SafetyCube: Building a Decision Support System on Risks and Measures

Heike Martensen; Kevin Diependaele; Wouter Van den Berghe; Eleonora Papadimitriou; George Yannis; Ingrid Van Schagen; Wendy Weijermars; Wim Wijnen; Ashleigh Filtness; Pete Thomas; Klaus Machata; Eva Aigner Breuss; Susanne Kaiser, S.; Thierry Hermitte; Rob Thomson

Belgian Road Safety Institute, Haachtsesteenweg 1405, 1130 Brussels, heike.martensen@bivv.be;
Belgian Road Safety Institute, Haachtsesteenweg 1405, 1130 Brussels, kevin.diependaele@bivv.be
Belgian Road Safety Institute, Haachtsesteenweg 1405, 1130 Brussels, wouter.vandenberghe@bivv.be
Department of Transportation Planning and Engineering, NTUA, 5 Heroon Polytechniou str. GR-15773, nopapadi@central.ntua.gr
Department of Transportation Planning and Engineering, NTUA, 5 Heroon Polytechniou str. GR-15773, geyannis@central.ntua.gr
Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, NL 2594 AW, 62 ingrid.van.schagen@swov.nl
Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, NL 2594 AW, 62 wendy.weijermars@swov.nl
Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, NL 2594 AW, 62 wim.wijnen@swov.nl
Loughborough Design School, Loughborough University, LE11 3TU, a.j.filtness@lboro.ac.uk
Loughborough Design School, Loughborough University, LE11 3TU, p.d.thomas@lboro.ac.uk
Kuratorium für Verkehrssicherheit, Schleiergasse 18, A-1100 Wien, susanne.kaiser@kfv.at
Kuratorium für Verkehrssicherheit, Schleiergasse 18, A-1100 Wien, eva.aigner-breuss@kfv.at
Kuratorium für Verkehrssicherheit, Schleiergasse 18, A-1100 Wien, klaus.machata@kfv.at
LAB, PSA Peugeot Citroën, 132 rue des Suisses 92000 Nanterre, thierry.hermitte@lab-france.com
Divison of Vehicle Safety, Chalmers University, SE-412 96 Göteborg, Sweden, robert.thomson@chalmers.se

Abstract

The EU research project SafetyCube (Safety CaUsation, Benefits and Efficiency) is developing an innovative road safety Decision Support System (DSS) collecting the available evidence on a broad range of road risks and possible countermeasures. The structure underlying the DSS consists of (1) a taxonomy identifying risk factors and measures and linking them to each other, (2) a repository of studies, and (3) synopses summarizing the effects estimated in the literature for each risk factor and measure, and (4) an economic efficiency evaluation (E3-calculator). The DSS is implemented in a modern web-based tool with a highly ergonomic interface, allowing users to get a quick overview or go deeper into the results of single studies according to their own needs.

Keywords

Road safety countermeasures, road risks, effectiveness, online system, review, cost-benefit

1. Introduction

Safety CaUsation, Benefits and Efficiency (SafetyCube) is a European Commission supported Horizon 2020 project with the objective of developing 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 of all road user types and all severities. The core of the project is a comprehensive analysis of accident risks and the effectiveness of safety measures. It focuses on road users, infrastructure, vehicles and post impact care framed within a system approach. Road safety stakeholders at the local, regional and national level, as well as the EU level and beyond have been consulted at all stages of the project.

The structure underlying the DSS consists of (1) a taxonomy identifying risk factors and measures and linking them to each other, (2) a repository of studies, and (3) synopses summarizing the effects estimated in the literature for each risk factor and measure, and (4) an economic efficiency evaluation (e3-calculator).

The ***taxonomy*** consists of four parts; (1) Road Users, (2) Infrastructure, (3) Vehicles and (4) Post Impact Care. The taxonomy is a main structural part of the DSS, it can be used as a search option in the DSS, it creates a uniform structure over all domains and it can be used as a basis for linking risk factors with their corresponding measures. The structure consists of three levels, which are topic, subtopic and specific topic.

The ***repository*** is a data-base of coded studies. The most important challenge for coding studies for the repository is the big variety of topics addressed, which also means that the studies addressing the topics tend to have different designs. A flexible coding template has been developed to be able to include different kinds of quantitative evaluation studies, preserving the information about study-design and type of information collected, but also allowing comparison of the results.

