

Developing the European Road Safety Decision Support System

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Abstract

The Decision Support System (DSS) is one of the key objectives of the European co-funded research project SafetyCube in order to better support evidence-based policy making. Results will be assembled in the form of a DSS that will present for each suggested road safety measure: details of risk factor tackled, measure, best estimate of casualty reduction effectiveness, cost-benefit evaluation and analytic background. The development of the DSS presents a great potential to further support decision making at local, regional, national and international level, aiming to fill in the current gap of comparable measures effectiveness evaluation. In order to provide policy-makers and industry with comprehensive and well-structured information about measures, it is essential that a systems approach is used to ensure the links between risk factors and all relevant safety measures are made fully visible. The DSS is intended to become a major source of information for industry, policy-makers and the wider road safety community.

Keywords: road safety, decision support system, road safety measures

INTRODUCTION

Although there has been a substantial progress in improving road safety and reducing traffic fatalities, in 2012 the EU Member States with the highest accident rate by population had a rate nearly four times that of the best performing countries. For that reason a number of countries have adopted a coherent approach to road safety management that follows the Safe System Approach [1].

Road safety policy-making is considered within the remit of governments and local/regional authorities. Nevertheless, all stakeholders who have an impact on road risks, including individual citizens, also have a responsibility to contribute to their reduction. The group of relevant stakeholders therefore includes not only publicly elected bodies but industry groups as well which involve insurance organizations, police, public health organizations, vehicle manufacturers, highway authorities and so on.

However, there are several gaps in the evidence base which constitute major challenges needing to be addressed. There is poor availability regarding the information relating to the causes of crashes and the estimation of the associated risks. There is also a lack of a clear and consolidated set of measure evaluations relevant to European road safety. Moreover, a priority setting for road safety measures within a systems approach cannot be fully supported due to lack of information. Lastly, there is an increased need for further detailed safety data analysis in support of road safety “hot topics”, including new technologies and other measures that have not yet been properly evaluated. The main objective of SafetyCube project (“Safety Causation, Benefits and Efficiency - www.safetycube-project.eu) is to address these gaps in the evidence base. More specifically, it is aimed to develop an innovative road safety Decision Support System (DSS) that will enable policy-makers and stakeholders to select and

implement the most appropriate strategies, measures and cost-effective approaches to reduce casualties and crash severity for all road users. The core of the project includes a novel and comprehensive analysis of accident causation factors combined with newly estimated data on the effectiveness and cost-effectiveness of safety measures, not just in relation to reduction of fatalities but also the number of injured. An operational framework will be established to provide future access to the DSS once the project is completed.

The project outputs will be framed according to the specific policy and stakeholder areas – infrastructures, vehicles and road users – so that the measures developed in the project can be most readily applied. A systems approach will ensure effective coordination between these areas. The close involvement of road safety stakeholders of all types at national and EU levels, and wider will enable the DSS to be focused on the most appropriate policy-making procedures and ensure the project outputs have global reach.

This paper describes the background, methodology and design principles of the European DSS within the SafetyCube project. For the development of the European DSS a comprehensive common methodology is designed and applied in existing and new studies of road safety measures effectiveness evaluation. Moreover, extensive consultation of road safety stakeholders is carried out, by means of several workshops, in order to define the user needs for the DSS. The structure and the functioning of the DSS will be also presented, both in terms of back-end database and front-end user interface, together with the first results of the application of the common methodology for the evaluation of road safety measures effectiveness.

SAFETYCUBE METHODOLOGY

The SafetyCube methodology is illustrated in this section and is based on two pillars; analysis of study designs and coding of the studies, in order to be used as input to the back-end database of the Decision Support System (DSS).

Taxonomy of risks, measures and related analysis methods

In order to carry out an analysis of the study designs, a complete taxonomy has to be built first for each of the following 3 categories: behaviour, infrastructure and vehicle. General categories of the three main areas were firstly considered and then the specific risk factors and measures were assigned to the respective category. More than 90 risk factors and 95 measures in infrastructure areas, more than 115 risk factors and 250 measures for behaviour, more than 60 risk factors and 60 measures for the vehicle area have been identified by means of a thorough review of existing safety areas and taxonomies.

The main elements included in the SafetyCube taxonomy are presented in Table 1. In each element, several specific risk factors and measures are considered.

