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Professional Paper

Pilot Implementation of a Network-Wide Road Safety Assessment Proactive Methodology in North Macedonia

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Abstract – **Road safety assessment is carried out using different methodologies. This paper presents pilot implementation of Network Wide Road Safety Assessment Methodology in North Macedonia, focusing on proactively addressing high-risk sections. The challenges and results from the pilot implementation are presented and discussed.**

Keywords – **RISM, Network wide assessment, Road crashes, In-built safety, Proactive methodology.**

I. Introduction

Road safety analysis plays an important role in the efforts to reduce the fatalities and serious injuries on roads. It is a process that allows to investigate the level of safety of a specific road or road network and it can be carried out using different methodologies that can be broadly separated into two categories: methodologies that rely on crash occurrence (also known as reactive or ex-post) and those that evaluate the in-built safety of roads (known as proactive or ex-ante)

With the update of the Road Infrastructure Safety Management Directive (RISM) directive 2008/96/EC [1], the European Commission (EC) asks all member states to carry out a Network-Wide Road Safety Assessment (NWRSA), which must be based on: (1) "*primarly, a visual examination, either on site or by electronic means, of the design characteristics of the road (in-built safety)*", and (2) "*an analysis of sections of the road network which have been in operation for more than three years and upon which a large number of serious accidents in proportion to the traffic flow have occurred*". This implies that this new procedure required by the EC must include a safety analysis based on crashes (reactive approach), and an analysis based on visual inspection and evaluation of the in-built safety (proactive approach) [7].

In accordance with the revised RISM directive 2019/1936 [2], Member States must carry out the first network-wide road safety assessment of Motorways and Primary roads by 2024, and regularly thereafter. To help the public authorities in EU Member States to carry out the safety assessments of their road networks as required under the revised RISM Directive, European Commission in January 2023 published guidelines on NWRSA [3]. The methodology is developed within a project "Study on a Methodology for Network-wide Road Safety Assessment" by National Technical University of Athens, University of Zagreb and FRED Engineering s.r.I.

The objective of the NWRSA methodology is to provide a cost-effective safety assessment of the road network within the scope of the Directive. 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 prioritize in an efficient way either targeted road safety inspections or direct remedial actions. Particular emphasis is placed on the needs of vulnerable road users, as required in Article 6b of the revised RISM Directive.

The methodology comprises two approaches: one for the assessment of roads on the basis of crash occurrence analysis (reactive methodology) and one for the assessment of the in-built safety of roads (proactive methodology). The two methodologies are both applied over the same network and the resulting assessment outcomes are combined via an integration methodology to provide the final road network rating and ranking.

The NWRSA reactive methodology is based on the assessment of crash data on fatal and injury crashes for the last three years (at least). If such data are unavailable the reactive methodology cannot be implemented, and the assessment will be based on the outcome of the NWRSA proactive methodology. Crash data includes crashes with all road users, namely motor vehicles, bicyclists and pedestrians. Three segmentation approaches are considered. In the first one, sections include both segments and junctions. In the second and third approaches, junctions are assessed separately from road segments and the difference between the approaches lies in the junction length; this can either be predefined based on the junction type or measured. Sections are defined with the objective to be roughly homogeneous based on number of lanes, junctions' presence and horizontal curvature. Recommended maximum section lengths are provided for each road type, with the objective to ensure large enough sections and so, adequate number of crashes per section. Then, available crash data is located to sections (and junctions). The next step is the definition of reference population per road type. Two safety performance metrics can be used for the assessment, namely crash density and crash rate and for each metric an upper and lower threshold are defined for the assessment. Based on the threshold, sections are classified as "High risk: or "Low risk". If the analysis does not yield to statistically significant results, sections are classified as "Unsure" [3].

The NWRSA proactive (in-built safety) methodology is initiated with the correct identification of the road type. The geographical limits of the assessment are clearly defined. The proactive methodology requires a first stage of data collection that is essential for the network segmentation. Two approaches are considered for the segmentation. Either a fixed length

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segmentation of short segments (e.g., of 500 m) or a varying length segmentation, focusing on the formation of roughly homogeneous sections. Roughly homogeneous sections that consist of segments and junctions are defined based on traffic volume, horizontal curve, speed limit and terrain type data. A second stage of data collection follows to gather all necessary road and operational data for the assessment of the parameters; six parameters are used for the assessment of urban and rural motorways and nine parameters are used for the assessment of primary (or other EU-funded rural) roads. A Reduction Factor (RF) is estimated for each parameter and based on the value of all RFs the final score of the section is estimated. Based on this scoring, each section is ranked as “High risk”, “Intermediate risk” or “Low risk”. An additional scoring criterion, related to the sections traffic volume, is applied: if the section has very low traffic volume compared to rest of the network (i.e., belongs to the lowest 15% of traffic ranking) and if the section has been classified as “High risk”, it is assigned to “Intermediate risk” class [3].