On the basis of the studies coded in the repository, a ***synopsis*** is written for each risk factor and each countermeasure summarising the existing effects of risk factors or measures by means of meta-analysis, vote-count analysis, or simply an overview. To address different types of DSS-users, each synopsis consists of three parts: (1) Summary, (2) Scientific overview, (3) Supporting document.

The DSS will be implemented in a modern ***web-based tool*** with a highly ergonomic interface. The structure is determined by the taxonomy and will be complemented by a powerful search engine. The DSS will allow users to find synopses or single studies related to one or more risk factors or measures, to define their own search criteria (e.g. only studies from a particular country), to identify measures most appropriate to address risk factors, and to have a quick overview of the "riskiness" of risk factors or the effectiveness of measures.

2. Taxonomy

The risk factors and the measures to be included in the DSS were identified based on a systematic analysis of the road safety literature. The risks and measures were assigned to one of four main areas:

- Road users
- Infrastructure
- Vehicles
- Post impact care (only measures)

The draft taxonomy was systematically evaluated during four workshops, where stakeholders were asked to prioritise and indicate missing topics. Three workshops were directed to a general audience of road safety policy makers and practitioners, one was focused on infrastructure.

2.1 Structure of the taxonomy

For each of the risk and measures areas, a three-level taxonomy was developed consisting of the main topic at level 1, several subtopics on level 2, and, if appropriate, specific topics at level 3. Table 1 is an example from the road users area. The same approach was taken with all risk factors and measures. The level 1 main topics for each area are shown in Table 2.

Table 1: An Example of the taxonomy (Road users)

Level 1 – main topic	Level 2 – subtopic	Level 3 – specific topic
Speed choice	Excess speed	Built-up areas
		Rural roads
		Motorways
	Inappropriate speed	Too fast weather-related
		Too fast traffic related
		Too slow
Fatigue	Insufficient (good) sleep	Not enough sleep
		Sleeping disorders
	Long drives	--

Table 2: Level 1 topics of the taxonomy

	Risk Factor	Measure
Road Users	Speed Choice	Law and Enforcement
	Influenced Driving – alcohol	Education and Voluntary Training/programs
	Influenced Driving – drugs	Driver Training and Licensing
	Risk Taking	Fitness to Drive Assessment and Rehabilitation
	Fatigue	Awareness Raising and Campaigns
	Distraction and Inattention	
	Functional Impairment	
	Insufficient Knowledge	
	Emotion and Stress	
	Misjudgement and Observation Errors	
	Traffic Rule Violations	
	Personal Factors	
	Age	
	Disease and Disorders	
Infrastructure	Exposure	Exposure
	Road Type	Infrastructure Safety Management
	Road Surface	Road Type
	Road Environment	Road Surface
	Workzones	Lighting
	Alignment Deficiencies – Road Segments	Workzones
	Cross-section Deficiencies – Road Segments	Alignment – Road Segments
	Traffic control – Road Segments	Cross-section – Road Segments
	Alignment – Junctions	Traffic Control – Road Segments
	Traffic Control - Junctions	Alignment – Junctions
		Traffic Control - Junctions
Vehicles	Crashworthiness	Crashworthiness
	Injury Mechanism	Active Safety/ADAS
	Protective Equipment Design	Tertiary Safety
	Relevant Factors in Crash Data	
	Technical Defects/Maintenance	
	Vehicle Design	
	Visibility/Conspicuity	
Post impact care	-	Ambulances/Helicopters
		Extraction from Vehicle
		Pre-hospital Medical Care
		Triage and Allocation to Trauma Facilities
		First Aid Training for Drivers

2.2 Linking risks and measures

All risks are intended to be linked to measures that have the potential of reducing this risk. These links are meant to reflect where a user of the system would look for effective measures rather than an evaluation in itself. This means a measure (e.g. skid training) could be linked to a risk-factor (e.g. snow) but in the end turn out not to be effective. The idea behind this is to give users access to an evaluation of the measure whenever they might consider the measure to be a solution to their problem.

The links between risks and measures are based on a dedicated model categorising risks as to (1) concerning the general state of the transport system (e.g. design of roads or vehicles, knowledge of the road users, etc.) or (2) the transient state of the system at the moment the crash occurred (e.g. defects, environmental conditions, road-user impairment, etc.), or (3) the consequences of a crash [1]. Moreover, risk factors that aggravate each other (e.g. road alignment deficiencies and road surface deficiencies) were clustered. Finally, all risk factors were categorised according to their relation to particular crash-scenarios. All these aspects are taken into account when checking for measures that should be considered as remedies for a risk factor in question.

