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A State-of-Practice Review on Crash Occurrence Analysis & Hazardous Location Identification

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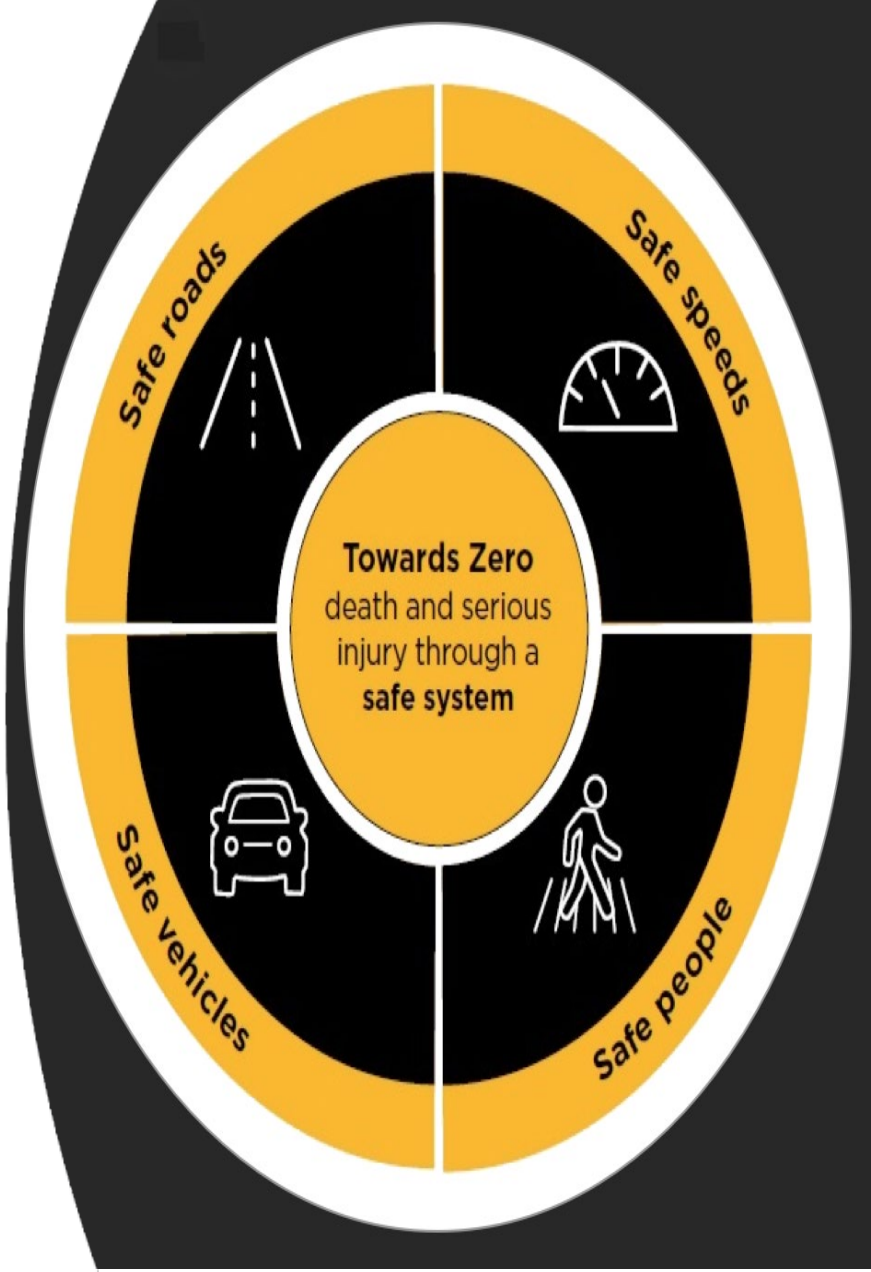
Introduction

- Road crashes:
  - are a public health issue as they result in injuries and fatalities,
  - are a leading cause of death in certain age groups and demographics, and
  - Fatalities cost most countries 3% of their GDP *(WHO)*.

- Crash occurrence analysis plays a critical role in safety management and is the main approach for the assessment of road infrastructure and the identification of safety countermeasures.