The integrated methodology combines the results of the proactive and the reactive methodologies. The integrated methodology assumes a five-class ranking system, namely “Very high priority”, “High priority”, “Intermediate priority”, “Low priority”, “Very low priority”. As the proactive and the reactive methodologies use a different segmentation approach, it is described how to combine these two different segmentation approaches and produce the final sections of the network [3].

In this paper Pilot Implementation of a Network-Wide Road Safety Assessment on selected road section using proactive (in-built safety) methodology is presented.

II. Methods and Materials

A. Selection of road section and determination of road type

For pilot implementation of a Network Wide Road Safety Assessment Methodology, a road section which is part of the state road A2 was selected. The A2 is an important route on TEN-T network (Corridor VIII) that serves several large towns along the southwest and northeast parts of the country. The road section of A2 selected for this pilot implementation of NWRSA is a 23.9 km section of rural road between Stracin and Kriva Palanka, which is part of the expressway that connects Kumanovo and Kriva Palanka. The location of the selected road section is showed on Fig.1.

Fig. 1. Location of the road section Stracin – Kriva Palanka

In terms of the road type, the road section is determined as primary undivided rural road with carriageway width of 12,5 m that consist of two drive lanes (one per direction) and two emergency lanes (one per direction). The typical cross section is shown on Fig. 2.

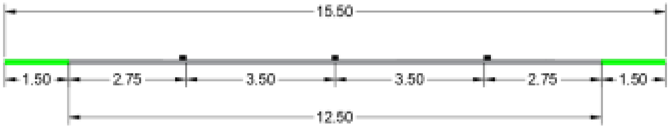

Fig. 2. Location of the road section Stracin – Kriva Palanka

B. Data collection

For the implementation of the network-wide in-built safety assessment methodology two types of data need to be collected: (1) Overview data at an aggregate level of detail that are needed for segmentation process and (2) Detailed data at a higher level of detail per segment needed for assessment process.

An overview data includes: traffic volume, number of lanes, speed limit and terrain type. As of primary undivided roads, the detailed data are related to the following nine parameters: lane width; roadside (clear zone width, obstacles, presence of barriers); curvatures; density of property access points; junctions; conflicts between pedestrians/bicyclists and motorized traffic; shoulder type and width; passing lanes; and signs and markings. An overview data and detailed data were derived from detailed design files, Google earth and recorded videos.

C. Segmentation of road section

The segmentation process involves dividing the road section into smaller parts. Two alternative approaches for segmentation can be considered, either sections of fixed length, indicatively 500m, or longer homogeneous sections in terms of traffic volume, number of lanes, speed limit, and terrain type. For segmentation of the road section Stracin – Kriva Palanka, an approach with homogenous sections was applied.

While not a mandatory criterion for segmentation, it is recommended the sections to be formed in a way that horizontal curves are either fully included or fully excluded from a section. Also, when homogeneous sections are formed, it is recommended that they should not exceed 2 km in length.

Following the aforementioned criteria for segmentation, the road section is divided on 13 segments presented on Fig. 3.

Fig. 3. Segments of the road section Stracin – Kriva Palanka

The length of the segments, the number of basic lanes and the speed limit per segments are presented in Tab. 1.

TABLE I

SEGMENTS OF ROAD SECTION STRACIN – KRIVA PALANKA

Segment	Start	End	L (m)	Basic Lanes	Speed Limit
1	0+000	1+700	1700	1	60
2	1+700	3+700	2000	1	110
3	3+700	5+300	1600	1	110
4	5+300	7+100	1800	1	110
5	7+100	8+700	1600	1	110
6	8+700	10+700	2000	1	110
7	10+700	12+700	2000	1	110
8	12+700	14+700	2000	1	110
9	14+700	16+700	2000	1	110
10	16+700	18+700	2000	1	110
11	18+700	20+700	2000	1	110
12	20+700	22+300	1600	2	110
13	22+300	23+900	1600	2	110

D. Estimation of reduction factors and final score

Each road segment is assessed based on a set of design or operational characteristics. Undivided rural roads are assessed considering both directions of traffic at the same time.

