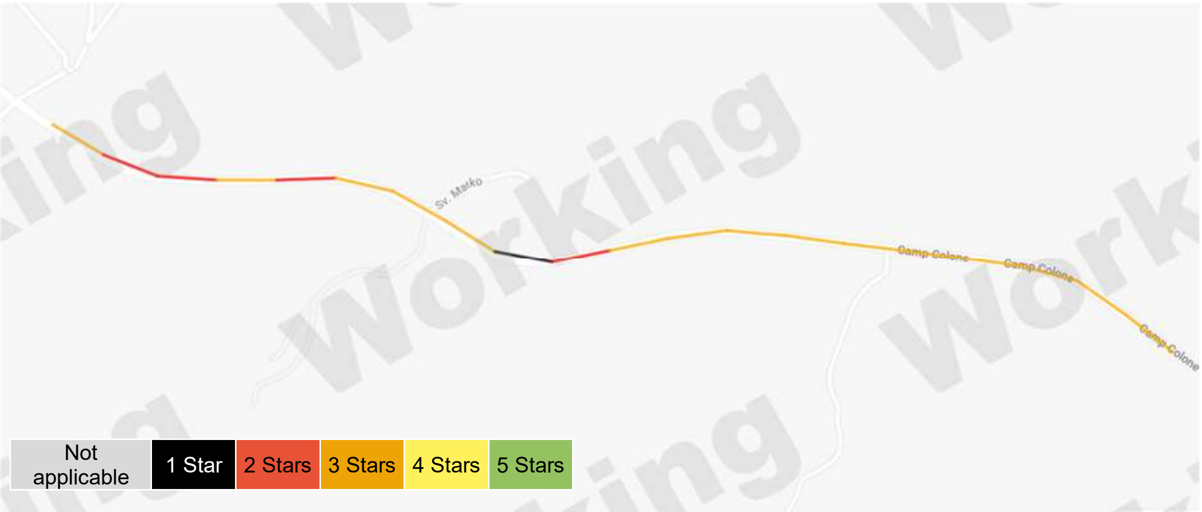

Figure 16 - Star Rating map for bicyclists, Road part 2

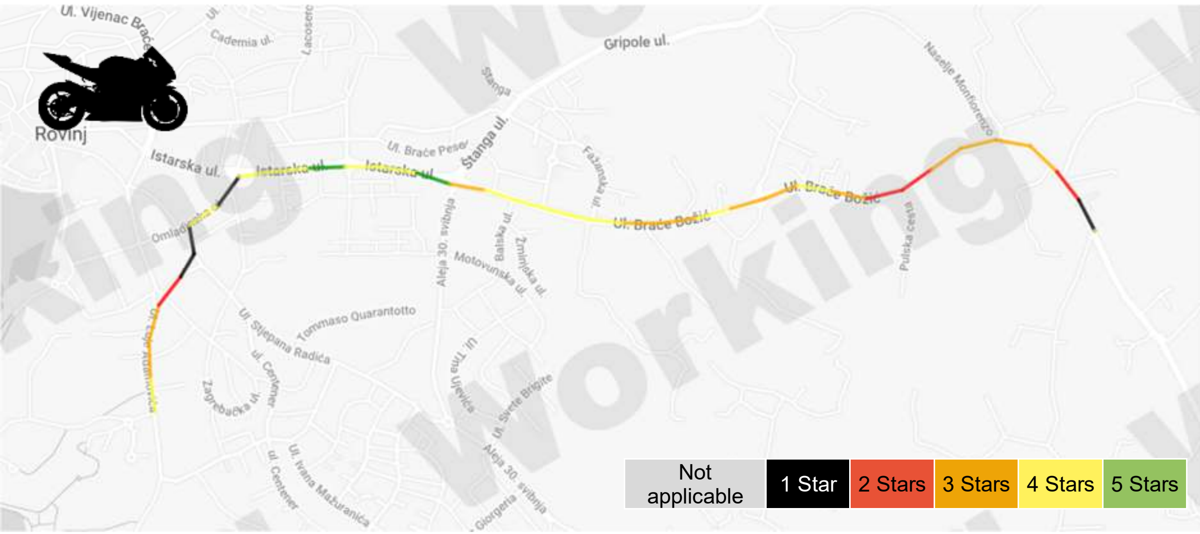

Figure 17 - Star Rating map for motorcyclists, Road part 1 1 and Road part 1 2

Figure 18 - Star Rating map for motorcyclists, Road part 2

