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The European Road Safety Decision Support System

A clearinghouse of road safety risks and measures

Deliverable 8.3

SafetyCube

The European Road Safety Decision Support System

A clearinghouse of road safety risks and measures

Work Package 8, Deliverable 8.3

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Project Coordinator:
Professor Pete Thomas, Transport Safety Research Centre, Loughborough Design School, Loughborough University, Ashby Road, Loughborough, LE11 3TU, UK

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National Technical University of Athens (NTUA), Greece

Report Author(s):
Eleonora Papadimitriou, George Yannis, Apostolos Ziakopoulos, Constantinos Marinos (NTUA)
Ashleigh Filtness, Rachel Talbot, Pete Thomas, Evita Papazikou (LOUGH)
Susanne Kaiser, Klaus Machata (KFV)
Wendy Weijermars, Ingrid Van Schagen (SWOV)
Rune Elvik (TOI)
Thierry Hermitte, Franck Leopold (LAB)
Rob Thompson (SAFER)

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Executive Summary

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 SafetyCube project is a comprehensive analysis of accident risks and the effectiveness and cost-benefit of safety measures, focusing on road users, infrastructure, vehicles and post-impace care, framed within a Safe System approach ,with road safety stakeholders at the national level, EU and beyond having involvement at all stages. The present Deliverable (8.3) outlines the methods and outputs of SafetyCube Task 8.3 - 'Decision Support System of road safety risks and measures'. A Glossary of the SafetyCube DSS is available to the Appendix of this report.

The **identification and assessment of user needs** for a road safety DSS was conducted on the basis of a broad stakeholders' consultation. Dedicated stakeholder workshops yielded comments and input on the SafetyCube methodology, the structure of the DSS and identification of road safety "hot topics" for human behaviour, infrastructure and vehicles. Additionally, a **review of existing decision support systems**, was carried out; their functions and contents were assessed, indicating that despite their usefulness they are of relatively narrow scope.

On the basis of the above, the **DSS Design principles**, the general structure and the main functionalities were defined. The back-end database, the front-end system and the search engine that links the two were designed, resulting in a framework system ready to be populated with the wealth of information that was accumulated within SafetyCube.

To that end, the results of the analyses carried out for risk factors and road safety measures were integrated in the database. Initially, identified risks and measures were organised per domain in what was defined as a hierarchical **taxonomy of risks and measures** for behaviour,k infrastructure, vehicle and post-impact care. A **literature search** process through scientific databases was conducted for high quality studies with quantitative estimates of risks and measures effects. Selected studies were individually coded in a standardised Excel coding template that was developed specifically to capture all relevant information from each study and enable to report information in a uniform way across topics.

Results of coded studies were then analysed by way of (1) meta-analysis, (2) vote-count analysis or (3) review-type analysis. For each risk factor and measure, a **Synopsis** was compiled, providing a synthesis of main findings, with both quantitative and qualitative information. Each synopsis consists of three parts: (1) summary, (2) scientific overview, and (3) supporting documentation; and it also includes a colour code that summarises the overall conclusion about its topic, indicating how risky an assumed risk factor or how effective a measure actually is.

As an added value feature of the SafetyCube DSS, all **risks were linked to measures** that have the potential of reducing this risk, and vice versa. After reviewing existing frameworks, **an dedicated model was developed** based on a Safe System approach, which aims for the ultimate prevention of death and serious injury through systematic intervention (pre-crash, during crash and post crash as well as involving all key system elements) and more results focused institutional delivery.

A separate tool was developed in SafetyCube to evaluate the economic efficiency of measures that were found to be effective: the **Economic Efficiency Evaluation (E^3) calculator**. This tool combines the information about the effectiveness of a measure with the costs of the measure, allowing to conduct cost-effectiveness and cost benefit analyses. The tool is unique to as it uses the most recent harmonized crash costs estimates in the European countries.

Serious injuries were given special attention, as they are increasingly used as an additional road safety performance indicator. Information on how to estimate the number of serious road injuries, on (health) impacts and costs of serious road injuries and on risk factors related to serious road injuries was compiled in order to be included in the DSS. **Accident Scenarios** were also developed and included in the DSS, as clustering individual accidents that have a sufficient degree of similarity is of interest to specific stakeholders, e.g. the automotive industry. This is because in-vehicle safety systems have to be efficient "regardless" of whether the risk they address is influenced by e.g. driver fatigue, or insufficient skills, or the road infrastructure.

Strict scientific **quality assurance procedures** were put in place for the DSS contents, comprising: (1) comprehensive guidelines, (2) peer reviewing of study coding and synopses, (3) a team of independent experts checked the information about coded studies and the content and consistency of synopses and (4) synopses went through a language check by a native English speaker.

The SafetyCube DSS Search is open since April 2017 and available at www.roadsafety-dss.eu. It is structured around two main pillars, i.e. risk factors and measures, and in three operational levels: Level 1: Search Pages; Level 2: Results Pages; and Level 3 - Individual study pages. These are reachable through five entry points (keywords, risk factors, measures, road user groups, accident categories).

More specifically, level 1 consists of the specific search methods which the user may want to use, based on the **five entry points**. The philosophy of this search is as follows:

- **Keyword search**: search on the basis of keywords retrieved through the SafetyCube list of master keywords, numbering more than 500 terms (each one of them linked to one or more of the thousands of keywords from the coded studies).
- **Risk factors**: search for a crash risk factor through the SafetyCube taxonomy
- **Measures**: search for a road safety measure through the SafetyCube taxonomy
- **Road user groups**: search for the risks and measures concerning particular road user group.
- **Accident categories**: search for risks or measures related to a specific accident category.

In the **DSS results pages**, the user has numerous options: to refine the search through a set of filters (e.g. country, road user type, road type, more specific topic), to download the synopses available, to browse the related risks / measures, or to select one of the individual studies available for the topic. In the **individual study pages**, the abstract and source of each study are provided, together with information on the design and sampling used, the estimates provided, their confidence intervals and the statistical significance. Links to the full text are also provided, depending on the access rights of each user.

The **DSS Calculator** consists of a web-based application of the E^3 tool, allowing the user either to perform his/her own Cost-Benefit Analysis, or select one of the SafetyCube examples of Cost-Benefit Analysis of selected effective road safety measures. In each case, the possibility to run a sensitivity analysis and compare the results on the same screen is provided.

Finally, the **DSS Knowledge** section summarises the outputs in terms of synopses, accident scenarios and serious injuries, while the **Methodology and Support pages** provide all the related meta-data, disclaimers and relevant documentation.

Being now in its completed stage, the DSS includes the following:

Taxonomy, risk factors and measures:

- 4 areas: road user, infrastructure, vehicle, post impact care
- **88 risk factors and measures** (38 risk factors, 50 measures) e.g. distraction, roadside, crashworthiness.
- **313 specific risk factors and measures** (120 risk factors, 193 measures) e.g. mobile phone use, no clear-zone, low pedestrian rating (NCAP)

Contents and outputs:

- **1300 studies** (out of which more than 90 meta-analyses, existing or original) including more than 7500 effects of risk factors or measures
- **215 synopses** on risk factors and measures effects
- 8 Accident scenario synopses
- **38 cost-benefit analyses** - Behaviour (12 examples), Infrastructure (19 examples), Vehicle systems (4 examples), Post-impact care (1 example)

Links within a Safe System approach:

- A total of **762 links between risk factors and measures**. Risk Factors (118) are linked to one or more Road Safety Measure(s) (167) - A few risk factors or measures (e.g. post-impact care) were not "linkable".
- **3350 database keywords**, out of which 2005 useful keywords, **linked with 531 Master keywords**
- A total of 380 links between risks, measures and Accident Scenarios; 8 scenarios are linked with 109 specific risks and 271 specific measures.

The SafetyCube DSS is **the first integrated road safety support system developed in Europe**. It aims to be a core reference system for road safety in Europe, constantly improved and enhanced. Therefore, the development of the DSS presents a great potential to further support evidence-based decision making at all levels, aiming to fill in the current gap of integrated risks and measures effectiveness evaluation across Europe and worldwide.

Future developments of the SafetyCube DSS will start from the following key priorities:

- Further improvement of the Safe System implementation, namely the possibility to account for **inter-relations between interventions within integrated programmes**. The links between risks and measures currently applied in the DSS may not directly support such policy objectives.
- **Enhanced emphasis on serious injury**: At the moment the scientific knowledge on serious injury lags behind understanding of fatalities from road crashes. As this knowledge increases future updates of the DSS will reflect this and strengthen the promotion of Safe System approach.
- **Expansion to other countries and languages**:Although studies from all countries are included, expansion of the scope of the DSS to include more information for developing countries should be pursued, as also pointed out by stakeholders. The presentation of the contents in other languages, through a translation option would contribute to this direction, especially for local policy makers.
- **Regular update of the contents** with the most recent state-of-the-art knowledge, especially as regards emerging topics and new technologies.

1 Introduction

This chapter describes the project and purpose of the deliverable. A short description of SafetyCube WP8 is also provided.

1.1 BACKGROUND

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.

In this document, 'risk factor' (or 'risk') refers to any factor that contributes to increasing road accidents frequency or injury severity. 'countermeasure' (or 'measure') refers to any system, decision or regulation that contributes to mitigating the consequences of road accidents or reducing their frequency. A full Glossary of definitions is available in Appendix 6 of this report.

SafetyCube aims to:

1. develop new analysis methods for (a) Priority setting, (b) Evaluating the effectiveness of measures (c) Monitoring serious injuries and assessing their socio-economic costs (d) Cost-benefit analysis taking account of human and material costs
2. apply these methods to safety data to identify the key accident causation mechanisms, risk factors and the most cost-effective measures for fatally and seriously injured casualties
3. develop an operational framework to ensure the project facilities can be accessed and updated beyond the completion of SafetyCube
4. enhance the European Road Safety Observatory and work with road safety stakeholders to ensure the results of the project can be implemented as widely as possible

The core of the project is a **comprehensive analysis of accident risks and the effectiveness and cost-benefit of safety measures focusing on road users, infrastructure, vehicles and injuries framed within a Safe System approach** with road safety stakeholders at the national level, EU and beyond having involvement at all stages.

1.1.1 SafetyCube WP8

The objectives of SafetyCube WP8 are:

- to set up **the European Decision Support System (DSS)** for supporting evidence-based policy making;
- to co-ordinate the analyses undertaken in WP 4 – 7 and ensure that the research outcomes integrate road user, vehicle and infrastructure factors, that the evaluation of risks and measures are comprehensively handled between WP 4 – 7, and that the results of the "hot topics" analyses are properly integrated;

- to compile the project outputs into a suitable form to be incorporated within the DSS and the European Road Safety Observatory;
- to develop the structure, operational procedures and business plan to enable the DSS to continue to support evidence based road safety policies beyond SafetyCube.

1.2 PURPOSE AND STRUCTURE OF THIS DELIVERABLE

This report describes the methods and outputs of SafetyCube Task 8.3 - **'Decision Support System of road safety risks and measures'**.

Within this Task, the results of the analyses carried out throughout the project were integrated and made available through a Decision Support System (DSS) of road safety risks and measures. The system includes information on the risk factor tackled, the safety effectiveness related to the proposed measure - with particular emphasis on the quality of the studies and data used to produce the estimates, and special notes on the sources of uncertainty and the conditions for transferability of the measures effects - and the results of efficiency assessment of the proposed measures in different countries, settings etc.

The structure of the DSS allows the ranking of measures on the basis of a number of criteria, in order to enable policy support under different policy priorities also in an integrated manner. The road safety DSS thus includes:

- Information on the characteristics of measures (safety effects, costs, cost-effectiveness), particularly in relation to the hot topics identified by the stakeholders groups
- Methods to estimate the costs and safety effects of measures, and to conduct cost-benefit analysis
- A ranking of risks and measures on the basis of the results of the analyses
- A website delivering the best information on risks and the effectiveness of road safety measures
- A set of concrete policy support tools for the future development of the European Road Safety Observatory and for the short and long term priorities for the improvement of road safety in Europe.

This report is structured as follows: The following **Chapter 2** presents the analysis of user needs and feedback received during the project. It starts with a review of existing systems at international level, allowing to identify gaps and needs for a new road safety DSS. Subsequently, the SafetyCube stakeholder consultation activities are described, in which valuable feedback was obtained regarding the SafetyCube methodologies and outputs, the design and the main functionalities of the DSS under development etc. Particular emphasis is given to the identification of 'hot topics'.

Chapter 3 outlines the main characteristics of the DSS design and structure, as well as the main technical features in terms of infrastructure, software and user interface.

Chapter 4 summarises the methodologies and procedures implemented throughout the project in order to populate the DSS with state-of-the-art information on road safety risks and measures. The SafetyCube taxonomy of risks and measures is presented, together with the methodological guidelines for searching the literature, selecting, 'coding' and analysing stydies, and synthesizing the results for each taxonomy topic. The SafetyCube methodology for linking risks and measures is also outlined. Moreover, information on the methods and outputs regarding Economic Efficiency Evaluation, Serious Injuries and Accident Categories are described. Finally, the Quality Assurance procedures for the DSS contents are outlined.

In **Chapter 5**, the development of the DSS is described. First, an overview of the DSS entry points and navigation paths is provided. The database keywords processing is described, which led to the consolidation of different system entry points. The DSS Search, Results and Individual study pages are decribed, together with the main functionalities, outputs and user interfaces. The E3 Calculator, a tool for cost-benefit analysis available through the DSS, is also described. Finally, the structure and contents of the 'static' pages of the DSS, concerning Knowledge, Methodology and Support are outlined.

Chapter 6 presents the summary and conclusions of the work presented in this report. Key figures regarding the developed DSS are provided, as well as an overall ranking of risk factors and measures analysed and made available through the DSS. Special focus is given on the challenges and conditions for transferability of the DSS outputs and results. Finally, the added value of the DSS is described, in light of the benefits of the Safe System approach used.

Finally, **Chapter 7** outlines the main challenges involved in the future development of the DSS. An overview of the numerous dissemination activities is provided. Moreover, the users feedback on the operation of the DSS (both pre- and post-launch) is described, with focus on the key messages from the users. The envisaged future developments and upgrades are also described.

2 User needs

The identification and assessment of user needs for a road safety DSS was conducted on the basis of a review of existing systems, and a broad stakeholders' consultation to identify user needs from the DSS and "hot topics".

2.1 REVIEW OF EXISTING SYSTEMS

At the time of design of the SafetyCube DSS, there were already several web-based tools available to support road safety professionals & decision makers. Most of these systems and repositories, however, are compilations of interventions and their impacts on crashes. The first step in the development of the SafetyCube Decision Support System (DSS) was therefore to review existing systems and identify their key features and limitations.

It is noted that the review is limited to Decision Support Systems that fall within the scope of SafetyCube, i.e. systems in the form of a 'clearinghouse' or a 'repository' in which the user may query for specific information through a search engine. Certainly, there are numerous additional road safety on-line resources, web-portals and observatories, namely the European Road Safety Observatory and other national observatories; however, these provide various types of (usually more general) information e.g. statistics, fact-sheets, web-texts, publications, news, links etc. and are thus of a different scope.

2.1.1 Crash Modification Factors (CMF) Clearinghouse (www.cmfclearinghouse.org)

The CMF Clearing House is funded by the U.S. Department of Transportation Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. A CMF is an estimate (number or function) of the change in crashes expected after implementation of a countermeasure. As of March 2018, the Clearinghouse featured 6,251 CMFs across 19 categories of infrastructure measures. The Clearinghouse developed a star quality rating system (1 to 5) to indicate the quality or confidence in the results of the study producing the CMF. Results can be filtered such as by star rating, crash type and/or severity, and roadway or area or intersection type. The front end (Fig.2.1) allows to search either for all fields in the database, or countermeasures by name, for keywords in study abstracts or study citations, or single ID's of CMFs. Resulting measures can be compared using a dedicated tool which, however, was under development at the time of review.

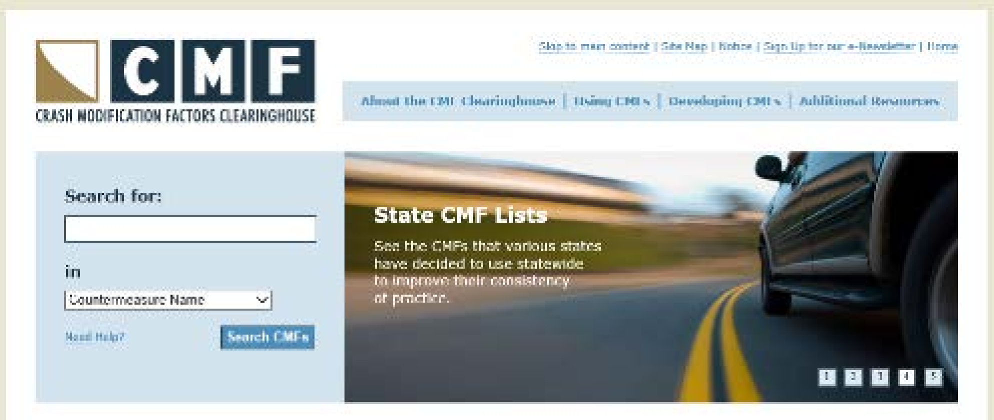


Figure 2.1: The U.S. FHWA's Crash Modification Factors (CMF) Clearinghouse (www.cmfclearinghouse.org)

Limitations: The system exclusively features infrastructure measures and does not include any measures from the domains of human behaviour, vehicle technology or post impact care. It does not provide any assessment of road safety risks. The system is designed for the professional and is limited to retrieval of CMFs and related studies, the abstract of which is provided. There are only single studies and no introductions or summary (synopsis) documents whatsoever available on any specific intervention. Although resources are listed to support Cost Benefit Analysis, no online tool for economic efficiency evaluation is included in the Clearinghouse.

2.1.2 PRACT Repository (www.pract-repository.eu)

The acronym PRACT stands for "Predicting Road ACcidents – a Transferable methodology across Europe". It was developed by the University of Florence, the National Technical University of Athens, the Technical University of Berlin and the Imperial College London in a tendered project financed by the Conference of European Directors of Roads (CEDR). The Repository contains the most recent Accident Prediction Models (APMs) and Crash Modification Factors (CMFs), concretely, as of March 2018, 889 CMFs and 273 APMs.

The search for specific CMFs or APMs can be narrowed down by various filters, such as for road elements and types, geographic area of studies, types of intersections and traffic control as well as crash severity and types (see Figure 2.2).
The results page presents a specific CMF or APM along with its relevant variables and values from the PRACT database, supplemented with a reference to the original study. There are no study abstracts or assessments of study quality provided.

Limitations: The system focuses on CMFs and APMs in the sphere of infrastructural road features and interventions. It is designed for road infrastructural professionals with prior knowledge of theory and application of CMFs or APMs. Apart from a well-developed glossary, no introduction or synthesis documents for the novice user are provided. The system is not intended to directly support CBA Analysis and does not provide any assessment of road safety risks.

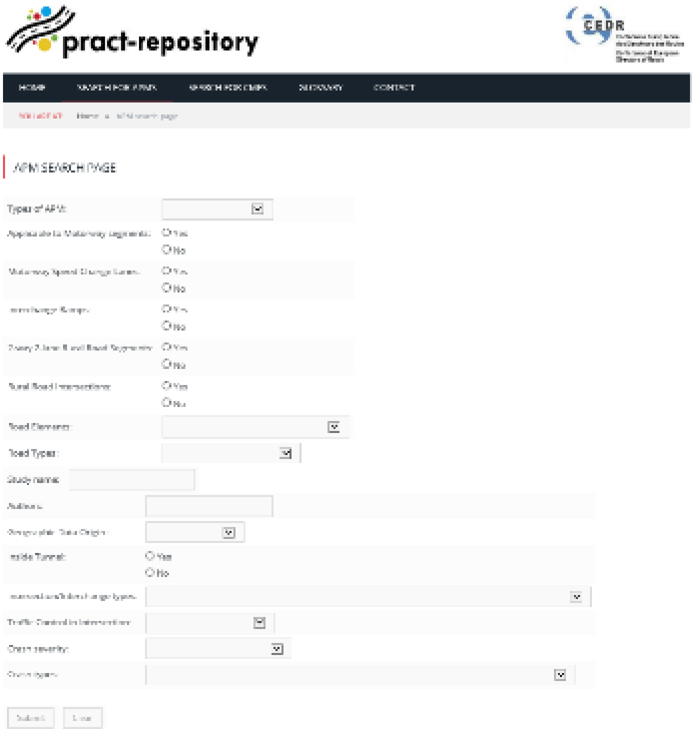


Figure 2.2: The PRACT Repository (http://www.pract-repository.eu/)

2.1.3 Road Safety Engineering Kit (www.engtoolkit.com.au)

The Road Safety Engineering Toolkit (Figure 2.3) was designed as a reference tool for road engineering practitioners in state and local governments. It is provided by Austroads (Australia) and includes 67 types of infrastructural interventions, grouped in various combinations under the topics: crash type (e.g. head-on collisions, cyclist crashes), safety deficiencies (e.g. pavement issues, roadside hazards) and treatment types (e.g. hazard management, speed management).

All interventions are described in common language, together with a qualitative & quantitative description of their benefits, their cost class (one of five) as well as their potential implementation issues. A list of technical references with links to guidelines and manuals concludes the description. Although the system is claimed to be designed for practitioners, it is comprehensible also for consultants and decision-makers novice to road safety.

Limitations: The Road Safety Engineering Toolkit is limited to infrastructure treatments. It is mostly focussed on textual, easily accessible descriptions of safety deficiencies and countermeasures. There is no well-developed search engine with filters available, only a series of drop-down boxes – or, as an alternative, side-menus – to select for sub-groups of interventions. Likewise, there is no detailed information or abstracts of underlying scientific studies available, only a mouse-over text highlighting study references of the information crash reduction figures (which seems to be pointing at the same three publications for most of interventions). The system is not intended to directly support CBA Analysis. The assessment of risk factors ("safety deficiencies") is mostly limited to common-language descriptions.

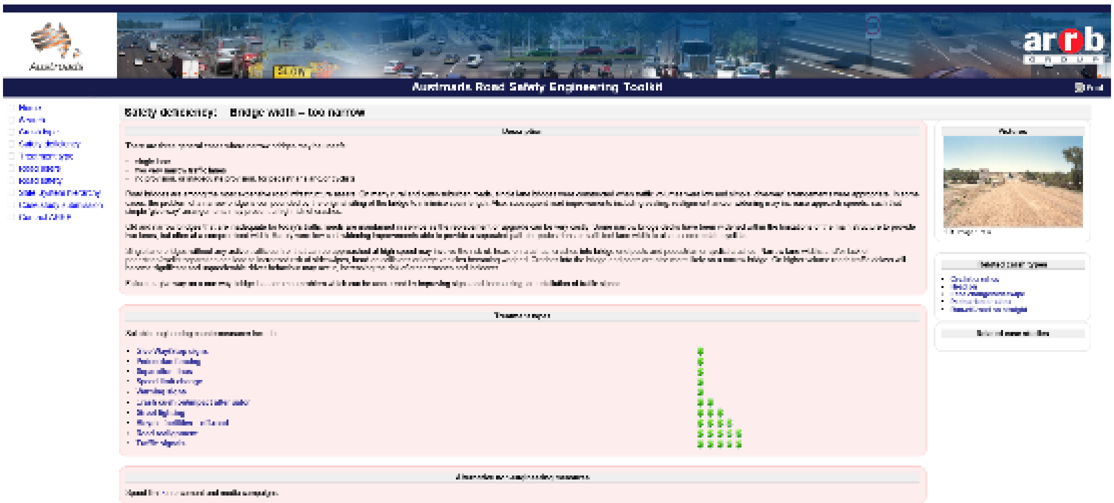


Figure 2.3: Austroads' Road Safety Engineering Kit (www.engtoolkit.com.au)

2.1.4 iRAP Road Safety Toolkit (www.toolkit.irap.org/)

The Road Safety Toolkit is the result of collaboration between the International Road Assessment Programme (iRAP), the Global Transport Knowledge Partnership (gTKP) and the World Bank Global Road Safety Facility. The ARRB Group (Australian Road Research Board) provided expert advice during the Toolkit's development. As target groups of the tool, iRap lists "engineers, planners and policy makers".
As of March 2018, the Toolkit hosts information on 58 types of interventions, 42 on infrastructure, 5 on vehicle safety, and 11 on behaviour ("Safer People"). Interventions can be accessed through several entry points, either through "Crash Types" (selecting from eight common accident scenarios), "Road Users" (six main road user groups) or directly through "Treatments" (grouped in infrastructure, vehicles, behaviour).

All treatments are described in common language, with special sections on description of benefits, implementation issues, a summary box on costs, treatment life and effectiveness, as well as a reference box with links to guidelines, fact sheets and studies. There are also links to worldwide case studies in the respective topical area. In a "management" section, the system provides text documents and links for the topics crash costing, data systems, road safety management, and road safety plans (see Figure 2.4).

Limitations: The Road Safety Toolkit is focused on common language advice on treatments across various fields of road safety work – excluding post impact care. Several links to source documents are broken. The available source documents are usually not scientific studies but rather guidebooks, project reports, or links to other websites. The system is not intended to directly support CBA Analysis and does not provide any assessment of road safety risks.

Figure 2.4: The iRAP Road Safety Toolkit (www.toolkit.irap.org/)

2.1.5 The UK Road Safety Observatory (www.roadsafetyobservatory.com)

The UK Road Safety Observatory claims to provide easy access to independent road safety research and information for anyone working in road safety and for members of the public. It has been developed as part of the UK Government's Strategic Framework for Road Safety and is operated by an independent Programme Board, comprising UK road safety organisations and the Department for Transport.

Although labelled "Observatory", this system has many features of a knowledge repository. The Observatory (see Figure 2.5) features keyword search and seven topical entry points (drivers, riders (incl. bicycle and horse), pedestrians, vehicles, roads, compliance and the law, other). Under each of the topics, a range of connected "topic areas" expands, across the domains of road safety (e.g. the topic "riders" would expand to 14 topic areas, ranging from "convictions & violations" to "[road] surfaces". Each of the topic areas features the following entries:

- Key facts: Common-language findings, and (non-linked) source information
- Summary: a brief list of conclusions with relevance for road safety
- Review: a pdf document presenting a synthesis of the research findings
- Evidence: a list of relevant project reports, fact sheets and scientific papers, each of which with a link to abstract or full document as well as a brief description of objectives, methodology and key findings.

- How effective?: Brief information on effectiveness of countermeasures, and other relevant numerical information, together with (non-linked) citation information

Limitations: The UK Road Safety Observatory makes various information on road safety related problems and risks easily accessible. The system is not intended to directly support CBA Analysis and does not provide any structural assessment of road safety risks. There is no assessment of the quality of the underlying studies given.

Figure 2.5: The UK Road Safety Observatory (www.roadsafetyobservatory.com)

2.2 REVIEW OF USER NEEDS & STAKEHOLDERS INPUT

From the outset, the SafetyCube Road Safety Decision Support System (DSS) was aimed at a broad range of target groups, from practitioners to decision makers. It was for this reason that the SafetyCube consortium invested substantial resources – mainly by way of dedicated stakeholder workshops – into reviewing the needs of potential users and to query stakeholders what contents they would expect from a DSS so that their professional work would be eased.

The groups of stakeholders invited to the workshops were selected to cover a wide range of interests and knowledge, from government, industry, research, and consumer organizations, covering the three road safety pillars: vehicle, infrastructure, and road user behaviour. Feedback was sought in the areas of data collection and coding methodologies, DSS structure and operation, and applications of the DSS.

2.2.1 Stakeholder comments on the SafetyCube methodology

The stakeholders were highly interested in the basic **data collection methodology**. The main type of question was related to the source of the reference material, especially the age and source of the technical data.

→ For the SafetyCube study coding exercise, peer reviewed journal articles were the preferred source of data. More recent studies were the focus and English language publications led to a bias to European and US studies. National reports were difficult to include if they were not in English but often these larger reports are also documented in journals. Future development of the DSS could contain other languages.

There was a concern that the DSS may introduce **biased impressions** of some measures if one domain has 10 studies on a countermeasure but only one is found in another domain. This could lead to a conclusion that the domain with more solutions is the only one to investigate further.
→ The DSS contains synopses which can provide more information than may be contained in the coded studies. The SafetyCube team also identified the goal to have the DSS lead the stakeholder to all possible countermeasures addressing the three pillars (or domains) for a road safety risk factor.

The **Cost Benefit Analysis** was a concern for the stakeholders. The disparity in costs among the countries reporting CBA studies makes it difficult to generalize actual costs in Europe.
→ The SafetyCube Economic Efficiency Evaluation (E3) calculator allows user specific data to be entered to address national differences.

The DSS will use **keywords** reported by the coding staff in the SafetyCube project. The stakeholders were concerned about alternative spellings and variations of words for similar concepts.
→ Text based searches are limited to terms coded by the SafetyCube researchers, however accompanied by an extensive set of synonyms for these keywords, e.g. "elderly" and "seniors", will both lead to the exact same search results.

There may be a reoccurring **crash type** that a stakeholder wishes to address but the specific risk factors may be numerous or even unknown to the stakeholder.
→ The concept of accident scenarios is used by SafetyCube to allow the user to query the system and begin exploring the risks and measures related to specific crash types. SafetyCube created a subset of existing scenarios, grouping as many topics as possible into main headings. The goal was to reduce the complexity of the tool and guide the user to the appropriate studies as quickly as possible.

