DOI: 10.7251/JTTTP2202066D
UDC: 0

ORIGINAL SCIENTIFIC PAPER

Contemporary methods of road safety risk management

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Received: December 14, 2022
Accepted: December 19, 2022

Abstract: The problem of road safety is an important factor in traffic safety, recognized as one of the main goals in the process of improving traffic safety. Improving both the capacity and safety of roads requires, along with large financial investments, planning and developing new tools in order to ensure prevention of traffic accidents and mitigation of their consequences. Establishing a road safety system is based on detailed knowledge of the current safety of the road, as well as on implementing adequate countermeasures that would eliminate existing safety risks. For this, traffic safety tools used for assessing safety are very important, especially in the road design stage, as well during assessment of traffic safety on the existing road.

Key words: traffic safety, tools, road check, road design.

INTRODUCTION

The issue of road safety is especially considered and treated in the design and construction stages, i.e. during the operatinal stage after certain changes occur over the road and the road belt. The existing road infrastructure should meet increasingly rigorous safety requirements. Improving, building new and reconstructing the existing roads that had been built over 30 years ago involves implementation of modern road surfacing materials, modern carriageway markings and vertical signalling, as well as adjusting bend radiuses and road areas, first of all in order to prevent traffic accidents from occurring, and then to mitigate their consequences. In contemporary international relations, road safety is treated through prevention based on the Directive EC/2008/96.

Road safety improvement tools are:

1. Risk mapping (iRAP/EuroRAP methodology),
2. Black Spot Management,
3. Road Safety Impact Assessment,
4. Road Safety Audit,
5. Road Safety Inspection,
6. Network Safety Management,
7. In Depth Analysis and
8. Independent assessment of road's contribution to occurrence of traffic accidents. [1]

ROAD SAFETY IMPROVEMENT TOOLS

That is why this approach is called "proactive" because it is not necessary to wait for a traffic accident to occur in order to realise that a section of the road is particularly dangerous or with a high risk factor. Road safety improvement tools included both primary and secondary road network.

Risk mapping (iRAP/EuroRAP methodology)

Developed countries that are leaders in traffic safety analyse their road networks by using iRAP/EuroRAP methodology. The iRAP model is based on the assessment of road safety characteristics without using data on traffic accidents and their consequence. iRAP analyses road safety by using contemporary road camera recording equipment, collecting large quantities of data about the road, which are then processed in a special software.

The iRAP provides for identifying high risk locations, as well as proposed measures to mitigate those risks. Unlike the iRAP methodology, the EuroRAP is based on calculating objective risk, i.e. the risk calculated based on traffic accidents and consequences of traffic accidents on sections of the road network.

This methodology involves the following activities:

- Recording the roads with cameras; in accordance with the iRAP methodology, based on the determined road network, using high-resolution cameras placed on a vehicle and GPS coordinates,
- Coding the recorded material: the recorded material is turned into coded data on road safety properties, in accordance with iRAP specifications,
- Collecting supporting data: data on the number of traffic accidents, killed and severely injured

people, number of vehicles, speed and other data in accordance with iRAP specifications on necessary supporting data,
- Processing and analysing the data: processing and analysing the data in accordance with iRAP specifications, as well as imputing processed data into specialised online iRAP software (ViDA),
- Creating an accessible and economically sustainable counter-measure programme, which includes recommendation for road improvements and assessment of the numbers of killed and severely wounded that could have been prevented,
- Report: Along with the standard project report, this report will be also available through the online iRAP software (ViDA). [2]

The methodology being used in the EuroRAP has been developed by a workgroup with representatives from the Swedish Road Administration, Ministry of Traffic of the Netherlands, National Roads Authority of the Republic of Ireland, Traffic Research Laboratory (TRL), with contributions from the National Highways Agency from England, German Federal Highway Research Institute (BASt), and engineers and analysts from leading European motor vehicle organisations and EuroRAP. Both methodologies are based on the road safety assessment using stars aimed to rank 100-metre sections of the road from the aspect of safety and recognise even the smallest of risks, formulate proposed remediation measures that would improve the safety of that particular section.

The iRAP programme for assessing and raking road safety using stars is also recognized in the Global Status Report on road safety published by the World Health Organization in 2015 as a methodology providing a single assessment of road safety from the aspect of road user, separately for categories of drivers and passengers in motor vehicles, motorcyclists, pedestrians and cyclists. This methodology has been used on over 500,000 km of roads in 62 countries. Standards are set up for comparing sections of roads and their ranking, with recommendations for improving each specific location and moving them to one of the "higher" safety ranks, with higher number of stars. The use of this methodology is increasing globally, because it is a proactive method relating to road safety, while analysing the road without the need for traffic accidents to and their consequences to occur in order to analyse them.