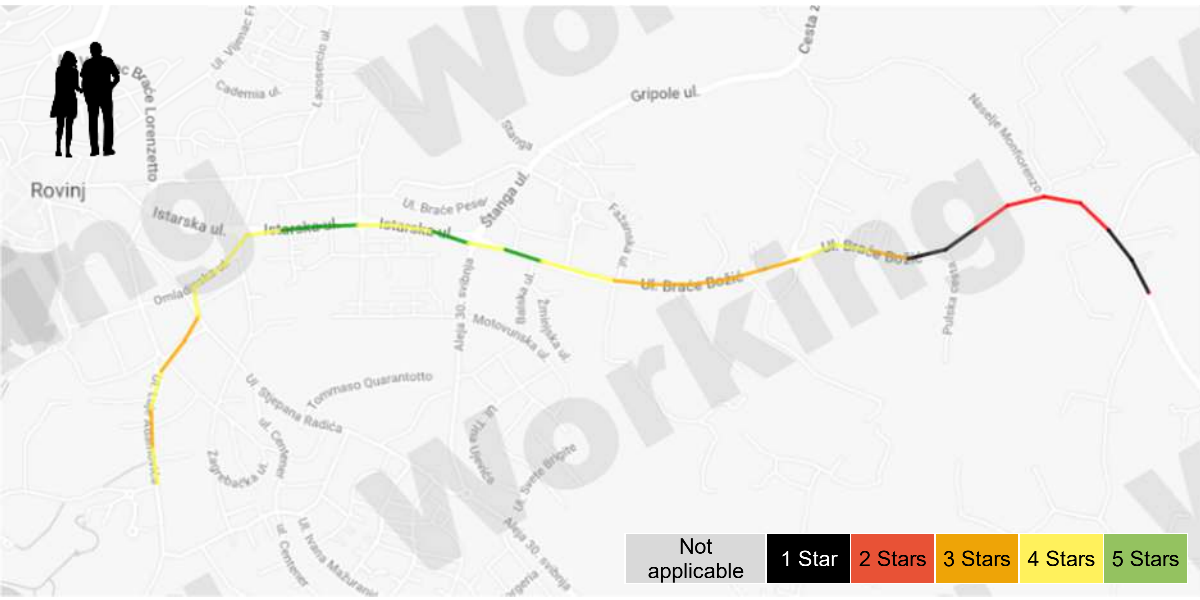

Figure 19 - Star Rating map for pedestrians, Road part 1 1 and Road part 1 2

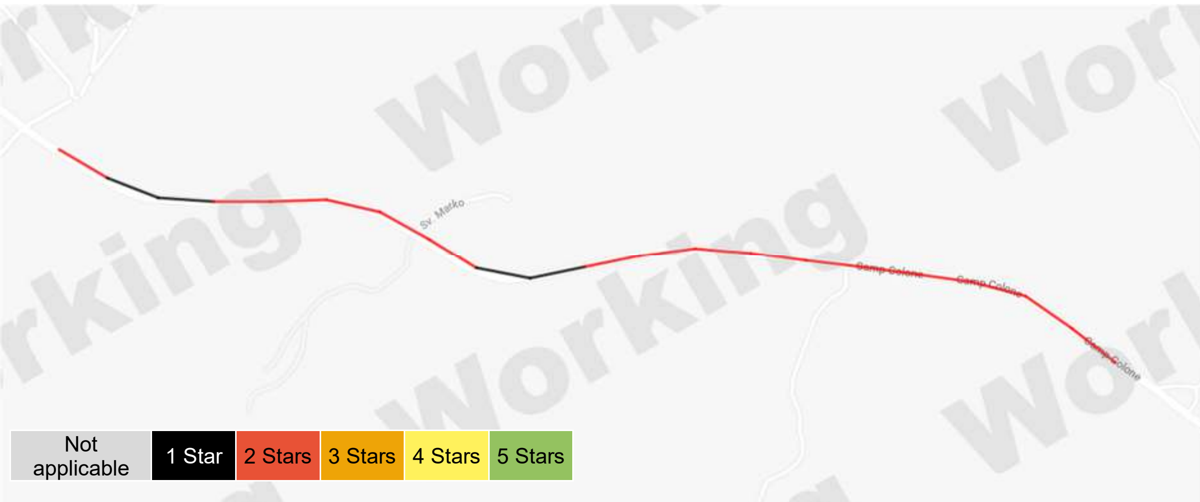

Figure 20 - Star Rating map for pedestrians, Road part 2

The Star Rating results for the Roads in Rovinj are presented in the figure 18 for each user group.