2.2.2 Stakeholder comments on the structure of the DSS

There was considerable discussion on the design and function of the web-based DSS system. The points raised by the stakeholders focused on the areas of **text based search** and on the presentation of information. There were questions raised about the search possibility of specific words like "truck" and "pedelec". These terms are sensitive to the coders keyword choice and on the SafetyCube glossary.
→ A full glossary has been developed for SafetyCube (see Appendix 6) and all foreseen variations were addressed. It is also dependent on where the terms are reported, as "truck" may appear in both measures and risks for example. The development team cautioned that free text searches can lead to inappropriate results if implemented incorrectly and this was not intended as the main use of the DSS.

The stakeholders were interested in how **filters** could be applied to the search terms such as time of day.
→There are filters in place to sort search results by road user or road type. Additional filters will be difficult to apply but the glossary should help in selecting appropriate keywords. The way the user progresses through the filter process was also of interest as the software allows the user to reduce the risk factors to a certain grouping and then related safety measures can automatically be selected that address these risks.

There was a discussion on the **type and access to statistical data** in the DSS.
→ *The system uses "synopses" as a method to summarize an overview of a topic with numerous references. These synopses contain figures that present the information to the user and provide overviews of the information without the need to read all the text. The SafetyCube team investigated different presentation and table structures that can assist the stakeholders when reviewing the query results.*

Suggestions for how the **result tables** are presented by the DSS were offered by the stakeholders. There was interest in how the results could be **prioritised** in the tables.
→ *The SafetyCube team considered how year of study or effectiveness of a countermeasure could be used to rank and present results.*

2.2.3 Stakeholder comments on the application of SafetyCube results

There were questions and comments regarding who the tool would be most useful for. While the tool is intended to be useful for all stakeholders, the audience suggested that very high-level stakeholders (such and politicians and advisory board members) would not likely be hands-on users. The main users were likely to be the technical advisers to the decision makers as they are the ones collecting and analysing the information and making recommendations to their superiors.

There was a comment that the tool developers should resist making the **tool too specific** as this may create too much detail for high-level decision makers. There was another comment that the tool is too biased towards the researcher and not necessarily for the decision maker. This comment was most likely directed to the quantitative details available in the database. This seemed to reflect that a "text heavy" output describing complex statistical results output would be difficult for senior managers to quickly process if it is not well structured. Informative graphics would be a good support to the text.
→ *The available resources in SafetyCube were limited and it was not possible to incorporate graphic presentations in all cases. Presentation of the results is a key feature for the users and it is good that results are summarized in tables that can be explored further by the user, but not all information needs to be presented at once. The SafetyCube synopsis structure was developed in a way to introduce different layers of information for the user. The initial summary of the topic addressed in the synopses should cue the reader to continue further in the document if they need more details, otherwise they may be satisfied with the information and not need to read further. Synopses are "summaries of summaries" and should be sufficient for high-level decision makers while reviewing individual coded studies may be the goal of most technical advisors, engineers, and researchers.*

The role of the DSS with regards to different application types raised a crucial point. There were questions regarding the use of SafetyCube results when governments are considering larger programs. The group pointed out that SafetyCube is focused on the results of individual studies of risks and measures and **integrated programmes** could not be addressed by the DSS.
→*The SafetyCube team indicated that other tools, like ERSO, would be better choices for analysis of broader scope.*

One stakeholder indicated that the **CBA tool may be the most useful part** of the SafetyCube DSS.

2.3 IDENTIFICATION OF HOT TOPICS

One of the key challenges of SafetyCube, as already outlined in the project proposal, was detailed safety data analysis in support of road safety "hot topics", especially in areas that had not yet been properly evaluated. Therefore, the issue received prime attention in the first stakeholder workshops (Kick-off & Stakeholder Workshop - Brussels 2015, Stakeholder Workshop - Ljubljana 2015, Infrastructure Stakeholder Workshop - Brussels 2016, Mid-term workshop – Brussels 2016). Due to the vast differences in available evidence and methodology, the contextual work packages on behaviour, infrastructure and vehicles identified their respective lists of hot topics in different ways, as outlined in the following three sub-chapters. During DSS design, it was subsequently assured to cover all hot topics identified.

2.3.1 Human behaviour

In addition to inputs given by stakeholders in workshops, relevant research, project and policy documents at European or international level were consulted and individual experts interviewed on their views on hot topics. Based on these inputs, the following issues were identified as key priorities in terms of road safety **risks**:

- Speed choice
- Drunk driving/riding
- Drugged driving/riding (legal, medicine)
- Fatigue
- Cell phone use & operation other devices (e.g. in-vehicle information systems)
- Cognitive Impairment
- Aggression and anger
- Elderly road users
- Young adult road users
- Children

The following issues were subsequently added to the above list to make sure to cover a wide range of important topics:

- Drugged driving/riding (illegal drugs)
- Risk taking – overtaking and close following
- Insufficient skills and knowledge
- Functional impairment – vision loss and hearing loss
- Diseases and disorders – diabetes
- Personal factors – sensation seeking and ADHD
- Distraction through conversation with passengers, music/entertainment systems and outside of vehicle
- Observation errors

In relation to **measures**, a questionnaire on behaviour-related interventions was disseminated at the SafetyCube mid-term workshop in Brussels in September 2016. Stakeholders were invited to indicate the most important human related road safety measures in their view for the risk factors speeding, DUI, fatigue, distraction, cognitive impairments, aggression, and non-use of safety devices such as helmets. The most nominations were made for awareness raising and law & enforcement measures.

2.3.2 Infrastructure

An infrastructure stakeholder workshop (Brussels, February 2016) served as prime input for infrastructure-related hot topics. In this workshop, a general list of hot topics identified through earlier consultations was examined and ranked by stakeholders.

Both the four general areas and the specific topics within each area were ranked. The four main areas are ranked as follows:

1. **Urban road safety measures** and **Self-explaining and forgiving roads** (which received equal ranks),
2. **Road safety management**,

3. ITS applications.

The top ranked specific infrastructure topics as rated by the infrastructure stakeholders for each area are shown in Table2.1. It is noted that some of the "hot topics" cannot be addressed from an infrastructure risk factor point of view, as some are clearly related to measures and/or interventions (e.g. road safety management, ITS applications), while others were accounted for during the finalisation of the taxonomy and the related risk factors (e.g. self-explaining roads).

Table 2.1: Ranking of hot topic" by road infrastructure stakeholders.

1.Urban road safety (detailed ranking was not possible)	2. Self-explaining and forgiving roads	3. Road safety management	4. ITS application
- Pedestrians / cyclists	1. Removing obstacles	1. Quality of measures implementation	1. ISA
- Upgrade of Crossings	2. Introduce shoulder	2. Appropriate speed limits	2. Dynamic speed warning
- New crossings	3. Alignment (horizontal / vertical)	3. Enforcement	3. ADAS and active safety with V2I
- Junctions / roundabouts treatments for VRU	4.Sight distance	4. Availability of cost-effectiveness data	4. Implementation of VMS
- Visibility	5. Traffic signs	5. Work zones	
	6. Raised crossings / intersections		

2.3.3 Vehicles

The list of vehicle-related hot topics was collated based on a) the abovementioned stakeholder workshops, b) a questionnaire sent to industry stakeholders (members of ACEA, EUCAR, ACEM, OICA), and c) Interviews with experts with engineering profile in automotive industry.

There was a notable difference in expectations coming from the industry and those of other stakeholders. It became obvious that even if safety is a priority among private enterprises, it may not be their ultimate aim.

Despite these differences, a common topic which emerged from the different inputs was the subject of ITS (connected vehicles) and vehicle automation. The core issues in terms of vehicle safety priorities are the following:

- How effective are vehicle safety countermeasures (and under which circumstances)?
- What is the effect of the new vehicle technology on road safety (autonomous vehicles, connected vehicles, ADAS ...)?
- How well do active safety systems prevent accidents?
- What is the relative risk created by new technologies?
- Crash modification functions of measures (for different variables) with a qualitative background information on the factors influencing boundaries
- Cost benefit estimation of each measure in the global road safety system (education, vehicle technologies, infrastructure, ...)

- Unit cost (for customer) of adding safety systems and relative risk versus benefit
- A priori evaluations of effectiveness of new ADAS: how to harmonise methodologies?
- Acceptability of ADAS: balance between false and missing detection

2.3.4 Hot topics in the DSS

The hot topics identified during the stakeholders' consultation received special emphasis in the subsequent analyses, in order to make sure that sufficient evidence is provided, i.e. an adequate number of representative studies and a clear conclusion on the topic.

However, this by no means implies that other topics were neglected, as the same standards for the number and quality of studies applied to all topics examined. It is also acknowledged that the hot topics identified may not be exhaustive; further consultations would most probably reveal additional topics, for instance seat-belt wearing in the behaviour field and road restraint systems in the infrastructure field were - rather counter-intuitively - not brought forward by stakeholders. Moreover, it is expected that hot-topics in stakeholders' agendas will not remain unchanged, as road safety science and policy evolve.

For these reasons, it was decided not to 'flag' the hot topics as such on the DSS, but fully take into account the need to provide the best scientific evidence for these (and all other) topics.

3 Design of the Decision Support System

On the basis of the review of existing systems and the feedback from stakeholders regarding their needs and preferences for a road safety DSS, the design principles, the general structure and the main functionalities of the SafetyCube DSS were developed. These are described in this Chapter.

3.1 DESIGN PRINCIPLES

The DSS was designed as a modern web-tool consisting of three elements:

- **a back-end database**, in which results on road safety risks and measures are stored in a structured and inter-linked way
- **a search engine**, with 'queries' developed to retrieve information from the database)
- **a front-end system**, including a web-based application with a user interface to present, process and export the results.

The DSS was developed on the basis of the following design principles:

- **Linked search and linked results:** the user may 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, and so on.
- **Fine level of detail:** the user may refine the search and filter the results with many parameters among those found in the database (e.g. road types, road user groups, countries etc.).
- **Flexibility:** the user my continuously adjust the search according to the results.
- **Transparency:** the process is fully documented and the user may access background information at any stage (links, etc.).

3.2 STRUCTURE OF THE DSS

The DSS was developed after taking the prospective users' needs into account, which were recorded after stakeholder consulting as described in section 2.2. After the concept of the DSS was solidified, the basic design of the system was formulated. When it was completed, the DSS was populated with the introduction of the scientific products of SafetyCube (coded studies, synopses, cost-benefit analyses, accident scenarios etc.) thus reaching the end result that is accessible by all users, from experienced stakeholders and road safety experts to all people interested in road safety.

The SafetyCube DSS was designed with a structure of **three operational levels** plus an initial 'dummy' level for the Home Page:

- Level 0: Home Page,
- Level 1: Search Pages,
- Level 2: Results Pages,

- Level 3: Individual study pages.

The Search Pages include **a dynamic part and a static part**. The dynamic part concerns:

- The **Search** tab allows the user to query the DSS backend database and retrieve results for risk factors or measures, through **five entry points** (keywords, risk factors, measures, road user groups, accident scenarios), all leading to a **Results page**, as shown in Figure 3.1. Moreover, links between risks and measures will be implemented in the results pages. The results pages will include all the DSS outputs in terms of coded studies, summaries etc., and a selection of one of these outputs will lead to the **Individual study page** with detailed information on the specific study.
- The **Calculator**, a one-page web application which allows the user to retrieve one of the SafetyCube examples of cost-benefit analysis, edit it with own values or perform his/her own cost-benefit analysis of a road safety measure.

The static part includes additional one-level pages with supporting documentation, text and links as follows:

- The **Knowledge** tab**:** compiles the SafetyCube key documents as a knowledge library.
- The **Methodology** tab**:** includes key background information and documents on the SafetyCube methodology and related disclaimers.
- The **Support tab:** includes contact information, the guide to DSS users, the possibility to send feedback or questions, and useful links to other systems.

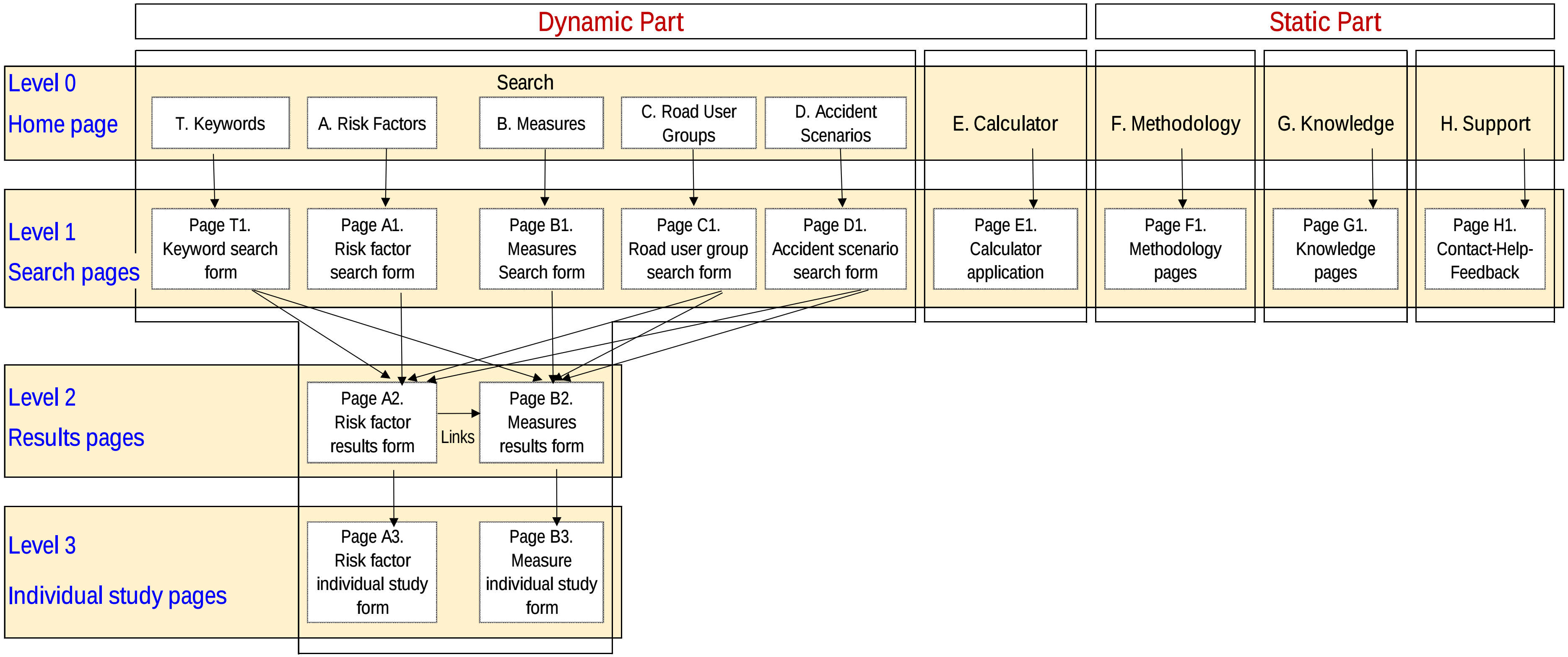


Figure 3.1: Conceptual Structure of the DSS

3.3 BACK-END DATABASE

The DSS back-end is is a relational database (MySQL) running under Ubuntu Linux. The structure of this relational database is shown in Figure 3.2.

The creation of the database first required the parsing and debugging of information coded by the SafetyCube partners in predefined excel sheets / templates (these are described in detail in section 4.2). Python scripts were developed to access the data in the Excel sheets and transfer these data to the appropriate tables in the database. Whenever a data or consistency problem was encountered, the original template was checked to correct the error. Some errors were corrected centrally; for other errors the original coder was contacted and required to adapt the excel template. At regular intervals the database was "frozen" and a full copy sent to the front-end developer, where it replaced the previous version.

The back-end database is presented in further detail in SafetyCube Deliverable D8.2 (Van den Berghe et al., 2017). It can be outlined that it includes the following key linked Tables (and numerous other support, additional information and linking Tables):

- **Taxonomy**: the different taxonomies / topics for behaviour, infrastructure, vehicle and post-impact care, and their hierarchy are stored and linked to individual studies.
- **Reference**: The database is built around the reference table, which stores the bibliographic information for every coded study as well the main topic (risk factor or measure); this table is linked with all relevant other information in the database.
- **Keywords**: The Keywords of the studies are stored in a separate table. They can be linked with single studies (one-to-many relationship).
- **Master keywords**: A list of "master keywords" was generated within the project. These are stored in a separate table with their one-to-many links to the original study keywords. The rationale and details are described in section 5.2.
- **Study design**: A Table listing the study designs, linked to the reference Table.
- **Sample frame**: A Table including the different design variables that have been used to decompose the effects (risks or measures) in each study).
- **Exposure and outcome**: All exposure and outcome variable definitions used in the different studies are stored in the corresponding tables. They are linked with the individual studies (one-to-many).
- **Direction**: of particular importance in the project was the distinction of whether a study is directed "from exposure to outcome"(i.e. effects deal with a contrast between different exposure variable levels (or a regression on exposure variables) of "from outcome to exposure" (i.e. where effects are influential on different outcome variable levels). Methodological implications are provided in Martensen et al. (2016); the main implication for the DSS development was that a different query needed to be designed to retrieve the desired information.
- **Effect**: This table stores all individual coded effects (of risk factors and measures) in each study; it is linked to the reference table.
- **Links between riskfactors and measures**: This table provides the consolidated links between the (most recent) risk factor and measure taxonomy levels. Details on the methodology for creating these links are provided in section 4.3.

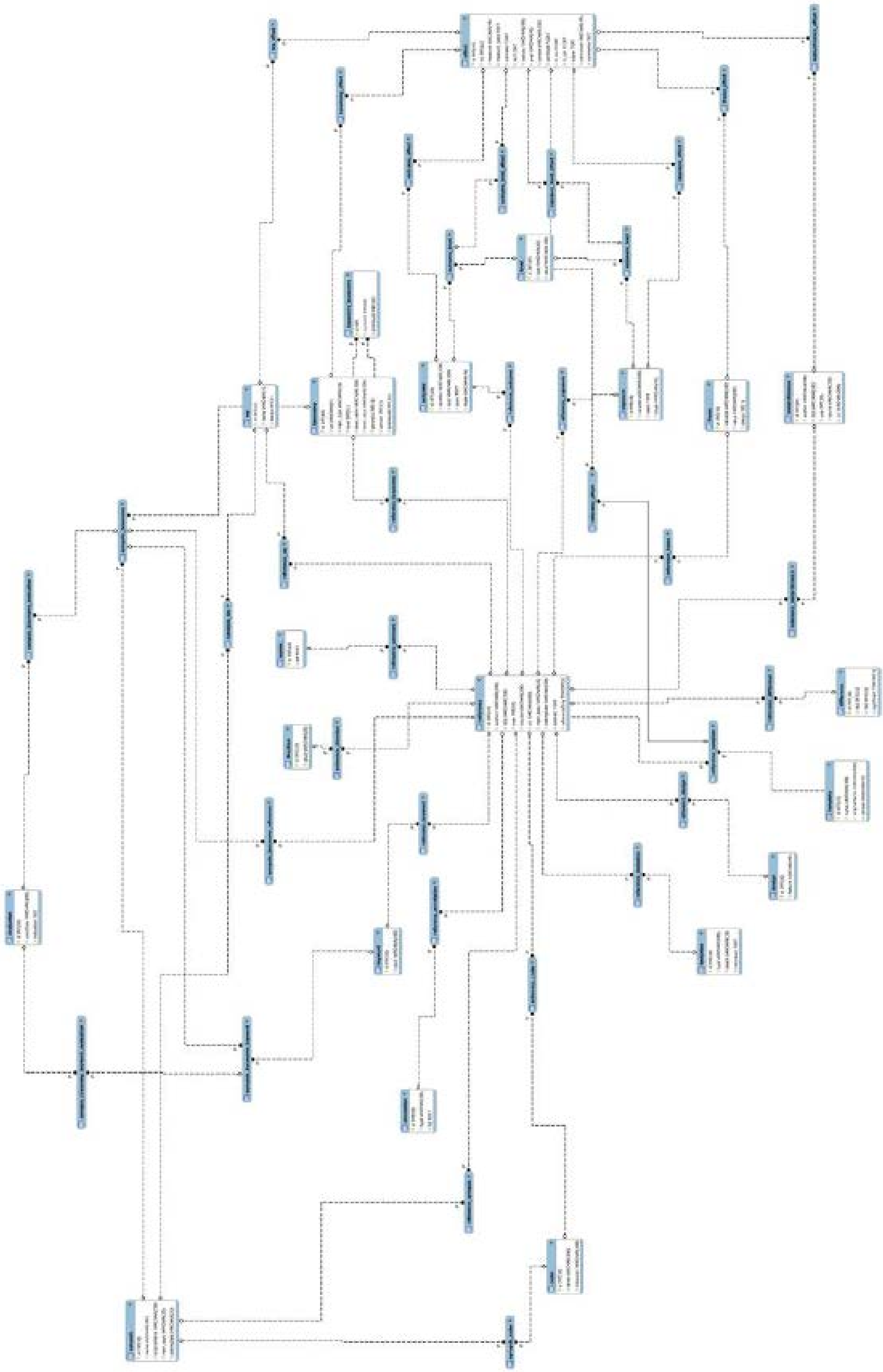


Figure 3.2: Structure of the back-end database underlying the DSS

3.4 DSS TECHNICAL SPECIFICATIONS

The DSS is available at the following URL: http://www.roadsafety-dss.eu. The DSS server is hosted in the Cloud, and running in Ubuntu Linux environment. The database queries used to retrieve information are MySQL.

The architecture stack of SafetyCube DSS is based on the following key technologies:

- Node.js: a software platform for creating a web server and building web applications on top of it. Node.js uses Google's open source V8 JavaScript engine at its core.
- Express: a minimal and flexible Node.js web application framework for web and mobile applications; it is used as a middleware between database and frontend. It is open source.
- Angular JS: a JavaScript framework for working with data directly in the frontend. Angular JS is open source.

The main strength of the chosen stack architecture lies in its centralization of JavaScript as the main programming language. This solution has a representational state transfer (REST3) API feeding a single-page application. API is typically built with Express, and Node.js, with the Single Page Application being built in Angular JS.

4 Populating the Decision Support System

The methodologies and procedures used to produce the SafetyCube results intended to populate the DSS are described in this Chapter.

4.1 OVERVIEW

Having defined and developed the DSS structure, the next step was to ensure that the system is populated with relevant and high quality information on road safety risks and (cost-) effectiveness of road safety measures. This Chapter describes how this was done by describing successively:

- the procedures for identifying and analysing the road safety risks and the effects of measures (*Paragraph 4.1*),
- the approach for linking of risk factors to measures and vice versa (*Paragraph 4.2*),
- the development of the economic efficiency evaluation tool (*Paragraph 4.3*),
- the development and analysis of accident scenarios (*Paragraph 4.4*), and
- the information about size and impact of serious injuries in traffic (*Paragraph 4.5*).

It is of crucial importance that the contents of the DSS are of high quality and scientifically valid. Therefore, all information about the risk factors and the road safety measures presented in the DSS went through a strict quality assurance procedure, as described in *Paragraph 4.6*.

4.2 IDENTIFICATION AND ANALYSES OF RISKS FACTORS AND MEASURES

The DSS distinguishes between road safety risks and road safety measures. **A risk factor refers to any factor that contributes to either the occurrence of a road accident or the severity of an accident. Similarly, a road safety measure refers to any measure that prevents the occurrence of an accident or reduces the chance of fatal or non-fatal serious injury.**

In order to populate the DSS with information of the most important risks factors and measures, a stepwise approach was applied, as elaborated in the subsequent sections:

- Creation of risk factor and measure taxonomies
- Literature search and selection of relevant studies
- Coding of the characteristics and results of individual studies
- Analysis of the results of all coded studies in a particular field
- Creation of synopses and assignment of colour codes per risk factor and measure

Within the methodology Work Package of the SafetyCube project, detailed guidelines were developed for the different steps of the analysis of risk factors and measures. These guidelines can be found in Martensen & Lassarre (2018).

4.2.1 Creation of risk factor and measure taxonomies

The main elements of a road system are the infrastructure, the vehicle and the road user. In the DSS, risk factors and measures in each of these domains are represented. A first step consisted in identifying of all relevant risk factors and measures and assigning them to one of these three domains. In addition, the DSS presents information about post impact care; this just involves measures.

Subsequently, identified risks and measures were organised per domain in what we called a taxonomy. The taxonomies consisted of a maximum of three levels: 1) main topic, 2) subtopic, and 3) specific topic. *Table 4.1* is an example of part of the road user risk factor taxonomy with its three levels.

Table 4.1. An extract of the road user risk factor taxonomy (Martensen et al., 2018)

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	--

This exercise resulted in seven mutual exclusive taxonomies (*Table 4.2*). The construction of the taxonomies was based on a systematic analysis of the road safety literature in combination with expert knowledge of the researchers involved in the project. The resulting draft taxonomies were presented and discussed during four workshops with the intended future users of the DSS (see also *Chapter 2*). Three workshops were directed to a general audience of road safety policy makers and practitioners; one was focused on infrastructure risks and measures. The participants were asked to indicate missing topics and to prioritise the identified topics. This resulted in the final taxonomies which formed the main structure of the DSS search function and formed the basis for linking risk factors with their corresponding measures (see *Paragraph 4.2*).

Table 4.2. Overview of the seven DSS taxonomies.

	Risk factors	Measures
Road users	x	x
Road infrastructure	x	x
Vehicles	x	x
Post impact care		x

For a detailed description of the taxonomies in the four domains we refer to Filtness et al. (2016) and to Appendix 1. For detailed information about the procedures in each of the domains we refer to Aigner-Breuss et al. (2017) regarding road users, to Usami et al. (2017) regarding road infrastructure, to Hermite et al. (2016) and Jaensch & Leopold (2016), regarding vehicles.

In particular as regards the Post-impact care taxonomy, risks were not considered, as post-impact care measures explicitly aim to reduce the consequences of crashes. Effective trauma care might for example prevent a severly injured casualty from deceasing. There might be risks associated with post impact care, like risks of medical errors. However, these risks are not directly associated with road safety and therefore outside the scope of the Road Safety DSS. Therefore, the post-impact care taxonomy is limited to measures.

4.2.2 Literature search and selection of relevant studies

For each of the risk factors and measures in the taxonomies a standardised systematic literature search pointed at potentially relevant studies. Which literature databases and sources were searched depended on the specific area of interest, but generally included Scopus and TRID. Searches were based on well-defined logical strings of keywords (see *Table 4.3* for an example).

Table 4.3. Example of the search terms for the main topic of 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"

Initial searches mostly took place on the second level of the taxonomy (see *Paragraph 4.1.1*), and in several cases on the third level as well. In addition, the reference list in relevant studies pointed at additional potentially relevant studies.

The resulted list of potentially relevant studies were then screened to assess their eligibility for further analysis and inclusion in the DSS. The screening was first based on the abstract, then on the full paper. The main criterion for inclusion in the DSS was that a study had to give a quantitative estimate of the size of the risk of the risk factor under consideration or of the effect of the measure under consideration. Preferably, the studies reported at the level of accidents, e.g. accident numbers or injury severity. Second best were studies that reported on safety performance indicators (SPIs). An SPI is an indirect measures of road safety, but a measure that is causally related to the number or severity of accidents. SPIs can be related to road user behaviour (e.g. speeding), to road infrastructure (e.g. the presence of cycle paths), or to vehicle safety (e.g. the presence of airbags).

While the aim was to include as many studies as possible, for some topics the literature search resulted in an unfeasibly high number of studies. In these cases, the **selection of studies for further analysis and eventual inclusion in the DSS was based on the following criteria**:

- **Relevance**: Information about accidents prioritised over incidents prioritised over observed information prioritised over self-reported information.
- **Transferability**: European studies prioritised over USA/Australian/Canadian studies prioritised over studies from other countries.
- **Recency**: Recent studies prioritised over older studies, though older studies of particular relevance were included.
- **Quality**: Peer reviewed papers prioritised over non-peer reviewed papers.
- **Language**: Papers in English prioritised over other language papers.

For several risk factors and measures, meta-analyses were available. If that was the case, **the most recent meta-analysis was used as the basis, and complimented with additional studies published after**, and consequently not included in the meta-analysis.

The above criteria served as a general guideline for prioritisation, and were not meant to be applied 'strictly', given that for particular topics the resources and types of results may vary considerably. Therefore, a case-specific study selection took place, on the basis of the above criteria and the expert judgment of the partners involved.

Despite the prioritisation of European studies, the combined application all the criteria resulted in some cases in a final selection with a large share of studies being from outside Europe, namely from the US. In order to address the potential implications on transferability of the outcomes, an analysis and a related disclaimer on transferability of results was decided to be included in each topic Synopsis.

Moreover, despite the prioritisation of peer-reviewed papers, other publications and reports were also included when deemed necessary. This was the case when not a sufficient number of peer-reviewed papers could be found. There were also topics for which very high quality results could be found in government reports or other publications (e.g. naturalistic driving studies research reports on distraction), and were therefore included.

4.2.3 Coding of study characteristics and results

The selected studies were individually coded in **a standardised Excel coding template** that was developed specifically for this purpose. This template captured all relevant information from each study and made it possible to report the information in a uniform way across topics.