Black spot management

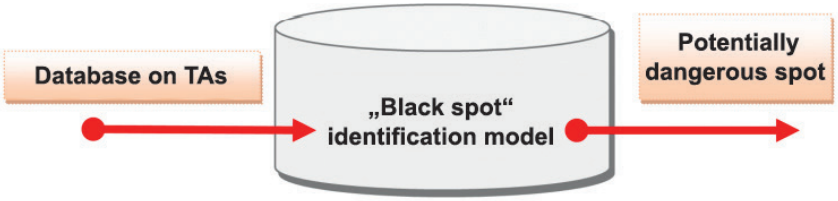
Black spot management is one of the oldest reactive tools – it is a reaction to dangerous spots on the road, identified based on data on traffic accidents and their consequences. The European Union Directive (2008/96/EC) on road infrastructure safety management, which is covered and monitored within the negotiation Chapter 14 – Transport Policy is important for meeting preconditions of B&H for the accession to the EU.

Black spot management consists of the following activities:
- defining and identifying black spots on roads,
- analysis of traffic accidents and risk factors at black sports in order to identify safety risk and propose adequate "treatment" of black spots, and
- implementation and evaluation of applied treatments over black spots.

Defining and identifying black spots is the first step of the "black spot" management procedure, and it is conducted in order to recognise parts of the road network where the road and its surroundings represent the most significant factor contributing to traffic accidents (Picture 1).

After the black spots have been identified the black spot analysis project follows which processes in detail all safety aspects at that particular location, as well as an in-depth analysis of traffic accidents at that particular location. This is followed by defining guidelines for the black spot remediation project, which takes into consideration all recommendations defined in the traffic safety analysis. After the project has been developed we move to the remediation of the black spot, while the results of realised measures are analysed in the following time period. An important segment of this stage is monitoring of realised measures in order to point out their efficiency so that there would be further improvement of safety at those locations.

A black spot is each spot on a public road up to 300 metres in length outside populated areas, or up to 100 metres in populated areas, where in the time period of consecutive three years there were at least six traffic accidents with consequences on lives and health of people,



Picture 1. Black spot identification process [8]

or four traffic accidents of the same characteristics with consequences on health and lives of people.

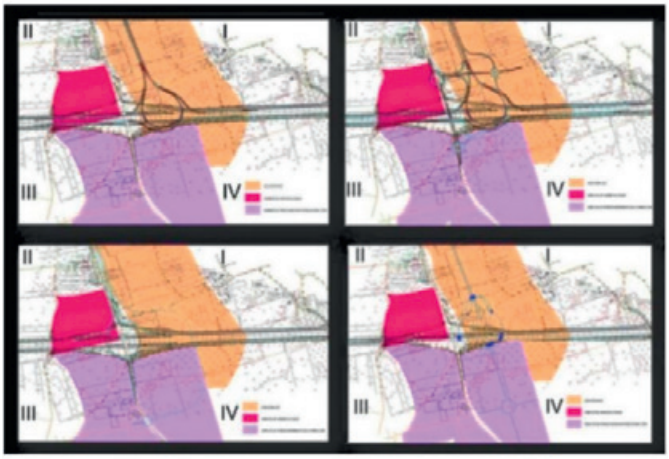
The second level, i.e. the second step involves more concrete requirements in terms of the selection of a black spot. In the second step there is a more detailed analysis in order to determine whether the traffic accidents on this particular place are in a direct link with the road and a more precise definition of the black spot location (up to 500 metres in length).

Local risk factors include all specifics of the micro-location where an increase of traffic accidents has been recorded. Those specifics could, for example, be: small radius of the bend, poor condition of the carriageway, presence of dangerous objects in the road belt, insufficient visibility, etc. After the identification has been finished, further steps are taken in the black spot management. There are proposals and analysis of black spot remediation measures. We can select optimal measures, calculate remediation costs, assess effects and analyse cost/benefit relation of investments. After the cost/benefit has been calculated for all black spots, we can rank all of them again and define the remediation sequence (black spot programme evaluation).

Road Safety Impact Assessment

RSIA - Road Impact Assessment or Road Safety Impact Assessment is an analysis conducted in the process of designing roads and routes. RSIA is a strategic comparative impact assessment of the new road or a modification of the existing network on the safety properties of the network.

This analysis is aimed at establishing difference of potential impact between several building solutions for a particular part of the network and selection of the best solution from the aspect of traffic safety. Examples of several technical traffic solutions during the construction of a part of the network is shown in Picture 2, and the application of the RSIA is aimed at identifying the version with the best performance in terms of traffic safety.