Objective

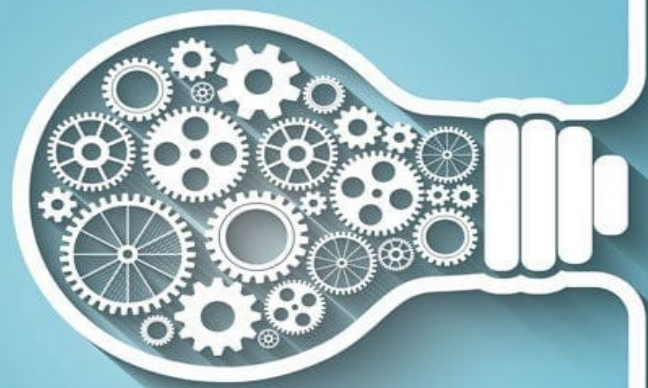
- In the EU, 60% of fatalities in 2021 took place in rural roads (52%) and motorways (8%) with similar trends before the COVID-19 *(European Commission, 2022)*.

- The objective of this study is the review and synthesis of current methodologies and practices for the safety assessment of rural roads and motorways based on historic crash data.

- The focus is primarily on the EU road network and therefore, an emphasis has been placed on resources related to EU countries.

Methodology

- A questionnaire survey was designed and disseminated to all Member States and associated countries.
- The questionnaire survey collected information on applied practices and methodologies, either through direct responses or through the provision of relevant resources.
- Scientific articles, reports, and guidelines in the EU context were identified and reviewed, too.
- Lastly, the work of international associations with a leading role in road safety was analyzed.

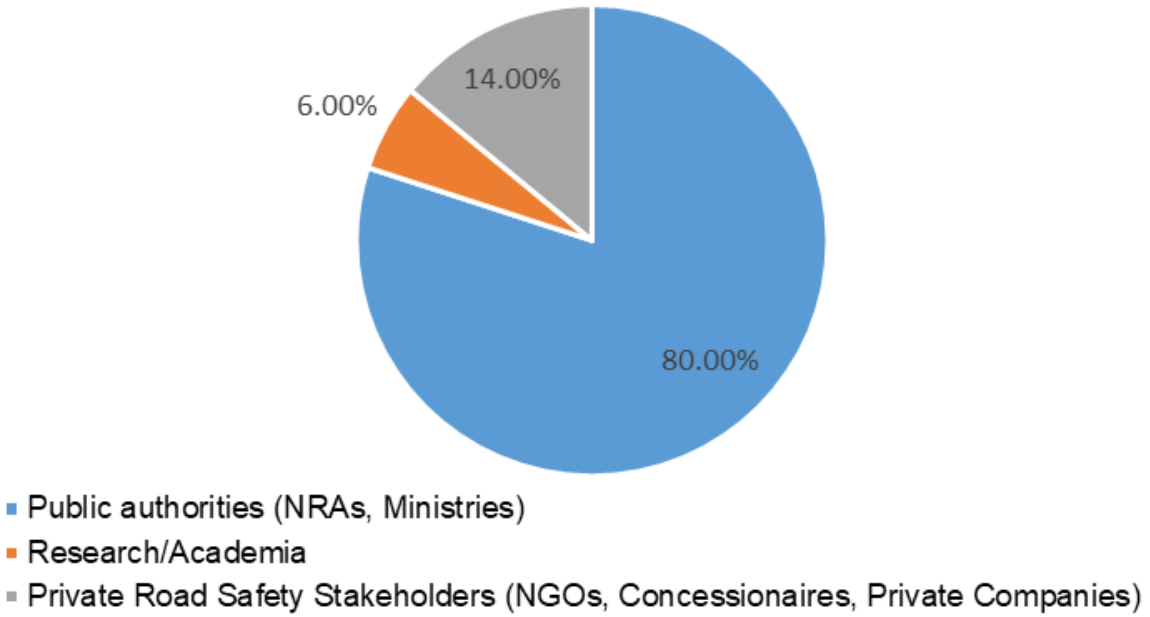


Questionnaire survey

- The questionnaire survey was completed by 35 responders representing 29 European countries
  - 26 Member States
  - IS, NO, and the UK

- Responses included both links to reports and national guidelines and also description of the used methodologies.

- In the EU, all countries, with the exception of Sweden, rely on the analysis of historic crash data for the identification of hazardous locations on their motorways and rural roads.