The coding template consisted of several sheets, requiring the researcher to provide information, mostly in predefined categories, about

- Road safety domain (road user, infrastructure, vehicle, post impact care), risk factor or measure, and the level of the relevant taxonomy.
- The bibliographic features of the study (title, author, year, source, origin) and the study abstract
- Characteristics of the study population (e.g., road user group, age groups)
- Characteristics of the study design (e.g., experimental or observational)
- The type of effect estimator (e.g., Crash Modification Factor, Odds Ratio etc.)
- The numerical results of the study with their confidence intervals or other relevant statistical details (for different subgroups if appropriate)
- The scientific quality of the study (e.g., limitations, biases)

In addition, the researcher had to compile an overall brief summary of the study, including the main findings, as well as an overall assessment of their reliability and usefulness, given the study design and potential biases. Coded studies were cross checked by a second researcher in order to optimize quality.

Table 4.4 is an example of a result sheet in the excel template, completed for a study on the effect of bicycle helmets.

Table 4.4. Example of a result sheet of a coded study

☐ 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

The coding template was designed with the aim to accommodate the wide variety and complexity of different study designs. Guidelines provided detailed instructions on how to use the template (Elvik et al., 2015; Martensen & Lassarre, 2018) and coders attended a workshop and/or webinars to practice.

Per topic, the DSS provides an overview table with all coded studies for that topic. From the table with coded studies, the DSS user can subsequently access pages with more detailed information for the individual studies and a link to the full paper (accessibility to the full paper depends on copyrights).

4.2.4 Analysis of the results of coded studies

After having coded all of the selected studies for a particular topic, the researchers analysed the results with the aim to come to a well-balanced preferably quantitative overall assessment of the importance of a risk factor or the effectiveness of a measure. Three ways had been defined to **analyse and summarise the results** (Martensen & Lassarre, 2018), in the decreasing order of priority:

- **Meta-analysis**. A meta-analysis combines the numerical results of multiple studies and yields a weighted average of the risk factor/measure effect from the results of the individual studies. A meta-analysis was performed if there was a sufficiently large number of studies that were comparable in terms of both their research design features and the type of results they produced.
- **Vote-count analysis**. A vote-count analysis compares the share of studies that showed a positive effect, no effect, or a negative effect. This type of analysis was performed if there was a sufficient number of studies but a meta-analysis was not possible due to large differences between studies.
- **Review-type analysis**. In a review-type analysis the results are summarised in a more qualitative way, generally including a qualitative summary table of effects with the related interpretation. This analysis was performed if the number of studies was small or if the studies were so heterogeneous that a vote-count analysis was not meaningful.

In each type of analysis, the most relevant modifying conditions were identified (e.g., a measure that works in urban, but not in rural settings or a factor that is particularly risky for novice drivers). In meta-analysis or vote-count analyses this was addressed by analyses at relevant sub group level.

4.2.5 Creation of synopses and assignment of colour codes

Finally, for each risk factor and measure, a synopsis was compiled. Depending on the amount of information, the synopsis dealt with topics on the second or the third level of the taxonomy (See *Paragraph 4.1.1*). **The synopsis provides a synthesis of the main findings**, including both quantitative information from the coded studies and more qualitative information from, for example, review studies.

Each synopsis consists of three parts:

- **Summary**: In maximum two pages, the summary very briefly reports the 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.

For some topics there were insufficient quantitative studies, e.g. for topics related to new in-vehicle technologies. These were reported in what we called 'Abbreviated synopses'. These abbreviated synopses are not or hardly based on the quantitative coding and analysis process as presented in the previous two paragraphs, but predominantly on qualitative information as well as the knowledge and the expertise of the author(s).

Each of the studied risk factors and measures also got a colour code. This colour code summarises the overall conclusion about a risk factor or a measure. It indicates how risky an assumed risk factor or how effective a measure actually is. *Table 4.5* summarises the colour codes and their meaning for both risk factors and measures.

Table 4.5. Colour codes of risk factors and measures and their interpretation

	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.
Yellow	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.

4.3 LINKING RISK FACTORS AND ROAD SAFETY MEASURES

In the SafetyCube DSS, all risks considered in the SafetyCube taxonomies are intended to be linked to measures that have the potential of reducing this risk, and vice versa. There is obvious added value in this feature, as it will assist DSS users in:
(a) knowing which risks can be remedied by which types of measures
(b) knowing which types of risks will be reduced by a particular measure.
These links are meant to reflect situations where a user of the system would be looking for effective measures. This means a measure (e.g. winter maintenance) 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 a solution to their problem.

4.3.1 Review of current frameworks

A common framework for analyzing the accident process combining road user, infrastructure, vehicle and crash characteristics is **the multilevel hierarchical accident model**, according to which road users are 'nested' into vehicles / roads, and vehicles / roads are 'nested' into accidents (e.g. Vanlaar, 2005; Huang & Abdel-Aty, 2010; Dupont et al. 2013). This disaggregation of the accident process allows to take into account the crash characteristics that have common (and sometimes unobserved) attributes: road users in the same vehicle are more likely to sustain similar injuries, as they will be jointly affected by the vehicle speed, mass and protection; vehicles involved in the same accident will be jointly affected by the road traffic and environmental conditions at the crash site (e.g. weather, traffic, visibility, road design deficiencies etc.). This framework provides a meaningful linking of infrastructure, user and road characteristics, and has been mostly helpful in statistical modelling purposes, but is very microscopic and lacks the necessary extension to road safety measures.

Another common framework for analyzing road safety processes is **the Haddon Matrix** (Haddon, 1980; 1999), which provides a useful cross-classification of different crash components (road, user and vehicle) with the crash event configuration and evolution (i.e. pre-crash, crash, post-crash). The matrix was explicitly developed to shift the focus from the approach of simply "correcting human errors", jointly evaluate all the factors that contribute to road injury and provide a methodology to assess the effectiveness of a full range of potential measures (OECD/ITF, 2016). It thereby assists in evaluating the relative importance of different factors and design interventions, by targeting specific combinations of component and crash phase. It is helpful for a broad assessment, but may be considered limited in the level of detail required for SafetyCube.

According to Hughes et al. (2016), **systems theory** and practices should be thoroughly applied to develop measures that improve the road system as a whole, rather than in isolation. The road system can be considered to be a socio-technical system, with road users, vehicles and road as the components that interact with each other in order to "produce" transport of people and goods (Larsson et al., 2010). A similar macroscopic approach is taken in the **SUNflower 'pyramid'** (Wegman et al., 2008), in which a six-level hierarchy is proposed, starting from structure and culture at the bottom level, to road safety programmes and measures, affecting first the operational level of road safety (e.g. road user behaviour) and then final outcomes.

However, SafetyCube is strongly based on a **Safe System approach**, which aims for *the ultimate prevention of death and serious injury through systematic intervention (pre-crash, during crash and post crash as well as involving all key system elements) and more results-focused institutional delivery (safety performance framework, long-term goal interim targets, key safety performance objectives, shared accountablity for results etc.)*. It should be underlined that systems approach and Safe System approach are not inconsistent – the former being accommodated in the latter in relation to intervention - but they are not the same. The systems approach is rather neutral in ambition and focuses merely on systematic intervention rather than results, intervention and institutional delivery aspects of road safety management covered by Safe System.

Elvik (2004) proposed **a theoretical framework for linking risks and measures in road safety**, starting from the concept suggested by Evans (1985, 1991). In this concept, a measure normally influences road safety by two causal chains: the engineering effect, and human behavioural feedback to engineering changes ("the behavioural effect"). The paper identifies nine distinct types of risk factors in the engineering effect and six types of behavioural adaptation effects. The idea behind this framework is that a risk factor arises as a result of either (i) physical hazards beyond road user control (e.g. a steep hill along the road) or (ii) inadequate behavioural adaptation among road users; a road safety measure will only be effective if it addresses risk factors arising this way. This framework has two unique contributions: first, the direct linking between risk factors and measures at a finer level of detail; and second, the separate consideration of risk factors as those that are beyond user control, and the behavioural ones.

4.3.2 The SafetyCube model for linking risks and measures

The proposed SafetyCube model for linking risk factors and measures is based on the conceptual framework of Elvik (2004) for the causal chain through which road safety measures influence road safety. More specifically, road safety measures may affect risk factors through two mechanisms: one related to 'generic' factors (i.e. which are beyond the user control) and one related to 'circumstantial' factors (i.e. crash-specific conditions), both eventually affecting road safety outcomes.

In the present approach, we extend this model by taking into account elements of the Safe System approach and the Haddon matrix, which in details means: (i) considering separately the system components i.e. road user, infrastructure and vehicle, (ii) considering the crash chain i.e. pre-crash, crash and post-crash separately and (iii) separately considering the road safety outcomes in terms of crash type and severity.

The **risk factors categories** can be described as follows:

- **Generic (pre-crash) risk factors**: refer to risk factors 'pre-existing' the crash and linked to system design and safety-related purpose . These have impact on the 'baseline risk' in association with combinations of user / vehicle / road infrastructure:
  - Infrastructure: the design of the road (alignment, safety barriers, road markings and traffic signs etc.), even when complying to safety standards, is associated 'by default' to a certain level of risk. For given categories of accidents, motorways are safer than rural roads, roundabouts are safer than crossroads, etc. Design deficiencies such as a concealed sharp curves, inadequate safety railings, uncontrolled rail-road crossings etc. would also fall under this category.
  - Vehicle: different types of vehicles are 'by default' associated to different levels of risk, e.g. passenger cars are more stable than motorcycles, vehicles equipped with advanced passive safety technologies have higher safety potential than others etc.
  - Road user: regardless of driving behaviour, older road users have higher risk of accident involvement and injury severity (vulnerability); functional disabilities or impairment (e.g. visual or cognitive) will increase risk most probably regardless of the road and traffic conditions, personality characteristics and attitudes such as aggressiveness or risk-taking are inherent to the individual road user etc.
- **Circumstantial (crash-specific) risk factors**: refer to risk factors that may be present circumstantially, creating specific high risk conditions (e.g. congestion, frost and snow, driving at night or under the influence, vehicle failure), over the 'baseline' risk level created 'by design'.

In many cases, risk factors pertaining to the two general categories above may 'act' separately, or be inter-related. For example, a road design deficiency may cause crashes even when no human error or lapse takes place; an alcohol-impaired driver may cause a crash on a perfectly designed road and while driving a five-star vehicle. On the other hand, a young driver (generic risk factor) may be more prone to speeding behaviour (circumstantial risk factor), the risk of a sharp curve will increase with inadequate friction (e.g. due to poor road surface maintenance or rainfall) etc.

Sets of risk factors can be associated with different crash outcomes. These can be categorized as well:

- **Crash types**: different (combinations of) risk factors may affect different crash types; for instance, alcohol and speeding may be more strongly associated with single-vehicle ran-off road crashes, whereas junction design or road design (e.g. lack of median separation) may be more strongly associated with crashes involving two vehicles.
- **Crash consequences**: different (combinations of) risk factors may affect different crash outcomes, overall or within crash types. For example, older age and physical vulnerability may affect the occurrence of pedestrian crash (older pedestrians have higher crash risk), but will also affect injury severity in all types of crashes.

The idea underlying this proposed decomposition of risk factors and outcomes is that each crash is caused by a combination of circumstancial risk(s), which are possible consequences of pre-existing generic risks. The combination of risk factors then may result in specific crash types. Therefore, each risk factor contributing to a specific crash type and its possible outcomes must be assessed and addressed by one or more specific measure.

As a consequence, all **measures can be classified** as primarily addressing a different component of the accident chain:

- **Measures addressing generic risk factors**: these are measures targeted at the entire population or at the road network, tackling safety standards or safety cultures that induce generic risks: road safety management, education, training and licensing, vehicle regulations etc. belong to this category.
- **Measures addressing circumstantial risk factors**: these are more relevant to circumstantial risk factors, for example speed management measures, visibility measures (either infrastructure or vehicle related), enforcement and campaigns on specific topics, vehicle systems to detect fatigue, alcohol etc.
- **Measures addressing crash types**: there are several measures that aim at preventing specific crash types, regardless of the risk factor(s) causing the crash. A good example of these are ADAS and in-vehicle systems for longitudinal and lateral cruise control. Lane Departure Warning systems warn in cases of running off-lane, regardless of whether this is caused by distraction, fatigue, alcohol, speed, inappropriate curve design or any other factor.
- **Measures addressing crash outcomes (injury severity)**: again regardless of the risk factor that causes the crash, there are measures directly aiming at mitigating the consequences of the crash. These include passive safety systems, protective systems (seat belts, helmets and clothing) both in terms of legislation and enforcement, dealing with road visibility and obstacles.

An overview of the proposed model to 'link' road safety measures to risk factors is presented in Figure 4.1.

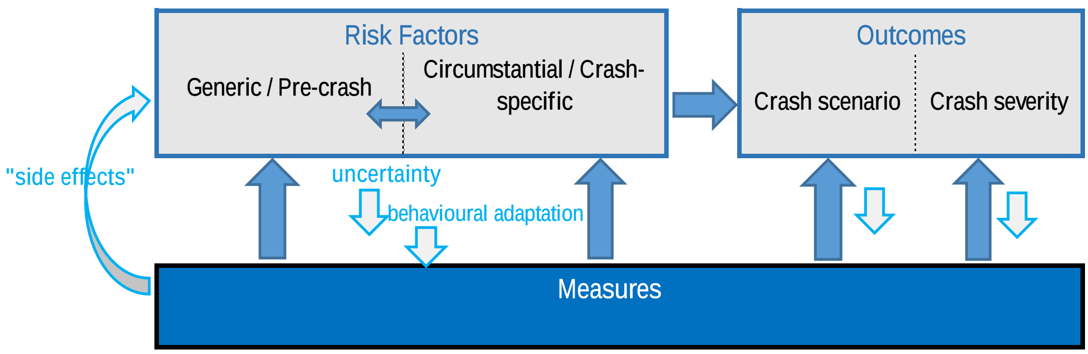


Figure 4.1. SafetyCube theoretical model for linking road safety risks and measures

There are two main points to note as regards the proposed framework:

First, it should be kept in mind that the expected **eventual effectiveness of measures** may be compromised:

- Due to **behavioural adaptation** of road users, e.g. infrastructure improvements may result in increased speeds.

- Measures may have other **"side-effects"** (such as the well known accident migration downstream the intervention site, or the induction of new risks for instance safety barriers inducing risks for motorcyclists etc.)
- There is always **uncertainty** in the effectiveness of measures, which will always vary in different conditions or settings.

It is therefore underlined that the proposed model reflects the **theoretical potential of measures to address risks**. Only the existing evidence in the literature can give the final answer as regards the (current) strength of each link between a risk and a measure. The DSS contents (individual studies, synopses and meta-analyses) may thus "validate" or "conditionalize" the links, assist to understand the conditions of measures effectiveness and flag the sources of uncertainty.

Second, in the proposed framework Safety Cube addresses the **results of individual risks and measures rather than integrated programmes** needed to apply a Safe System approach. In Safe System, the linkages between intervention in a holistic approach are important, however this was not fully achieved in the present model. Moreover, although addressing different crash outcomes, the model does have death and serious injury prevention as its main focus, and this also limits the full implementation of a Safe System approach.

4.3.3 Implementation of the links

The steps taken in order to implement the links in the DSS can be summarized as follows:

- The SafetyCube risk factors from the taxonomies were classified according to the above model as generic, circumstantial, or directly affecting the crash outcomes.
- Next, it was tested how the SafetyCube taxonomies conform to the proposed model of chains of risk factors and outcomes. In each case, the implementation started from the circumstantial risk factors and proceeded to linking:
    - related generic risk factors,
    - other related circumstantial risk factors and
    - related crash types.
- Figure 4.2 demonstrates indicative examples with infrastructure, vehicle and behaviour circumstantial risk factors placed in the center.
- Accordingly, the SafetyCube measures from the taxonomies were classified as addressing different risks / outcomes in the accident chain.
- Finally, the above models and classifications were exploited to attempt the actual linking of risks and measures.

The links between risks and measures were finally implemented at the lowest level of the SafetyCube taxonomy. The relationship between risks and measures is a "one-to-many" relationship, as each risk factor can be addressed by different measures, and each measure may mitigate different risk factors.

All these elements are integrated in the DSS and taken into account when checking for measures that should be considered as remedies for a risk factor in question. Moreover, by linking risk factors to measures from different domains, an important aspect of the **Safe System approach** is emphasized for the user. As an example, when looking for measures linked to a road user related risk like "speeding", the user will be guided to measures that address road users (campaigns, demerit point systems) or infrastructure (speed humps, section control) or the vehicle (ISA, adaptive cruise control).

The appearance and functionality of the links between SafetyCube risks and measures in the DSS is demonstrated in section 5.4.2.

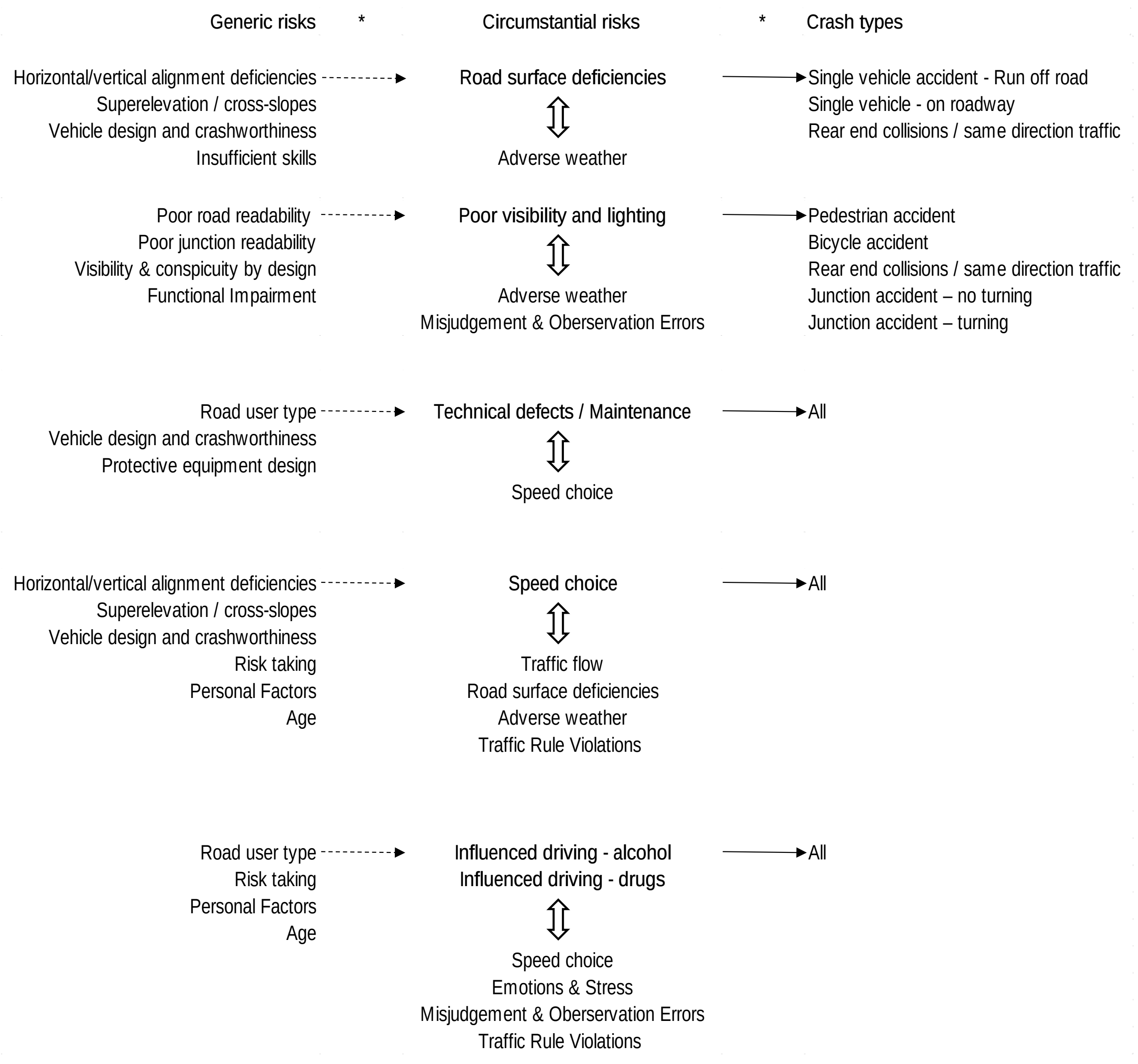


Figure 4.2. Examples of chains of risk factors and outcomes in SafetyCube taxonomies

4.4 ECONOMIC EFFICIENCY EVALUATION

A separate tool was developed in SafetyCube **to evaluate the economic efficiency of measures that were found to be effective: the Economic Efficiency Evaluation (E3) calculator** (Martensen et al., 2016, Martensen & Lassarre, 2018). The E3 calculator combines the information about the effectiveness of a measure, i.e. the percentage of accidents or casualties that this measure can prevent, with the costs of the measure. With the calculator two types of analyses can be done, resulting in two types of output. First, there is the *cost-effectiveness analysis.* This analysis calculates the costs for preventing one accident or one casualty. Outcomes for different severities, e.g. costs for preventing a fatal accident versus costs for preventing a serious injury accident, have to be addressed separately. Second, there is the *cost benefit analysis*. This analysis results in a ratio between the monetary value of the benefits of a measure (because of prevented accidents or casualties, jointly for different severities) and the total monetary costs of the measure. This type of information is very helpful for prioritising measures, i.e., getting best value for money.

As the monetary value of prevented accidents or casualties differs across Europe and the DSS aims to allow for cost-benefit analyses at a national level, the E3-calculator database contains information about **the costs of accidents and casualties of different severity from all European countries** (see Wijnen et al., 2017 for more information).

For the measures, the E3 calculator first requires **information about the effectiveness of a measure** in terms of the number of (targeted) accidents and resulting casualties prevented for four levels of severity: fatal, serious, slight, and damage-only. The E3 calculator also requires **information about the costs of a measure.** Here a distinction is made between the initial development and implementation costs and annual maintenance costs. Hence, the time horizon of the measure is also important. Based on this information, the E3 calculator compares the value of all benefits and all costs for each year within the time horizon of the measure, resulting into the following outputs:

- Number of accidents / casualties prevented (per unit of implementation)
- Cost effectiveness: cost per prevented accident / casualty for different severities:
  - per prevented fatality / fatal accident
  - per prevented severe injury / severe accident
  - per prevented slight injury / light accident
  - per prevented damage-only accident
- Total benefits
- Benefit-cost ratio (benefits/costs)
- Net effect (benefits – costs)

Figure 4.3 schematically shows the required input for as well as the output of the E3 calculator.

If no measure costs are entered, the break-even costs are calculated. This shows the costs of a measure assuming a benefit-cost ratio of 1. In other words, the break-even costs indicate how much a measure could maximally cost to still be cost-effective.

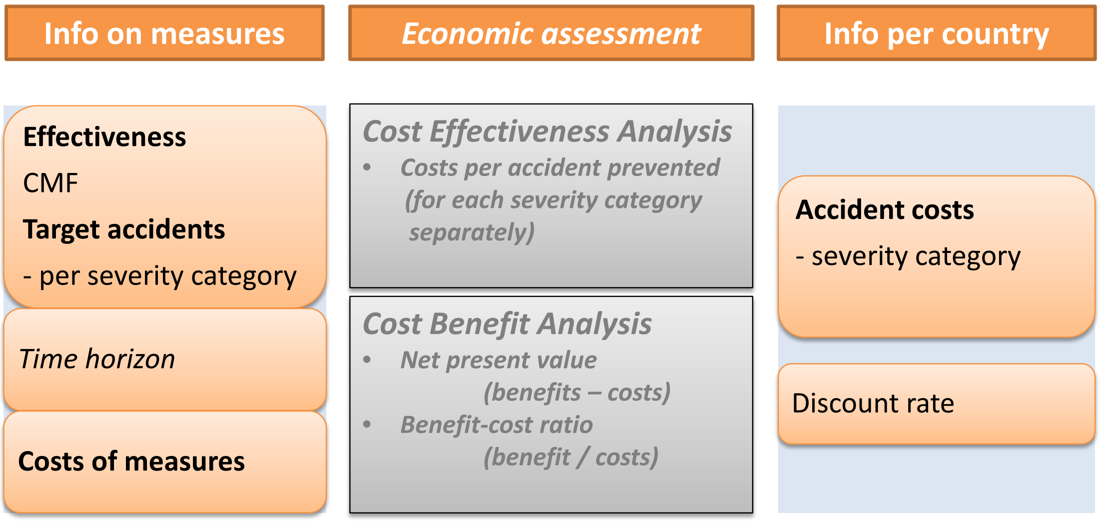


Figure 4.3. Economic Efficiency Evaluation (E3) calculator

Since both the information on the safety effects of a measure and its costs are uncertain, the E3 calculator provides the option to carry out a sensitivity analysis, giving a range of cost effectiveness and cost benefits under different cost and effectiveness scenarios.

By default the E3 calculations will be conducted for the country from which effectiveness and cost results are obtained. From there it is possible to transfer the results to any other European country or to the European average. It is also possible to use the calculator for additional analyses, e.g. by change the used values, e.g., of the measure cost estimates.

For each measure in the DSS that was classified as effective and for which a quantitative estimate of the effectiveness was available, an economic efficiency evaluation was performed using an Excel version of the E3 Calculator. The results are summarised in a two-page CBA synopsis document, linked to the measure in the DSS and are also available as examples in the E3 tool of the DSS.

4.5 ACCIDENT SCENARIOS ANALYSES

Clustering individual accidents that have a sufficient degree of similarity is common in the automotive industry. This is because accidental situations are often used as input to simulation tools, e.g. in order to assess the effectiveness of active safety systems in early design stages. A good example is Lane Departure Warning systems that are designed to prevent lane departures, in a way "regardless" of whether the lane departure is due to driver fatigue, or insufficient skills, or alcohol impairment. Relevant clustering allows to reduce the simulation effort without any loss of representativeness. Using clustering also helps in-depth accident investigation groups (research or investigators) in assessing individual accidents in terms of consequences or associated countermeasures. The resulting groups or clusters are called **scenarios**. As an example, they were used to define future regulations (e.g. GSR phase 2) or EuroNCap new protocols (e.g. AEB pedestrian).

It is important to understand that the clustering criteria do depend on the initial research question and can include a mix of infrastructure, road user and vehicle-related elements, so as to reach exhaustiveness (all accidents belong to at least one scenario). A noteworthy fact is that clusters have a hierarchy - in order to avoid double-membership (no accident can belong to two scenarios) – and a granularity of their own, the latter also depending on available characteristics of the accident samples. One additional advantage of scenario hierarchy is that it allows to deal with missing data. Individual accidents for which the relevant scenario cannot be selected at a low (detailed) level – out of missing information - will be classified at a higher (less-detailed) level, if possible. Levels 1 and (often) 2 of scenario hierarchy are thus chosen to be very generic.

This is why scenarios did not fit in any of the categories of the original Safety Cube approach and accident scenarios or categories were given special attention during the DSS development.

There are two main ways to build scenarios. One uses fully or partially automated **statistical clustering tools** (data clustering, K-means, Kohonen, hierarchical ascending classification, etc.).The other is based on **expert classification**.

Statistical methods require a set of markers (variables) selected to be the most relevant in view of the research question. This selection process can also make use of statistic methods (e.g. logistic regression) either by expertise or by a mixed method.The main difficulty in the use of these methods lies in the interpretation of the resulting clusters. Combinations of selection variables often result in clusters that are difficult to understand from a physical perspective – thus making the assessment of relevant countermeasures more complicated.

Expert classification method is the most often used method, to this day. It is based on a good interpretation of the research question but also on an excellent knowledge of the potential of the available data. The interpretation of each class is easier than in the statistic method because clustering is based on human opinion. The main difficulty in the use of these methods lies precisely in that: human are prone to errors, their opinions may be biased and they may oversee connections between accident situations, that a systematic statistic approach would have detected.

The "ideal" method appears to be a **combination of both approaches**. This has yet to be found and standardized, although attempts have been made to that effect. One of the aspects to be dealt with concerns the level of detail that should be used to define scenarios: should for instance traffic intensity, road coating or markings be incorporated in the selection criteria? This issue has yet to be addressed by researchers.

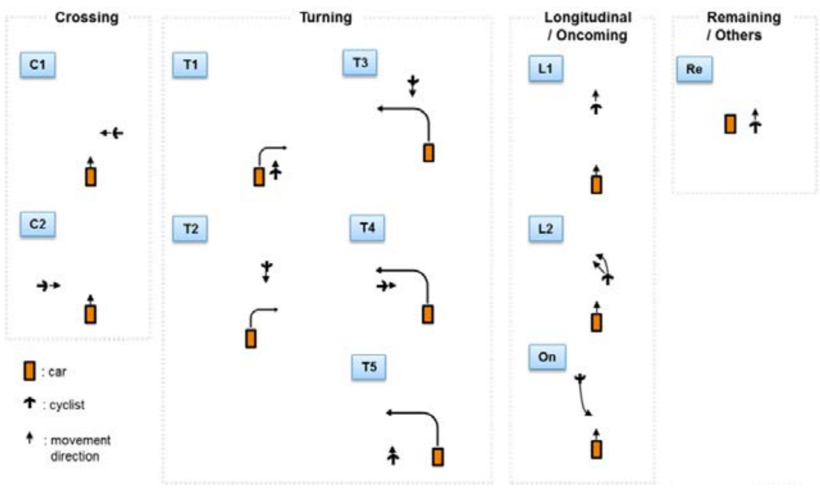


Figure 4.4. Scenarios used in the CATS project

One last aspect worth mentioning is that scenarios can be used in two ways. In a top-down approach, we can identify the main road safety issues, even those that no known safety measure can address at the time of study. In a bottom-up approach, we can identify the potential of existing safety systems, including all their limitations into the assessment.