Picture 2. Several models of technical traffic solutions on a particular location [8]

Road Safety Audit

The road safety audit is a formal safety check of the existing or future road by an independent team of auditors. This activity is ordered by a same procedure as the design process. The road safety audit can be performed in any stage of project development: from the planning stage and preliminary design, to the main project and construction stage. It can be performed on any project bearing in mind its size – from a small junction to a road, which is being modified in order to fit into much larger and wider projects (regional, international). [3]

RSA – Road Safety Audit – „traffic safety audit in road traffic" is an independent and detailed systematic safety check relating to designed properties of roads in all design stages, until the early construction stage. These activities are focused so that they can recognise and remove all deficiencies and potentially dangerous details in the early design stage of the road.

It is suitable to conduct the road safety audit in five following stages:

Stage 1: General project audit

During this stage the nature and the scope of the project are being assessed, starting points for concrete design are determined, such as different versions of direction of the road, important design standards, connection with the existing road network, number and type of junctions, access control, locations and types of intersections, impact on the existing infrastructure, as well as whether the new road needs to be open for all types of traffic. The whole of project is observed from the aspect of traffic safety.

Stage 2: Audit of the preliminary design

The audit can be conducted after the general project design is finished. The primary goal of the audit is to asses relative safety of junctions and intersections, horizontal and vertical profile, cross section, visibility and width of traffic and stop lanes, total slope and pedestrian capacity (children, elderly, disabled persons and cyclists) and other design standards, as well as visual appearance of junctions, before the design is adopted and before the acquisition of land. The audit in this stage should be finished before the purchase of land.

Stage 3: Audit of the final design

During this stage, the audit team examines properties of the final geometric design, traffic signs and pavement markings plans, lighting plans, land development, junction and intersection elements, such as funnels, acceleration and deceleration lanes length and turn radiuses. The team also considers elements for special groups of traffic users, drainage, protective fences and other facilities along the road, as well as possibility for their construction.

Stage 4: Audit of complete design immediately before and/or after the opening

Immediately before the road is opened the audit team should conduct a field visit in order to assess whether the safety requirements of all traffic users (pedestrians, cyclists, motorcyclists and other) have been adequately met. The audit team should take a day and a night drive during the inspection and, if possible, to conduct the inspection during different weather.

Stage 5: Monitoring.

This is an insight into the works and problems that were not easy to notice before the road was opened. Corrective measures, although they are more expensive in this stage, can still be cost effective. It is possible to assess whether the road is being used in a planned manner and whether changes in design are needed, all based on the actual behaviour of traffic users.

The number of audit stages depends on the type of project, and the audit during all five stages will usually be conducted only in cases of large new projects. In case of small facilities or reconstruction projects, separate audits in three first stages are rarely done (general, preliminary and final design).

Road Safety Inspection

Road safety inspection is an independent, formal and systematic check of elements of the existing road from the aspect of traffic safety. The aim of these checks is to identify all unsafe elements of the road that contribute to traffic accidents or their consequences.

[4] RSI – Road Safety Inspection – "inspection of safety on existing roads" is a periodic, detail check of traffic safety aimed at identifying deficiencies and necessary maintenance of the existing road in order to ensure required level of traffic safety. Picture 3 shows activity diagram for improving road safety, depending on the design stage, i.e. the operational stage it is being implemented in. This diagram shows the stages from design to use and activities on improving road safety that can be implemented within these stages.

Contemporary road design and remediation principle must include the use of these tools in order to have more efficient investment and direction of traffic safety measures on the most important traffic safety details.

These activities are being realised based on the Directive 2008/96/EC of European Parliament and of the Council that was adopted on 19 November, 2008 on proposition of the European Commission.

In order to efficiently realise obligations from this directive, the idea is have specially trained and licensed staff to handle the activities relating to road safety, so-called "traffic safety auditors".

Traffic safety inspection needs to be conducted in the following cases:

- when a section of the road or an junction has been identified as dangerous (according to data on traffic accidents or based on some of the road assessments (iRAP for example),
- when there are other information on serious traffic safety problems on the road, a section of the road or a junction received from the police, road maintenance service, local self-administration unit, or similar,
- when there is a planned reconstruction or remediation of the road in near future.

Participants of the road traffic safety audit are both the client and the auditor (the traffic safety auditor position is also recognized in the Draft addendum of the Law on Road Traffic Safety). The client orders a check and as a rule it is an institution in charge of road management (road manager). The client delivers necessary documentation to the auditor, who, after examining it and after conducting a detailed analysis, goes out into the field, identifies problems, and then produces a report on the check (Picture 4).

Picture 3. Tools for improving road safety depending on the stage of road use [8]

Picture 4. Traffic safety audit process [8]

Network Safety Management

NSM - Network Safety Management - management (classification) of road network from traffic safety standpoint involves the implementation of known and verified models of identification and ranking of the sections of a road that have been in use for more than three years and where there are records of increased number of traffic accidents. This activity is focused on recognising dangerous sections with increased risk of traffic accidents, and defining the list of priority sections that will be the focus of analysis and improvement of traffic safety.