Types of analysis

The questionnaire survey as well as the review of the relevant literature showed that it is common to deploy methodologies for the identification of:

a. hazardous locations (i.e., road facilities of short length such as intersections, curves, etc.)

– also known as "black spot" or "hot spot" identification or analysis

– types of crashes are used.

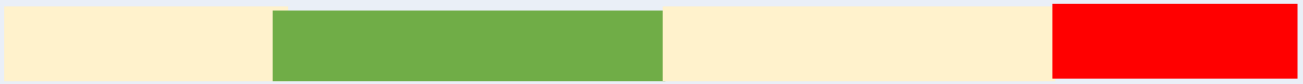
b. hazardous sections (i.e., sections that are several km-long)

– also known as "road safety management"

– crashes with fatalities and injuries are used

Steps

Overall, there is a common structure in the reviewed methodologies:

Identification of hazardous locations	Identification of hazardous sections
Network segmentation Sections of fixed length, or Groups of facilities (e.g., intersections)	Network segmentation Sections of fixed length Homogeneous sections
Network screening Safety performance metric calculation Safety ranking *(continue to the successive section)*	Safety performance metric calculation *(per section)* Safety ranking
	

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	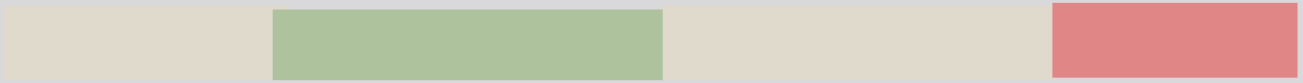

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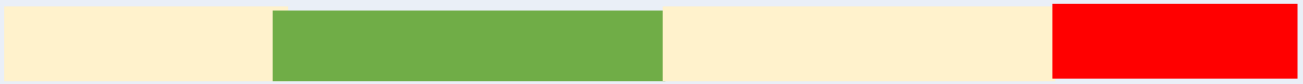
	

Network segmentation

Hazardous locations

- It is not clear how the network should be segmented.
- Usually there is a fixed length segmentation along with grouping facilities of the same type.

Hazardous sections

- Road networks are divided in sections of fixed length or in homogeneous sections.
- Sections of several km are formed.
- Horizontal and vertical curvature and cross-section characteristics such as median presence and type and number of lanes are usually considered for the definition of homogeneous sections however, no clear definition exists.

Network screening

Hazardous locations

- Screening aims to identify the exacts parts of the section where crashes are aggregated (based on some criterion).
- There are several approaches to "screen" the section and detect the most unsafe part(s) of it.
  - The sliding window method – *most popular*
  - Peak searching method
  - Simple ranking method

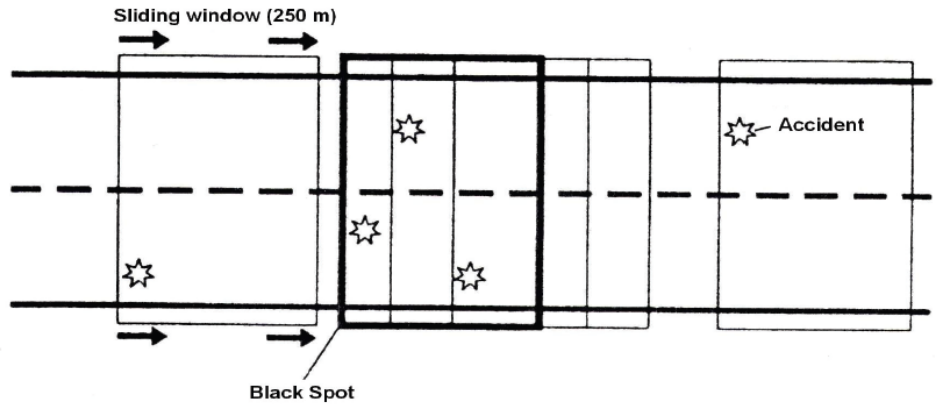


Figure 2: Identification of road accident black spots in Austria by sliding window approach. Source: Austrian guidelines for black spot identification.

Hazardous sections

The objective of the network segmentation might be the assessment of the entire section. In this case, the network screening step is skipped.