By linking risk factors to measures from different domains, the systems approach is emphasized for the user. As an example, when looking for measures linked to a behavioural risk like “speeding”, the user will be guided to measures that address behaviour (campaigns, demerit point systems) or infrastructure (speed humps, section control) or the vehicle (ISA, adaptive cruise control) when appropriate.

3. Literature search

To identify relevant studies for the inclusion into the DSS, a systematic scoping review was conducted for each item in the taxonomy. The aim of this approach is to represent the body of literature in a scientific way. While the criteria applied differed between research fields, there was a schematic approach followed for each review, consisting of initial search, screening, identifying additional papers, and prioritizing papers for coding.

2.1 Initial search

Initially, several relevant literature databases were searched, e.g., Scopus, Medline, and Google scholar based on well-defined logical strings of keywords. (See Table 3, as an example). The keywords as well as the resulting number of studies were documented.

Table 3: An Example of search terms (for the risk factor "fatigue")

Fatigue	"fatigue*" OR "Sleep*" OR "Tired*" OR "drowsy" OR "drowsiness" OR "alert*" OR "monotony" OR "time on task"
AND	
Road Safety	"road safety" OR "driv*" OR "road" OR "transport" OR "crash" OR "accident" OR "incident" OR "traffic" OR "collision" OR "traffic safety" OR "risk" OR "measure OR "Road Casualties" OR "Road Fatalities"

2.2 Screening

The potentially relevant studies were then screened to assess their eligibility for further analysis. Generally, only studies with quantitative results were coded for repository. Important qualitative results were, however, included in the Synopses (see Section 5). Moreover topic-specific inclusion and exclusion criteria were applied and documented. This was done first on the basis of the abstract, then on the basis of the full paper. If few relevant papers had been retrieved, the reference lists of the selected papers were examined to identify any additional relevant papers.

2.3 Prioritising

For several of the risk factors and measures, meta-analyses were already available. If this was the case, the most recent meta-analysis was used as the basis, and completed with additional studies published after, and consequently not included in that meta-analysis. Studies included in a meta-analysis were not included individually.

If there were too many other papers, they were listed in descending order of importance for the road safety DSS, based on outcome, transferability, recent publication date, language and source. Note that these criteria were applied flexibly depending on how many studies were available and the field of research. Papers that evaluated measures and risks in terms of observed crashes were considered more relevant than those based on observed road safety behaviour (e.g. speeding), which again were considered more relevant than studies that had other indicator variables as outcomes (e.g., self-reported behaviour, driving simulator data, simulated crash data, etc.). SafetyCube is focused on Europe, therefore prioritizing European studies above US/Australian/Canadian studies, which are prioritised above studies from other countries. Other criteria were publication date (recent studies before older studies, though older studies of particular relevance were included), language (papers in English before papers in other languages), and source (peer reviewed papers before non-peer reviewed papers).

4. Coding studies

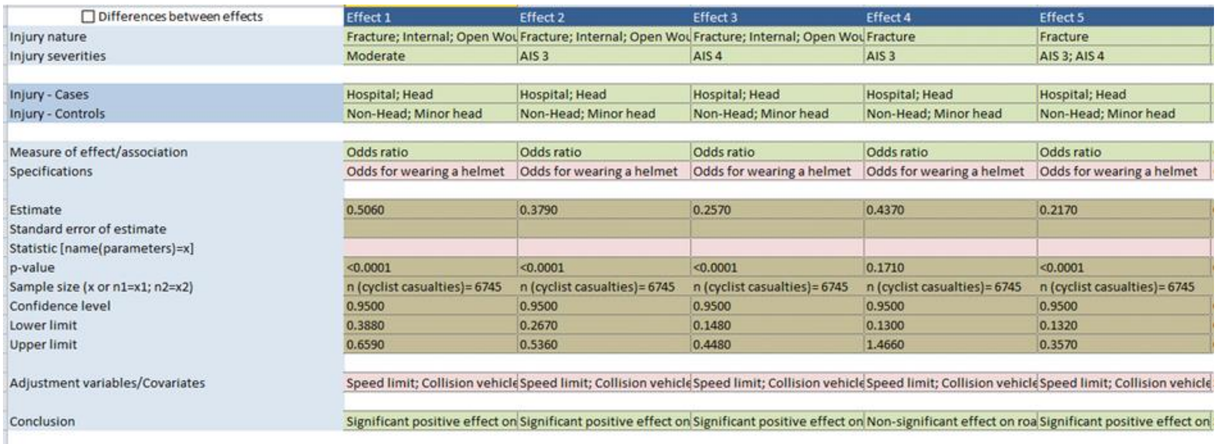
One of the main objectives of the SafetyCube project is to create a repository of estimates of risk factors and safety effects. While there are already a number repositories of safety effects around (CMF clearinghouse; Australian Clearinghouse), these are tailored to infrastructural measures. In SafetyCube a much broader scope is applied, comparable e.g. to the Handbook of Road Safety Measures [2], where measures directed towards infrastructure, vehicles, human behaviours and post impact care are evaluated. In contrast to all existing repositories, SafetyCube departs from the perspective of risk factors which makes the type of studies included into the repository even more diverse.