Table 1. Taxonomy elements of risk factors and measures

Road User	Infrastructure	Vehicle
speed choice driving under the influence of alcohol driving under the influence of drugs risk taking fatigue distraction and inattention functional impairment insufficient skills insufficient knowledge emotions and stress misjudgement and observation errors age diseases and disorders traffic rule violations	Exposure road type road surface road environment workzones alignment features traffic control	Crashworthiness technical defects/maintenance Design

A detailed and recorded literature research is carried out so that key studies are identified (at each detailed level of the taxonomy, i.e. for each specific risk factor or measure). There are different types of studies dealing with the safety effects of risks and measures. Study designs in road safety are closely related to those in epidemiology. Each study design is characterized by a number of principles (addressing exposure to risk/measure; experimental vs. observational; presence of control group; time dimension) and their principal application is mentioned. After the study design is appropriately categorized, the next step is to identify and record the estimators of effects, which may also vary (e.g. Crash Modification Factor (CMF), Absolute difference, Regression coefficient / slope, Odds ratios and so on).

Within SafetyCube, a framework was created in order to systematically characterize a range of identified studies for each specific risk factor or measure of the taxonomy. Overall, studies can be classified in two categories, namely, experimental and observational. Observational studies are further classified into analytical and descriptive studies which can then be divided to cohort studies, case control, case cross-over and cross-sectional. Similarly, the experimental studies can be classified in randomized or non-randomized control trials, quasi-experimental studies, between group, before and after studies, and cross over.

A core characteristic of the approach is to identify the outcomes and the exposure for each study, and their relationship to each other within the study design. Outcomes typically concern accidents or injuries and in particular, their (absolute/relative) numbers, their types and severities. Exposure, in the context of road safety, either refers to exposure to risk factors or exposure to countermeasures. For a full description and details, the reader is referred to Elvik et al. [2]. Figure 1 provides an overview of the categorization of studies.

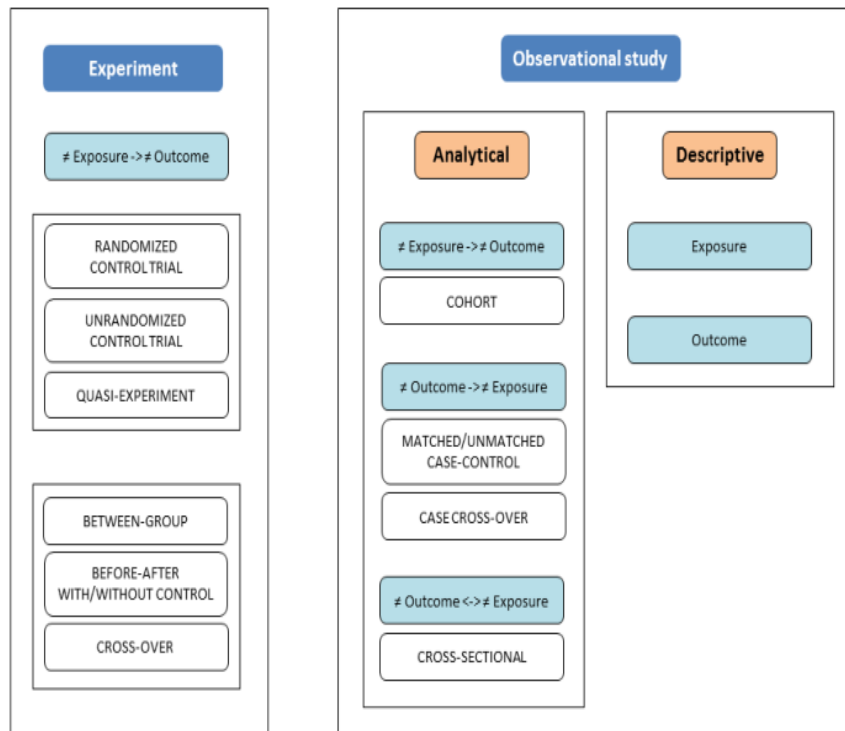


Figure 1. Study design in analysis of risk factors and evaluation of countermeasures (source: Elvik et al. 2015).

Coding template

The study design and the corresponding estimator of effects of interest are entered in a template which was constructed in Microsoft Excel especially for coding research studies and existing results. The template includes information on the core elements of the study (study design, authors, year, abstract, road users profile, severities, potential sources of biases etc.), flexible elements (e.g. additional information that characterizes the study design), exposures (e.g. risk factors or countermeasures), outcomes (e.g. accident severity, accident frequency, accident reduction, other safety indicators, and so on), reported results (measure of effects, estimates, p-values, confidence intervals, etc.) and also a brief summary (critical synopsis of the study).