Safety performance metrics

Metric	No. EU Methodologies	Explanation
*(Average) Crash frequency	10	(Average) number of crashes per year
*Crash density	10	Average number of crashes per year over the section length; for intersections this is the same as the average crash frequency
*Crash rate	13	Average number of crashes per year over a traffic volume metric usually AADT however it can also be ADT or peak hour volume.
Crash cost	4	All crashes are translated to monetary terms (or priority values) based on their severity level and finally, the total cost of those crashes is estimated. The crash cost information can also be combined with section length and/or traffic volume information to estimate crash cost density or crash cost rate.
Equivalent Property Damage Only (EPDO)	1	All crash severity levels (e.g., fatal crashes) are translated into PDO crashes considering the monetary value of each crash type. The nominator of this ratio is the total number of PDO crashes that have occurred, and the denominator is the studied time period. The EPDO information can also be combined with section length and/or traffic volume information to estimate EPDO crash density or EPDO crash rate.

In the US and Australian literature, additional metrics were identified but were not found in the national EU methodologies.

Data needs & challenges

All reviewed methodologies rely on crash data, but the number of years and the types of crashes used vary.

- At least three years of crash data is needed to ensure a representative average crash frequency.
  - Most countries align with this rule, but 3 countries rely on 1 year of crash data for hazardous location identification.
- While the Vision Zero approach emphasizes on fatal and injury crashes, focus on PDO crashes as well.
- Location information is critical and still not accurately recorded, especially in rural roads.
- Traffic data – generally is missing from rural roads.

Definition of criteria and safety ranking

- **Safety ranking** is the process that determines whether a location/section is hazardous or not.

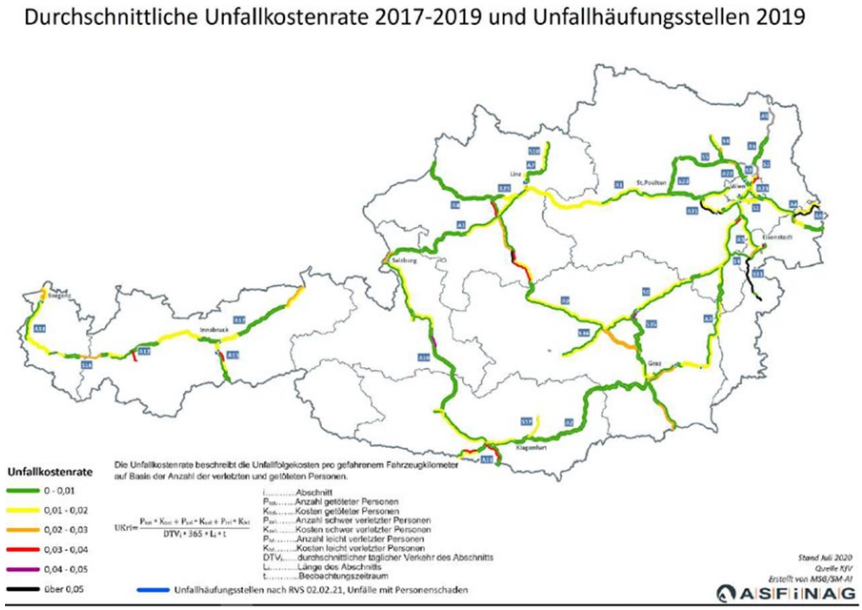
- Usually, a **criterion** is used for this classification, and it is likely that the type of the criterion affects the classification.

Hazardous locations

- Somehow arbitrary criteria
- The classification is binary (i.e., hazardous or not)

Hazardous sections

- More intuitive criteria (e.g., national average as ref. point)
- Classification is binary or multi-class



Conclusions (1/2)

- Across the EU and worldwide, there are many different methodologies for the road safety assessment based on historic crash data.
- Two main analysis types are defined – identification of hazardous locations & hazardous sections.
- While the methodologies have differences (e.g., different safety performance metrics), they have a same structure.
- There is limited research on comparing the different methodologies to identify which is more robust, valid, accurate etc. Some comparative efforts conclude that a methodology should be developed in a way that aligns with data availability.

Conclusions (2/2)

- For improved crash occurrence analysis, it is critical that Member States, National Road Authorities and all relevant stakeholders improve the crash data collection and storing processes.
- In that respect, consistency and alignment with systems like MAIS 3+ is also critical.
- Dealing with crash data availability and quality is a means of switching to most effective approaches such as crash prediction models (Elvik et al., 2003).
- At the same time, the adoption of proactive practices would highly benefit road safety levels.

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