	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
Star Ratings	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent
3 star or better	4.40	78.58%	4.40	78.57%	2.60	46.42%	4.20	75.00%
5 Stars	0.70	12.50%	0.30	5.36%	0.40	7.14%	0.90	16.07%
4 Stars	2.20	39.29%	1.30	23.21%	1.30	23.21%	0.70	12.50%
3 Stars	1.50	26.79%	2.80	50.00%	0.90	16.07%	2.60	46.43%
2 Stars	1.10	19.64%	0.80	14.29%	2.20	39.29%	1.30	23.21%
1 Star	0.10	1.79%	0.40	7.14%	0.80	14.29%	0.10	1.79%
Not applicable	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Totals	5.60	100.00%	5.60	100.00%	5.60	100.00%	5.60	100.00%

Figure 21 - Star Rating results

As seen in the Figure 21, only 21.43% roads are rated below 3 stars for the vehicle occupants and for the motorcyclists. The rating for the pedestrians is much worse, there is 53.58% of road segments rated below 3 stars. For the bicyclists the roads are rated below 3 stars on 25% of segments.

7 SAFER ROADS INVESTMENT PLAN (SRIP)

Safer Roads Investment Plan (SRIP) presents all the countermeasures which proved able to provide greater safety capacity and maximize the benefit over the spent cost of the planned investments. The countermeasures listed are indicative and will need to be assessed and sense-checked with local engineers prior to actual implementation.

The Safer Roads Investment Plan is not a “bill of works”. The cost of each countermeasure is compared to the value of life and serious injuries that could be saved, and the Benefit to Cost Ratio (BCR) is calculated for each countermeasure proposed. The minimum BCR for the entire SRIP was set to 0,1.

The SRIP for the entire surveyed network would prevent 91 fatalities and serious injuries over the analysis period of 20 years. The cost of these countermeasures adds up approx. 48 203,260 HRK (6 397,04 EUR).

The total BCR of the entire investment plan is 3. Figure 19 presents the top 13 countermeasures of the SRIP in terms of saved lives and serious injuries (FSI).

Total FSIs Saved	Total PV of Safety Benef ts	Estimated Cost	Cost per FSI saved	Program BCR
91	157,688,053	48,203,260	531,549	3

Countermeasure	Length / Sites	FSIs saved	PV of safety benef t	Estimated Cost	Cost per FSI saved	Program BCR
Central hatching	5.10 km	9	15,444,385	471,944	53,136	33
Centreline rumble strip / f exi-post	0.80 km	3	4,644,989	185,869	69,581	25
Clear roadside hazards - passenger side	0.30 km	2	4,094,746	19,000	8,068	216
Overtaking lane	3.00 km	20	34,592,515	9,240,000	464,468	4
Protected turn lane (unsignalised 3 leg)	1 sites	0.3	587,164	400,558	1,186,239	1
Roadside barriers - driver side	0.60 km	3	5,730,265	365,400	110,882	16
Roadside barriers - passenger side	0.60 km	5	8,429,324	365,400	75,378	23
Roundabout	8 sites	40	69,598,768	35,610,000	889,685	2
Shoulder sealing driver side (<1m)	0.60 km	0.5	868,347	83,400	167,009	10
Shoulder sealing driver side (>1m)	3.00 km	3	4,535,398	594,888	228,079	8
Shoulder sealing passenger side (<1m)	0.60 km	0.7	1,245,362	81,100	113,238	15
Shoulder sealing passenger side (>1m)	2.90 km	4	6,508,009	298,700	79,809	22
Street lighting (intersection)	1 sites	0.8	1,408,782	487,000	601,106	3
		91	157,688,053	48,203,260	531,549	3

Figure 22 - Top 13 countermeasures for the entire road network

Figure 23 - Star Rating map for the vehicle occupants after SRIP implementation, Road part 1 1 and Road part 1 2