It is aimed to analyse and code a large number of studies for each specific risk factor or measure, and then draw the findings together into a neat “synopsis” for each topic. The SafetyCube approach is that the resulted summaries represent a complete synthesis of knowledge on the topic. Furthermore, a meta-analysis of existing studies on the topic will be included when this is possible (e.g. when there is an adequate number of studies, studies are not heterogeneous, etc.).

Database

The templates of coded studies will undergo a thorough checking and debugging process, in order to be eventually stored in a relational database, which will serve as the back-end of the DSS. The database includes numerous Tables, however the main ones concern the study details, and the safety effects details. The database is designed and structured so that DSS user queries will be returning results in terms of key studies for each topic, safety effects reported in the studies, and SafetyCube synopses of the effects per topic. For each topic, the database will allow a customised search for results from specific countries, road user types, road types etc.

DSS DEVELOPMENT

Analysis of user needs

Stakeholders play a crucial role in developing the DSS and in achieving excellence. The SafetyCube project had already identified a core group of stakeholders from government, industry, research, and consumer organizations covering the three road safety pillars: vehicle, infrastructure, road user. The future users of the DSS include Public Authorities (local, regional, national, European and international level), Industry (Infrastructure, Vehicle, Insurance, Technology), Research Institutes, Non-Governmental Organisations, and Mass media.

In order to identify user needs 3 workshops were carried out. The first workshop on June 2015 was carried out in Brussels in order to start a dialogue between the project participants and a number of key stakeholders for road safety in Europe. The workshop both introduced the audience to the SafetyCube project and also solicited input from the stakeholders that will form the structure and priorities of a DSS. An extensive list of “hot topics” was also created on the basis of feedback from stakeholders, allowing to enhance the SafetyCube initial lists. A total of 30 delegates attended the event [3].

A second workshop was organized on October 2015 in Ljubljana, Slovenia. The first part of the workshop was a plenary session with about 150 participants from the Slovenian Road Safety Councils and IRTAD meeting. The SafetyCube project was presented as well as the plans for the Road Safety Decision Support System (DSS) and the “hot topics” from previous workshop. All participants were asked to give their feedback to the DSS and “hot topics”. Feedback was collected both in spoken and written form. The second part of the workshop was a breakout session continuing with participants from the IRTAD group. The breakout session started with a discussion where the 23 participants were giving more detailed feedback on their wishes and questions on the DSS. Thereafter the participants were asked to add, comment and prioritize the “hot topics”. This was done on six posters showing the “hot topics” from previous stakeholder consultation.

A more dedicated workshop was carried out on February 2016, in Brussels [4], where 12 road infrastructure stakeholders participated. The participants represented key road infrastructure stakeholders, including EC-INEA, EC-DG-MOVE, EURORAP, ASECAP, ETSC, POLIS network, FIA, BRRC and Belgian regional authorities. The objectives of the workshop were the analysis of infrastructure stakeholders’ needs for the DSS, as well as ranking of infrastructure related “hot topics”.

On the basis of the workshops results, it was indicated that the Decision Support System (DSS) should be suitable for use by a wide range of end users. It should not be limited to EU policy makers, but also be applicable for local authorities. It is intended that the system will help policy makers make an “informed decision”. In addition, it has to be an impartial system, which will not advocate for specific measures – the intention is “to guide, rather than to dictate”. Using this structured approach to policy making should eventually enhance public acceptance of measures by providing a solid evidence base for decisions.

Moreover, it was proposed that the DSS should have the following characteristics: include robust data which allow for critical analysis and transparency, access to the studies used and to all results as well, information of the best quality studies and recommendations. A platform built in the project should be operational after the project.

DSS design principles and inclusion criteria

The DSS is created on the basis of the following design principles:

- A Modern web-based tool
- High Ergonomic interface
- Simple structure
- Powerful Search Engines
- Fully Documented information
- Easily Updated

Regarding the SafetyCube DSS Website, a strong and easily found address is needed. Furthermore, the design should be consistent throughout all tools (e.g. unique visual identity, colours, design, messages, etc.). The design should be modern and ergonomic utilizing multimedia (photos and videos) wherever possible. As mentioned before, the system should allow for updates by receiving feedback not only from the users but also from visits traffic monitoring. Lastly, a robust promotion policy will be developed during and after the project via newsletters, social media and so on.

The content of the DSS is of high importance as well. The inclusion criteria are briefly illustrated. Quantitative results are required, therefore qualitative studies and literature reviews are not a priority (although may be useful). Information completeness and are very important and should be taken into account as well. In order to prioritize the information entered on the DSS, a set of priority criteria are also developed. In general, meta-analyses are preferred over simple analyses. Methodological soundness and high clarity (adequate sample size, appropriate statistical methods), are basic criteria for studies to be included in the DSS. Moreover, the year of each study is important, as recent studies are more likely to apply more appropriate methods, consequently, more recent studies are preferred.

