Development of Czech road safety impact assessment guidelines

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Abstract

During preparation of new roads or reconstructions, several impact assessments take place; environmental impact assessment (EIA) is probably the most known one, while road safety impact assessment (RSIA) is a relatively novel procedure. European Directive 2008/96/EC on road infrastructure safety management defines RSIA as "a strategic comparative analysis of the impact of a new road or a substantial modification to the existing network on the safety performance of the road network", which should be carried out for all roads of the trans-European network (TEN-T) at the initial design stage. The process involves definition and comparison of project variants ("do nothing" and alternative scenarios), whose road safety performance needs to be assessed, including impacts on adjacent road network. In this regards various approaches have been implemented and applied in EU countries, mostly relying on rates, derived from accidents and injuries, which were previously recorded on comparable road network categories. In contrast, state-of-the-art recommends using accident prediction models (safety performance functions) and accident modification factors, which quantify expected impact of contemplated road safety measures on accident frequencies. The paper describes current experience and findings from an on-going research project aimed at developing RSIA guidelines in the Czech Republic, using the state-of-the-art approach.

Keywords

Road infrastructure safety management, Road safety impact assessment, Accident prediction model, Accident modification factor

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1. Introduction

In 2008, Directive of the European Parliament and of the Council on road infrastructure safety management ("the Directive" in the further text) was brought into force. The main purpose of Directive 2008/96/EC is to establish management procedures to ensure that the road network is safe. It introduces four procedures: road safety impact assessments and road safety audits have to be carried out for new road constructions; for existing roads, road network safety ranking to find the critical sections and road safety inspections have to be periodically conducted. The present paper focuses on road safety impact assessment (RSIA). Its main idea is that road safety should play an important role in the decision making during the designing/planning stage (Wegman et al., 1994; ETSC, 1997; Laurinavičius et al., 2012). RSIA is defined by the Directive as "a strategic comparative analysis of the impact of a new road or a substantial modification to the existing network on the safety performance of the road network", conducted alongside with other impact assessments, such as environmental impact assessment (EIA).

By 2011, member states had a deadline for adopting the Directive procedures. The materials, into which the Directive procedures were implemented, are available on-line (http://ec.europa.eu/transport/road_safety/topics/infrastructure/national-guidelines_en). Nevertheless, most of them are legislative documents, which offer mere Directive translations, rather than detailed guidelines for practical use (TML, 2014).

In the Czech Republic, some of the procedures were in use already before the Directive introduction. CDV – Transport Research Centre ("CDV" in in the further text) worked on road safety audit implementation since 1990s and published its guidelines in 2006; road safety inspection manual followed in 2008 (Pokorný and Hrubý, 2010). Identification of hazardous locations on Czech roads has also had a long tradition, including CDV's 2001 guidelines. All mentioned CDV guidelines, related to infrastructure safety management, are available on-line (http://www.audit-bezpecnosti.cz/metodiky-a-kontrolni-listy/).

However, RSIA is a new tool in Czech conditions. The situation is similar also in other countries, as evidenced by EU synthesis on use of Directive procedures (TML, 2014) which concluded that RSIA still remains the least used by member states. TML report also warned about diverse Directive interpretations, which creates a lack of harmonisation and the process the process is often considered more formal than substantial. This motivated CDV to undertake a two-year research project aiming to develop support tools, including RSIA guidelines, which will be sufficiently detailed, yet efficient and feasible for practical use.

The presented paper describes current experience from the first year of the project, involving survey of both state-of-the-practice and state-of-the-art and final findings, which will direct the guidelines development.

2. State-of-the-practice vs state-of-the-art

RSIA process involves definition and comparison of project variants ("do nothing" and alternative scenarios), whose road safety performance needs to be assessed, including impacts on adjacent road network. Therefore, the underlying principle is quantification of safety. For this purpose, rates derived from accidents and injuries have been traditionally used, based on Police accident records and tabulated for several road network categories. However, in recent years, general use of accident rates is declining, since they were found to incorrectly assume a linear relationship between accident frequency and the degree of exposure (Hauer, 1995; Elvik et al., 2009; PIARC, 2015). In addition, relying only on Police-reported accidents is not recommended, as it does not account for the confounding effect of regression to the mean, i.e. random fluctuations around long-term mean value (Hauer, 1997). For these reasons, an empirical Bayes ("EB") approach, combining observed accident frequency with expected accident frequency according to accident prediction model (or safety performance function, SPF), has been recommended (Cheng and Washington, 2008; Montella, 2010; Lim and Kweon, 2013).

Another element of state-of-the-art approach to safety estimation involves accident modification factors (AMFs), also known as crash modification factors (CMFs) or crash reduction factors (CRFs). These are multiplicative factors, used for calculating the expected number of accidents after implementing safety measure at a specific site, through multiplication with expected accident frequency without treatment (Gross et al., 2010). An AMF value higher than 1.0 indicates an expected increase in accidents, while a value lower than 1.0 indicates an expected reduction in accidents after the treatment. Various methodologies may be used in order to obtain AMF values, while before-after methodology with empirical Bayes adjustment (previously mentioned "EB approach"), has been deemed the most suitable (Hauer, 1997; Shen and Gan, 2003; Persaud and Lyon, 2007). In addition, AMFs were recently put into the centre of evidence-based decision-making (Wegman et al., 2015), as a foundation of efficiency assessments to be applied in all cases, where "lack of reliable knowledge of the effects of countermeasures is a key barrier to the advancement of many critical, life-saving initiatives" (OECD, 2012).