The collected studies investigated the effect on different outcome variables: crash-counts, simulated crash data, injury severity, on-road driving, driving in a simulator, crash simulations, and so on. They employed a large variety of research designs: before-after studies, cross-sectional designs, case-control, induced exposure, time-series; and statistical methods: simple comparisons of counts or means, different types of regression analyses, empirical Bayes, hazard rate, to name just a few. The enormous differences between studies constitute a big challenge for the creation of a joint database. The structure has to be general enough to allow coding different kinds of safety- or risk effects and flexible enough to capture all important details of different types of studies. For each study, the template therefore includes general information of the sampling frame and study conditions (e.g. road user types, severity of crashes, road types included), but also allows for the inclusion of conditions that are relevant to the specific area only (e.g. the differentiation between different injury types or details of the roadway design). Furthermore, for each estimated effect the following specifications were registered:

- what was compared to what
- analysis method/model
- measure of effect (often odds ratio but also many other less used measures of effect)
- statistical results (standard error, confidence interval)
- conclusion (significant effect on road-safety or not).

The selected studies were individually coded in an Excel coding template. The coding template consisted of several sheets, requiring the researcher to provide information, mostly in predefined categories. On the basis of the study features coded, a result table shapes itself in which the results for all conditions that were coded can be entered. Figure 1 shows an example of a result sheet in the Excel template, completed for a study on the effect of a bicycle helmet.

Figure 1: An example of a coded study (result table).



☐ Differences between effects	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5
Injury nature	Fracture; Internal; Open Wou	Fracture; Internal; Open Wou	Fracture; Internal; Open Wou	Fracture	Fracture
Injury severities	Moderate	AIS 3	AIS 4	AIS 3	AIS 3; AIS 4
Injury - Cases	Hospital; Head	Hospital; Head	Hospital; Head	Hospital; Head	Hospital; Head
Injury - Controls	Non-Head; Minor head	Non-Head; Minor head	Non-Head; Minor head	Non-Head; Minor head	Non-Head; Minor head
Measure of effect/association	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio
Specifications	Odds for wearing a helmet	Odds for wearing a helmet	Odds for wearing a helmet	Odds for wearing a helmet	Odds for wearing a helmet
Estimate	0.5060	0.3790	0.2570	0.4370	0.2170
Standard error of estimate					
Statistic [name(parameters)=x]					
p-value	<0.0001	<0.0001	<0.0001	0.1710	<0.0001
Sample size (x or n1=x1; n2=x2)	n (cyclist casualties)= 6745	n (cyclist casualties)= 6745	n (cyclist casualties)= 6745	n (cyclist casualties)= 6745	n (cyclist casualties)= 6745
Confidence level	0.9500	0.9500	0.9500	0.9500	0.9500
Lower limit	0.3880	0.2670	0.1480	0.1300	0.1320
Upper limit	0.6590	0.5360	0.4480	1.4660	0.3570
Adjustment variables/Covariates	Speed limit; Collision vehicle	Speed limit; Collision vehicle	Speed limit; Collision vehicle	Speed limit; Collision vehicle	Speed limit; Collision vehicle
Conclusion	Significant positive effect on	Significant positive effect on	Significant positive effect on	Non-significant effect on roa	Significant positive effect on

Another important issue is the quality of research results. When comparing different studies one might wish to assign more value to good quality studies than to those that are likely to be flawed. However, the definition of a good quality study is very difficult and again varies strongly with the research area. Rather than rating the studies, it was therefore decided to indicate possible biases of a particular study and indicate how severe this possibility is believed to be. To this end, common biases for the major research designs were described and included into the coding template, so that these (or other) problems can be flagged if necessary.