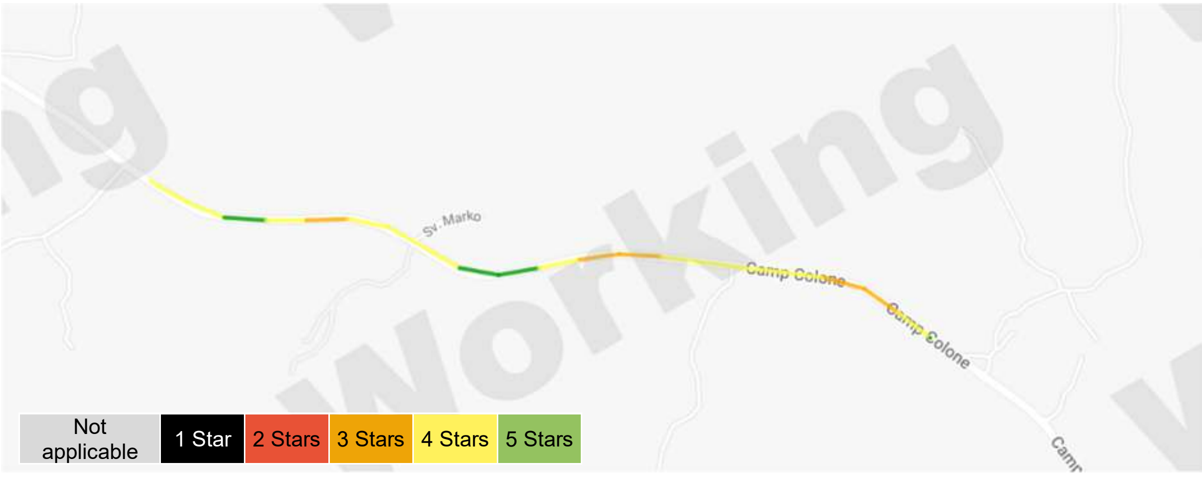

Figure 24 - Star Rating map for the vehicle occupants after SRIP implementation, Road part 2

Figure 25 - Star Rating map for motorcyclists after SRIP implementation, Road part 1 1 and Road part 1 2

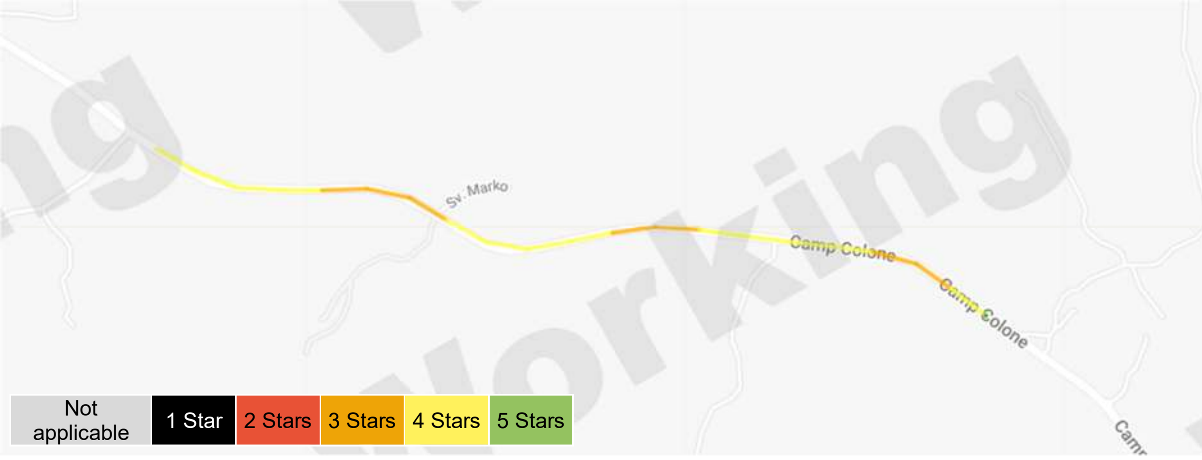

Figure 26 - Star Rating map for motorcyclists after SRIP implementation, Road part 2

Figure 27 - Star Rating map for pedestrians after SRIP implementation, Road part 1 1 and Road part 1 2

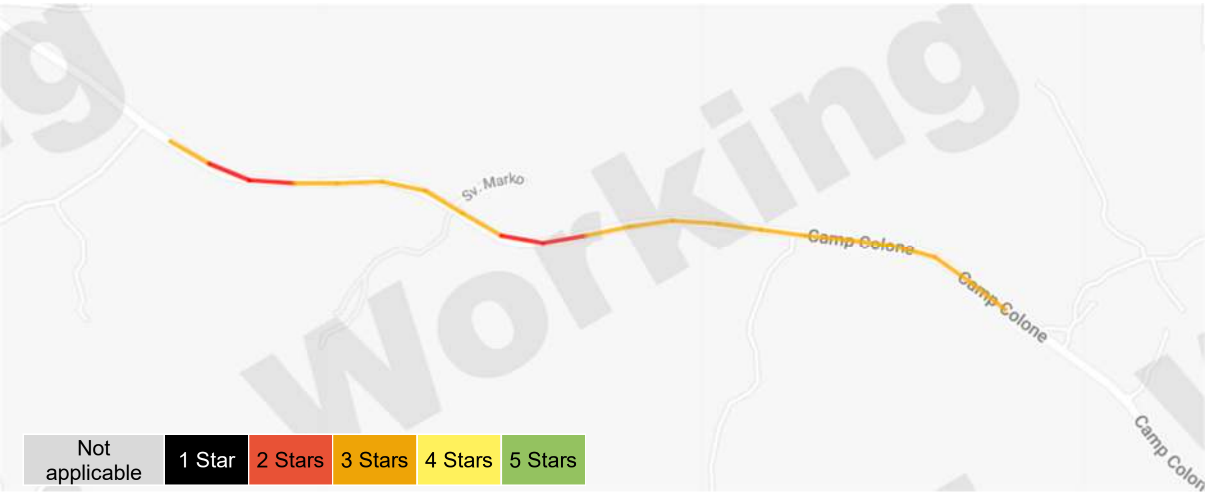

Figure 28 - Star Rating map for pedestrians after SRIP implementation, Road part 2

