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Summary:

Black Spot Management and Safety Analysis of Road Networks

- Best Practice Guidelines and Implementation Steps

Background and objective

Black spot management (BSM) has a long tradition in traffic engineering in several countries in the European Union. It is still considered as a very essential part of the site-specific traffic safety work in several countries. In the last 5 to 10 years, more and more countries have supplemented the traditional black spot management with identification and treatment of hazardous road sections named *safety analysis of road networks or network safety management (NSM)*.

However, the current approaches and quality of both BSM and NSM differ very much from country to country and the work can, in general, be characterised by a lack of standardised definitions and methods.

Thus, the objective of this part of the RIPCORD-ISEREST project in EU's Sixth Framework Programme is to describe and develop *state-of-the-art approaches* and *best practice guidelines* for BSM and NSM. State-of-the-art approaches are described in Elvik (2007), while best practice guidelines are described in Sørensen (2007). This report summarizes the findings and describes the necessary steps to implement the guidelines.

State-of-the-art approaches and best practice guidelines

Approaches for BSM and NSM are divided into state-of-the-art approaches and best practice guidelines:

- *State-of-the-art approaches* are defined as the best currently available approaches from a theoretical point of view.
- *Best practice guidelines* are the best approaches from a more practical point of view and can be used when the data and resources for developing, implementing and using a national method are limited.

Obviously state-of-the-art approaches are to prefer, but data and resources are often limited. In this case it is better to have and use some best practice guidelines rather than refrain from doing anything because the demands for doing the state-of-the-art approaches cannot be satisfied.

It is also preferable that the state-of-the-art approaches are used for all stages of BSM and NSM, but that will not always be a possibility. However, it is recommendable that the approaches as minimum are used for one of the stages, because to a certain it extent can compensate for the lack of use in other stages:

- Use of primitive identification methods place additional burdens on the analysis of accidents to sort out falsely identified locations.
- Use of primitive analysis methods place additional burdens on the identification stage to avoid many false positives that maybe will not be sorted out in the analysis stage.

Definition and philosophy

No standard definition exists of either *black spots* or *hazardous road sections*. However, from a theoretical point of view black spots and hazardous road sections should be defined as follows:

- *Black spot:* Any location that has a higher expected number of accidents, than other similar locations, as a result of local risk factors.
- *Hazardous road section:* Any road section that has a higher expected number and severity of accidents, than other similar road sections, as a result of local and section based accident and injury factors.

The philosophy in BSM and NSM is to use the accident history to identify locations with local risk factors that are related to the local detailed road layout. These locations can be treated inexpensively because it is only the detailed road layout and traffic behaviour that have to be changed and not the general road layout. Therefore, you get a lot of value for money used in terms of traffic safety. However there are some differences between BSM and NSM. These differences are summarized in table S.1.

Table S.1. Overall differences between BSM and NSM.

	BSM	NSM
Nature	– Reactive	– Reactive and proactive
Analysis	– Accident based	– Accident based and general knowledge
Measures	– Specific and remedial	– Remedial and preventive
Severity	– Not included in the identification	– Included in the identification
Length	– < 0.5 km	– 2 - 10 km
Frequency	– Every or every second year	– Every second to fourth year

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Stages in BSM and NSM

Both BSM and NSM can be divided into 10 stages. BSM and NSM starts with a systematic collection of data that enable the identification. Once black spots and hazardous road sections have been identified, accidents are analysed in order to find a common pattern of accidents and factors that contribute to accidents. If this analysis is not successful, it will be concluded that the hazardous location is likely to be false and no treatment will then be implemented. If a treatment believed to be effective is found, it should be implemented and its effects evaluated.

This report focuses on classification of roadway elements, identification principles and criteria, accident analysis and evaluation of the treatment. The stage of treatment is not treated in this report.

Classification of roadway elements

Black spots should be identified by reference to a clearly defined population of roadway elements as for example curves, bridges or four-leg junctions, while hazardous road sections should be identified by reference to 2-10 kilometres homogeneous road sections. This makes it possible to estimate the general expected number of accidents by use of an accident model.