Table 4: Overview of potential sources of bias per study design (example)

Study design	Most common estimator of effect	Potential sources of bias
Experiments	Odds ratio	Pre-trial non-equivalence
		Differential attrition
		Diffusion of treatment
		Unintended side-effects
Before-after studies	Odds ratio	Regression to the mean
		Long term trends
		Changes in traffic volume
		Co-incident events
		Use of several measures
		Accident migration

Finally, the researcher included a brief verbal summary of the study, including the main findings, as well as an assessment of their reliability and usefulness, given the study design and potential biases.

5. Summarizing studies

5.1 Analysis

After having coded all selected studies, the researchers analysed the results. Three ways had been defined to analyse and summarise the results, in a decreasing order of priority:

- Meta-analysis, if there is a sufficiently large number of studies that are comparable in terms of both their scientific design features and the type of results they produced. A meta-analysis combines the numerical results of multiple studies and yields a weighted average from the results of the individual studies.
- Vote-count analysis, if a meta-analysis is not possible due to large differences between studies, but if there is a sufficient number of studies. A vote-count analysis compares the share of studies that showed a positive effect, no effect, or a negative effect.
- Review-type analysis, if the number of studies is small or if the studies are so heterogeneous that a vote-count analysis is not meaningful. In a review-type analysis the results are summarised in a more qualitative way, generally including a table of study descriptions (e.g. sample, method, outcome), the observed effects and their interpretation.

In each type of summarising analysis attention was dedicated towards the identification of modifying conditions (e.g. a counter-measure that works in urban, but not in rural settings or a risk-factor that is more dangerous for novice drivers). In meta- or vote count analyses this was addressed by sub-group analyses.

5.2 Colour code

For each of the studied risk factors and measures, a colour code was based on the results of the (majority of) the studies'outcomes to indicate the overall conclusion about the effect. Each colour code is supported by a short statement of two to three sentences.

Table 5: Colour code for risk factors and countermeasures

Risk factor		Countermeasure	
Red	Results consistently show an increased risk when exposed to the risk factor concerned.	**Green**	Results consistently show that the countermeasure reduces road safety risk.
Orange	There is some indication that exposure to the risk factor increases risk, but results are not consistent.	**Light green**	There is some indication that the countermeasure reduces road safety risk, but results are not consistent.
Grey	No conclusion possible because of few studies with inconsistent results, or few studies with weak indicators, or an equal amount of studies with no (or opposite) effect.		
Green	Results consistently show that exposure to the presumed risk factor does not increase risk.	**Red**	Results consistently show that the countermeasure does NOT reduce road safety risk and may even an increase it.

5.3 Synopsis

Finally, for each risk factor or road safety measure, a synopsis has been compiled. The synopsis provides a synthesis of the findings for a specific risk factor or road safety measure, including both quantitative information from the coded studies and more qualitative information from previous review studies. The synopsis aims to complement other outputs of the DSS, like lists of available studies and direct access to the results of individual studies (see Section 7).

Each synopsis consists of three parts:

- Summary: In maximum two pages, the summary very briefly reports some background of the topic concerned, and the main results and conclusions based on the analysis.
- Scientific overview: In approximately four to five pages, the scientific overview describes the essence of the way the reported effects have been estimated, including a full analysis of the methods and results,

and its transferability conditions in order to give the user all the necessary information to understand the results and assess their validity.

- Supporting documentation: The supporting documentation gives a more elaborate description of the literature search strategy, as well as the details of the study designs and methods, the analysis method(s) and the analysis results. Here, also a full list of coded studies and their main features is provided.

6. Economic Efficiency Evaluation

The countermeasures for which the analysis of safety effects has resulted in an estimated reduction of crash occurrence are submitted to an economic efficiency evaluation. A tool for Economic Efficiency Evaluation (E3-calculator) of road safety counter measures will be implemented in the DSS. This tool allows to combine the information about the effectiveness of a measure (i.e. the percentage of crashes or casualties prevented) with the costs of these measures.

Different outputs are produced. In a *cost-effectiveness analysis* the costs for preventing one crash or casualty are calculated. Outcomes of different severity have to be addressed separately. In a *cost benefit analysis*, outcomes of different severity can be considered jointly by including a monetary valuation of these outcomes [3, 4, 5, 6]. To build the E3-calculator, the estimated costs for crashes and casualties of different severity have been collected from all European countries.