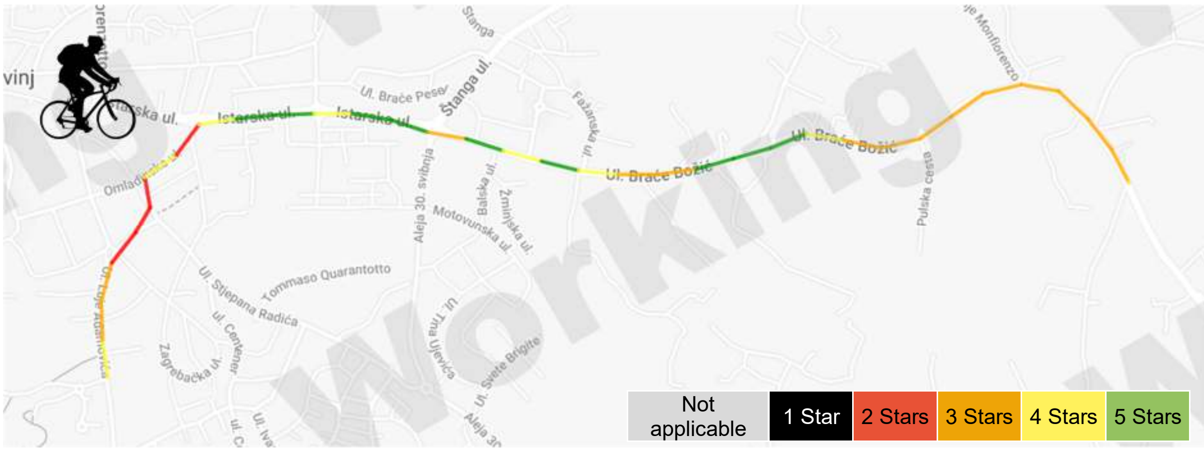

Figure 29 - Star Rating map for bicyclists after SRIP implementation, Road part 1 1 and Road part 1 2

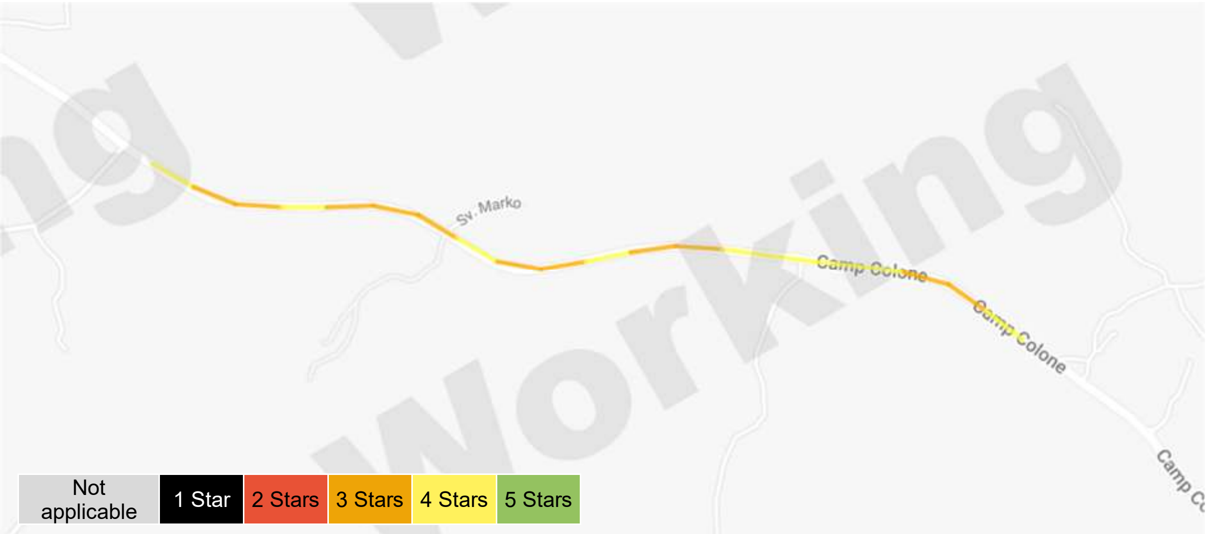

Figure 30 - Star Rating map for bicyclists after SRIP implementation, Road part 2

	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
Star Ratings	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent
3 star or better	5.50	98.22%	5.10	91.06%	4.90	87.50%	5.20	92.85%
5 Stars	1.50	26.79%	0.40	7.14%	0.50	8.93%	0.90	16.07%
4 Stars	2.40	42.86%	2.70	48.21%	1.10	19.64%	1.80	32.14%
3 Stars	1.60	28.57%	2.00	35.71%	3.30	58.93%	2.50	44.64%
2 Stars	0.10	1.79%	0.50	8.93%	0.70	12.50%	0.40	7.14%
1 Star	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Not applicable	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Totals	5.60	100.00%	5.60	100.00%	5.60	100.00%	5.60	100.00%

Figure 31 - Star Rating results after SRIP implementation

From the presented results, it can be concluded that proposed SRIP would improve the safety on the inspected part of the overall road network significantly.