4.5.1 Linking risks and measures with Accident Scenarios

Within SafetyCube, a hierarchical **taxonomy of accident scenarios** was developed by a dedicated group of partners (see Appendix 2), using the same structure as in risk factors and measures taxonomies. This allowed the identification of eight primary accident categories:

- Pedestrian Accident
- Bicyclist Accident
- Single Vehicle Accident
- Head-On Collision / On-Coming Traffic
- Rear-End Colllision / Same Direction Traffic
- Junction Accident (No Turning)
- Junction Accident (Turning)
- Railway Crossing

Several sub-categories were also considered within each scenario, corresponding to the different pre-crash configurations. For example, the Pedestrian Accident scenario has been divided into 9 sub-scenarios:

- pedestrian crossing road out of crossing path
- pedestrian crossing road on crossing path at straight stretch
- pedestrian crossing road in front of junction
- pedestrian crossing road behind junction
- pedestrian moving along the road
- vehicle reversing
- pedestrian sitting or lying on the ground
- pedestrian – changing mode (e.g. driver getting off the car)
- other pedestrian configuration

It is noteworthy that this hierarchy doesn't take the initial situation or factors having caused this kind of accident into account, but rely on the configuration prevailing prior to crash.

In order to integrate Accident Categories in the SafetyCube DSS, a **linking of risk factors and measures with each accident category** was carried out. This was based on the SafetyCube model for linking different measures with different types of risk factors along an accident chain, and with related outcomes corresponding to different crash types, as described in section 4.3. The linking was finalised based on feedback and suggested adjustments from experts in accident scenario analysis among the SafetyCube partners. This linking allowed for a separate entry point of the DSS to be developed, leading the user to select the scenario of interest and browse the related risks and measures, as is shown in section 5.3. The full list of links between accident categories with the SafetyCube risks and measures is provided in Appendix 3.

4.5.2 Accident Scenario Synopses

In addition to the above, a set of synopses in fact-sheet form were developed with key data and information concerning each one of the eight key accident scenarios. These synthesize macroscopic and in-depth crash data, to provide a complete picture of the causes and impacts of main crash categories. Each Synopsis includes detailed data on the crash frequency and severity related to the accident scenario in different countries, the crash and injury characteristics, and the pre-accident configurations for different sub-scenarios.

These include the following sections:

- **Definition**: The scenario is defined in terms of the crashes / casualties concerned
- **Data sources**: The databases used to retrieve the data and statistics of the scenario are outlined, together with any related disclaimers or limitations (e.g. representativeness, coverage, etc)
- **Overal figures**: Global (e.g. WHO), European (e.g. CARE) and national figures or graphs regarding the mortality related to each scenario are provided, together with estimates of the prevalence / share of crashes or casualties related to the scenario compared to other scenarios. Basic figures or graphs per vehicle type, injury type etc. are also presented.
- **Scenario in details**: A more detailed analysis of data concerning the sub-scenarios are provided, on the basis of in-depth accident investigation databases available in each case. Particular emphasis of given here on the pre-crash configurations.

The Accident Scenario Synopses are available in the Knowledge section of the DSS.

4.5.3 Scenario transferability

If anything, scenarios are **not easily transferable** from a country to another, be it in content or in frequency. For example, rear-end collisions are much more frequent in the United States, Japan or Germany than they are in France. PTW intense traffic generates accident situations in e.g. Vietnam or China that are virtually unknown in the rest of the world. The city traffic in India has many specific features (animals, three-wheelers etc.). In other words, scenario-related statistics (frequency, severity etc.) have to be estimated for each country, in order to take into account local aspects (behaviour, driving style, etc.) and can hardly be transferred. In the DSS, scenarios are based on the situation in France, as an example only.

4.6 SERIOUS INJURIES

Serious road injuries are increasingly used as an additional road safety performance indicator. Reducing the number of serious traffic injuries is for example one of the key priorities in the road safety programme 2011-2020 of the European Commission (EC, 2010). In June 2017, **the EU Transport Ministers have agreed to set a target of halving the number of serious injuries on EU roads between 2020 and 2030** (ETSC, 2017). This is a good and necessary development as serious road injuries result in huge economic and immaterial costs, and serious road injuries show less desirable trends than fatalities in many countries (e.g. OECD/ITF, 2011).

As it is a relatively new indicator, information on the number, impacts and relevant risk factors related to serious road injuries is quite scarce. Therefore, one of the Work Packages of the SafetyCube project was dedicated to serious road injuries. The key results of the activities within this Work Package are included in the *Knowledge* section of the DSS. The Knowledge section contains information on:

- How to estimate the number of serious road injuries

- Impacts and costs of serious road injuries
- Risk factors related to serious road injuries

These topics are discussed in more detail below.

It should be noted that the DSS barely contains information on the magnitude of a risk factor or the effectiveness of a measure specifically for serious road injuries. The main reason is that available studies often do not report a separate effect for serious road injuries. Some studies make a distinction between fatal accidents and injury accidents, but serious (non-fatal) injuries are often not distinguished as a separate group. Moreover, definitions of a serious road injury differ between studies, and studies are mostly based on police reported crashes, whereas serious injury crashes are known to be underreported by the police (e.g. Watson et al., 2015).

4.6.1 Information on how to estimate the number of serious road injuries

Since 2013, the official EU definition of a serious road injury is a non-fatal road traffic casualties with an injury severity level of MAIS3+. This definition was established by the High Level Group on Road Safety, in which all EU Member States are represented. Moreover, The High Level Group identified three main ways Member States can arrive at data on serious road injuries:

1) by applying a correction on police data,
2) by using hospital data and
3) by using linked police and hospital data.

Within SafetyCube, for each of these three ways, practical guidelines have been developed to help countries determining the number of MAIS3+ road casualties. Moreover, it was examined how comparable data from different methods are, and how differences in data availability affect the results. The Knowledge section of the DSS contains a 4-page summary of these guidelines. For the full guidelines, please see Perez et al. (2016).

4.6.2 Information on (health) impacts and costs of serious road injuries

It is clear that non-fatal serious injuries can have a major impact on the quality of personal, social and working life of a crash survivor as well as on the quality of life of their relatives. Besides these individual consequences, road traffic injuries also pose a burden to society and result in considerable societal costs. Within SafetyCube, physical and psychological consequences of non-fatal road traffic injuries were investigated by means of a literature review and analysis of additional data and studies that the SafetyCube partners had access to. Moreover, the burden of injury, expressed in Years Lived with Disability (YLD), was calculated for a number of countries. The costs related to serious road injuries were analysed by means of a survey among European countries that was developed and distributed in a joint effort with the InDeV project (indev-project.eu).

The Knowledge section of the DSS provides a summary of the main findings concerning the impacts and costs related to serious road injuries. More information on the impacts of serious road traffic injuries can be found in Weijermars et al (2016). For more information on costs related to serious road injuries, please see Schoeters et al. (2017).

4.6.3 Information on risk factors related to serious road injuries

To a certain extent, serious road injuries could be prevented by similar measures as fatalities. However, it is also conceivable that crashes resulting in serious injury differ in their characteristics from fatal crashes and/or are influenced by other contributing factors and injury mechanisms. This could also explain the fact that in many countries serious road injuries show a less positive trend than fatalities. Additionally, road safety policy setting should also be aimed at reducing long term heath impacts. To be able to develop the appropriate countermeasures, it is important to understand which contributing factors and injury mechanisms are relevant for crashes with serious road injuries.

Within SafetyCube, groups of casualties of special relevance concerning MAIS3+ injuries were determined along with the crash relevant contributory factors and injury mechanisms relevant for them. The Knowledge section of the DSS presents the main findings from these analyses, more detailed results can be found in Reed et al. (2017). Reed et al. (2017) also provide an overview table in which the identified contributing factors for the specific groups or MAIS3+ casualties were linked to measures included in the DSS. The links were based on a search in the DSS on specific risk factors in relation to the general group of casualties (e.g. cyclists). The overview table is also displayed in Appendix 3.

4.7 QUALITY ASSURANCE PROCESSES

The scientific quality of contents of the Road Safety DSS has been a top priority during the development phases. Strict quality assurance procedures were put in place, comprising **four steps**:

1. Comprehensive guidelines, supported by workshops, webinars, Q&A sessions, and a help desk assisted the expert SafetyCube researchers with their work (*Paragraph 4.6.1*).
2. The selection and coding of studies, as well as the analyses and synopses of the findings, were peer reviewed within the project (*Paragraph 4.6.2*).
3. A small pool of independent experts checked both the information about individual coded studies and the overall contents of the synopses, applying a set of predefined quality criteria and procedures. One expert specifically looked at consistency within and between synopses (*Paragraph 4.6.3*).
4. All synopses went through a language check by a native English speaker.

4.7.1 Guidelines

The guidelines (Elvik et al., 2015; Martenssen & Lassarre, 2018) cover all aspects related to selecting, coding, analysing and describing the relevant information about the identified risk factors and countermeasures.

- In order to ensure a systematic and transparent procedure for including studies in the DSS, the guidelines provide concrete instructions for identifying potentially relevant studies and prioritising them for coding.
- Coding and interpreting the study results correctly requires a good understanding of how exactly the studies were conducted. The guidelines present a taxonomy of study designs, and discuss the main features of the different designs, including potential biases and flaws.
- Analysing and integrating the findings from different studies can be done in different ways, ranging from a merely descriptive approach to advanced statistical analyses. The guidelines describe several options and specify the related criteria and conditions.

- The main results and conclusions are summarised in a synopsis. The guidelines describe the required structure of a synopsis, its lay-out and approximate length of the various sections.

4.7.2 Internal peer review

SafetyCube experts have been appointed to coordinate the development of the DSS work, distinguishing between the areas 'behaviour, 'infrastructure, 'vehicle', and 'post impact care'. These coordinators, assisted by technical DSS developers, performed an initial check and peer review of the study coding and synopses in their area to see if they fulfilled the main requirements concerning structure, lay-out as well as the contents.

4.7.3 Independent expert reviews

A Quality Assurance Committee, consisting of eight Senior Experts from the SafetyCube partner institutes, guided and coordinated a subsequent Independent Expert review of all synopses. The main aim of this stage was to detect obvious errors or omissions in the messages and conclusions of the synopses. Synopses were assigned to a limited number of Senior Researchers with proven expertise in the relevant area. These reviewers focused on (see *Appendix 4* for the detailed review checklist):

- The selection and prioritising of studies for coding, including the search terms that were used, the database(s) that were checked, and the transparency of the study selection.
- The contents of the 2-page synopsis summary, for example whether the abstract covered the most relevant findings, whether the reported results were valid and logical, and whether the summary sufficiently reflected the current state of knowledge.

If needed, as so decided by the QA Committee, a more thorough review was carried out and/or the original author(s) was/were asked to improve the synopsis. Finally, for all synopses the abstract and the overall conclusion - as expressed in the assigned colour code - were checked by one and the same expert in order to ensure readability as well as consistency of information within and between synopses.

The review of the coded studies concerned a scan of the DSS output for each of the (~1300) eventually coded studies (for the Checklist see *Appendix 3*). This review was executed by a pool of nine experienced coders. For studies that looked problematic, the reviewer opened the excel template to see whether the problem could easily be fixed. In case the problem could not be fixed by the reviewer, the coding template was sent back to the coder with a description of the problem and the coder was asked to solve the problem. Technical issues were reported back to the developers of the DSS.

5 Development of the Decision Support System

The DSS was developed on the basis of a simple yet robust design, allowing to accommodate and make searchable the wealth of results produced during the project, in a flexible, efficient and user-friendly way. In the following, a full demonstration of the front-end system and related user interface is carried out, including all the search options and related outputs.

5.1 OVERVIEW OF DSS ENTRY POINTS AND NAVIGATION PATHS

As described in Chapter 3, the SafetyCube DSS Search (i.e. the dynamic part of the system) is structured in three operational levels: Level 1 - Search Pages; Level 2 - Results Pages; and Level 3 - Individual study pages. These are reachable through five entry points (keywords, risk factors, measures, road user groups, accident categories). More specifically, Level 1 consists of all the alternative search methods which the user may want to use, based on five possible entry points.

The entry points of the search and navigation paths after a search topic (query) is selected by the user are shown schematically on Figure 5.1. The Figure also serves as a map for linking the components that will be analysed throughout this chapter. It should be highlighted that users can naviagate back and forth between Levels freely, but not within a single Level. For instance, if a user is on a specific Level 2 - Results Page, they would need to return to a Level 1 - Search Page to reach a different Level 2 - Results Page.

The philosophy and overview of this search is as follows:

- **Keyword search:** the system will let the user type in a keyword in free text and – as they type – will show all potential matches with **master keywords** in the database. Once a keyword is entered (or selected from the dynamic pop-up list), the system will respond with the related subsets of risk and measure taxonomies for further selection.
- **Risk factors:** the user may search for a crash risk factor through the SafetyCube taxonomy
- **Measures:** the user may search for a road safety measure through the SafetyCube taxonomy
- **Road user groups:** if the user wishes to inquire about risks or measures specifically related to a particular road user group, he/she may enter the DSS via the road user groups' entry point. As with keyword search, the system will respond with the adequate subsets of risk and measure taxonomies – in relation to that road user group – for further selection.
- **Accident categories:** if the user wishes to inquire about risks or measures specifically related to a specific accident category.

Figure 5.1: Overview of the DSS Search structure and sequence of pages

5.2 DSS KEYWORD PROCESSING

5.2.1 The Role of Keywords

The SafetyCube database includes thousands of keywords keywords from the studies coded. These keywords include terms at an even finer level of detail than the SafetyCube taxonomies, as the related coded studies may concern very specific road safety questions, analysis conditions etc. It was therefore important to exploit this wealth of information and make it easily available to the DSS users.

A dedicated search method was therefore designed and implemented, to allow the DSS users to directly find very specific information, without necessarily going through the taxonomy hierarchy. The **need to allow the users to search through the DSS contextually** was therefore a deciding factor for the SafetyCube keywords processing. This is particularly relevant also for non-expert users, who might be less familiar with the distinctions made within the SafetyCube taxonomy, for instance. This is largely in accordance with the related functionality of many popular search engines, databases or repositories in various fields, where "search by keyword" is applied.

The keywords function of the DSS was designed to allow a free text entry in a provided field, which will return the relevant matches with keywords in the DSS database. The users can then select one of the relevant DSS keywords and obtain the respective results for different topics of risk factors and/or road safety measures.

The keyword search is therefore meant to serve as a shortcut to even more specific results than those of the SafetyCube taxonomy, or to horizontal issues for which results may be present at different topics of the SafetyCube taxonomy. For example, "children" is a horizontal topic, for which results can be found at the "behaviour" (e.g. age), "infrastructure" (e.g. school zones) or "vehicle" (e.g. child restraint systems) taxonomies. Moreover, a user may be interested in the "child booster seats" specific restraint system; in principle, the taxonomy does not lead to this level of detail, but the functionality of being able to search directly for "child seats" may guide the user to related coded studies under "restraint systems", "campaigns", "enforcement" etc.

5.2.2 Keyword Assortment and Processing

In its initial form, the DSS database contains thousands of keywords from the coded studies, however not all of them useful. There were words that were synonyms (eg. "drunk driving", "drink driving", "driving while intoxicated", "driving under the influence" etc.) or had identical meanings (eg. "work zone" and "work-zones") or even words that were irrelevant to a road safety DSS (eg. "review").

It was thus essential to process the initial, 'raw' database of keywords and assort them so that a smaller number of 'master' keywords were available for presentation to the users. To define the DSS 'master keywords' (i.e. the list of meaningful keywords to be searchable by DSS users), the following process was followed:

- Following study coding, the predefined coding templates were uploaded into the DSS. Thus the list of all initial, 'raw' keywords was obtained from the corresponding fields of the templates.
- The 'raw' keyword list was assorted and its keywords were identified either as useful or as irrelevant ("junk").

- The useful database keywords list was initially compared with the SafetyCube taxonomy terms, and database keywords directly corresponding to a taxonomy term were identified. In this case, the taxconomy term was considered a master keyword.
- For the other useful keyword, the main corresponding master keywords and their main synonyms were identified. Decisions on which keywords best represent their group of terms were made.
- The unified list was filtered one last time, to merge any remaining synonyms, to correct any errors (typos or misspellings) etc.
- This led to the finalisation of **a Master Keywords list, linked with the database keywords list** on the basis of a one-to-many relationship.
- Keywords irrelevant to road safety were discarded and do not appear in the DSS searches.

The above process was undertaken initially in a mid-term stage for keywords from risk factors only, and at a latter stage for all studies, both from risk factors and road safety measures. The database keywords processing and the included sets, as well as their linkage to master keywords are shown schematically in Figure 5.2.

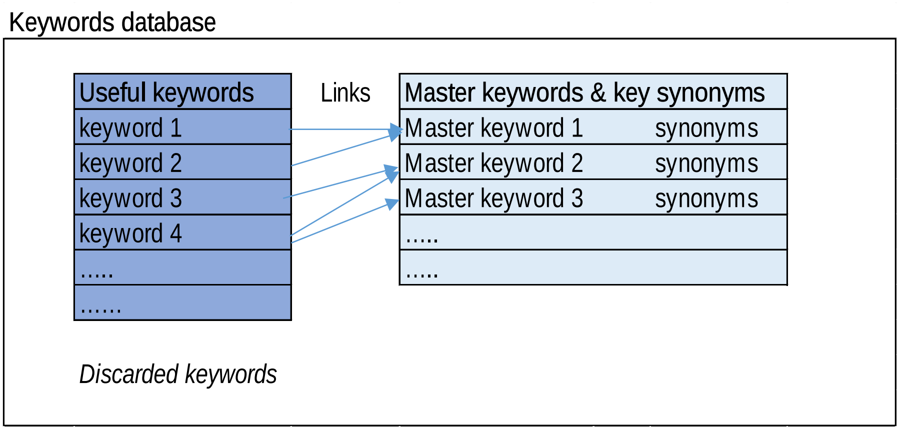


Figure 5.2: Database keywords processing and linking to a master keywords list

For example, in Table 5.1 the matching of database keywords with master keywords and main synonyms is demonstrated for a part of keywords related to alcohol. The database keywords are presented in alphabetical order. It can be seen that a whole set of database keywords concern Alcohol, which is the main master keyword here. Additional master keywords related to all the alcohol-related database keywords are "drinking and driving", "driving under the influence", "DUI" and "impaired driving". This actually means that by searching with any of these five master keywords, the user will be guided to the results corresponding to these database keywords concerning alcohol.

It can be also noted that there are three database keywords concerning alcohol interlock; these are all linked to the following master keywords: "Alcohol Interlock", "Interlock", "Ignition Lock", "Rehabilitation", meaning again that the four master keywords is what will be searchable by DSS users, but the same results will be provided.

Finally, at the last row of the Table, it can be seen that the subsequent database keyword "Algorithms" was not considered useful for DSS users, and was therefore discarded (i.e. it is not linked to any master keyword).

Table 5.1. Extract of the linked database keywords with master keywords and synonyms

Database keywords	Master keywords				
ALCOHOL	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOHOL ABUSE	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOHOL AND TRAFFIC	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOHOL CONSUMPTION	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOHOL INTERLOCK	ALCOHOL INTERLOCK	INTERLOCK	IGNITION LOCK	REHABILITA TION	
ALCOHOL INTOXICATION	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOHOL INVOLED CRASHES	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOHOL POLICIES	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOHOL RELATED CRASHES	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOHOL-IMPAIRED DRIVING	ALCOHOL	DRINKING AND DRIVING	DRIVING UNDER THE INFLUENCE	DUI	IMPAIRED DRIVING
ALCOLOCK	ALCOHOL INTERLOCK	INTERLOCK	IGNITION LOCK	REHABILITA TION	
ALCOLOCK-INTERLOCK	ALCOHOL INTERLOCK	INTERLOCK	IGNITION LOCK	REHABILITA TION	
ALCOLOCKS/IGNITION INTERLOCKS	ALCOHOL INTERLOCK	INTERLOCK	IGNITION LOCK	REHABILITA TION	
ALGORITHMS					

The list of searchable DSS master keywords is provided in Appendix 5.

5.3 DSS SEARCH PAGES

As also shown in Figure 5.1, the entire Search component of the SafetyCube DSS is based **on two interlinked pillars**: Risk Factors and Road Safety Measures. In fact, all entry points at Level 1 (Search Pages) eventually lead to a selection of risk factors or measures of interest, and only by selecting one does the user retrieve the results at Level 2 (Results Pages) and from there potentially to Level 3 (Individual study pages).

5.3.1 Option 1: Keyword search

Following the process described in section 5.2.2, the users have the capability of searching for their topic of interest via keywords. Upon selecting "Keyword Search" the system will let the user type in a keyword in free text and will show in auto-complete form all potential matches in the database master keywords (as shown in Figure 5.3). Once a keyword is entered (or selected from the dynamic auto-complete list), the system will respond with adequate subsets of risk and measure taxonomies for further selection. These taxonomies are identified through a bottom-up approach: the master keyword leads to the respective database keywords, from which the related studies are identified, and subsequently the taxonomies to which these studies correspond (ie the risk or measure topic for which they have been coded) are retrieved.

It is underlined that the results corresponding to synonyms of the typed keyword will also appear e.g. either one types "elderly" or "seniors", both terms will lead to the exact same search results. Selecting one of the two taxonomy entries (risk factors or measures) will take the user further to the respective results page. In this case, only the studies including the specific keyword will be retrieved for each risk factor or measure (and not all the studies available for the risk factor or measure).

It should be kept in mind that the Keyword Search returns the lists of risk factors and measures taxonomy topics, in which the selected keyword *is found among the original keywords of one or more of the studies* coded under each topic. If the specific keyword is not found among the keywords of any of the studies coded under a taxonomy topic, the taxonomy topic will not appear in the results (although in theory the topic may be related to the selected keyword).

Figure 5.3: Keyword Search example: Already as the word "pedestrians" was only partly typed in ("ped"), the system suggested various potential matches in the database; "PEDESTRIANS" was then selected from the list of suggestions.

5.3.2 Options 2 & 3: Searching for Risk Factors and Measures

Another entry point which can be selected is "Risk Factors", the SafetyCube taxonomy of crash risks will open, sorted by the domains "Road User", "Infrastructure" and "Vehicle" (as shown in Figure 5.4). Similarly, if the entry point "Road Safety Measures" were selected, the

SafetyCube taxonomy of road safety measures would appear, including, in addition to the three domains, a fourth domain on "Post Impact Care" (as shown in Figure 5.5). Selecting one of the taxonomy entries will take the user further to the respective results page (Results Pages are described in section 5.4).

Figure 5.4: Risk Factors Search example: the SafetyCube taxonomy of crash risks on the DSS, with the three available pillars of "Behavior", "Infrastructure" and "Vehicle".

Figure 5.5. Measures Search example: the SafetyCube taxonomy of road safety measures on the DSS, with the previous three pillars plus "Post Impact Care".

5.3.3 Option 4: Searching for Road User Groups

In addition to the previous, there is also the option to use a "Road User Groups" as an entry point, as shown in Figure 5.6. This is essentially a focused keyword search, and can serve as a shortcut to the results concerning risks factors or measures specifically related to a Road

User Group. This function can be particularly useful when a stakeholder intends to design or intervene in an area with a particular group in mind, e.g. cyclists.

Figure 5.6. Road User Group Search example: By choosing 'pedestrian' from the list, the system responds with SafetyCube taxonomies on risk factors & measures specific to pedestrians.

The system similarly responds with appropriate subsets of risk and measure taxonomies – in relation to that road user group – for further selection. Selecting one of the two taxonomy entries will lead to the respective results page (described in in section 5.4). The results, as in the case of the "keyword" search, include only the studies concerning the specific road user group (and not all the studies available for this risk or measure).

The available road user groups are the following:

- Cyclists
- LGV / Van
- Bus
- Pedestrians
- HGV / Truck
- PTW
- Passenger Car

5.3.4 Option 5: Searching for Accident Categories

The final search option consists of searching for Accident Categories, as shown in Figure 5.7. This is somewhat similar to the previous option, in that it constitutes a shortcut for crash risks or road safety measures pertinent to a specific accident category. The system will then respond with adequate subsets of risk and measure taxonomies (see Appendix 3) – in relation to that accident category – for further selection. Selecting one of the two taxonomy entries will take the user further to the respective results page (described in section 5.4).

Figure 5.7: Road User Group Search example: By choosing 'pedestrian' from the list, the system responds with SafetyCube taxonomies on risk factors & measures specific to pedestrians.

The available accident categories are the following:

- Pedestrian Accident
- Bicyclist Accident
- Single Vehicle Accident
- Head-on Collision / On-coming Traffic
- Read-end Collision / Same Direction Traffic
- Junction Accident (No Turning)
- Junction Accident (Turning)
- Railway Crossing

5.4 DSS RESULTS PAGE

5.4.1 Results Page

After utilizing one of the five entry points, the user is led to a Results Page which corresponds to the search terms they provided as input. These pages have several components, which include (see Figure 5.8):

- Short introductory texts and the colour code(s) from the analyses of one or more available SafetyCube synopses, describing the magnitude risks or the effectiveness of measures
- Links to one or more available SafetyCube synopses on the issue (pdf link button(s) next to the colour code)
- A table listing the available meta-analyses and other coded studies in the SafetyCube database together with their main characteristics such as title and source, design, country, and year of publication. Selecting a study from the Table will lead the user to the individual study page (described in section 5.5)
- Depending on the selected domain, adaptive search filters are available on the left side of the results page. Filters include: keyword, specific risk factor (corresponding to the most detailed taxonomy level), road user group, road type, country. The keyword filter appears only when entering from the "keyword" or "road user group" entry point, and allows the user to "un-filter" the results and obtain all the studies related to the risk factor or measure (and not only those related to the keyword or road user group).
- A button which links to related measures (if the results page is in the risks domain) or to related risk factors (if the results page is in the measures domain).

An example Results Page for the risk factor of "work zones" is provided in Figure 5.8. Two color codes from related synopses (red from "Presence of workzones-Workzone length" and yellow from "Presence of workzones-Workzone duration"), amongst all other features, can be observed.

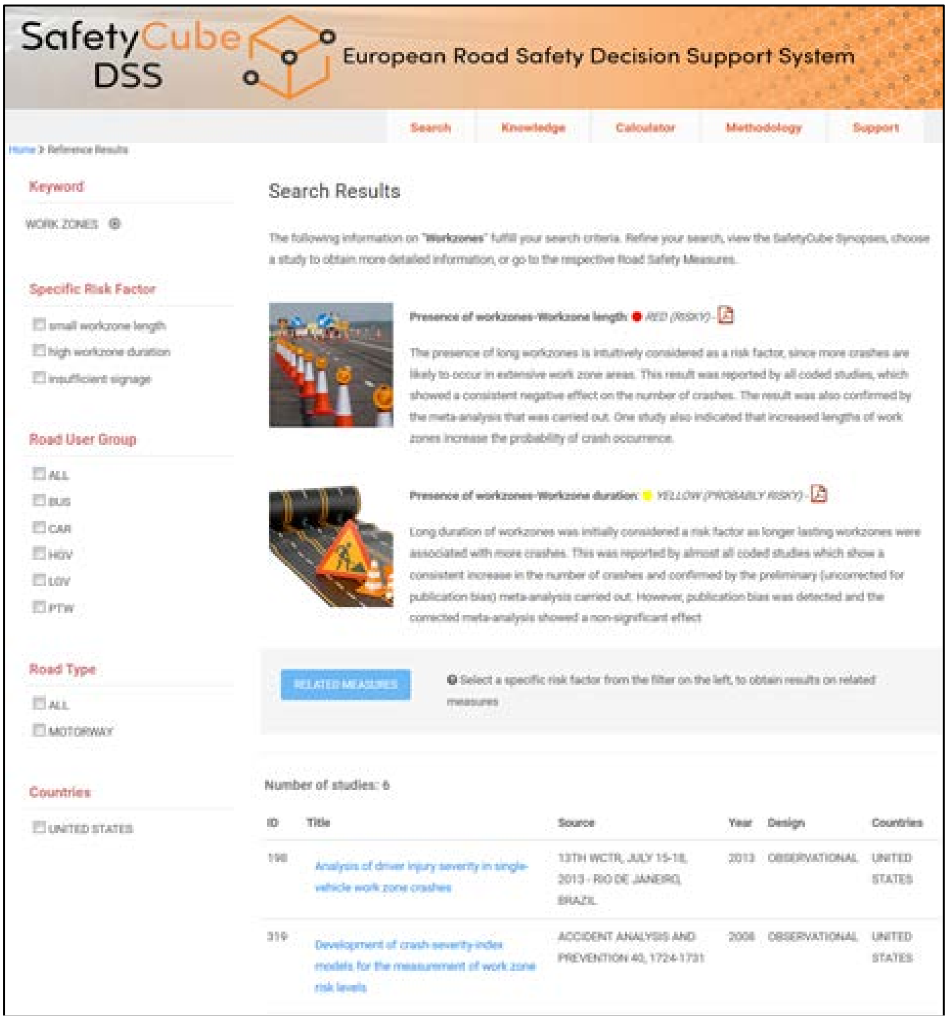


Figure 5.8: The Results Page of risk factor "work zones" (entered through the keywords entry point)

5.4.2 Related Risk Factors / Measures

With regards to the related risk factors / measures function, considerable and systematic effort has been made for the appropriate linking of risk factors and road safety measures as explained in section 4.5. This feature is important in order to assist DSS users in:
(a) learning which risks can be remedied by which types of measures and
(b) learning which types of risks will be reduced by a particular measure.