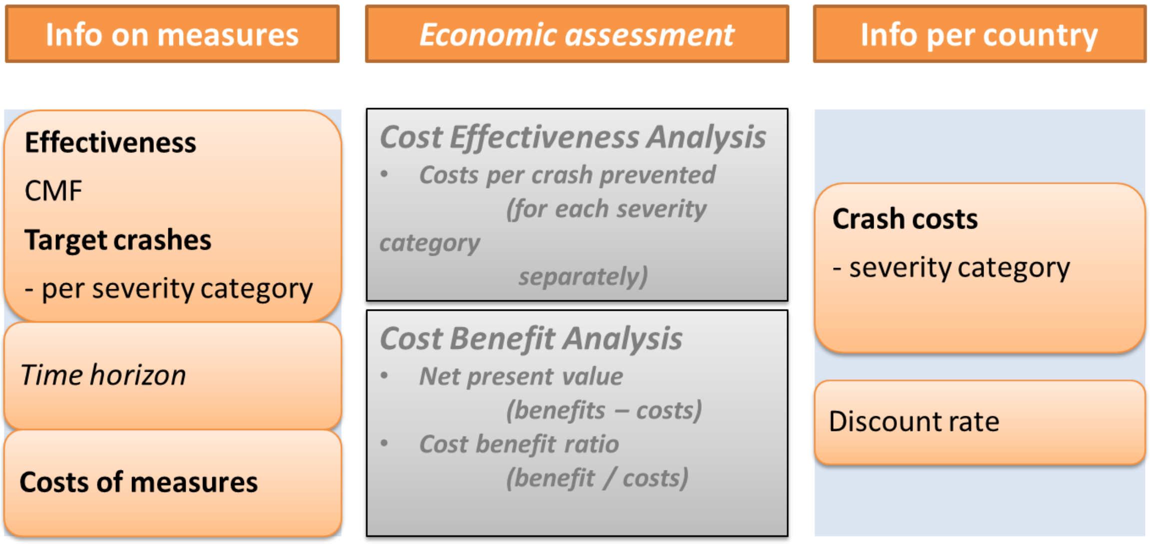


Figure 2: Economic Efficiency Evaluation (E3) in SafetyCube

6.1 Crash- and casualty costs

First an overview was presented of the components that should be included in crash cost estimates and how each cost component should be determined according to the international guidelines (e.g. [7]) and best practices (e.g. [8, 9]). The component logic was applied to costs per crash and costs per casualty. *Second*, information on costs of crashes and costs of casualties was collected by means of a survey among all EU countries. Four severity levels were differentiated: fatal, serious injuries, slight injuries, and damage only (with the last category available for crash-costs but not casualty costs). *Third*, for some countries not all information is available or costs are not calculated according to the international guidelines. In those cases, additionally to the country's own estimates (if available) comparable estimates according to the standard procedure were provided by means of value transfer. In that way, an estimate for the total costs of crashes and casualties in the EU was provided as well [10].

6.2 E3-calculator

As input to the calculator for the Economic Efficiency Evaluation, the following is needed

- Measure costs
  - Initial costs
  - Annual costs
- Number of crashes / casualties prevented (for each level of severity)
  - Target crashes of countermeasure

- ○ % reduction
- Time horizon of a measure

On the basis of this input and the crash- or casualty costs, the calculator adds for each year within the time horizon the present value of all costs and benefits, resulting into the following outputs:

- Number of crashes / casualties prevented (per unit of implementation)
- Cost effectiveness: cost per prevented crash / casualty
  - ○ Costs per prevented fatality / fatal crash
  - ○ Costs per prevented severe injury / severe crash
  - ○ Costs per prevented slight injury / light crash
  - ○ Cost per prevented damage only crash (if applicable)
- Total benefits
- Cost benefit ratio (benefits/costs)
- Net effect (benefits – costs)

The monetary valuation of the benefits – the crashes or casualties prevented – as well as the discount rate are provided on the basis of the work described under 6.1[10]. By default the SafetyCube analyses will be conducted for the country from which effectiveness and cost results are obtained. DSS users can transfer these results to any other European country or to the European mean. Users can also use the tool for their own analysis or change the values of a SafetyCube analysis according to their own information (e.g. enter their own measure cost estimates).

If no measure costs are entered, the break-even costs are calculated: the costs of the measure at a cost-benefit ratio of 1. This indicates how much a measure could maximally cost and still be cost-effective.