An ideally safe road segment receives a safety score equal to 100 points. Less safe segment gets a lower score, and reduction is determined with the use of Reduction Factors (RF). Each RF corresponds to a parameter used for the assessment of roads and expresses the safety level of the specific parameter. RFs range from zero (without being equal to zero) to one and one corresponds to the safest condition.

After estimating the final Reduction Factor (RF) for each parameter, the total score of the segment can be estimated based on the following equation:

$$RSS_i = 100 \cdot RF_{1i} \cdot RF_{2i} \cdot \ldots \cdot RF_{ni} \quad (1)$$

Where RSSi is the safety score of the i-th road section. RSSi is a function of the RFji where j denotes the different parameters used for the assessment.

In addition to the parameters, operational characteristics such as traffic volume - AADT (if data is available), speed limit, operation speed V85 (if data is available) and presence of automated speed enforcement, affecting either the safety scoring (Reduction Factors) of selected parameters or the final ranking.

The estimation of the final CMFs and RFs for each parameter and of the final proactive assessment score per segment, was conducted using an excel-based tool developed to assist in coding the information for each parameter.

E. Classification and mapping of road segments

After obtaining the final score, the segment is assigned to a safety class, based on the final score value. For primary road section, the following class thresholds are recommended:

- Low Risk - Class 1: score ≥ 80%, colour coded as green
- Intermediate Risk - Class 2: 50% ≤ score < 80%, colour coded as yellow and
- High Risk - Class 3: score < 50%, colour coded as red

At the end of the proactive methodology implementation, every road segment is classified as "high risk", intermediate risk" or "low risk".

Once the classification was done, the road segments were visualized in red, yellow and green colour respectively on a map using geographic information system - QGIS.

III. RESULTS AND DISCUSSION

The results from the pilot implementation of the Network Wide Road Safety Assessment Proactive Methodology on the road section Stracin – Kriva Palanka are presented in Tab. 2 and shown on Fig. 4.

TABLE II

ROAD SAFETY SCORE AND CLASSIFICATION PER SEGMENT

Segment	Score	Classification
1	37,5	High Risk
2	64,8	Intermediate Risk
3	64,8	Intermediate Risk
4	64,9	Intermediate Risk
5	87,5	Low Risk
6	65,2	Intermediate Risk
7	87,5	Low Risk
8	87,5	Low Risk
9	87,5	Low Risk
10	87,5	Low Risk
11	67,9	Intermediate Risk
12	83,1	Low Risk
13	79,1	Intermediate Risk

Fig. 4. Mapping of road safety class per segments of the road section

As it can be noted from Tab.1 and Fig. 1, one segment of the road section is classified with High risk, six segments are classified with Intermediate risk and remained six segments are classified with Low risk.

The results related to distribution of road safety risk in terms of road section length is presented on Fig. 5.

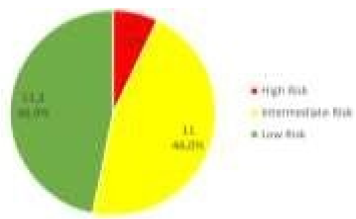

Fig. 5. Distribution of road safety risk in terms of road section length

The Fig. 4 shows that 1,7 km or 7,1 % of the road section are classified with High risk, 11,0 km or 46,0% are classified with Intermediate risk and 11,2 km or 46,9 km are classified with Low risk.

The NWRSA proactive methodology can be considered as fast and cost-effective procedure. It does not require highly-formed personnel for caring out. However, it relays on many high-level road data. The biggest challenge was the roadside Hazard Rating.

IV. Conclusion

The European Union has put a lot of effort and dedication into improving road safety, providing Road Safety Authorities (RSAs) with guidelines to manage the impact of road infrastructure on safety. With the update of the RISM directive 2008/96/EC, the procedure Network Wide Road Safety Assessment was introduced. The network wide road safety assessment proactive methodology has been tested on a primary undivided road section Stracin – Kriva Palanka in North Macedonia, categorized as expressway. The results prove the robustness of the NWRSA proactive methodology. However, to be proved its effectiveness it should be compared to actual level of road safety based on road crashes.

Road sections classified as "High Risk" and "Intermediate Risk" should potentially be subject to Road Safety Inspection (RSI), depending also on the results of the reactive (crash-based) assessment approach and on available funds. Based on the outcome of the RSI, follow-up actions will be determined. As road safety funds are not unlimited, it is important to effectively prioritize the further treatment of segments that affect a larger number of road users.

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