The "related risk factors / measures" button is activated only once a "Specific Risk Factor" or a "Specific Measure" is selected from the adaptive search filters on the Results Page on the left. Selecting one related risk factor / measure from the list will cause a table listing the available synopses and studies in the SafetyCube database for the related risk factor / measure to appear. Adaptive search filters are also available on the left side. Then, selecting an entry of the table will lead the user to the individual study page (section 5.5).

An example is presented in Figure 5.9. Initially, "Distraction and inattention" was selected as a general risk factor topic. Then "Distraction within vehicle or within the riding or walking situation" was selected as a specific risk factor. When using the "related risk factors / measures" button, the system provides several related measures from the SafetyCube taxonomies. The results for each measure appear after selecting it; in the example "Installation of median" was selected.

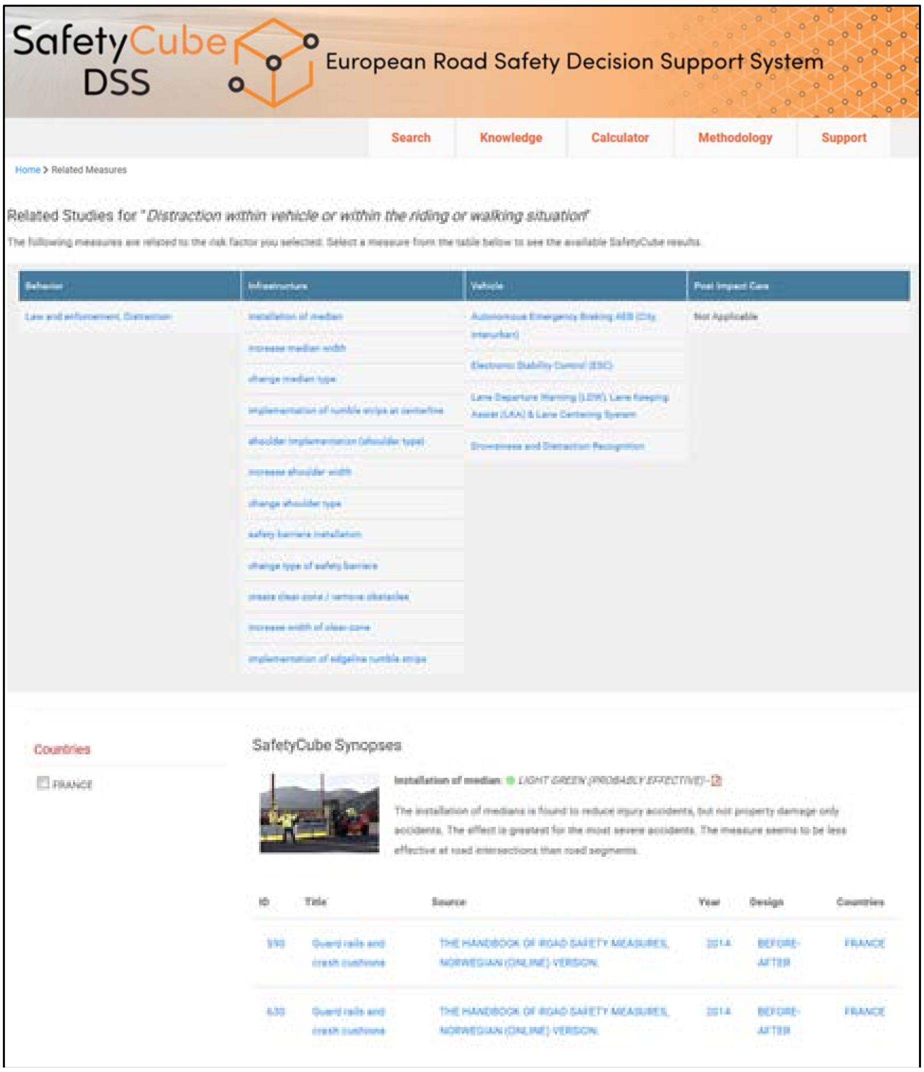


Figure 5.9: Example of the Related Risk Factors / Measures Function: related measures for "Distraction within vehicle or within the riding or walking situation", selection: "Installation of median"

5.4.3 Synopses

Within the SafetyCube project, a number of synopses were developed for risk factors and road safety measures, as explained in section 4.1.4. Each synopsis provides both a comprehensive analysis of scientific evidence of the examined topic and a concise manner to present said evidence to a wide range of users with various backgrounds and professions.

An example Synopsis Page for the risk factor of "work zone duration" is provided in Figure 5.10.

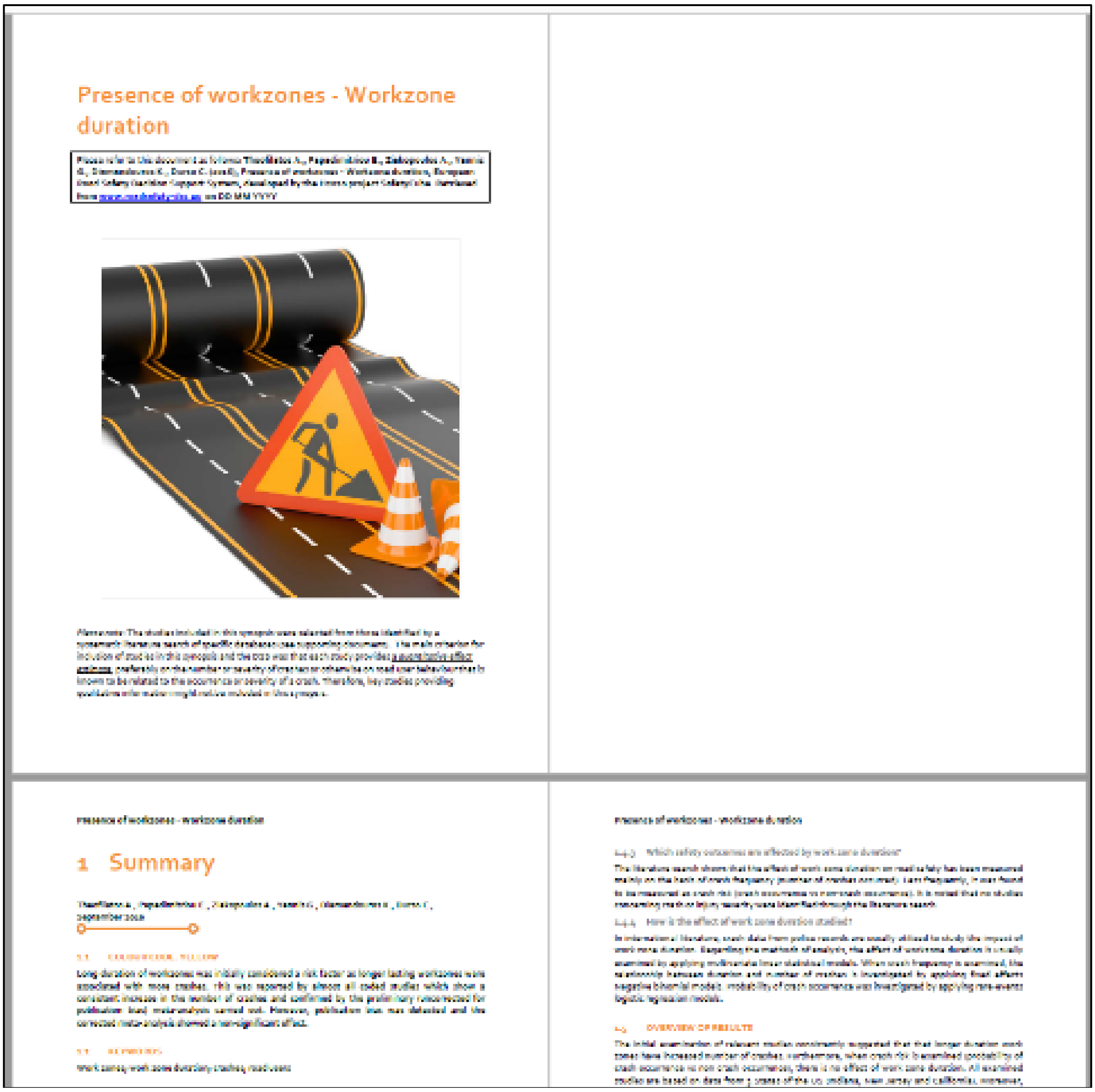


Figure 5.10: Indicative screenshot of the Synopsis file of risk factor "Presence of workzones-Workzone duration"

It is noted that not all synopses include information for all road user groups, and therefore these may not appear when entering from the “keyword” or “road user group” entry point. On the other hand, some synopses include separate information for different road user groups, and / or a different colour code for different road user groups, if applicable. All the Synopses produced are also listed and available for download via the Knowledge tab of the SafetyCube DSS (see section 5.7.1).

5.5 DSS INDIVIDUAL STUDY PAGE

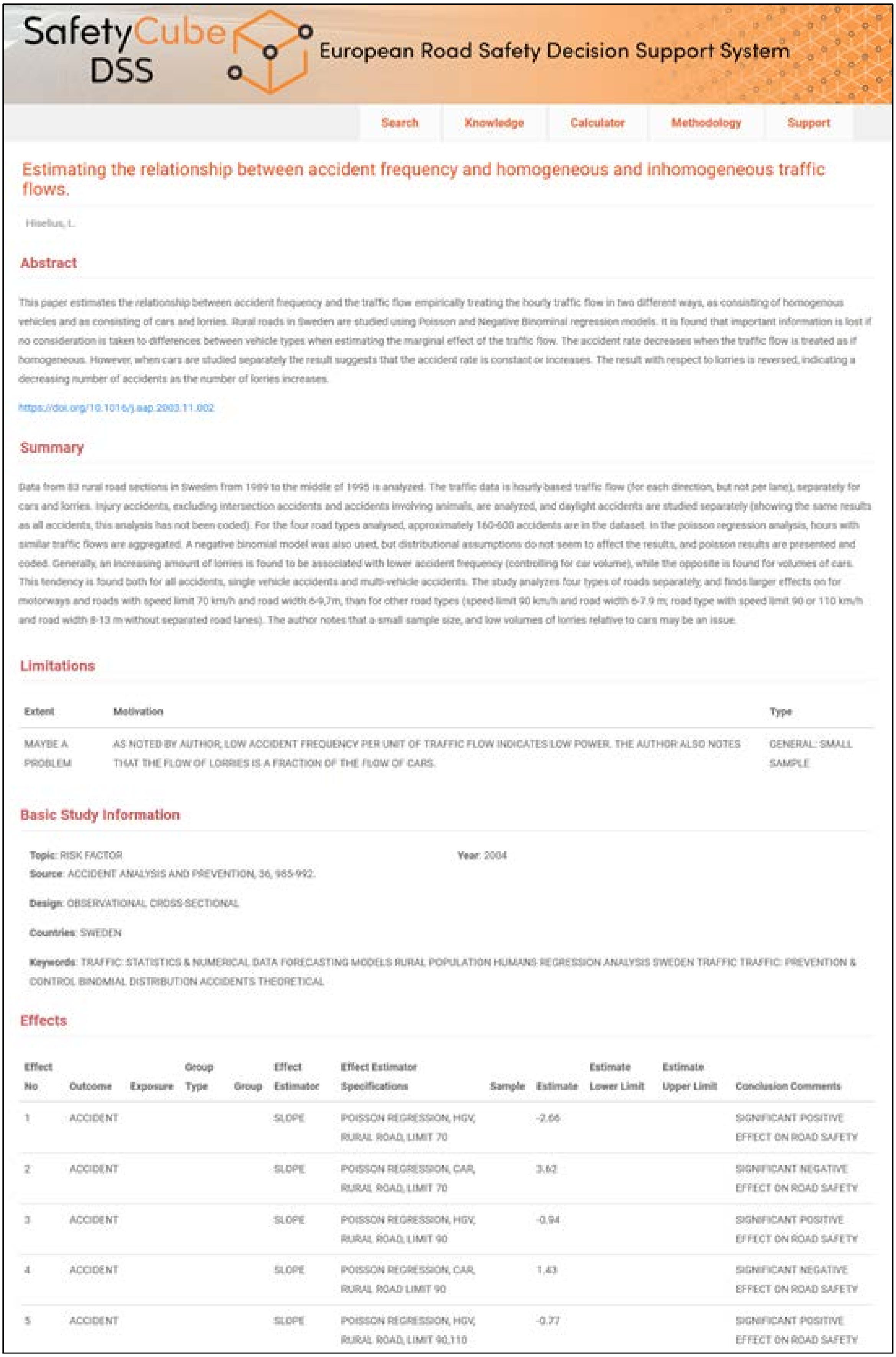
When a user wants to access evidence at a more disaggregate level, the usual path is to seek the details of individual studies. Another important issue is that some studies are not included in a corresponding synopses. This occurs due to a lack of a sufficient overall number of studies to create a synopsis. However, the scientific knowledge provided by those few studies that were located is not lost, the studies are included in the DSS and are able to be exploited.

The individual study results are provided in Level 3 and include:

- the study abstract (as it appears in the original publication),
- the related URL,
- a table of all risk / measure safety effects available in the study containing:
  – test and reference conditions (e.g. helmet vs. not helmet)
  – types of outcome (e.g. injury severity)
  – types of estimate (e.g. CMF, odds ratio)
  – statistical significance indicators where applicable
- summary
- description of potential methodological issues or biases

The summary provides an outline of the main study features and findings as written by the SafetyCube expert who analysed and coded the study. The same experts have written explicit outline of potential methodological issues or biases, in studies where they were observed. These study pages were thoroughly checked and inspected as part of the Quality Assurance processes described in section 4.6.

An indicative study page of a coded study for the risk factor of "traffic flow" is shown in Figure 5.11; only the first effect rows are visible due to space constraints.



SafetyCube DSS

European Road Safety Decision Support System

Search | Knowledge | Calculator | Methodology | Support

Estimating the relationship between accident frequency and homogeneous and inhomogeneous traffic flows.

Hiselius, L.

Abstract

This paper estimates the relationship between accident frequency and the traffic flow empirically treating the hourly traffic flow in two different ways, as consisting of homogenous vehicles and as consisting of cars and lorries. Rural roads in Sweden are studied using Poisson and Negative Binominal regression models. It is found that important information is lost if no consideration is taken to differences between vehicle types when estimating the marginal effect of the traffic flow. The accident rate decreases when the traffic flow is treated as if homogeneous. However, when cars are studied separately the result suggests that the accident rate is constant or increases. The result with respect to lorries is reversed, indicating a decreasing number of accidents as the number of lorries increases.

https://doi.org/10.1016/j.aap.2003.11.002

Summary

Data from 83 rural road sections in Sweden from 1989 to the middle of 1995 is analyzed. The traffic data is hourly based traffic flow (for each direction, but not per lane), separately for cars and lorries. Injury accidents, excluding intersection accidents and accidents involving animals, are analyzed, and daylight accidents are studied separately (showing the same results as all accidents, this analysis has not been coded). For the four road types analysed, approximately 160-600 accidents are in the dataset. In the poisson regression analysis, hours with similar traffic flows are aggregated. A negative binomial model was also used, but distributional assumptions do not seem to affect the results, and poisson results are presented and coded. Generally, an increasing amount of lorries is found to be associated with lower accident frequency (controlling for car volume), while the opposite is found for volumes of cars. This tendency is found both for all accidents, single vehicle accidents and multi-vehicle accidents. The study analyzes four types of roads separately, and finds larger effects on for motorways and roads with speed limit 70 km/h and road width 6-9,7m, than for other road types (speed limit 90 km/h and road width 6-7.9 m; road type with speed limit 90 or 110 km/h and road width 8-13 m without separated road lanes). The author notes that a small sample size, and low volumes of lorries relative to cars may be an issue.

Limitations

Extent	Motivation	Type
MAYBE A PROBLEM	AS NOTED BY AUTHOR, LOW ACCIDENT FREQUENCY PER UNIT OF TRAFFIC FLOW INDICATES LOW POWER. THE AUTHOR ALSO NOTES THAT THE FLOW OF LORRIES IS A FRACTION OF THE FLOW OF CARS.	GENERAL: SMALL SAMPLE

Basic Study Information

Topic: RISK FACTOR | **Year**: 2004

Source: ACCIDENT ANALYSIS AND PREVENTION, 36, 985-992.

Design: OBSERVATIONAL CROSS-SECTIONAL

Countries: SWEDEN

Keywords: TRAFFIC: STATISTICS & NUMERICAL DATA FORECASTING MODELS RURAL POPULATION HUMANS REGRESSION ANALYSIS SWEDEN TRAFFIC TRAFFIC: PREVENTION & CONTROL BINOMIAL DISTRIBUTION ACCIDENTS THEORETICAL

Effects

Effect No	Outcome	Exposure	Group Type	Group	Effect Estimator	Effect Estimator Specifications	Sample	Estimate	Estimate Lower Limit	Estimate Upper Limit	Conclusion Comments
1	ACCIDENT				SLOPE	POISSON REGRESSION, HGV, RURAL ROAD, LIMIT 70		-2.66			SIGNIFICANT POSITIVE EFFECT ON ROAD SAFETY
2	ACCIDENT				SLOPE	POISSON REGRESSION, CAR, RURAL ROAD, LIMIT 70		3.62			SIGNIFICANT NEGATIVE EFFECT ON ROAD SAFETY
3	ACCIDENT				SLOPE	POISSON REGRESSION, HGV, RURAL ROAD, LIMIT 90		-0.94			SIGNIFICANT POSITIVE EFFECT ON ROAD SAFETY
4	ACCIDENT				SLOPE	POISSON REGRESSION, CAR, RURAL ROAD LIMIT 90		1.43			SIGNIFICANT NEGATIVE EFFECT ON ROAD SAFETY
5	ACCIDENT				SLOPE	POISSON REGRESSION, HGV, RURAL ROAD, LIMIT 90,110		-0.77			SIGNIFICANT POSITIVE EFFECT ON ROAD SAFETY

Figure 5.11: The Individual Study page for a study concerning "traffic flow" as a risk factor

5.6 THE E³ CALCULATOR

5.6.1 Overview

After the identification of effects of risk factors and road safety measures, and the linking of the risk factors to road safety measures in order to appropriately counter them, it was necessary to provide a tool in order to assess the cost-effectiveness of each road safety measure.

This tool is the calculator for Economic Efficiency Evaluation (E³) of road safety measures, which was developed within the methodological framework of the SafetyCube project. This calculator allows partners, 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. The calculator also integrates the information of crash-costs collected in the SafetyCube project, allowing to express all costs and benefits of a measure in monetary values and conducting cost-benefit analyses. To summarise the function of the calculator, indicative input and output parameters are concisely given in the following sections (see Figure 5.12 for an overview). The users should bear in mind that the year of reference for cost figures is 2015 and the currency is Euros.

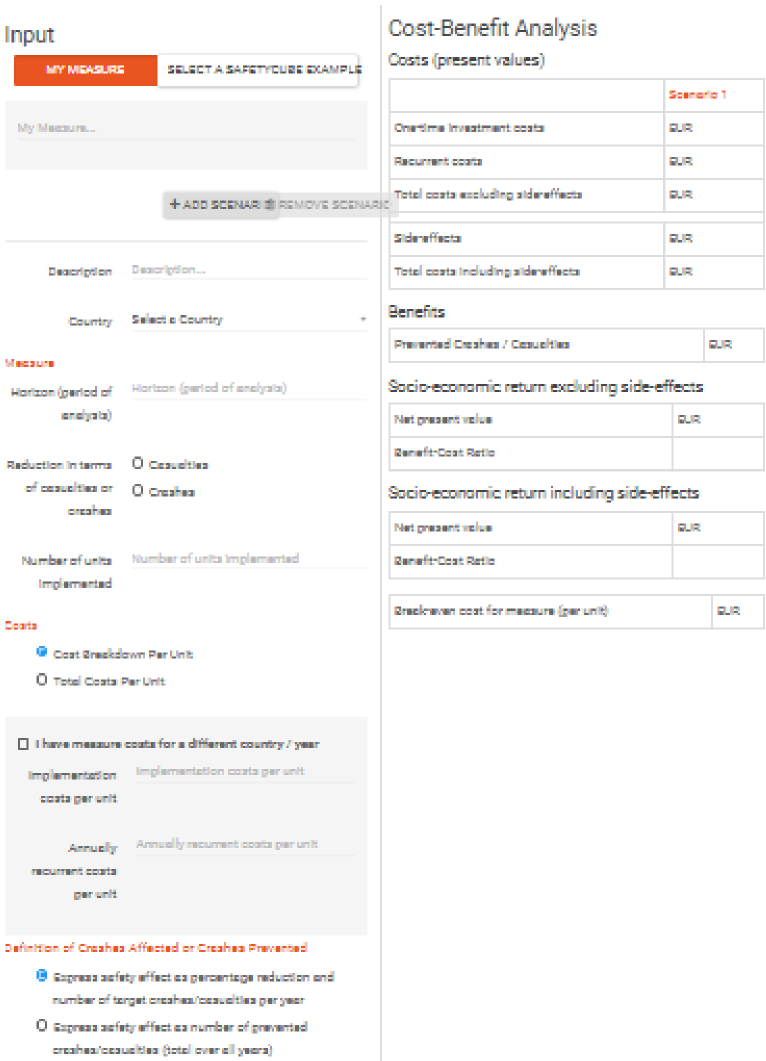


Figure 5.12. Overview of the DSS Calculator

The calculator can be used in two ways: Firstly, the user can provide their own values for a measure, in order to determine whether it is cost effective, which requires respective data availability and/or collection. This is achieved by selecting the **"My Measure"** button. Input and output fields are presented in detail in the following sections.

Alternatively, DSS users can browse through available SafetyCube examples, which are the cost-benefit analyses conducted for specific measures within the SafetyCube project. This is achieved by selecting the **"Select a SafetyCube example"** button (see Figure 5.13). In that case, all figures required to reach a cost-benefit ratio have been already provided by the SafetyCube partners, they are retrieved from the database and the input values of the Calculator are pre-filled. By hitting Submit the user obtains the SafetyCube example results, as well as a link to the pdf Synopsis of the specific CBA example. In some cases there was a lack of economic data for a certain measure, and the break-even costs are calculated instead.

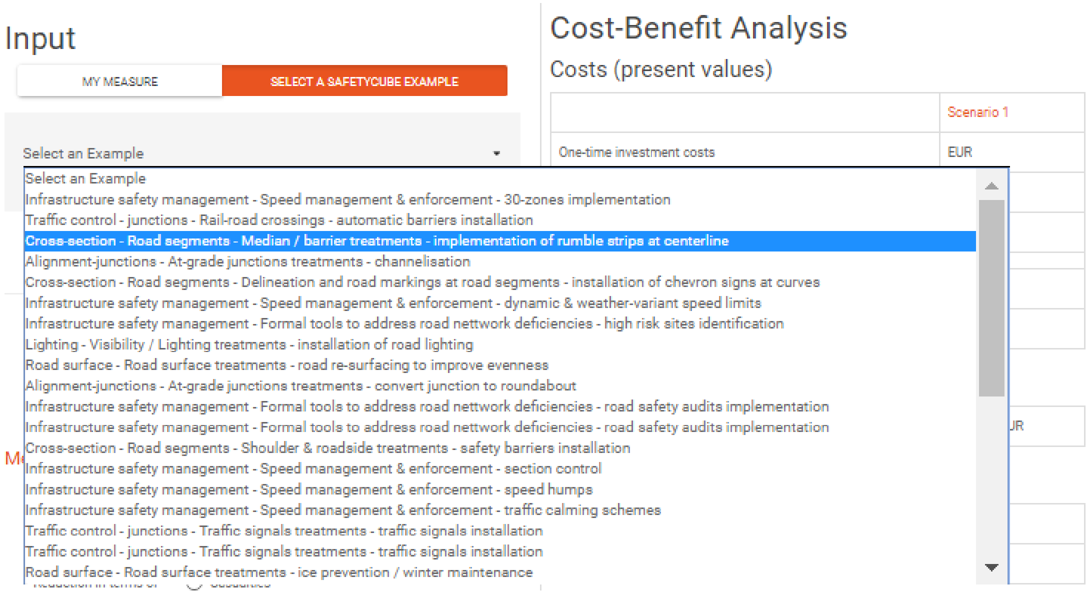


Figure 5.13. The list of SafetyCube CBA examples available in the Calculator

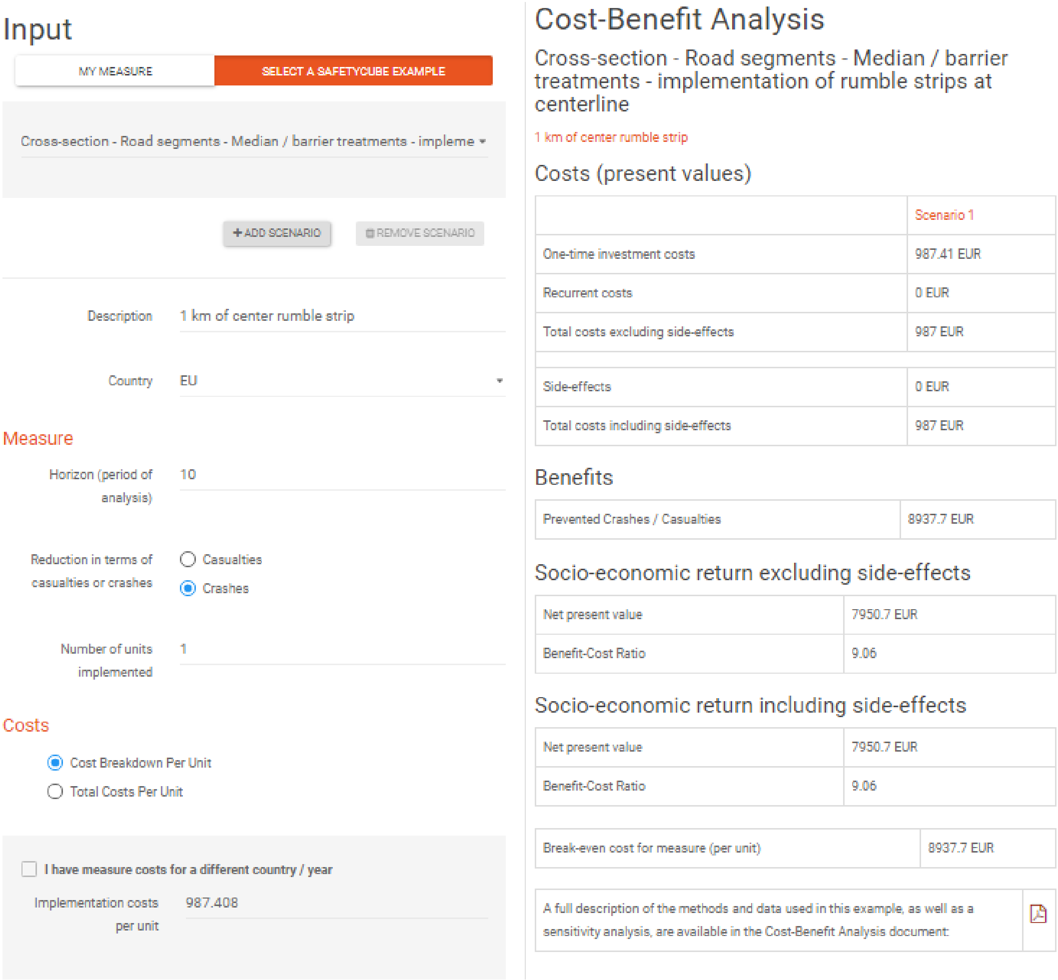


Figure 5.14. SafetyCube example on "rumble strips" - pre-filled input, output, and Synopsis (pdf)

5.6.2 Input for the E³ Calculator

As input to the calculator for the Economic Efficiency Evaluation, the following parameters are needed:

- Decision on whether to conduct an analysis based on crashes or casualties prevented
- Measure costs
  – Initial costs
  – Annual costs
- Number of crashes / casualties prevented (for each level of severity)
  – Target crashes of countermeasure
  – Percentage reduction
- Time horizon of a measure

In case the user has measure cost values for a different country or year than that of the example, **a converter is provided, converting the values of the basis of inflation (for year) and purchase power parity (PPP, for country).**
This is in combination with the information concerning the country for which the analysis is conducted:

- Crash/casualty costs per unit
  – fatal crashes
  – severe crashes

– slight crashes
– damage only crashes (only for crashes – no casualty analysis)

The SafetyCube analyses are conducted for the country from which effectiveness and cost results are obtained. The crash-cost tables that are included in the calculator (based on Wijnen et al., 2017) can be used to transfer these results to any other European country or to the European mean.