DSS development

Figure 2 illustrates the DSS development methodology. Firstly, the existing road safety DSS worldwide will be analysed. At the same time, an analysis of User Needs (stakeholder workshops, on-line surveys) as well as the development of common methodology and contents collection will be carried out. All these actions will lead to the design of the DSS, which will eventually lead to the development of the DSS.

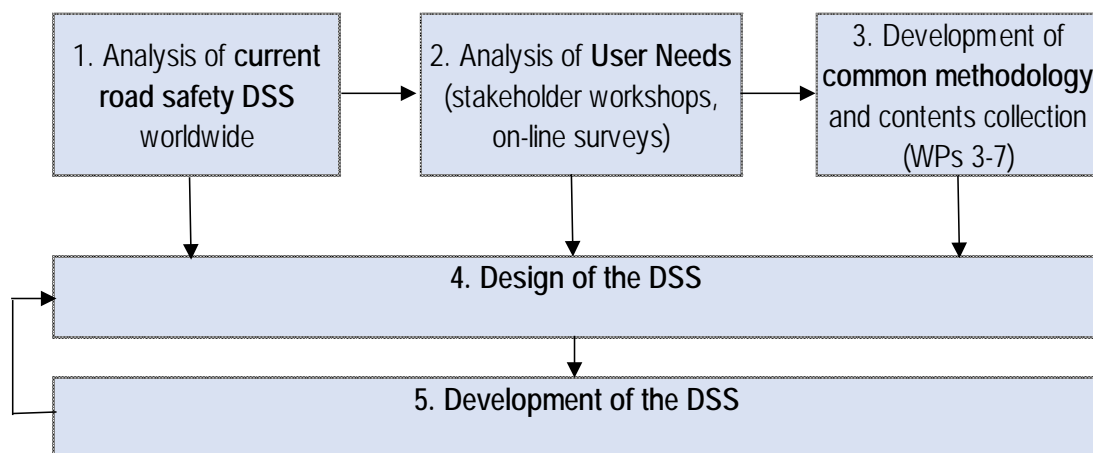


Figure 2. DSS development methodology.

Figure 3 demonstrates the DSS interface design. The heart of the DSS consists mainly of two main pillars and three levels. These two pillars represent: (A) the road safety problems (risk factors) and (B) road safety measures. There is also another pillar (C) dedicated to road safety tools, which will include more static outputs (reports, web-texts, glossary etc.).

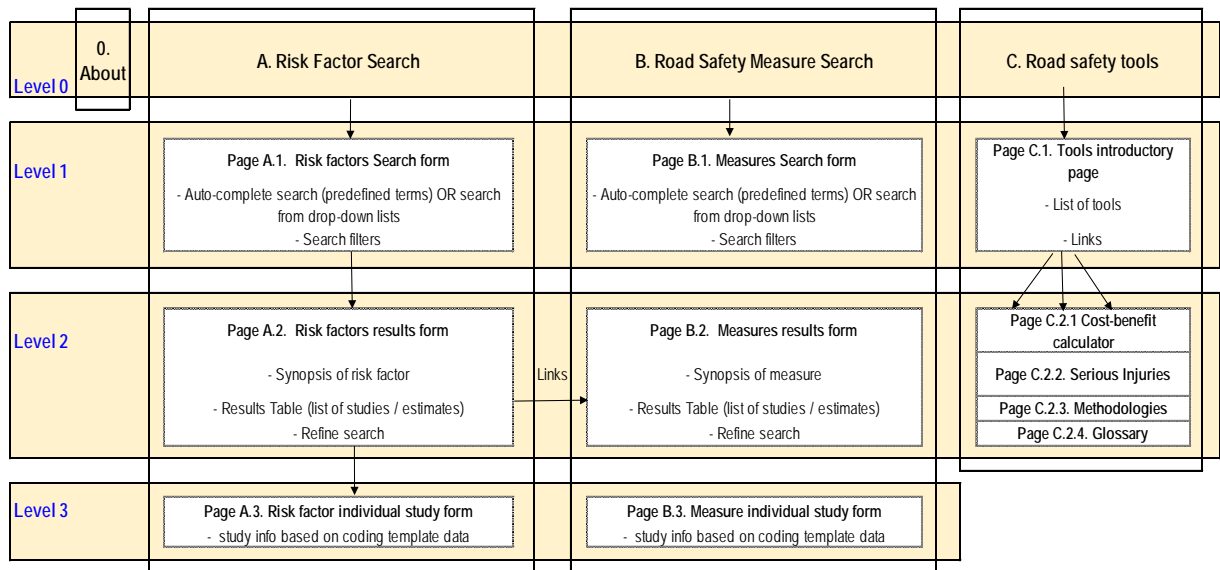


Figure 3. DSS User Interface design.