8 EUROS@P ROAD SAFETY INSPECTIONS PROCEDURE ON OBSERVED ROADS

Road Safety Inspections are recognized as an effective tool for identifying safety deficiencies of road infrastructures. They represent a low cost process for the evaluation of the network safety performance. Its applicability in rural local roads, where accident data generally do notgive enough information for the safety analysis, make the procedure very attractive. However, due tothe subjective nature of the process RSI may give rise to disagreements which limit their effectiveness.

iRAP Star Ratings are used for road safety inspection (RSI), road safety impact assessments, and in designs. They provide an objective measure of the safety level inherent in a road by considering over 50 road attributes that influence the risk for various road users, including vehicle occupants, motorcyclists, bicyclists, and pedestrians. The comprehensive approach allows for a thorough evaluation of the road's safety features, aiming to enhance overall safety standards and reduce potential hazards for all users.

As it can be seen from the figure 29 and figure 30, the road "part 1 1" and road "part 1 2" are, according to the Star Rating analysis, **most dangerous sections for vehicle occupants** than the observed road "part 2" due to the fact that they have a higher number of roads rated below 3 stars.

	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
Star Ratings	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent
3 star or better	2.70	77.14%	2.70	77.14%	2.60	74.28%	2.60	74.28%
5 Stars	0.60	17.14%	0.20	5.71%	0.40	11.43%	0.90	25.71%
4 Stars	1.40	40.00%	1.30	37.14%	1.30	37.14%	0.70	20.00%
3 Stars	0.70	20.00%	1.20	34.29%	0.90	25.71%	1.00	28.57%
2 Stars	0.70	20.00%	0.40	11.43%	0.50	14.29%	0.90	25.71%
1 Star	0.10	2.86%	0.40	11.43%	0.40	11.43%	0.00	0.00%
Not applicable	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Totals	3.50	100.00%	3.50	100.00%	3.50	100.00%	3.50	100.00%

Figure 32 - Star Rating results for the Road part 1 1 and Road part 1 2

	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
Star Ratings	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent
3 star or better	1.70	80.96%	1.70	80.95%	0.00	0.00%	1.60	76.19%
5 Stars	0.10	4.76%	0.10	4.76%	0.00	0.00%	0.00	0.00%
4 Stars	0.80	38.10%	0.00	0.00%	0.00	0.00%	0.00	0.00%
3 Stars	0.80	38.10%	1.60	76.19%	0.00	0.00%	1.60	76.19%
2 Stars	0.40	19.05%	0.40	19.05%	1.70	80.95%	0.40	19.05%
1 Star	0.00	0.00%	0.00	0.00%	0.40	19.05%	0.10	4.76%
Not applicable	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Totals	2.10	100.00%	2.10	100.00%	2.10	100.00%	2.10	100.00%

Figure 33 - Star Rating results for the Road part 2

To improve the condition of the roads, EuroS@P **visual field inspections were conducted** to identify deficiencies, and based on that, field form checklists were filled out to detect and resolve these issues as it can be seen in the following figures (figure 31 – figure 35). Every section for each 200 m of the road has two tables according to the position of the inspector within the vehicle, in the front or back seat. Safety issues are ranked as high level problem and low level problem.

FRONT SEAT INSPECTOR	0,2		0,4		0,6		0,8		1,0		1,2		1,4		1,6		1,8	
Roadside	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L
Embankments																		
Bridges																		
Dangerous terminal and transitions																		
Trees, utility poles and transitions																		
Ditches																		
Accesses																		
Dangerous accesses																		
Presence of accesses		x																
Alignment																		
Inadeguate sight distance on horizontal curve		x		x														
Inadeguate sight distance on vertical curve																		

Figure 34 - Road Safety Inspections for the road part 1 1, Front seat inspector

BACK SEAT INSPECTOR	0,2		0,4		0,6		0,8		1,0		1,2		1,4		1,6		1,8	
Markings	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L
Edge lines	x		x		x		x		x		x		x		x		x	
Center lines	x		x		x		x		x		x		x		x		x	
Cross section																		
Lane width																		
Shoulder width																		
Pavement																		
Friction		x		x		x		x		x		x		x		x		x
Unevenness		x		x		x		x		x		x		x		x		x
Signs																		
Warning signs, regulation signs		x		x	x									x				
Delineation																		
Chevron																		
Guideposts and barrier reflectors																		

Figure 35 - Road Safety Inspections for the road part 1 1, Back seat inspector

As it can be seen from the figure 31 and figure 32, a minor amount of road safety issues were detected. By looking at the figures it can be seen that the most issues constitute of horizontal markings while in every 200m section there is a part where the center line is very faded and the edge line does not even exist (figure 33). According to the IASP Safety Inspection Manual these problems belong to the high level problem.