In-Depth Analysis of traffic accidents

Around the world in-depth analyses of traffic accidents have been recognised as a good method to determine factors influencing the occurrence and consequences of traffic accidents. The European Council has defined the in-depth analyses as one of basic procedures to determine factors influencing the occurrence and consequences of traffic accidents. In order to develop a contemporary model of in-depth analyses it is necessary to collect as many road factors influencing traffic accidents as possible, so that they could be systematically organised and determine which of them cause traffic accidents, which give contribution for the accidents to occur, and which influence the possibility to avoid them or avoid severe consequences.

The task of traffic accidents in-depth analyses is to conduct detailed data on the traffic accident in order to determined factors that caused it, as well as factors that influenced the consequences of that traffic accident. The SafetyNet project defined a large quantity of variables in relation to the accident that are necessary to collect, using a research principle known as the SafetyNet Accident Causation System (SNACS). In terms of defined factors of influence the best work has been done in Germany, where they defined several thousands of factors of influence within the GIDAS in-depth analysis database. In-depth analysis of traffic accident is based on high quality databases, i.e. high quality collection of data on traffic accidents. The key for in-depth analysis is establishing high standards of investigation of traffic accidents and the manners of fixing tracks on the scene.

Speed is one of the basic parameters defined in simulation models in order to describe as much as possible the real conditions of traffic.

Independent assessment of road's contribution to occurrence of traffic accidents

The road as a safety factor influences both the number and the consequences of traffic accidents due to:

- size of longitudinal and cross slope being incompatible with the speed and properties of the vehicle,
- geometric elements of the road being incompatible with calculated speed and gauge of the vehicle,
- insufficient longitudinal and cross visibility splay of the road in the bend and in the line,
- insufficient width of the carriageway,
- poor quality of surfacing, so there is insufficient adhesion force between the wheel and the surface,
- insufficient and inaccurate information for the drivers on the road, facilities on the road, along the road and other,
- insufficient width and unreliable shoulders,
- placing road elements that force the driver to suddenly change the mode of driving,
- existence of conflict zones along the road where roads intersect,
- insufficient sensitivity of dangerous junctions, pedestrian crossings, intersections, facilities in the road area, etc.,
- incorrect implementation of horizontal and vertical road signalling, and others. [5]

The independent assessment of road's contribution to traffic accidents occurring is recognised as an obligation of the road manager, according to the Law, for all

Picture 5. Forgiving road concept [8]

traffic accidents with fatalities. This procedure is an in-depth analysis model, but the focus is directly on the road's contribution, which does not exclude considering other contribution factors, but definitely required direct identification of road's contribution.

Contemporary road design

Contemporary approach to the deseing and remediation of the road has established contemporary road development concept that involves implementation of contemporary technical and technological measures. The contemporary principles involve designing of "self-explanatory" and "forgiving" roads. Both domestic and global literature has a large number of papers and documents where experts specialised for this area stated, examined and described the implementation and results of technical, regime and other measures for improving traffic safety from the aspect road and its surroundings. The "forgiving road" concept is based on the tendency to develop the road and its surroundings in a way that they can compensate for drivers' mistakes, in order to mitigate the consequences that occur from traffic accidents. This concept of the road and its infrastructure is a measure aimed at passive safety of the driver and passengers (Picture 5).

The "self-explanatory roads" concept is based on the tendency for the road with its surroundings to offer complete information on the line of the road, conditions on the road and the mode of driving that that the driver needs to adhere to in order to be safe on the road.

CONCLUSION

Road network safety management in its original meaning should enable the road manager (at state or local level) to simplify the use of legally prescribed traffic safety tools: risk mapping, section ranking, "black spot" management, traffic safety check, storing check results, audits, independent assessment of road's contribution to occurrence of traffic accidents with fatalities, etc.

Road safety management should provide for the very management decision process to be raised to a higher level. The manner in which the comprehensive use of road network traffic safety tools is described it should provide that all legal obligation of the road manager are initiated timely from one location, that all implementation of tools is monitored, and that the results are easily available, which certainly makes for easier management (Network Safety Management).

The road manager would have available data on the safety of the road network, where it would be most efficient to implement measures, and it would be possible to monitor investments into the road network, as well as efficiency of measures taken. This would provide for a systemic road network management. To start a high quality road network safety management you need a good database containing digitalised road network and data on traffic accidents. These two sets of data should be considered a basis. All other data such as: road categorisation (road markings, nodes, sections, etc.), road signs cadastre, school zones position, areas in/outside populated areas, quality of lighting, automatic use of road safety management tools, etc. are all upgrades that are much easier to implement if there is a basis. [6]

The implementation of the methodology presented here, i.e. the road safety improvement tool, is considered efficient if after its implementation over a long period of time we can conclude there is improvement of traffic safety, which is at the same time the direction of further research into effects of measures taken.

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