5.6.3 Output of the E³ Calculator

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)

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.

5.6.4 Sensitivity Analysis

When using the E³ calculator, it is important to remember that the estimates provided are dependent of the data used as input. Expert judgement from professionals is always required to reach the final decisions as to what would constitute an optimal solution for a given road safety problem. The particularities of a measure or a study area (for instance, extraordinarily high maintenance costs) must always be taken into account and inputed properly in the calculator in order to reach effectiveness estimates that are as precise as possible.

For that purpose the **"Add / remove scenario"** function was developed, allowing the user to enter in a second column **variations in the values of costs or safety effects**, re-submit the input and obtain a comparative assessment of the CBA outputs in a second column next to the initial output.

5.7 DSS ADDITIONAL PAGES (KNOWLEDGE/METHODOLOGY/SUPPORT)

Further to the previous DSS components, additional static pages are included in the DSS that complement its contents and provide more information to the user.

5.7.1 Knowledge page

This page gives access to several fields of road safety knowledge developed within the SafetyCube project.

The first part of the knowledge page is the **"Road Safety Synopses"** section, accessible via a button with the same name. This section lists all risks and measures synopses developed in SafetyCube, initially sorted alphabetically, including the links to their pdf files. This provides useful access to the synopses without having to go through the search process beforehand, and rather presenting an overview of road safety aspects.

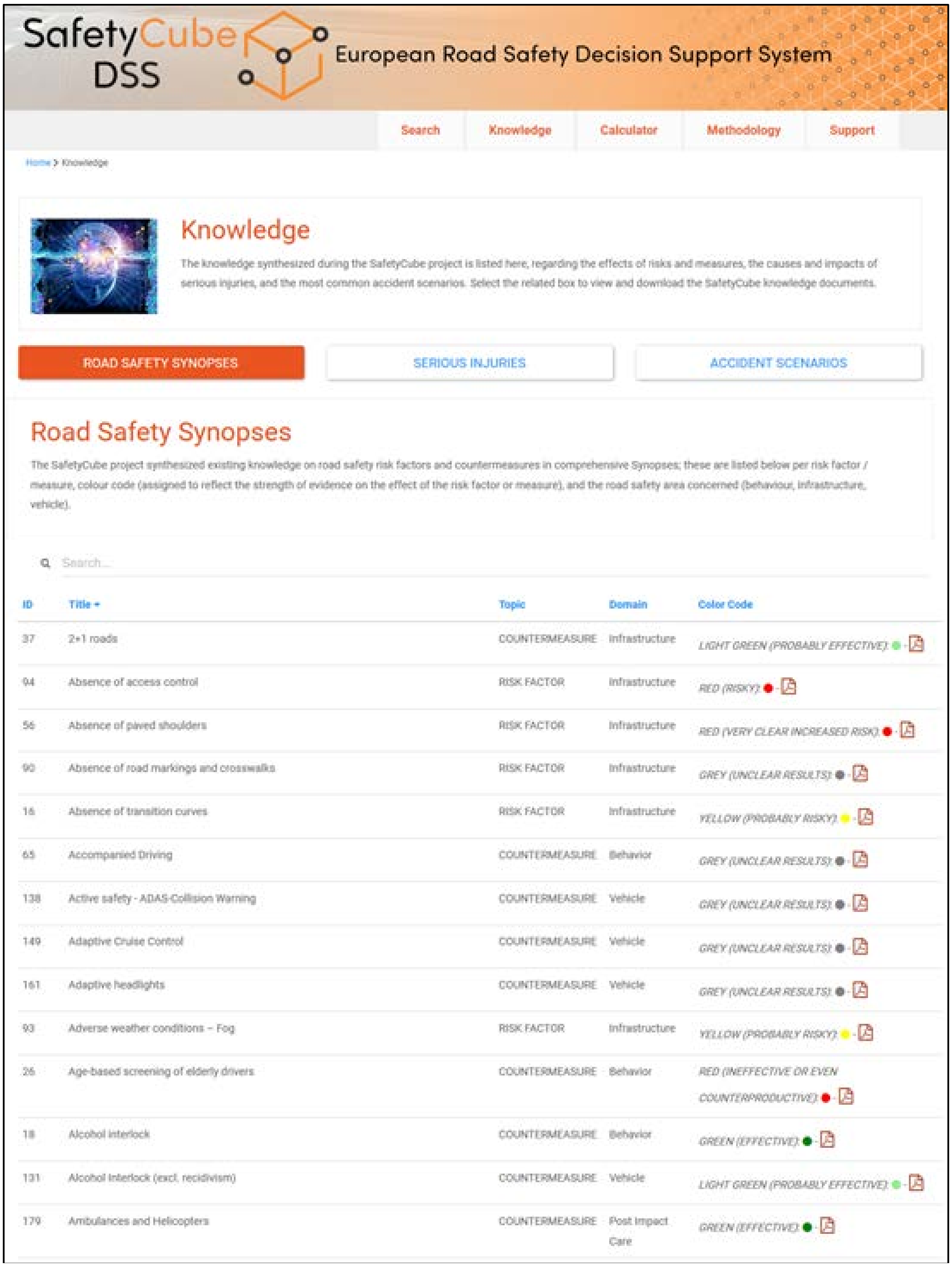
The page further allows the user to (1) filter the synopses by typing a "keyword" in a search bar, and (2) sort them on the basis of risk factor or measure tackled, area (road user behaviour, infrastructure, vehicle or post-impact care), and colour code. The "Road Safety Synopses" section is shown in Figure 5.15

The second part of the knowledge page is the **"Serious Injuries"** section, accessible via a button with the same name. This section provides information on three topics related to serious road injuries: Estimating their numbers, Impacts and costs, and Related risk factors. The topics appear briefly on the DSS page but there are links to detailed documentation in separate pdf files. The "Serious Injuries" section along with the related pdfs is shown in Figure 5.16.

The third part of the knowledge page is the **"Accident Scenarios"** section, accessible via a button with the same name. The SafetyCube Accident Scenarios Synopses synthesize macroscopic and in-depth crash data, to provide a complete picture of the causes and impacts of main crash categories. Each scenario concerns a specific category:

- Pedestrian Accident
- Cyclist Accident
- Single Vehicle Accident
- Opposite Direction Accident
- Same Direction Accident
- Junction Accident

The "Accident Scenarios" section along with an example of the related pdfs is shown in Figure 5.17.



SafetyCube DSS

European Road Safety Decision Support System

Search | Knowledge | Calculator | Methodology | Support

Home > Knowledge

Knowledge

The knowledge synthesized during the SafetyCube project is listed here, regarding the effects of risks and measures, the causes and impacts of serious injuries, and the most common accident scenarios. Select the related box to view and download the SafetyCube knowledge documents.

ROAD SAFETY SYNOPSES | SERIOUS INJURIES | ACCIDENT SCENARIOS

Road Safety Synopses

The SafetyCube project synthesized existing knowledge on road safety risk factors and countermeasures in comprehensive Synopses; these are listed below per risk factor / measure, colour code (assigned to reflect the strength of evidence on the effect of the risk factor or measure), and the road safety area concerned (behaviour, infrastructure, vehicle).

Search...

ID	Title ▾	Topic	Domain	Color Code
37	2+1 roads	COUNTERMEASURE	Infrastructure	LIGHT GREEN (PROBABLY EFFECTIVE)
94	Absence of access control	RISK FACTOR	Infrastructure	RED (RISKY)
56	Absence of paved shoulders	RISK FACTOR	Infrastructure	RED (VERY CLEAR INCREASED RISK)
90	Absence of road markings and crosswalks	RISK FACTOR	Infrastructure	GREY (UNCLEAR RESULTS)
16	Absence of transition curves	RISK FACTOR	Infrastructure	YELLOW (PROBABLY RISKY)
65	Accompanied Driving	COUNTERMEASURE	Behavior	GREY (UNCLEAR RESULTS)
138	Active safety - ADAS-Collision Warning	COUNTERMEASURE	Vehicle	GREY (UNCLEAR RESULTS)
149	Adaptive Cruise Control	COUNTERMEASURE	Vehicle	GREY (UNCLEAR RESULTS)
161	Adaptive headlights	COUNTERMEASURE	Vehicle	GREY (UNCLEAR RESULTS)
93	Adverse weather conditions – Fog	RISK FACTOR	Infrastructure	YELLOW (PROBABLY RISKY)
26	Age-based screening of elderly drivers	COUNTERMEASURE	Behavior	RED (INEFFECTIVE OR EVEN COUNTERPRODUCTIVE)
18	Alcohol interlock	COUNTERMEASURE	Behavior	GREEN (EFFECTIVE)
131	Alcohol Interlock (excl. recidivism)	COUNTERMEASURE	Vehicle	LIGHT GREEN (PROBABLY EFFECTIVE)
179	Ambulances and Helicopters	COUNTERMEASURE	Post Impact Care	GREEN (EFFECTIVE)

Figure 5.15: The "Road Safety Synopses" section of the Knowledge page of the SafetyCube DSS

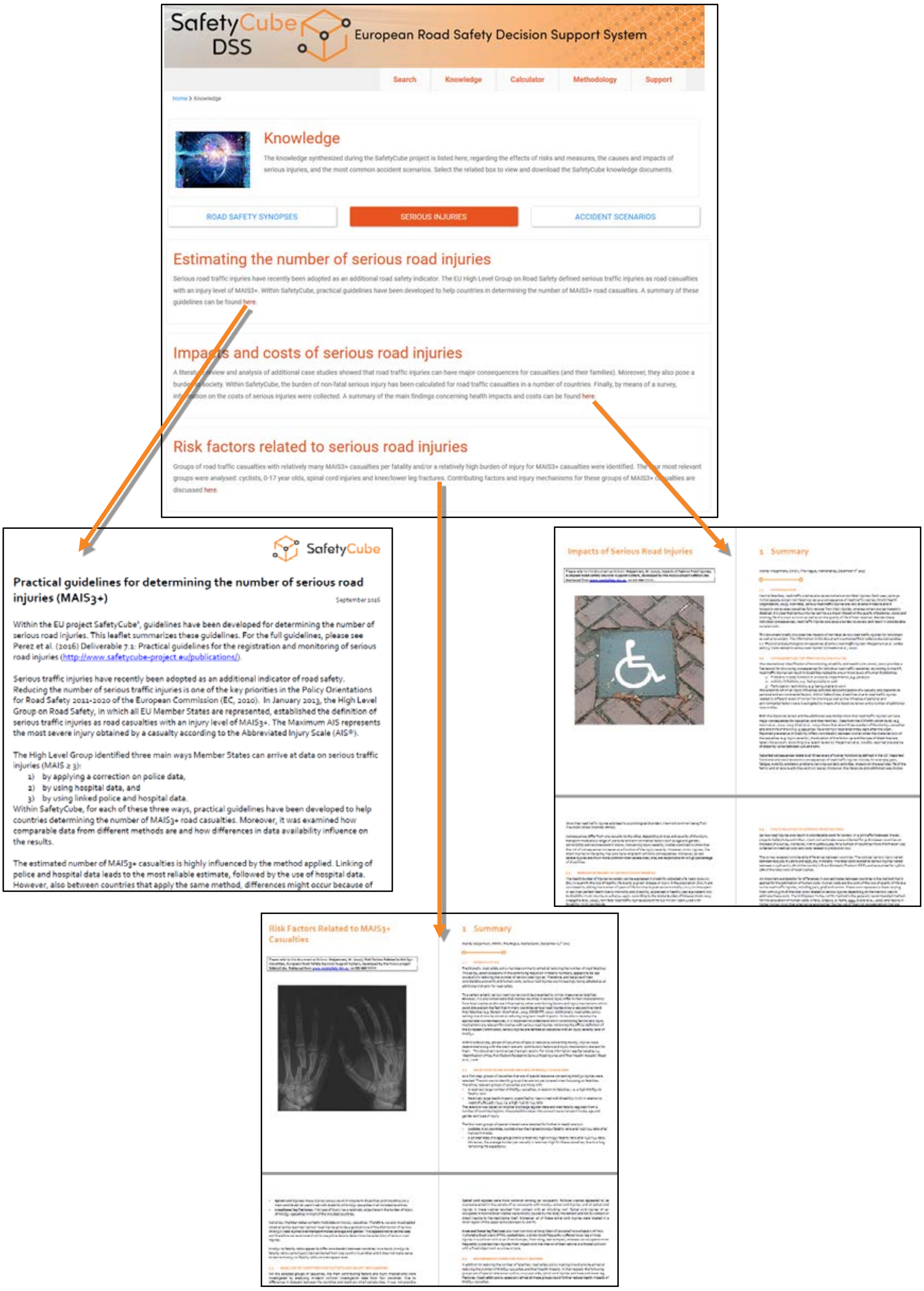


Figure 5.16. The "Serious Injuries" section of the Knowledge page of the SafetyCube DSS and related documents.

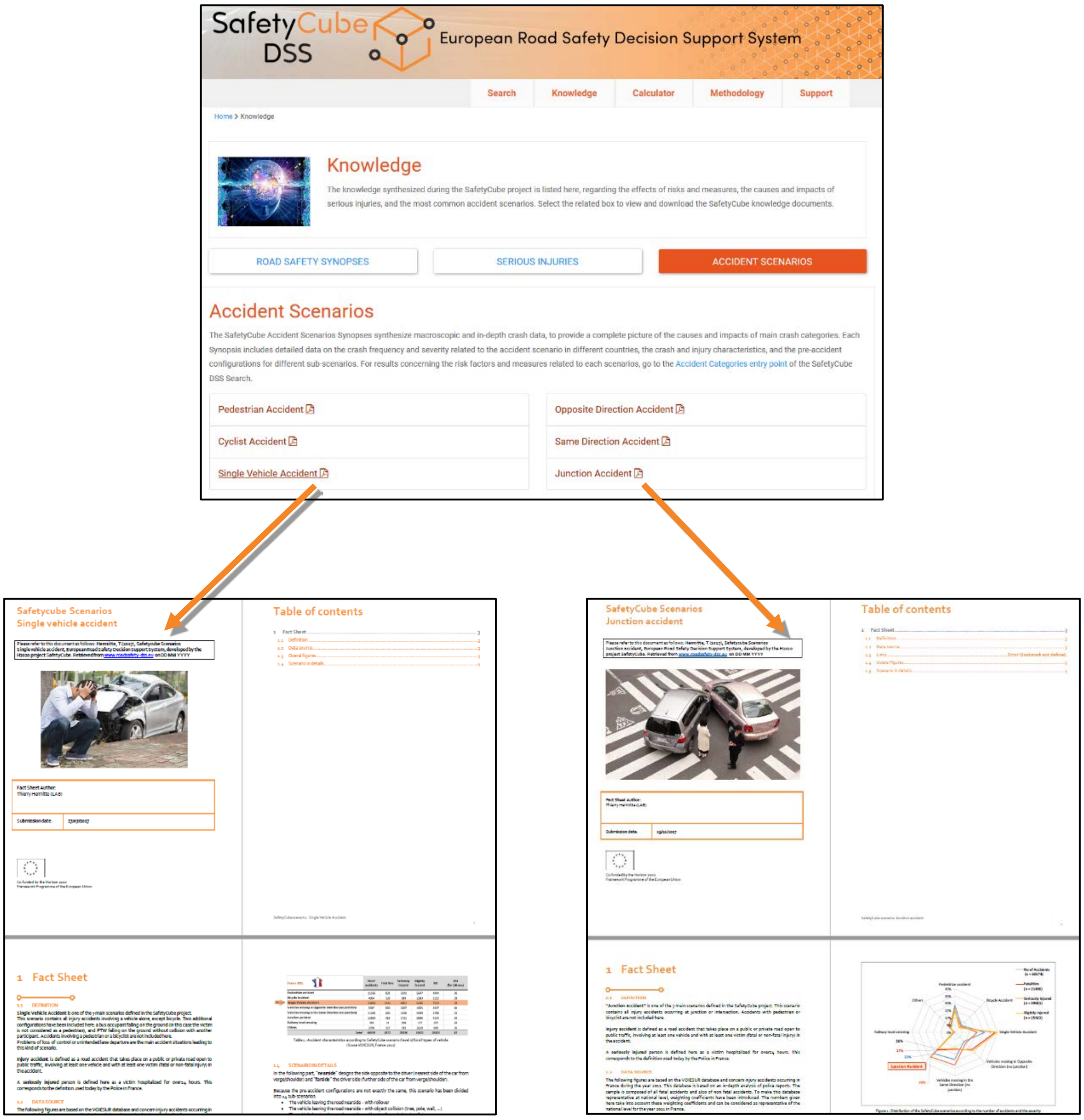


Figure 5.17. The "Accident Scenarios" section of the Knowledge page of the SafetyCube DSS and related documents.

5.7.2 Methodology page

This page includes background information on the SafetyCube project, the methodology implemented, a disclaimer document with details about using the DSS as well as its limitations, a glossary (also available in Appendix 6 of this report), as well as details on the Quality Assurance procedures. As with the knowledge page, all sections link to relevant websites or pdf documents. The Methodology page along with an indicative section of the related pdfs is shown in Figure 5.18.

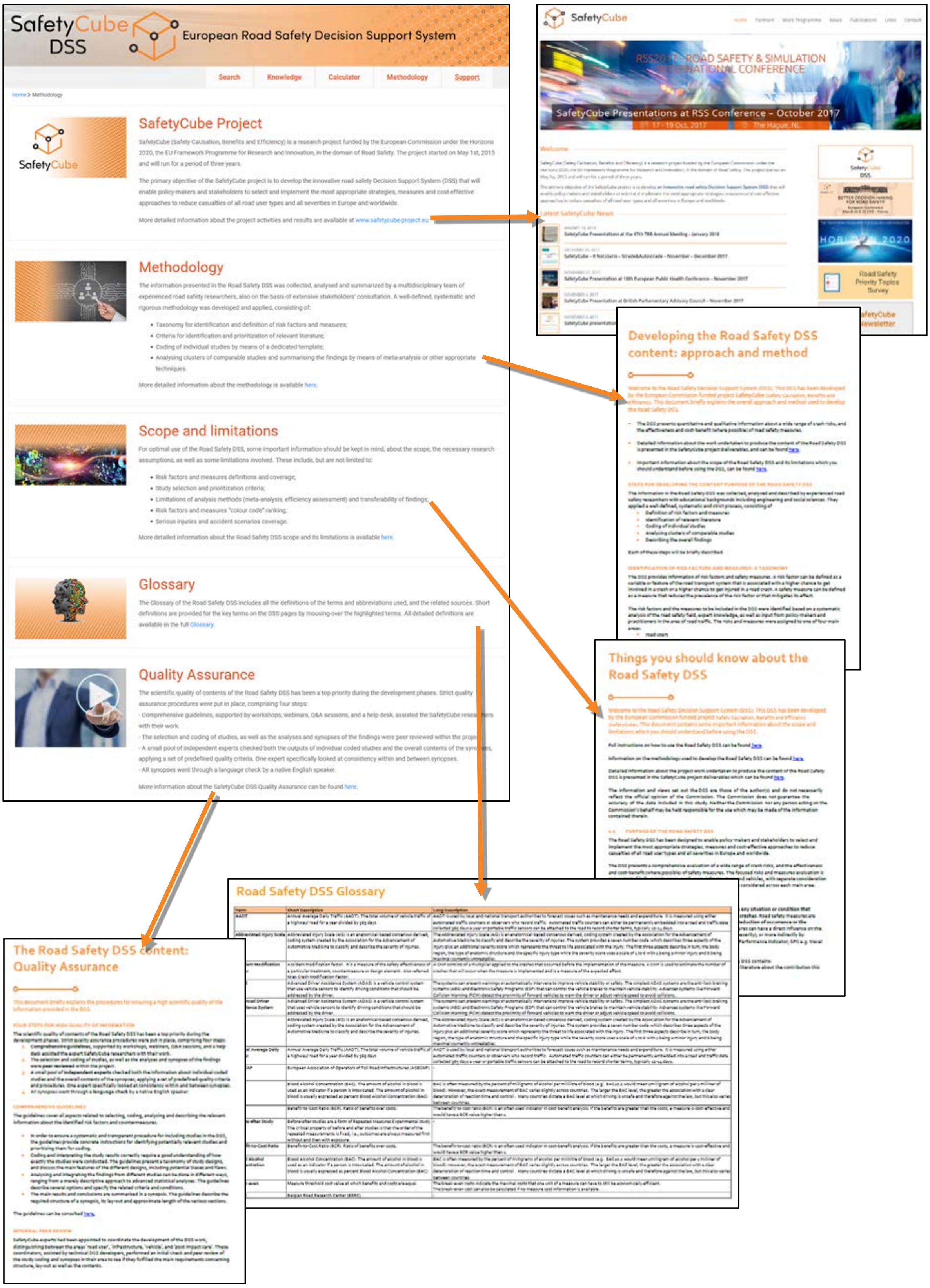


Figure 5.18: The Methodology page of the SafetyCube DSS and related documents.

5.7.3 Support page

The Support page presents contact information for user support, linking to the project coordinators (Loughborough University). The help field allows download of the Quick Guide (Machata et al., 2017) that serves as the DSS manual, and to access a dedicated user feedback survey through which feedback can be sent to the SafetyCube partners.

Finally, links to other road safety information systems (PRACT Repository, iRAP toolkit, CMF Clearinghouse, Road Safety Engineering Kit) are provided. The Support page is shown in Figure 5.19.

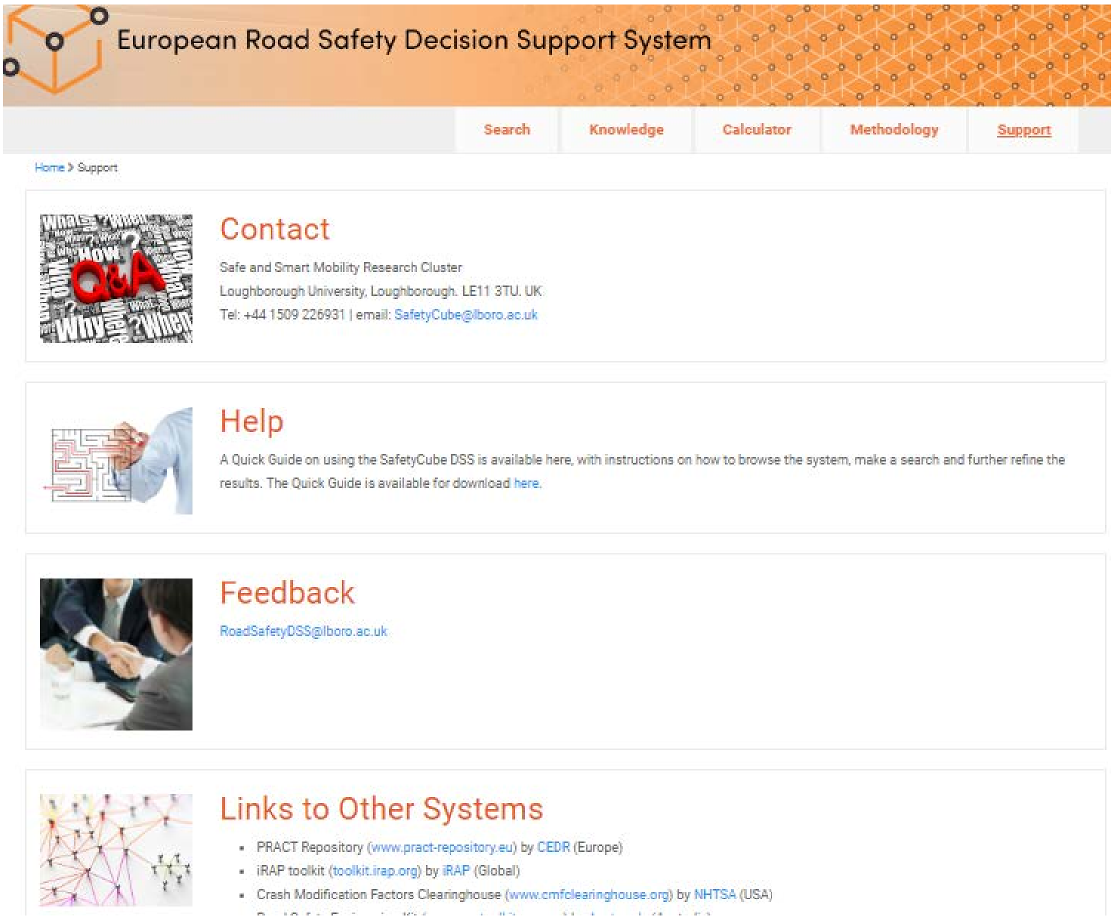


Figure 5.19: The Support page of the SafetyCube DSS.

6 Conclusions

The summary and conclusions of the work are presented here: the key figures regarding the developed DSS, the overall ranking of risk factors and measures in the DSS, the conditions for transferability of the DSS outputs, and the added value of the DSS, in light of the benefits of the Safe System approach used.

6.1 THE DSS IN FIGURES

This section summarises the DSS technical features and contents in key figures.

Taxonomy, risk factors and measures:

- **4 areas**: road user, infrastructure, vehicle, post impact care
- **88 risks and measures** (38 risk factors, 50 measures) e.g. distraction, roadside, crashworthiness
- **313 specific risk factors and measures** (120 risk factors, 193 measures) e.g. mobile phone use, no clear-zone, low pedestrian rating (NCAP)

Links within a Ssafe System approach**:**

- A total of **762 links between risk factors and measure**s. Risk Factors (118) are linked to one or more Road Safety Measure(s) (167) - A few risk factors or measures (e.g. post-impact care) were not "linkable".
- 3350 database keywords, out of which 2005 useful keywords, linked with **531 Master keywords**
- A total of **380 links between risks, measures and Accident Scenarios**; 8 scenarios are linked with 109 specific risks and 271 specific measures

Contents and outputs:

- **1300 studies** (out of which more than 90 meta-analyses, existing or original) **including more than 7500 effects** of risk factors or measures
- **215 synopses** on risk factors and measures effects
- **8 Accident scenario** synopses
- **38 cost-benefit analyses** - Behaviour (12 examples), Infrastructure (19 examples), Vehicle systems (4 examples), Post-impact care (1 example)

About half of the studies included in the DSS come from the USA, while another 26% comes from Europe; this is a results of the SafetyCube study selection criteria in terms of quality, and clearly indicates a gap in recent high quality research in Europe. In order to address the possible consequences in terms of relevance of results for known differences in traffic composition, vehicle and infrastructure design, a disclaimer on transferability of results is included in each Synopsis, taking into account the region of origin of the studies selected for each topic.

It is also noted that a small share of results concerning Low or Middle Income Countries (LMI) are available through the DSS. A considerable share of the studies concern multiple countries (10%) (see Figure 6.1).

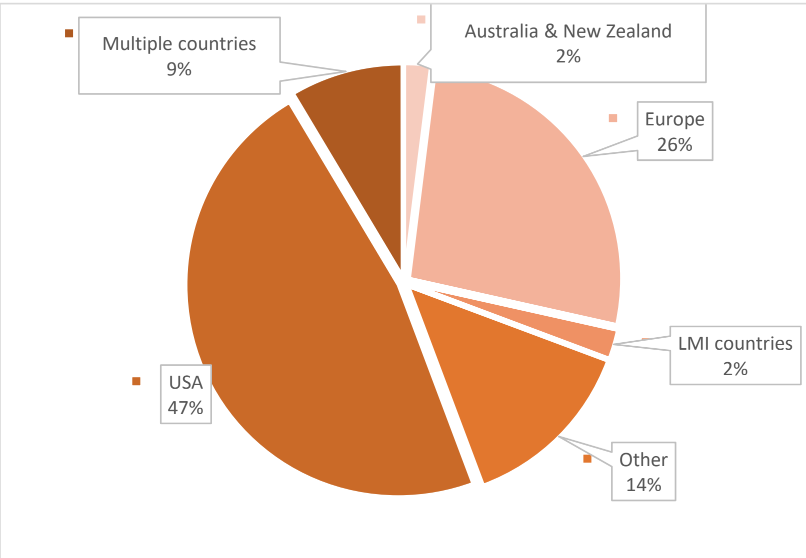


Figure 6.1: Distribution of the studies included in the DSS per grographical area.

On the other hand, Figure 6.2 clearly shows the priority given in recent studies. The vast majority of results concern studies published during the last decade, including the most recent available meta-analyses.

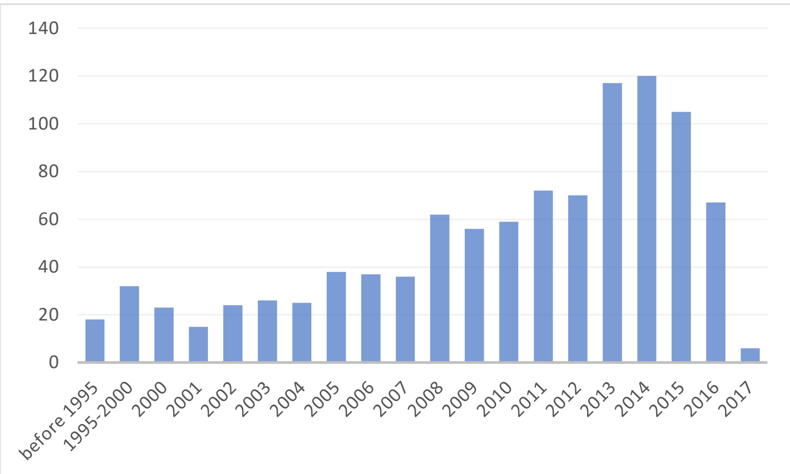


Figure 6.2: Distribution of the studies included in the DSS per year of publication.