7. DSS webtool

The DSS consists of the backend (relational database), the front end (website) and the way they integrate (queries). At first, the templates of coded studies are undergoing a thorough checking and debugging process. Together with the synopses, the templates are eventually stored in a relational database, which will serve as the back-end of the DSS. Front-end DSS results will be retrieved through queries on the back-end database (DSS search engine) [11].

The following characteristics were pursued for the DSS Search Engine:

- Fully linked search: search a road safety problem alone or through the measures, search a measure alone or through the road safety problems, search for risks and measures related to specific road user groups or crash types
- Fully detailed search: search by any parameter in each data table (risk factors, measures)
- Fully flexible search: adjust search according to results
- Fully documented search: access background information at any stage (links, etc.)

The heart of the DSS consists of the searchable/dynamic and static aspects: 5 entry points and 3 operational levels, as shown in the structure of Figure 3.

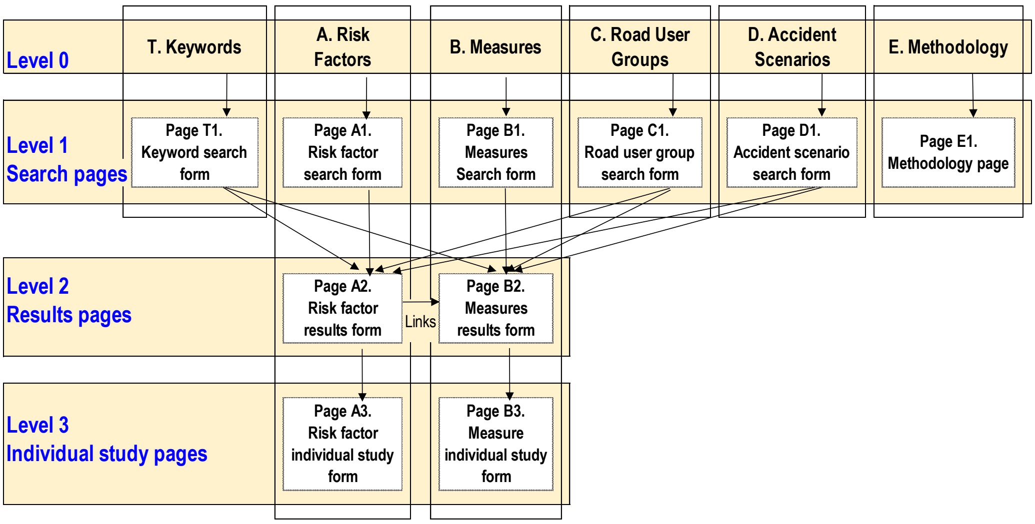


Figure 3: Structure of the DSS.

More specifically, these five entry points of the DSS are:

- Key-word search
- Road Safety Risk Factors
- Road Safety Measures
- Road User Groups
- Accident Scenarios

The users will be able to select one of these five entry points depending on the type of search that they wish to conduct. More specifically, the text search allows the users to enter database key-words, the road safety risk factors/measures entry points allows them to seek specific risk factors or measures from the SafetyCube taxonomies respectively. On the other hand, the road user groups entry point enables a dedicated search of both risk factors and measures related to a selected group of road user (e.g. pedestrians, motorcyclists etc.). The same applies to accident scenarios as well, which is addressed to users looking for risks and measures related to specific crash configurations (e.g. single vehicle crashes, intersection crashes etc.). Figure 3 illustrates the Main Menu of the DSS as well as the entry points.

The three levels of the DSS are briefly summarized as follows:

- Home Page - Level 0
- Level 1: Search Pages - Key-words / Risk Factors / Measures / Road User Groups / Accident Scenarios
- Level 2: Search Results - Provides the synopses and studies available for the selected search topic(s), the possibility to refine the search, and the related links between risk factors / measures
- Level 3: Individual study results - Provides the abstract, characteristics and main results of an individual study.

The Home Page (Level 0), provides a general description of the system and enables an initial selection of the element of interest (e.g. risk factor or measure, via one of the entry points). The main menu "Method" provides basic information about SafetyCube and the DSS, as well as background information, resources and methodology, including extensive glossary.

Figure 4: Overview of the Main Menu and entry points of the DSS.