To sum up, EB approach requires accident, traffic and infrastructure data to develop accident prediction model (APMs); subsequently it may be used to produce accident modification factors (AMFs). These elements constitute the foundations of evidence-based road safety management (Hauer, 2007; Dupont et al., 2012; Yannis et al., 2016). However, most of existing APMs and AMFs were developed in North America, Australia or North-Western Europe (Yannis et al., 2012), and it is known that these results may not be easily transferable (OECD, 2012; Hasson et al., 2012; La Torre et al., 2016). This means that should state-of-the-art approach be applied, a number of member states, including the Czech Republic, will have to develop their own tools.

In order to learn from real applications in European countries, a survey of practices and guidelines was undertaken, combining literature review and e-mail interviews with selected experts. It was found that most countries (including former East Bloc, but also German-speaking countries or the Netherlands) use simple approaches, relying on accident rates. Three examples from the countries, using state-of-the-art elements (accident prediction models and/or accident modification factors) are presented in the following paragraphs.

3. Selected state-of-the-art examples

3.1. Finland

According to OECD (2012), since 1995, practically all traffic safety effects of road improvements have been evaluated using an evaluation tool. This tool called TARVA uses EB safety predictions for selecting locations for safety improvements and provides estimates of their safety benefits (Peltola et al., 2013). The estimation of safety effects is a four-phase process:

1. For each entity (road section, intersection, …), EB estimate is obtained through combination of accident record and predicted frequency. The models are of simple form A=a·mileage, with a coefficients tabulated for conditions of road types, intersection types, proportion of entering traffic from minor road, etc.
2. To predict the number of accidents without road improvements, the EB estimate is corrected by the traffic growth coefficient. Also the effects of fundamental changes in land use may be taken into account.
3. The effects of the measures on injury accidents are estimated using "impact coefficients" (i.e. AMFs). User may use 92 pre-defined measures, based on Elvik et al. (2009).
4. "Severity change coefficients" are applied to control for severity of accidents still occurring on the road after treatment. Using the evaluated injury accident reduction percentage and available knowledge on the

average severity (fatalities per 100 injury accidents) and its change, TARVA produces an estimate of yearly-avoided fatalities.

3.2. Sweden

In Sweden, all road projects are evaluated using so called “EVA” tool (Trafikverket, 2016). Accident prediction models are of following forms:

$$A_{car} = a \cdot \left(I_p + I_s\right)^b \cdot \left(I_s/\left(I_p + I_s\right)\right)^c \quad (1)$$

$$A_{cyc} = a \cdot (I_{car})^b \cdot \left(I_{cyc}\right)^c \quad (2)$$

$$A_{ped} = a \cdot (I_{car})^b \cdot \left(I_{ped}\right)^c \quad (3)$$

where A_{car}, A_{cyc}, A_{ped} are frequencies of car-car, car-cyclist and car-pedestrian accidents, respectively; analogically I_{car}, I_{cyc}, $I_{ped}$are respective volumes; I_p and I_s are car volumes on primary and secondary intersection arms; and a, b, c are coefficients given for section and intersection characteristics, such as volumes, speed, geometry, etc. Accident modification factors are also reported, being a mixture of qualitative and quantitative information, often based on Elvik et al. (2009).

3.3. United Kingdom

In UK, COBALT *(Cost and Benefit to Accidents – Light Touch)* computer programme is used to undertake the analysis of the impact on accidents as part of economic appraisal for a road scheme (DfT, 2015). Accident prediction model form is

$$A = a \cdot f^b \quad (4)$$

where A is accident frequency, f is flow (traffic volume), a and b are parameters given for each of 15 types of road sections and 96 types of intersections, based on speed limit, number of intersection legs, road types and other characteristics.

4. Lessons learned for Czech application

The survey and interviews shown that most European countries do not apply state-of-the-art approach to RSIA, which should be based on accident prediction models and accident modification factors. Nevertheless, based on information from three countries that do, two main lessons may be learned:

1. Applied accident prediction models are relatively simple. They are developed for specific road types and intersection types and involve only traffic volume. This practice is consistent with recent Czech applications,

where simple models were also found to provide sufficient quality of safety estimates (Ambros and Sedoník, 2016; Ambros et al., 2016b).

2. Accident modification factor sets are usually combined from local estimates and international sources, mainly the Norwegian Handbook of Road Safety Measures (Elvik et al., 2009). While this practice may be sufficient for relatively similar conditions of Sweden and Finland, suitability in the Czech Republic is uncertain. In a recent study, where AMF for Czech roundabout conversions was developed (Ambros et al., 2016a), results were found consistent with international findings. However, more studies will be needed in order to reach consensus about transferability possibilities.

5. Conclusions

In order to foster application of RSIA in the Czech Republic, the described project aims to develop RSIA support tools, including practical guidelines. With this idea, a survey of both state-of-the-practice and state-of-the-art was undertaken, in order to learn from experience of other European countries.

It was found that the main elements of state-of-the-art approach are accident prediction models and accident modification factors, which enable quantitative assessment of planned or existing infrastructure. From practices in the countries, which currently use these tools, it emerged that:

1. simple accident prediction models (i.e. exposure-based models) are sufficient, and
2. accident modification factors may be derived from local data or transferred from the countries with similar conditions.

These findings will direct further steps of developing Czech RSIA guidelines. Simple accident prediction models will be created for core road network (i.e. motorways and national roads) and accident modification factors will be developed for selected key countermeasures. Based on their results, in comparison with established international values, a conclusion will be made about possible transferability.

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