Another unique aspect of the DSS is that it is not limited to a particular study design or a particular type of estimator of the effects of risks and measures. Figure 6.3 shows the different study designs included in the DSS, but it should be noted that these are not mutually exclusive. In fact, more than 80% of the DSS studies include more than one of these design elements (e.g. Quasi-Experimental | Before-After | Empirical Bayes, Before-After | Meta-Analysis).

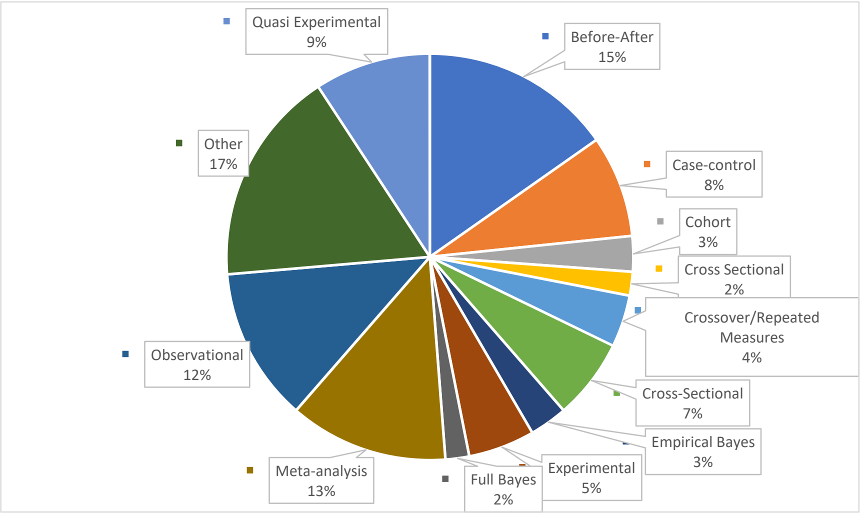


Figure 6.3: Distribution of the study designs included in the DSS coded studies (one study may include more than one categories).

Finally, unlike most existing systems which provide one type of effect estimator (the most common being Crash Modification Factors (CMFs), the SafetyCube DSS includes quantitative effects of risk factors and measures expressed by different effect estimators (see Figure 6.4).

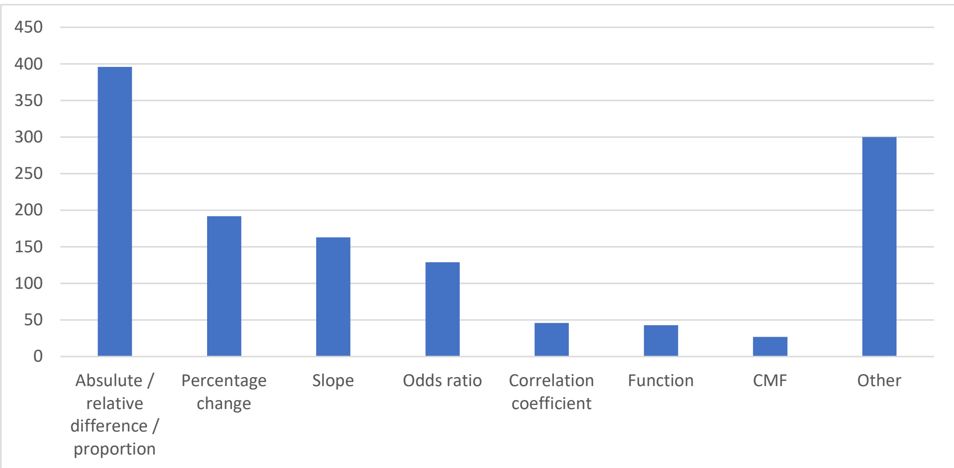


Figure 6.4: Distribution of the effect estimators used in the DSS coded studies.

6.2 RANKING OF RISK FACTORS AND ROAD SAFETY MEASURES

This section summarises the ranking of risk factor and measures made within SafetyCube available in the DSS. In Table 6.5, the colour codes description for the ranking is reminded. In the case of measures found to be effective (green or light green) the Benefit-to-Cost ratio is also provided.

Table 6.5: Description of colour codes for risk factors and countermeasures (Martensen, 2016).

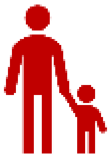
	Risk factor			Countermeasure
Red	Results consistently show an increased risk when exposed to the risk factor concerned.		Green	Results consistently show that the countermeasure reduces road safety risk.
Yellow	There is some indication that exposure to the risk factor increases risk, but results are not 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.

6.2.1 Ranking of risk factors

Table 6.6: Risk factors rated with colour code red

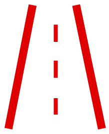
Colour code RED
Results consistently show an increased risk when exposed to the risk factor concerned

Road user related



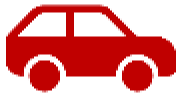
- Driving under the influence – legal and illegal drugs
- Traffic rule violations – red light running
- Distraction – cell phone use – Handheld
- Distraction – cell phone use – Texting
- Fatigue – sleep disorders – sleep apnea

Infrastructure related



- Effect of Traffic Volume on safety
- Risks associated with Traffic Composition (VRUs only)*
- Road Surface - Inadequate Friction
- Poor Visibility – Darkness (pedestrians only)*
- Adverse weather – Rain (motor vehicles only)*
- Workzone length
- Alignment deficiencies - Low Curve Radius
- Cross-section deficiencies - Number of Lanes
- Shoulder and roadside deficiencies -Absence of paved shoulders
- Shoulder and roadside deficiencies - Narrow Shoulders
- Interchange deficiencies – absence of access control
- At-grade junction deficiencies - Risk of different junction types
- At-grade junction deficiencies - Gradient
- Uncontrolled rail-road crossing

Vehicle related



- Powered two wheelers – visibility, conspicuity, sight obstruction and small size
- Pedestrians – crashworthiness – low NCAP rating
- Passenger car – injury mechanism – risk of injury in rollover
- Passenger car – risk of being injured following side impact
- Passenger car – risk of injury in frontal impacts
- Passenger car – compatibility (self and partner protection) and age
- Light goods vehicle – visibility limitation due to design
- Unrestrained occupants in heavy goods vehicles and busses
- Heavy goods vehicles – risks resulting from the blind spot issue by right turning truck
- Busses and coaches – risks resulting from rollovers

*The risk factors which are underlined have more than one colour code, but for different road user types.

Table 6.7: Risk factors rated with colour code yellow

Colour code YELLOW
There is some indication that exposure to the risk factor increases risk, but results are not consistent

Road user related

- Risk taking – overtaking
- Risk taking – close following
- Functional impairment – vision loss
- Diseases and disorders – diabetes
- Personal factors – sensation seeking
- Emotions – aggression, anger
- Fatigue – not enough sleep, driving while tired
- Distraction – conversation with passengers
- Distraction – cognitive overload, inattention

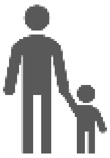
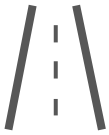
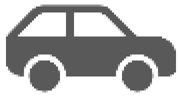
Infrastructure related

- Congestion as a risk factor
- Occurrence of Secondary crashes
- Alignment deficiencies - Absence of Transition curves
- Road functional class
- Poor Visibility – Darkness (all and two-wheelers only)*
- Poor visibility – fog
- Adverse weather – Rain (all)*
- Workzone duration
- Alignment deficiencies - High grade
- Presence of Tunnels
- Cross-section deficiencies - Superelevation
- Cross-section deficiencies - Narrow lanes
- Undivided road
- Cross-section deficiencies - Narrow median
- Shoulder and roadside deficiencies - Risks associated with Safety Barriers and Obstacles
- Shoulder and roadside deficiencies - Sight Obstructions (Landscape, Obstacles and Vegetation)
- At-grade junctions deficiencies - Number of conflict points
- At-grade junction deficiencies - Skewness / Junction angle
- At-grade junction deficiencies - Poor sight distance
- Poor junction readability - Uncontrolled junction

Vehicle related

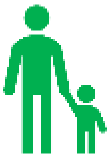
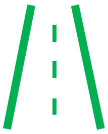
- Powered two wheelers – accident characteristics
- Pedestrians – vehicle design, vehicle shape
- Passenger car – technical defect – maintenance
- Passenger car – risk of being injured in rear impact
- Passenger car – low star rating (Euro NCAP)
- Prevalence of factors in crash data – accident characteristics – light goods vehicles
- Light goods vehicles – crashworthiness – compatibility

Table 6.8: Risk factors rated with colour code grey

Colour code 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		
Road user related	Infrastructure related	Vehicle related
		
? Functional impairment – hearing loss (few studies)	? Risks associated with Traffic Composition (HGVs only)*	? Powered two wheelers – technical defects or maintenance
? Distraction – music – entertainment systems	? Risks associated with the distribution of traffic flow over arms at junctions	? Prevalence of factors in crash data – injury level – light goods vehicle
? Distraction – operating devices	? Adverse weather – Rain (other road users only)*	? Heavy goods vehicles – compatibility
	? Adverse weather - Frost and snow	? Heavy goods vehicles – configuration of HGV and busses
	? Alignment deficiencies - Frequent curves	? Bicycles – visibility and conspicuity
	? Alignment deficiencies - Densely spaced junctions	? Bicycles – injury level
	? Interchange deficiencies - Ramp Length	? Bicycles – accident characteristics
	? Interchange deficiencies - Acceleration / deceleration lane length	
	? Poor junction readability - Absence of road markings and crosswalks	

*The risk factors which are underlined have more than one colour code, but for different road user types.

Table 6.9: Risk factors rated with colour code green

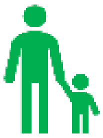
Colour code GREEN Results consistently show that exposure to the presumed risk factor does not increase risk		
Road user related	Infrastructure related	Vehicle related
		
-	✓ Poor Visibility – Darkness (cars only)*	-

*The risk factors which are <u>underlined</u> have more than one colour code, but for different road user types.

6.2.2 Ranking of measures

Table 6.10: Measures rated with colour code green

Colour code GREEN
Results consistently show that the countermeasure reduces road safety risk

Road user related		Infrastructure related		Vehicle related		Serious injuries	
							
Countermeasure	BCR*	Countermeasure	BCR*	Countermeasure	BCR*	Countermeasure	BCR*
✓ Alcohol interlock programme	10.9	✓ Installation of section control	19.5	✓ Electronic stability control (ESC)	13.9	✓ Ambulance and helicopters	5.87
✓ DUI checkpoints, selective and random breath testing	7.3	✓ Installation of speed humps	18.2	✓ Powered two wheeler – enhanced braking system (ABS, TCS)	7.8		
✓ Law and enforcement for seatbelt wearing	1.4	✓ Implementation of rumble strips at centreline	9.1	✓ Powered two wheeler protective clothing – Helmet	1.2 to 4.3		
✓ Law and enforcement for speeding	1.0	✓ Installation of chevron signs	2.7	✓ Child restraint system – 'CRS'	3.4		
✓ License suspension		✓ Implementation of 30-zones	1.6	✓ Emergency Braking Assistance system	3.0		
✓ Hazard perception training		✓ Dynamic speed limits	1.1	✓ Seatbelts	1.6		
✓ Law and enforcement for speeding		✓ Installation of lighting & improvement of existing lighting	0.7	✓ Autonomous emergency braking AEB (pedestrians & cyclists)	0.77 to 1.5		
		✓ Automatic barriers installation	0.05	✓ Autonomous emergency braking AEB (city, inter-urban)	0.6		
		✓ HGV traffic restrictions		✓ Cyclist protective clothing			
		✓ Speed limit reduction measures to increase road safety		✓ Cyclist protective clothing - Helmet			

✓	Installation of speed cameras	✓	Powered two wheeler protective clothing
✓	Workzones: Signage installation and improvement	✓	Child Restraint System – 'Booster seats'
✓	Dynamic speed display signs	✓	EuroNCAP frontal full & ODB
✓	Traffic sign installation; Traffic sign maintenance	✓	Daytime running lights
✓	Convert at-grade junction to interchange	✓	Anti-whiplash – EuroNCAP
✓	Sight distance treatments	✓	Frontal Airbag
✓	Creation of by-pass roads	✓	Side Airbag

*BCR = Benefit-to-Cost Ratio (best estimate) if available for measure; see also SafetyCube's deliverables 4.3, 5.3 and 6.3

Table 6.11: Measures rated with colour code light green

Colour code LIGHT GREEN There is some indication that the countermeasure reduces road safety risk, but results are not consistent						
Road user related		Infrastructure related		Vehicle related		Serious injuries
Countermeasure	BCR*	Countermeasure	BCR*	Countermeasure	BCR*	Countermeasure
✓ Formal pre-license training	125	✓ Road safety audits (light measure case)	21.7	✓ PTW Airbag	0.03	✓ Prehospital care
✓ Seatbelt campaigns	42.2	✓ Safety barriers installation; Change type of safety barriers	19.5	✓ Intelligent Speed adaptation + Speed Limiter + Speed regulator		
✓ Child restraint campaigns	4.6	✓ High risk sites treatment	16.1	✓ Rescue Data Sheet & Rescue code		
✓ Red light cameras	3.7	✓ Convert junction to roundabout	9.2	✓ Directive 96/79/CEE et ECE.R94		
✓ Pedestrian skills training	2.6	✓ Channelisation	8.4	✓ Directive 96/27/CEE et ECE.R95		
✓ DUI campaigns	2.1	✓ Road surface treatments (BCR=winter maintenance)	6.0	✓ Regulation UN R135 (Pole side-impact protection)		
✓ Lowering BAC limits (general and novice drivers)		✓ Road safety audits (heavy measure case)	2.9	✓ EuroNCap (MBD & Pole)		
✓ Increasing traffic fines		✓ Traffic signal installation - highways	3.7	✓ Vehicle inspection		
✓ Hours of service regulations (commercial drivers)		✓ Traffic signal installation	1.1	✓ ECE R100 (Battery electric vehicle safety)		
✓ Demerit point systems		✓ Installation of traffic calming schemes	0.4	✓ eCall		
✓ Graduated driver licensing and probation		✓ 2+1 roads		✓ Underrun protection		
✓ Fitness to drive assessment – medical referral		✓ Road safety inspection		✓ Pedestrian protection - 'active technology'		
✓ Rehabilitation courses for drink-driving offenders		✓ Increase median width		✓ Pedestrian protection - 'vehicle shape'		

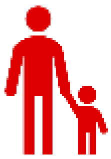
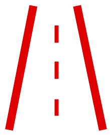
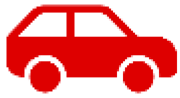
✓ Road safety campaigns – general	✓ Implementation of narrowings	✓ Pedestrian regulation
✓ Speeding campaigns	✓ Change median type	✓ Blind Spot Detection
✓ Campaigns against aggressive and inconsiderate behaviour	✓ Shoulder implementation (shoulder type)	✓ AEB for trucks
	✓ Increase shoulder width	✓ Vehicle to Vehicle communication
	✓ School zones	✓ Event Data Recorder
	✓ Create clear-zone / remove obstacles & Increase width of clear-zone	✓ Alcohol Interlock (ALC)
	✓ Road markings implementation	
	✓ Implementation of edgeline rumble strips	
	✓ Variable message signs	
	✓ Installation of rail-road crossing traffic sign	

*BCR = Benefit-to-Cost Ratio (best estimate) if available for measure; see also SafetyCube's deliverables 4.3, 5.3 and 6.3

Table 6.12: Measures rated with colour code grey

Colour code GREY Results consistently show that the countermeasure reduces road safety risk			
Road user related	Infrastructure related	Vehicle related	Serious injuries
? Laws and enforcement for mobile phone use ? Non-statutory training for novice drivers	? Implementation of woonerfs ? Installation of median ? Increase number of lanes ? Increase lane width ? Change shoulder type ? Installation of cycle lane and cycle path ? V2I schemes ? Improve skewness or junction angle ? Convert junction to roundabout (cyclists) ? Convert 4-leg junction to staggered junctions ? STOP / YIELD signs installation / replacement ? Implementation of marked crosswalk Traffic signal reconfiguration	? Anti-submarining (airbags, seat shape, knee airbag, seatbelt pretensioner, ...) ? Collision Warning ? Adaptive Cruise Control (ACC & ACC Stop & start) ? Enhanced Headlights (automated, adaptive, advanced system, ...) ? Night Vision ? Tyre Pressure Monitoring and Warning ? Emergency Stop Signal (ESS) ? Rollover Protection system ? Lane Keeping systems ? Vehicle Backup Camera	? Triage ? First aid training for drivers ? Extraction from vehicle

Table 6.13: Measures rated with colour code red

Colour code RED Results consistently show that the countermeasure does NOT reduce road safety risk and may even increase it			
Road user related	Infrastructure related	Vehicle related	Serious injuries
			
× Age-based screening of elderly drivers		-	-

6.3 CONDITIONS FOR TRANSFERABILITY

The information given in the Decision Support System about risk factors and road safety measures is taken from studies made in many countries during a long period. The question therefore naturally arises if the results of a study made in one country at a certain time can be transferred to a different country at a different time. This issue is referred as the **transferability of knowledge**. Transferability is discussed in the synopses summarising knowledge about risk factors and road safety measures.

The conditions for transferability are influenced by the range of countries and the length of time during which research as been conducted. Conditions are good if there are many studies, reported in many countries, and showing consistent results. One then knows that, at least for the sample of countries included, and for the period covered by the studies made in these countries, there were no large differences in results.

In an earlier project, the concept of range of replications was developed. This concept was intended to indicate both the number of countries in which studies had been made and the length of time during which studies had been made (Elvik 2012). The range of replications is simply a count of the number of different countries and different years studies have been reported. Thus, the first study of road lighting was reported in the United States in 1948. It gets the count of 1. The second study of road lighting was reported in Great Britain in 1955. That study added 1 new country, and 7 years elapsed since the first study, thus increasing the range of replications from 1 to 9 (1 for new country, 7 for years elapsed).

By adding new studies this way, the total range of replications for road lighting came to 74. 13 countries contruibuted during a period of 61 years (1948 to 2009). If only new countries and new years are counted, you can produce Figure 6.14, which shows how the mean effect on injury accidents of road lighting has changed over time as new countries contributed knowledge.

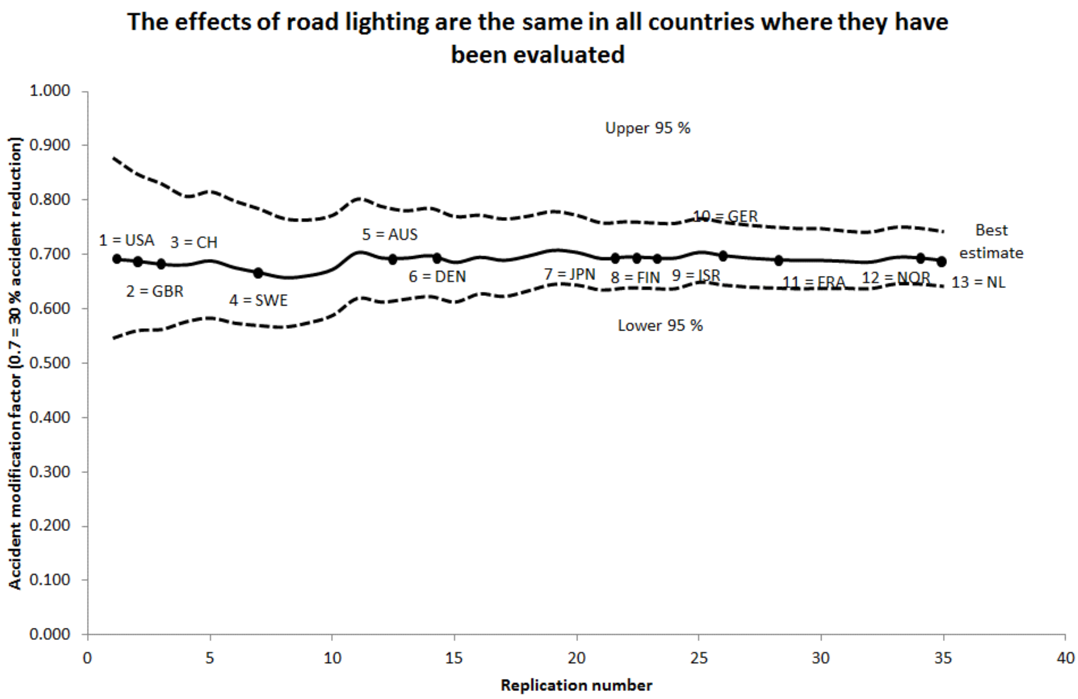


Figure 6.14. Stability between countries and over time in effects of road lighting

It is seen that the effects remain very stable over time (across replications) and as new countries have been added to those in which the effects of road lighting have been evaluated. This kind of stability supports a belief in transferability. Results have been found to be transferable between countries and over time so far.

Sometimes, **it is possible to test the transferability of results in meta-analysis**. This can be done by means of meta-regression, by specifying country and year as independent variables. In a recent meta-analysis of studies evaluating road safety effects of converting junctions into roundabouts (Elvik 2017), it was found that effects were the same all over the world with respect to fatal injury; but were greater for non-fatal injury in America and Oceania (Australia and New Zealand) than in the rest of the world.

In general, research is based on the presumption that knowledge is transferable. In very many fields of knowledge, it is. A cancer treatment found to be effective in Norway, will be effective in Argentina or Japan. Healthy food is healthy everywhere, and unhealthy food is unhealthy everywhere. Physical activity is good for health all over the world. A ship built according to scientifically based engineering principles will float everywhere, and so on and so forth.

Road safety research is, and must be, based on the same assumption of transferability. Otherwise, it would not make sense. If all knowledge was local and transient, there would be no point in reporting the knowledge, as it could not be applied outside the particular location and the short span of time it was valid. Having said this, it is clear that knowledge about risk factors and road safety measures can get both outdated and irrelevant for a specific country. As an example, having alcohol in your blood increases the risk of accident involvement, but the steepness of the increase varies between countries (Elvik 2015). Thus, a risk curve for Portugal would be highly misleading for Norway. Yet, there is an increase in risk in both countries. In that sense, results are consistent and transferable. But they differ in the details.

The assessment of transferability in SafetyCube is informal, yet systematic. We have judged how similar countries are to each other. We have judged if studies are too old or can still be treated as relevant. We have considered the numberb of countries in which studies have been made and the similarity of results between countries. We have assessed the similarity of the research methods applied in different studies.

Although these assessments can rarely be quantified in any meaningful sense, we are sure they are indispensable and useful and give users of the Decision Support System guidance about the transferability of the knowledge presented in it.

6.4 ADDED VALUE OF THE DSS

Evidence based road safety policies are becoming more desirable and there is increasing availability of national data which can be used to inform policy. However, in order for road safety policies to be effective there is a need for state of the art knowledge and understanding of accident risk factors and potential measures to address them. **Existing road safety Decision Support Systems worldwide have a number of limitations**. For instance, the CMF Clearinghouse (FHWA) has a focus only on CMFs on infrastructure. Similarly, the Road Safety Engineering Kit (AustRoads) and the PRACT Repository (CEDR) have a focus on infrastructure measures only.

SafetyCube addresses these gaps by generating new knowledge about accident risk factors and the effectiveness of measures relevant to Europe and integrating it into a European Road Safety Decision Support System (DSS). The SafetyCube DSS aims to enable policy-makers and stakeholders to identify, select and implement the most appropriate strategies, measures and cost-effective approaches to reduce casualties of all road user types and all severities. 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 (Yannis et al. 2018).

The SafetyCube DSS is unique in a number of ways:

- **The SafetyCube DSS combines road user, infrastructure, vehicle and post impact care aspects framed within a Safe System approach.** The risk factors and the measures included in the DSS taxonomies were identified based on a systematic analysis of the road safety literature. The draft taxonomy was systematically evaluated during four workshops, where stakeholders were asked to prioritise and indicate missing topics.
- Another major gap of knowledge that is addressed by this DSS is the **linking between risk factors and the respective measures**, as most available systems and repositories so far are compilations of interventions and their impacts on crashes. Links between risks and measures have been developed for the first time at a fine level of detail, and on the basis of a solid theoretical background, taking into account existing frameworks.
- **The dedicated SafetyCube methodology behind the DSS development** and its population with state-of-the-art findings is another added value of the present system. To identify relevant studies for the inclusion into the DSS, a systematic scoping review was conducted for each item in the taxonomy. 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.

- **Rigorous selection criteria** were implemented, in order of importance for the road safety DSS, based on quantitative outcome, transferability, recent publication date, language and source.
- **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.
- **A set of dedicated tools and guidelines** were developed for coding studies and performing analyses (meta-analyses, vote count analyses, etc.), allowing not only to code information in a standardized way and with common methodological considerations, but also to accommodate the large variations in study types. Special mention should be given here to the **DSS Calculator for performing CBA analysis**, which provides for the first time a standardized tool guiding the user to perform an analysis which can be reliable, rigorous yet tailored to the question.
- The enormous differences between studies also constitutes 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**.
- **The SafetyCube synopses** provide 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. Each synopsis consists of three parts, addressed to readers of different types, roles and scientific backgrounds.
- In these synopses, risks and measures are **ranked on the basis of a consistent, exhaustive and meaningful colour code system**.
- The **SafetyCube CBA examples** were developed on tha basis of standardized methodology and standardized European crash costs estimates.
- The DSS makes available additional key knowledge on priority aspects such as the **Serious Injuries aspects** of risks and measures.
- **Quality Assurance** was given special emphasis on all stages of the project.
- The **amount of information included in the DSS** is impressive: The system consists of more than 1300 studies, including more than 7,500 specific effects estimates, summarized in 215 synopses, 38 cost benefit analyses and 8 accident scenario synopses.
- The **design of the DSS** is simple yet flexible, and made to accommodate the needs of different stakeholders and interest groups, by means of different entry points for searching, and different levels of detail in the presentation of results.
- The system is built around **two major pillars, risk factors and neasures**, but even the most specific search that the user wishes to carry out can be implemented on the basis of five entry points, numerous filtering options for the results, and all the details of the specific studies available in each case.

Overall, it is the only road safety DSS with the following features:

- comprehensive and linked information both on crash risks and measures so that users are directed from problems to solutions on a user-friendly graphical interface
- locates both risks and measures in robust taxonomies, mapping the whole road safety domain, across the fields of human behaviour, infrastructure, vehicles and post-impact care.

- Allows users with various backgrounds to benefit from the vast knowledge contained in the system by casting scientific evidence on every risk and every measure (or groups thereof) into comprehensive synopses, reachable through different entry points.

Moreover, the SafetyCube DSS is **the first integrated road safety support system developed in Europe**. It aims to be a core reference system for road safety in Europe, constantly improved and enhanced. Therefore, the development of the DSS presents a great potential to further support evidence-based decision making at all levels, aiming to fill in the current gap of integrated risks and measures effectiveness evaluation across Europe and worldwide.

6.5 BENEFITS AND LIMITATIONS OF THE SAFE SYSTEM APPROACH

The systems approach has been employed in strategies to mitigate safety incidents in a range of contexts – from industrial to aviation to road safety. The approach considers these incidents as failures of the social-technical system, resulting from unexpected, uncontrolled relationships between a system's constituent parts (Levenson, 2004). According to Reason (2000), systems theory "concentrates on the conditions under which individuals work and tries to build defences to avert errors or mitigate their effects." The ethos of this approach is that **understanding accidents and defining the appropriate measures require the study of the system as a whole, rather than considering its parts in isolation** (Rasmussen, 1997).

In applying a Safe System approach to road safety, the elements of the road system should be considered in interaction and in combination with each other. The Safe System approach starts with the ethical imperative that no human being should be killed or seriously injured in a road crash and aims to strengthen all dimensions of road safety, including the organisational levels, and manage them holistically and not as separate parts in "silos" (OECD/ITF, 2016).

Within road safety it is often stated that more than 90% of all road traffic accidents can be attributed to driver error. This simplistic outlook ignores the dynamic interactions among the road environment, the vehicle, and the road-user which can mislead to the inexact conclusion that improving driver behaviour is the only effective road safety strategy. In fact the road transport system consists of a plethora of components in the form of road users, vehicles and infrastructure elements that see millions of interactions each day. **A Safe System approach in road safety recognises the complex nature of the transport system acknowledging that multiple factors interact to culminate in a crash** (Zein and Navin, 2003).

SafetyCube through the DSS, provides evidence-based information that considers the interrelationship of both risks and the appropriate measures across the road safety system. Including elements of infrastructure, road user behaviour and vehicles. In addition it recognises a key element of **a Safe System is the drive to irradiate serious injury as well as fatalities**. To address this the DSS includes specific information about injury prevention and, indicates the added value of measures for reducing serious injury. **The DSS, applies a systems perspective to the latest road safety research in an easy to understand format suitable for use by policy makers**.