The Home Page (Level 0), will provide a general description of the system and enable an initial selection of the element of interest (risk factor, countermeasure). This will be the main menu of the DSS. The next three levels are dedicated to: (1) risk factors and measures search forms, (2) risk factors and measures results forms (customised lists of studies / effects) and (3) individual study forms (detailed description of each study). Users will be able to find measures associated with each road safety problem, by means of links between risks results and measures results. It is considered that the DSS will also allow addition of new measures by users of the DSS in the future.

The search engine is of critical importance for the DSS. The search will have the following characteristics:

- **Fully linked search**
 - Search a road safety problem alone or through the measures
 - Search a measure alone or through the road safety problems
- **Fully detailed search**
 - Search by any parameter in each data table (road safety problems, measures)
- **Fully flexible search**
 - Adjust search according to results
- **Fully documented search**
 - Access background information at any stage (links, etc.).

Consequently, the relational database of the back-end will be structured including the following: one main table with Road Safety Problems (including sub-Tables with meta-data and assessment results), one main Table with Road Safety Measures (including sub-Tables with meta-data and assessment results), as well as Links between the two Tables (including the sub-Tables). The links between risk

factors and measures is of high importance as well. The DSS will be a fully hierarchical and interactive system full of tags and links:

- **For each road safety problem (risk factor)**
 - list of relevant measures
 - list of other relevant road safety problems

- **For each measure**
 - list of road safety problems addressed
 - list of similar measures

PROGRESS AND NEXT STEPS

A high number of risks, measures and studies have been identified and coded according to the selection criteria mentioned earlier in the paper (meta-analyses, but also recent studies and high quality studies - prestigious journals preferred). So far, more than 500 studies have been analysed in the area of road risks and measures, and many more are in progress. In addition, more than 20 existing meta-analyses are updated and about 65 more are in progress. Summary reports (synopses) which will provide a critical synthesis of each risk factor and measure are under development.

The design of the DSS is finalised and the first static prototype of the DSS will be available by the end of June 2016. The DSS testing phase (with test tables) will be ready in August 2016, while the DSS Pilot Operation will start on September 2016. The final opening of the DSS will start on September 2017 and will be constantly updating from April 2018 and onwards.

The DSS is intended to become a major source of information for industry, policy-makers and the wider road safety community; it will incorporate the knowledge base of accident causation, risks and measures that will be developed in the project and the underlying methodological systems. It will be developed in a form that can readily be incorporated within the existing European Road Safety Observatory of the European Commission DG-MOVE. The development of the DSS presents a great potential to further support decision making at local, regional, national and international level, aiming to fill in the current gap of comparable measures effectiveness evaluation across Europe and worldwide.

ACKNOWLEDGEMENTS

This paper is based on work carried out within the SafetyCube project of the H2020 programme of the European Commission (Grant number 633485). The information and views set out in this paper are those of the authors and may not reflect the official opinion of the European Commission. The authors would like to thank all the partners involved in the “road user”, “infrastructure” and “vehicle” work packages of SafetyCube for their valuable contribution. Special thanks are addressed to the road safety stakeholders for their valuable feedback and suggestions during the SafetyCube workshops.

REFERENCES

1 Bliss, T, Breen, J, Country Guidelines for the Conduct of Road Safety Management Capacity Reviews and the Specification of Lead Agency Reforms, Investment Strategies and Safe System Projects. The World Bank Global Road Safety Facility, 2009.

2 Elvik, R. , Hesjevoll, I. S., Papadimitriou, E., Yannis, G., Perez, C., Olabarria, M., Hermitte, T., Talbot, R., Lassarre, S., Diependaele, K., Martensen, H., Preliminary guidelines for identification of risk factors and evaluation of road safety measures, Milestone 3.1 of the H2020 project SafetyCube, 2015.

3 Hagström, L., Thomson, R., Skogsmo, I., Houtenbos, M., Durso, C., Thomas, P., Elvik, R., Wismans, J., Definition of user needs, Deliverable 2.1 of the H2020 project SafetyCube, 2015.

4 SafetyCube, SafetyCube Stakeholder Workshop, Brussels, 22nd February 2016, <http://www.safetycube-project.eu/safetycube-stakeholder-workshop-brussels-february-2016>, 2016