Figure 36 - Faded center line and missing edge line

In figure 34 it can be seen that the traffic sign is in the opposite direction to the road which makes it not clearly visible and in this situation the roadmark markings are also faded which makes this traffic situation potentially unsafe.

Figure 37 - Not visible sign and roadmarks

As a low level issue, it has been detected that some of the signs were installed at the wrong height (figure 35). According to national Ordinance on road signs, signalling and road Equipment traffic signs should be at height between 0,30-2,20 m.[24]

Figure 38 - Signs installed at wrong height

FRONT SEAT INSPECTOR																		
	0,2		0,4		0,6		0,8		1,0		1,2		1,4		1,6		1,8	
Roadside	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L
Embankments																		
Bridges																		
Dangerous terminal and transitions																		
Trees, utility poles and transitions																		
Ditches																		
Accesses																		
Dangerous accesses																		
Presence of accesses							x		x		x				x		x	
Alignment																		
Inadeguate sight distance on horizontal curve								x		x		x		x		x		x
Inadeguate sight distance on vertical curve																		

Figure 39 - Road Safety Inspections for the road part 1 2, Front seat inspector

[24] https://narodne-novine.nn.hr/clanci/sluzbeni/2019_09_92_1823.html

BACK SEAT INSPECTOR	0,2		0,4		0,6		0,8		1,0		1,2		1,4		1,6		1,8	
Markings	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L
Edge lines	x		x		x		x		x		x		x		x		x	
Center lines		x		x						x		x		x		x		x
Cross section																		
Lane width																		
Shoulder width																		
Pavement																		
Friction		x		x		x		x		x		x		x		x		x
Unevenness		x		x		x		x		x		x		x		x		x
Signs																		
Warning signs, regulation signs																		
Delineation																		
Chevron																		
Guideposts and barrier reflectors					x		x		x		x		x		x		x	

Figure 40 - Road Safety Inspections for the road part 1 2, Back seat inspector

At the figure 36 and 37 it can also be seen that there is an indicative issue with horizontal markings. At every section of the roads the inspectors have detected some degree unevenness which can lead to potentially dangerous situation due to surface grip. The reason can be cracking of the road surface, the unevenness of the substrate due to manholes or the connection between old and new asphalt (figure 38) which is registered as a low level problem.

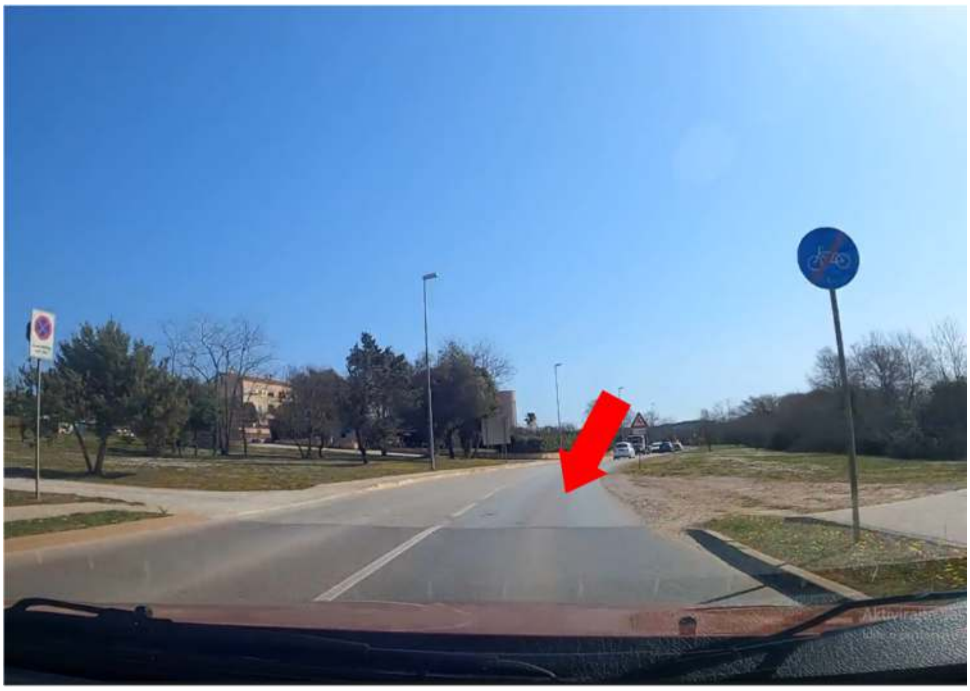

Figure 41 - The connection between old and asphalt

The problem detected as a high level problem is related with guideposts and barrier reflectors because there is a section of the road where they don't exist (figure 39).