Identification principles and criteria

The identification of hazardous locations should rely on a more or less advanced model based method, ideally speaking the empirical Bayes method. The argument for that is that model based methods are the best to make reliable identification of sites with local risk factors related to road design and traffic control, because systematic variation and partially random fluctuation are taken into consideration.

Hazardous locations should be defined:

- In terms of the expected number of accidents and not the registered number of accidents.
- As locations that have a higher expected number of accidents than the normal expected number on similar roadway elements due to specifically local risk factors.
- As locations where the absolute difference between the expected and normal number of accidents (the savings potential) exceed a predefined number
- Or as a certain percentage of the road network with the largest savings potential

Due to more accidents, accident severity should be an integrated part of the identification criterion in the NSM, but not in the BSM. Severity should be integrated by weighting by use of monetary valuations and the average number of injured of a given severity in different severity categories.

Accident analysis – hypotheses and testing

The state-of-the-art approach for accident analysis consists of two stages:

- Detailed examination of accidents to suggest hypotheses regarding risk factors that may have contributed to the accidents.
- Test of the hypotheses by a double blind comparison of each black or hazardous location and a safe location.

According to the best practice guidelines, the analysis stage should as a minimum consist of:

- A general accident analysis
- A collision diagram
- A road inspection
- Relevant traffic and road analyses

In NSM results from the general accident analysis and the collision diagram should be combined into an extended collision diagram.

The general accident analysis, the collision diagram and the extended collision diagram should be compared with the normal pattern of traffic accidents for the given type of location.

Finally, an active and written assessment of whether the presumed hazardous locations are a true hazardous location should be made.

Evaluation of the treatment

Evaluation of the effects of the treatment should employ the empirical Bayes before-and-after design, because it controls for local changes in traffic volume, long term trends in accidents and regression-to-the-mean.

When it is not possible to make an empirical Bayes before-and-after evaluation, the evaluation should be made as a simpler before-after-study controlling for long-term trends in the number of accidents, local changes in traffic volume and regression-to-the-mean by use of correction factors.

Implementation steps – data collecting and modelling

To make the division of the road system into clearly defined populations of roadway elements and homogeneous road sections it is necessary to collect data about accidents, traffic volume, road design and the surrounding environment.

These data have to be unambiguously located on the road network by use of for example stationing along all roads in the road network. In addition, the data have to be immediately interoperable with each other. This is necessary to develop an accident model.

The development of a model could be summarized in the following steps:

1. Decide what the model should be used for and if the model should be used for state-of-the-art or best practice identification
2. Select possible dependent and independent variables
3. Collect data about these variables
4. Choose a method for estimation
5. Make the estimation based on the work in the previous steps
6. Evaluates the models ability to explain and estimate the systematic variation
7. Make an empirical Bayes estimation of the expected number of accidents on each location.

In the identification of hazardous road sections it is recommended that accident severity is included. To integrate severity it is recommended to develop accident models for each severity category. The development of such models follows the same steps as estimation of a model for all accidents. In addition, it is necessary to provide information about mean costs for traffic accidents.

Implementation steps – accident analysis

In the accident analysis a comparison with a safe location or a normal accident pattern should be made. To make this possible it is necessary to:

1. Make an identification of safe locations using the same procedure as for identification of hazardous locations.
2. Match each hazardous location as closely as possible to a similar safe location.
3. Make a supplementary collection of relevant data for analysis of the matched pair.
4. Make a procedure for the analysis securing that the analysts do not know which site is hazardous and which site is safe.

Regarding the comparison with the normal accident pattern, it is necessary to make an estimation of the normal accident pattern and a procedure for matching the hazardous locations to a relevant pattern.

Maintenance and updating

An essential part of the implementation of the recommended methods is to make a procedure that secure that the data and methods continuously are being maintained and updated and that resources for this work are set aside.