Level 1 consists of the specific ***search*** that the user wishes to carry out on the basis of the five entry points. The philosophy of this search is as follows: at first the user has to select the keyword / risk / measure / road user group / accident scenario of interest, and then the related list of risk factors and / or measures is presented (for behaviour, infrastructure or vehicle). It is important to highlight that all entry points at Level 1 eventually lead to a selection of risk factors or measures of interest at Level 2. The more general level of the taxonomy is displayed and they can then choose for a general family of risks / measures (e.g. formal tools to address road network deficiencies, speed choice etc.). A more specific measure such as road safety audits, campaigns, lower speed limits and so on may be selected in the search refinement at Level 2.

Level 2 provides the results of the search. A ***list of studies*** available with their main features (author, year, design, country) in table form. The *synopses* of risk factors or measures are provided at this level, as well as the *colour code*. Two more search options are provided. The one is to refine the search. The other is the link to related risk factors or measures as users will be able to find measures associated with each road safety problem, by means of links between risks results and measures results.

Finally, the user may select a specific study from the results page, and have the ***individual study results*** provided in Level 3, including the abstract, the related URL, and a table of all risk / measure safety effects available in the study containing

- test and reference condition (e.g. helmet vs. not helmet)
- type of outcome (e.g. injury severity)
- type of estimate (e.g. odds ratio)
- statistical significance

If a study analysing a countermeasure results in an input suitable for an economic efficiency evaluation, a link will lead to the ***E3-calculator*** (under development) prefilled according to the study results. The user can change the input (e.g. select another country, or enter measure costs according to their own estimation) to evaluate how this changes the results in comparison to the prefilled SafetyCube analysis. The E3-calculator will also be usable stand-alone (i.e. without input from SafetyCube).

8. Conclusion and next steps

So far, more than 500 studies have been analysed in the area of road risks with more than 3,500 risk estimates, summarised in more than 60 synopses (including approximately 10 meta-analyses and analysis of in depth-accident databases), and the related measures analyses are in progress.

As for the design of the DSS, it is finalised and the first dynamic prototype of the DSS was available since December 2016 and is currently under refinement. The DSS internal pilot operation started in early 2017. The beta-testing of the DSS is scheduled for mid-2017 and will be constantly updating until April 2018 (end of the SafetyCube project) and beyond.

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. The development of the DSS presents a great potential to further support evidence-based 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.

References

1. Elvik R. (2004). To what extent can theory account for the findings of road safety evaluation studies? *Accident Analysis and Prevention 36* (2004) 841–849.
2. Elvik, R., Hoye, A.; Vaa, T., Sorensen, M. (2009). *The handbook of road safety measures.* 2nd Edition. Emerald, Bingley, UK.
3. Martensen, H, Van den Bergh, W, Wijnen, W., Weijermars, W., Carnis, L, Elvik, R. (2016), *Preliminary guidelines for priority setting between measures, Deliverable Number 3.4 of the H2020 project SafetyCube*.
4. Wijnen, W., Wesemann, P. & de Blaeij (2009). Valuation of road safety effects in cost-benefit analysis. *Evaluation and Program Planning,* 32, pp. 326-331.
5. Hakkert, S. & Wesemann, P. eds (2004). *The use of efficiency assessment tools. Solutions to barriers*. ROSEBUD Report Nr. 5.
6. Elvik, R. 2001. Cost-benefit analysis of road safety measures: applicability and controversies. *Accident Analysis and Prevention, 33,* 9-17.
7. Alfaro, J. L., Chapuis, M., Fabre, F. (Eds.) (1994). *Socio-economic cost of road accidents: final report of action COST 313*. Commission of the European Community, Brussels.
8. ECMT (1998). *Efficient transport for Europe; Policies for internalisation of external costs*. Organisation for Economic Co-operation and Development OECD, Paris.
9. Bickel, P. et al. (2006). *Proposal for harmonised guidelines*. EU project HEATCO Deliverable 5. University of Stuttgart, Stuttgart.
10. Wijnen, W., Weijermars, W., Vanden Berghe, E., Schoeters, A., Bauer, R., Carnis, L., Elvik, R., Theofilatos, A., Filtness, A., Reed, S., Perez, C. and Martensen, H. (2017), *Crash cost estimates for European countries, D3.2 of the H2020 project SafetyCube.*
11. Filtness A., Thomas P., Talbot R., Quigley C., Papadimitriou E., Yannis G., Theofilatos A., Aigner-Breuss E., Kaiser S., Machata K., Weijermars W., Van Schagen I., Hermitte T (2016), *The application of systems approach for road safety policy making, Deliverable 8.1 of the H2020 project SafetyCube*