Figure 42 - Missing roadside guideposts

Figure 40 and figure 41 displays the final section of the analysed roads.

FRONT SEAT INSPECTOR	0,2		0,4		0,6		0,8		1,0		1,2		1,4		1,6		1,8		2,0	
Roadside	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L
Embankments																				
Bridges																				
Dangerous terminal and transitions																				
Trees, utility poles and transitions																				
Ditches																				
Accesses																				
Dangerous accesses																				
Presence of accesses		x		x		x		x		x		x		x		x		x		x
Alignment																				
Inadequate sight distance on horizontal curve		x		x		x		x		x		x		x		x		x		x
Inadequate sight distance on vertical curve																			x	

Figure 43 - Road Safety Inspections for the road part 2, Front seat inspector

BACK SEAT INSPECTOR	0,2		0,4		0,6		0,8		1,0		1,2		1,4		1,6		1,8		2,0	
Markings	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L
Edge lines	x		x		x		x		x		x		x		x		x			x
Center lines		x		x		x		x		x		x		x		x		x		x
Cross section																				
Lane width																				
Shoulder width																				
Pavement																				
Friction		x		x		x		x		x		x		x		x		x		x
Unevenness		x		x		x		x		x		x		x		x		x		x
Signs																				
Warning signs, regulation signs																				
Delineation																				
Chevron	x								x											
Guideposts and barrier reflectors			x																	

Figure 44 - Road Safety Inspections for the road part 2, Back seat inspector

According to the IASP Safety Inspection Manual the high level problem in this section are chevrons mainly because they are only added in one direction, as it can be seen in the figure 42.

Figure 45 - Missing chevrons in one direction

Inadequate sight distance on the vertical curves is present and identified as a high level problem, as shown in the figure 43.

Figure 46 - Inadequate sight distance on vertical curves

9 NIGHT INSPECTION PROCEDURE

Night road inspections have long been a contentious subject in road safety assessment methodologies, and were particularly discussed within the frameworks of EuroS@P RSI system. The primary concern has been the low visibility and inadequate quality of video inspection material obtained during nighttime. Low-light conditions inherently reduce the clarity of footage, making it harder to discern road features, defects, or hazards that might be evident in daylight. This compromises the integrity of data and poses challenges in accurate evaluation. Even with advanced technologies, the quality of video inspection material at night does not match that acquired during the day, leading to potential misinterpretations or oversights in road safety assessment.

Given these challenges, the use of nighttime inspections has been deemed unsuitable and not recommended within the aforementioned methodologies. The unreliability of results obtained from such inspections undermines the very purpose of these rating systems – to objectively evaluate and ensure road safety. The foundational objective of EuroS@P is to deliver comprehensive and dependable evaluations that can drive safety enhancements and interventions. If the inspection material does not guarantee accuracy due to inherent limitations of nighttime conditions, it could lead to incorrect evaluations, potentially resulting in misallocated resources or misguided safety strategies. Hence, to maintain the robustness and credibility of the EuroS@P RSI rating systems, nighttime road inspections are advised not to be incorporated within the scope of methodology.

10 CONCLUSION

In conclusion, the practical implementation of road safety inspection is an indispensable aspect of ensuring safer roadways and reducing the alarming rates of accidents and fatalities. Throughout this exploration, we have highlighted the significance of regular and comprehensive inspections that encompass various elements such as infrastructure, signage, vehicle conditions, and human behaviour. By addressing these critical aspects, road safety inspection plays a pivotal role in identifying potential hazards, assessing risks, and implementing necessary corrective measures.

The benefits of investing in practical road safety inspection are far-reaching, including the preservation of countless lives, reduced medical and economic burdens, and increased public confidence in transportation systems. Furthermore, improved road safety enhances mobility, encourages sustainable transportation options, and fosters overall socio-economic development.

In essence, the practical implementation of road safety inspection is a crucial and non-negotiable component in the pursuit of a safer, more efficient, and sustainable transportation network. By embracing this approach, we pave the way for a future where road accidents and fatalities are drastically reduced and where people can confidently traverse the roads with peace of mind. Let us continue to prioritise and invest in road safety inspections to foster a world where every journey is secure, and every life is protected.