The Safe System approach rejects the more traditionally 'human error' blame focussed perspective to road safety, and instead takes into account all 'components' in a system (i.e. road users, vehicles, roads) which contribute to a risk of an accident occurring. Therefore, in DSS, risk factors have been identified and evaluated from across the system. Additionally a large range of measures are considered and all applicable measures have been linked to relevant risk factors. In practice this means that while a risk factor may originate in one area of the system (e.g. road user behaviour) the range of measures which are applicable to address this may come from all areas of the system (e.g. road user behaviour, infrastructure or vehicle focused). In this way, **instead of treating measures in isolation (one measure to one risk), the potential for added value of multiple measures is apparent and has been taken into account through the innovative SafetyCube approach to linking risks and measures**.

DSS, grounded in Safe System approach, constitutes a very useful tool for policy makers and other stakeholders, as it provides the full picture regarding the risk factors and the road safety measures and can facilitate an evidence-based policy. However, the DSS is itself a tool and is limited by the information found within it.

In developing the DSS **two major areas where future benefits of the Safe System approach may be realised are apparent: the consideration of serious injuries and combining measures**. A true Safe System approach seeks that no human is killed or seriously injured, however, scientific studies more commonly consider the impact of risks and measures on fatalities than serious injury. To address this lack of knowledge the DSS considers serious injury as a specific topic. However, from a systems perspective this is not ideal. It is hoped that future research will consider serious injuries alongside fatalities, once this research knowledge is developed the DSS could be fully enhanced to cover all areas of the system.

Another limitation of the current DSS content is that the majority of studies included consider road safety measures in isolation. A challenge to the research community is to depart from traditional research silos and evaluate measures in combination. The novel SafetyCube approach to linking risks and measures demonstrates the potential areas where measures can be combined. It is hoped that future research will use these links and evaluate a combined measures approach.

7 Dissemination, user feedback and next steps

Throughout the SafetyCube project interaction and feedback from stakeholders has been in invaluable in shaping the DSS. The dissemination of SafetyCube findings is an essential step in the stakeholder communication process. Great effort has been taken to disseminate findings to as wide an audience as possible. As a result of the interactions with stakeholders, useful feedback for the improvement and adjustment to the user needs was obtained during the DSS development within the project, and a number of future upgrades and areas for potential improvements to the DSS have been identified for beyond the end of the SafetyCube project.

7.1 DSS DISSEMINATION & RELEVANT PUBLICATIONS

The dissemination plan of the SafetyCube project has had two primary strategies. At the beginning of the project, events were planned where potential stakeholders could identy their needs for road safety information. A number of workshops were hosted in the first for information gathering. Beyond the technical and structural content of the DSS, the events provided contact information for targeting stakeholders in future DSS dissemination.

As the DSS structure was developed in the project, SafetyCube's dissemination strategy became more oriented to information spreading. The turning point for the project was the midterm workshop where the content and DSS structure couldbe first presented to a broad audience. Presentations were made to several international audiences with two main DSS events, the launch event in October 2017 and the final conference in March 2017. The final official dissemination activities for the project will be during the TRA conference in April 2018 where SafetyCube has a significant presence.

In addition to presentations at workshops or technical meetings, SafetyCube was successful at presenting the DSS in international conferences and academic journals. Conferences exposed a broad audience to the DSS and had an impact during the project duration. Academic journals have a longer implementation process and some publications may not become online until after the project is complete, however journals ensure a lasting footprint for the DSS and provide peer approval.

Throughout the SafetyCube project, a website www.safetycube-project.eu has been continuously updated to keep stakeholders informed. The website has the traditional structure to allow viewers to retrieve information on the project. A "News item" feature keeps the website populated with the latest activities and newsletters were peridocally generated and distributed to the SafetyCube mailing list which had over 200 registered users. The newsletter and newsitem feature of the website ensured that new and existing SafetyCube contacts were exposed to the SafetyCube activities and DSS.

A final dissemination activity to note is the preparation of training and information for the users of the DSS. A series of videos are being prepared and a webinar will be held on April 10, 2018 to further support the dissemination of the DSS.

To summarise the key DSS dissemination activities in its various forms:

Websites:

- www.safeycube-project.eu
- https://www.roadsafety-dss.eu/

Linked website

- http://www.cmfclearinghouse.org (International, US based, resource for crash prediction)
- https://ec.europa.eu/transport/road_safety/specialist/erso_en (in progress) EC resource for road safety

Workshops

- Seven SafetyCube workshops were organised during the course of the project (2015-2018)
- Webinar introducing the DSS (2018)

Conferences

- SafetyCube presentations at:
    - Transportation Research Board Annual Meeting; Washington DC, USA, 2016,2017, 2018
    - International Cycling Safety Conference; Bologna, IT2016,
    - European Symosium on Accident Reconstruction; Hannover, DE; 2016
    - Safety 2016 World Conference; Helsinki, FI, 2016
    - ERF European Road Safety Congress; Leeds, UK, 2016
    - 10th European Public Health Conference, Stockholm, SE, 2017
    - Road Safety & Simulation International Conferene, the Hague, NL, 2017
    - 8th International Congress on Transportation Research, Thessaloniki, GR, 2017

Presentations at International Working Groups and Association

- International Traffic Safety Data and Analysis Group (IRTAD) (2016, 2017, 2018)
- Community Road Accident Database (CARE) 2016, 2017
- Queensland University road safety meeting, Brisbane, AU 2017
- Annual Meeting of European Association of Motorcycle Manufacturers, Brussels, BE, (2016)
- British Parliamentary Advisory Council; London UK, (2017)
- International Co-operation on Theories and Concepts in Traffic Safety (ICTCT) Workshop; Olomouc, CZ, 017
- TRB Safety Performance Midyear meeting / American Association of State Highway and Transportation Officials, Irvine, CA, USA, 2017
- 10th Annual Conference on Managing Fatigue, San Diego, US, 2017

Press releases / Magazine articles

- Article in on SafetyCube in "Le Strade" April 2017
- Reference to SafetyCube in Euroean Commission Road Safety Press Release, April 4, 2017

- SafetyCube highlighted in European Commission Road Safety Newsletter, April 4, 2017
- SafetyCube featured in "World Highways", March 2016
- Article on SafetyCube in "Strada and Autostrade", January 2016
- Article in on SafetyCube in "Le Strade" October 2015

More details on the SafetyCube dissemination activities will be available in project report D2.6 – "Updated Dissemination Plan" (Thompson et al., 2018).

7.2 PRE- & POST-LAUNCH USERS FEEDBACK

In the initial launch period of the DSS, two main methods were used to collect user feedback – an evaluation survey and group discussions during the official launch workshop on 5th October 2017.

7.2.1 User feedback Survey

Prior to the official launch of the DSS, a consultation was conducted to gather user feedback on both its content and its ease of use. During August 2017, a range of potential users from national and international organisations were contacted and asked to try out the DSS and then fill in a brief survey. They were also provided with a 'quick guide' to give them a brief overview of the DSS and its structure. The project partners were also encouraged to evaluate the DSS and pass the survey to their colleagues.

In total 31 survey responses were received, fifteen of which from partner organisations – either from those directly involved in the project or their colleagues. Six were received from international organisations and the remaining ten were received from organisations working in individual countries (Hungary, Sweden, Germany, Italy, UK, Czech Republic, Serbia, Belgium). The majority of respondents stated that they were **researchers** (19, 61%) with smaller numbers stating they were a **lobbying group** (4, 13%) or a **policy maker** (2, 7%) – see **Figure 7.1**.

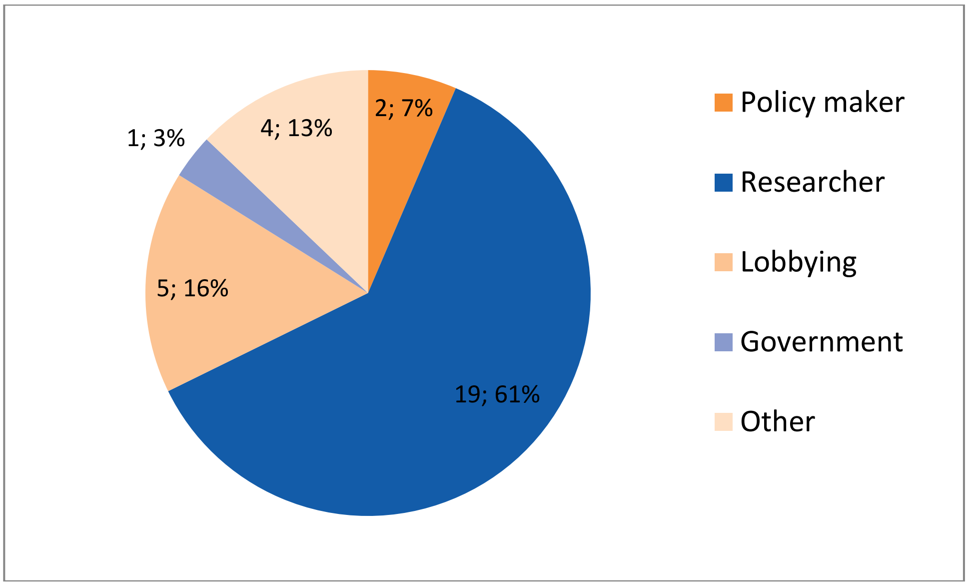


Figure 7.1: Survey respondents' main job role

The questionnaire asked a series of questions and used a 4-point scale to record answers with additional space for comments. Point 1 and 2 are considered the most positive responses with 3 and 4 being more negative. The following paragraphs will describe some of these results and give some examples of comments received.

The majority of respondents frequently needed **scientific evidence or advice** in road safety for their work (Everyday vs Hardly ever: 1 = 15, 48%; 2 = 13, 42%; 3&4 = 3, 10%). Many thought that the DSS allowed them to more easily and efficiently access information compared to existing sources of road safety information (Strongly agree vs Strongly disagree: 1 = 9, 31%; 2 = 12, 41%; 3&4 = 8, 27%). In general respondents also thought that the DSS helps them access more useful/understandable information compared to existing sources (Strongly agree vs Strongly disagree: 1 = 7, 25%; 2 = 14, 50%; 3&4 = 7, 25%). The following comments are examples of those given for this latter question:

"Because the information is collected together concerning a well-defined topic, you know that you are not wasting your time by searching useful information"

"The current version is quite complex but seems very rich in information"

"it makes it easier (helps) but I'm not sure I wouldn't find it anyway"

The majority of respondents found it **easy to navigate** the DSS however a small proportion found this difficult (Very easy vs Very difficult: 1 = 10, 32%; 2 = 16, 52%; 3&4 = 5, 16%). They also found what they wanted quickly (Quick vs Time consuming: 1 = 15, 50%; 2 = 9, 30%; 3&4 = 6, 20%) and overall they found the structure of the DSS useful (Strongly agree vs Strongly disagree: 1 = 10, 38.5%; 2 = 10, 38.5%; 3&4 = 6, 23%). The following comments illustrate this and were received in response to the first question described here:

"The way you have to use the several buttons on the query page is clear. The drop down menus when typing are helpful to specify your search."

"I tried a number of queries and variations but obtained very limited information from the system?"

"It's a simple design – works well but could be difficult to find something very specific."

In general respondents thought the evidence contained in the DSS was **reliable** (Strongly agree vs Strongly disagree: 1 = 13, 48 %; 2 = 10, 37%; 3&4 = 4, 15%) and that the methodology for analysis and synthesis of knowledge appeared appropriate (Strongly agree vs Strongly disagree: 8 = 10, 30%; 2 = 13, 48%; 3&4 = 6, 22%). These questions also resulted in a variety of comments including:

"The final results look academic and trustworthy."

"The methodology for identifying studies is clear and there is a rationale behind the screening which reassures the user that only good quality studies are included in the results"

"I do not see the sense of listing some measures which at least show that there is no effect for road safety"

"When I select specific measure, I obtain a list of studies. How can I compare their quality/reliability?"

Concerns were also expressed about future updating:

"The question about up-to-date data arises. In a couple of years, what will happen to the data base? Is it regularly updated?"

Respondent were also asked whether they would **regularly use the DSS** in the future (Strongly agree vs Strongly disagree: 1 = 12, 44 %; 2 = 8, 30%; 3&4 = 7, 26%) and whether they see it as adding value to their work (Strongly agree vs Strongly disagree: 1 = 11, 42 %; 2 = 8, 31%; 3&4 = 7, 27%). There was a similar spread of answers for both questions suggesting that the majority thought the tool would be useful but for some the August 2017 version of the DSS did not appeal.

Comments suggested that respondents liked the **summaries** and the **colour code** (indicating level of evidence for risk/effectiveness of measure) although one respondent found multiple colour codes for one topic confusing. One respondent noted the links between risks and measures to be a positive attribute and a number of comments expressed interest in the Economic Efficiency Evaluation (E3) Calculator (this was under development at the time of the survey). Criticisms of the DSS included missing studies, that the tool is "*more designed for academics or scientists than policy makers or Stakeholders*" and difficulties finding information via the keyword search.

Overall the feedback received was positive however many suggestions for improvement regarding the navigation and usability of the DSS were made as well as concerns about not being able to find content or content not being available. With regards to the content, this was partly due to not all the content being available at the time of the survey and partly because the structure of the DSS was not clear to all users. Improvements have since been made to the written guidance on the website and tutorial videos have been developed to explain certain aspects which have been imbedded in the DSS.

The comments related to the usability and navigation of the DSS have been very useful in its further development. Many of these were addressed in the update prior to the official launch or in subsequent updates.

7.2.2 Launch workshop

The DSS was launched on 5th Oct 2017. A series of presentations that explained and demonstrated the DSS were followed by three breakout group discussions which aimed to gather additional feedback on the DSS, user training needs and how the DSS could continue to be updated in the future. These were broad discussions that were less focused with the specific content and functionality of the DSS. The following give a brief overview of the type of ideas suggested.

General feedback on the DSS

- One attendee stated that the DSS could be a very useful tool if the problem had already been identified e.g. through statistical analysis. They were concerned that if politicians directly access information it might be risky - if they use information directly and bypass experts.
- Get the message across in the headline. DSS SafetyCube doesn't tell people what it does "How to take good decisions in road safety"
- Researcher – "I found it quite easy but policy-makers might not be so familiar with some of the terminology."
- "A glossary would be good." (Now included)

- Funding/promotion of the DSS

- It was suggested that the EuroNCAP model could be used to fund future development and updates of the DSS. For example, a university/ies act as controllers to input data and oversee quality. A number of member states fund it and appoint tech services. It is of general interest.
- FERSI could promote SafetyCube DSS for local user.
- Promotion to universities/umbrella organisations would be a good idea. If you start your career using the DSS you will continue.
- #Safetycube, Twitter account?

Training Needs:

- System easy to use but there needs to be instructions on the website.
- Prefer short demonstration videos, video demonstrations would be appreciated
- Information about what information the tool does not cover, link to other information.
- Background is as important as technical details
- Educationally it is good to have a workshop, demonstration, maybe within organisations as well. Also talk about other areas, like Serious injuries

7.3 FUTURE UPGRADES OF THE DSS

The DSS is the major output from the SafetyCube project; this is a living tool which can be further enhanced in the future. Now that the system is in place and operational it can provide a valuble service to users. However, there are always enhancements that could be made now that the tool is established. The potential for future development will ensure the longevity of the DSS. The future of the DSS is discussed in detail in Thomas et al. (2018). Briefly, the key areas at which future upgrades will be targeted are:

- Expanding and updating the content. The DSS represents the state of the art knowledge in transport safety at the time of the SafetyCube project. Now that the process is established it is intended that future studies canand will be added.
- Translation to other languages. The content of the DSS is presented in English. Within the resources of the SafetyCube project it was not possible to display content in any other language. Ideally local policy makers would be able to access the content in their native language. It is hoped that a future upgrade will include translation.
- Expansion to other countries. The current DSS content is targeted towards the EU, as such the inclusion of scientific studies from the Europe, USA, Australia and New Zeeland were prioritised. A future upgrade of the DSS could include expanding the scope to include developing countries.
- Expansion of displayed study content. The key information to understand each included scientific study is presented on the DSS. However, within the backend database a greater volume of information has been coded. A potential option for future upgrade of the DSS includes allowing the user to request additional information about studies of interest which is held within the DSS.
- Enhanced emphasis on serious injury. The current state of the art on serious injury is included under the knowledge tab of the DSS. At the moment the scientific knowledge on serious injury from road crashes lags behind understanding of fatalities from road crashes. As this scientific knowledge increases a future update of the DSS is desirable to reflect this.

- Learning from DSS use. The biggest indicator for beneficial future upgrades will be the users of the DSS. The web traffic demonstrating how the DSS is being used will be monitored. This information will be fed into future projects to inform targeted upgrades of the DSS. Additionally, feedback is welcome and invited from users. A dedicated email address is provided on the DSS website to receive any feedback which will be considered in future upgrades.

8 References

Aigner-Breuss, E., Kaiser, S., Usami, D.S., Reed, S. & Weijermars, W. (2017). Inventory of road user related risk factors and safety measures, Deliverable 4.4 of the H2020 project SafetyCube

Dupont, E., Papadimitriou, E., Martensen, H., & Yannis, G. (2013). Multilevel analysis in road safety research. Accident Analysis & Prevention, 60, 402-411.

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

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.

ETSC press release. EU sets new target to cut serious road injuries. http://etsc.eu/eu-sets-new-target-to-cut-serious-road-injuries/. Accessed November 10, 2017.

European Commission (EC) (2010) Towards a European road safety area: policy orientations on road safety 2011-2020. COM (2010) 389 final. Brussels, European Commission.

Evans, L. (1991). Traffic Safety and the Driver. Van Nostrand Reinhold, New York, NY.

Evans, L. (1985). Human behavior feedback and traffic safety. Human Factors 27, 555–576.

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.

Haddon W Jr. (1999). "The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based". Inj. Prev. 5 (3): 231–5.

Haddon W Jr. (1980). "Advances in the epidemiology of injuries as a basis for public policy". Public Health Rep. 95 (5): 411–21.

Hermitte T. and al. (2016a), Identification of Vehicle Related Risk Factors, Deliverable 6.1 of the H2020 project SafetyCube.

Jaensch M., Leopold F. et al. (2016), Identification of Vehicle Related safety measures, Deliverable 6.2 of the H2020 project SafetyCube.

Huang, H., Abdel-Aty, M., 2010. Multilevel data and Bayesian analysis in traffic safety. Accident Analysis and Prevention 42, 1556–1565.

Hughes, B. P., Anund, A., & Falkmer, T. (2016). A comprehensive conceptual framework for road safety strategies. Accident Analysis & Prevention, 90, 13-28.

Larsson, P., Dekker, S. W. A., & Tingvall, C. (2010). The need for a systems theory approach to road safety. Safety Science, 48(9), 1167-1174.

Leveson n. (2004). A New Accident Model for Engineering Safer Systems, Safety Science, 42:4, 2004, pp. 237–270

Machata et al. (2017). A Quick Guide to the SafetyCube DSS

Martensen, H. & Lassarre, S. (eds) (2018), Methodological framework for the evaluation of road safety measures, Deliverable 3.3 of the H2020 project SafetyCube.

Martensen, H.; Diependaele, K.; Van den Berghe, W.; Papadimitriou, E.; Yannis, G.; Van Schagen, I.; Weijermars, W.; Wijnen, W.; Filtness, A.; Thomas, P.; Machata, K.; Aigner-Breuss, E.; Kaiser, S.; Hermitte, T.; Thomson, R (2018, in press). SafetyCube: Building a Decision Support System on Risks and Measures. Accepted for publication in Accident Analysis and Prevention.

Martensen, H. et al. (2016), Preliminary guidelines for priority setting between measures, Deliverable Number 3.4 of the H2020 project SafetyCube.

OECD/ITF. (2016). Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System. Paris.

OECD/ITF. (2011). Reporting on serious road traffic casualties : combining and using different data sources to improve understanding of non-fatal road traffic crashes. OECD, Paris.

Perez et al. (2016) Practical guidelines for the registration and monitoring of serious road injuries, Deliverable 7.1 of the H2020 project SafetyCube. (http://www.safetycube-project.eu/publications/).

Rasmussen, J., 1997. Risk management in a dynamic society: a modelling problem. Safety Science 27 (2/3), 183–213

Reason, J. (2000). Human error: models and management. BMJ : British Medical Journal, 320(7237), 768-770.

Reed, S., Weijermars, W., et al. (2017). Identification of key risk factors related to serious road injuries and their health impacts, Deliverable 7.4 of the H2020 project SafetyCube.

Schoeters, A., Wijnen , W., Carnis, L., Weijermars, W., Elvik, R., Johannsen, H., Vanden Berghe, W., Filtness, A. and Daniels, S. (2017). Costs related to serious road injuries. D7.3 of the H2020 project SafetyCube.

Thomas et al. (2018) Business plan for future Decision Support System. Deliverable 8.5 of the H2020 project SafetyCube.

Thomson et. al. (2018), Updated Dissemintation Plan, Deliverable 2.6 of the H2020 project SafetyCube.

Usami, D.S., Papadimitriou, E., Ziakopoulos, A., Quigley, C., Katrakazas, C., Durso C. (Eds.)(2017), Inventory of assessed infrastructure risk factors and measures, Deliverable 5.4 of the H2020 project SafetyCube

Van den Berghe, W., Martensen, H., Diependaele, K., Talbot, R., Papadimitriou, E, Yannis, G. (2017), Compilation of analyses of risks and measures, Deliverable 8.2 of the H2020 project SafetyCube.

Vanlaar, W. (2005). Multilevel modelling in traffic safety research: two empirical examples illustrating the consequences of ignoring hierarchies. Traffic Injury Prevention 6 (4), 311–316.

Watson A, Watson B, Vallmuur K (2015). Estimating under-reporting of road crash injuries to police using multiple linked data collections. Accident Analysis & Prevention 83:18-25.

Wegman F., Eksler V., Hayes S., Lynam D., Morsink P. and Oppe S., (2005). SUNflower: A Comparative Study of the Development of Road Safety in the SUNflower+6 countries: Final Report, 2005, SWOV Institute for Road Safety Research; Leidschendam, the Netherlands.

Weijermars, W., Meunier, J.-C., Bos, N., Perez, C., Hours, M. et al. (2016). Physical and psychological consequences of serious road traffic injuries. Deliverable 7.2 of the H2020 SafetyCube project.

Wijnen, W., Weijermars, W., Vanden Berghe, W., 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, Deliverable 3.2 of the H2020 project SafetyCube.

Yannis G., Papadimitriou E., Theofilatos A., Thomas P., Filtness A., Martensen H,, Van den Berghe W., Diependaele K., Elvik R., Machata K., Kaiser S., Aigner-Breuss E., Weijermars W., Hermitte T., Thomson R. (2018). SafetyCube - the European Road Safety Decision Support System. In the Proceedings of the Transport Research Arena, Vienna, April 2018.

Zein S., Navin F. (2003). Improving Traffic Safety: A New Systems Approach. Transportation Research Record: Journal of the Transportation Research Board Volume 183.

Appendices

APPENDIX 1 - THE SAFETYCUBE TAXONOMIES OF RISK FACTORS AND MEASURES

Below follow the taxonomies of Risk Factors and Road Safety Measures as were created and utilized within SafetyCube.

Table App.1.1: Behaviour Risk Factors Taxonomy

Topic	Subtopic	Specific risk factor
Speed choice - *Hot topic*	Speeding	Built-up areas
		Rural roads
		Motorways
	Inapropriate speed	Too fast weather-realted
		Too fast traffic related
		Too slow
Influenced driving - alcohol	Drunk driving or drunk riding (cyclists/mopeds) - *Hot topic*	0-0,5‰
		0,51-0,8‰
		0,81-1,6‰
		> 1,6‰
Influenced driving - drugs	Drugged driving/riding, legal (medicine) - *Hot topic*	Benzodiazepines
		Z-drugs
		Medicinale opiate
		Others (antidepressants etc.)
	Drugged driving/riding, illegal - *Hot topic*	THC
		Cocaine
		Amfetamines
		Illegale opiate
		Synthetic drugs
	Combined usage	Combined usage
Risk taking	Risky overtaking - *Hot topic*	Risky overtaking: wrongside
		Without adequate visibility
		Without warning others
		Into oncoming traffic
	Headway distance	Misjudgement
		Tailgating
Fatigue - *Hot topic*	Not enough sleep	Not enough sleep
		Sleeping disorders

Topic	Subtopic	Specific risk factor
	Driven a long time	Driven a long time
Distraction and inattention	Distraction within vehicle or within the riding or walking situation	Conversation with person, passenger/codriver - *Hot topic*
		Music, entertainment systems - *Hot topic*
		Cellphone use - talking - handheld mode - *Hot topic*
		Cellphone use - talking - hands-free mode - *Hot topic*
		Cellphone use - texting - *Hot topic*
		Operating devices (IVIS, navigation systems etc.) - *Hot topic*
		Animals, insects, others
		Consumation of goods (eating, drinking, smoking)
	Distraction outside vehicle (if car user) - *Hot topic*	Watching persons, situations
		Static objects (advertisement, traffic management information etc.)
		Sun, other vehicles' lights
	Distraction through state of mind and cognitive overload	Distraction through state of mind (pondering etc.) and cognitive overload
	Inattention	Inattention, daydreaming
Functional Impairment	Reduced vision (Adaptation, visual field, visual acuity, Contrast perception) - *Hot topic*	Night time driving
		Safety margins
		Pedestrian detection
		Road sign recognition
		Driving out of a tunnel
		Maneuvering
		Permanent impairment (physical condition)
		Missing out auditive informations of other road users
	Reduced hearing - *Hot topic*	Decreased driving preformance under presence of distractors
		Missing out auditive informations of other road users
		Permanent impairment (physical condition)
	Cognitive impairment - *Hot topic*	Dementia
		Alzheimer disease
		Mild cognitive impairment
		Parkinson's disease
		Depressive symptoms
		Other psychiatric disorders
Insufficient skills - *Hot topic*	Skills (motor etc.), operating errors	Vehicle manoeuvring related (control of speed and position, shifting...)
		Traffic situation related (communication, speed adjustment, observation...)
		Trip related (planning the trip)
		Control over how life goals and personal tendencies affect driving behaviour
	Knowledge	Knowledge about effects of vehicle properties

Topic	Subtopic	Specific risk factor
Insufficient knowledge *- Hot topic*		Traffic situation related (knowledge of traffic regulations)
		Trip related (knowledge of location, effects of time pressure in car...)
		Knowledge about life goals and personal tendencies affect driving behaviour
Emotions & Stress	Intrinsic stress	Overburdend
	Extrinsic stress (time pressure)	Time pressure
	Positive emotions	Euphoria
	Negative emotions	Aggression / anger *- Hot topic*
		Fear / anxiety
Misjudgement & Oberservation Errors	Misjudgement of oneself	Underestimate of own speed
		Misjudgement of braking distance / acceleration
		Misjudgement of behaviour of own car or two-wheeler (dynamic, stability...)
		Misinterpretation of driver assistance information
	Misjudgement of others / situation	Speed
		Distance
		Development of situation
		Misunderstanding between road users
	Observation errors	Missed
		Late
		False
Traffic Rule Violations	Red light running	Red light running
	Disregard of right of way	Not yielding for pedestrians at ped. Crossing
		Running stop sign / yielding sign
	Disregard of obligatory usage of car devices	Not using vehicle light when dark
		Not indicating direction
	Wrong way driving	One-way roads
		Wrong side of road
	Using road lane dedicated to other road user or for other function	Bus lanes
		Truck lanes
		Emergency lanes
		Cycle lanes
Personal Factors	Sensation Seeking *- Hot topic*	Sensation Seeking
	Type A personality (impatience, time urgency, and hostility)	Type A personality (impatience, time urgency, and hostility)
	ADHD/ADD etc. *- Hot topic*	ADHD/ADD etc.
	Locus of control	Locus of control
	Introversion/Extraversion	Introversion/Extraversion
Age	Children (4-12 years) *- Hot topic*	Children (4-12 years)
	Adolescents (12-18 years)	Adolescents (12-18 years)

Topic	Subtopic	Specific risk factor
	Young people (18-24 years) *- Hot topic*	Young people (18-24 years)
	Elderly (65+) *- Hot topic*	Elderly (65+)
Diseases and disorders	Diabetes *- Hot topic*	Type A
		Type B
	Epilepsy	Epilepsy
	Influenza	Influenza
	Psychiatric disorders	Anxiety Disorder
		Mood disorder
		Psychotic disorder
		Personality disorder
		Impulse control disorders
	Sudden illness	Heartattack, stroke
		Fainting

Table App.1.2: Behaviour Measures Taxonomy

Topic	Subtopic	Specific countermeasure
Law and enforcement - *Hot topic*	Speeding	General police enforcement, speeding
	Drunk driving/riding	Random breath testing
		DUI checkpoints/selective breath testing
		Lowering BAC limits
		BAC limits for specific groups (novice or professional drivers)
	Drugged driving/riding (illegal)	Drugged driving/riding enforcement
	Aggressive and unsafe driving/riding	Aggressive driving enforcement
	Fatigue, professional drivers	Hours of service regulation
	Distraction	Laws restricting the mobile phone use (hand held)
		Laws restricting the mobile phone use (hands free)
		Enforcement of driving while using the mobile phone
	Seat belt	Seat belt law and safety effects
		Seat belt enforcement
	Child restraint	Child restraint law and safety effects
	Protective clothing (excluding helmet)	Protective clothing
	Helmet, cyclists	Helmet wearing law
		Law on helmet standards
		Safety effect of helmet
	Helmet, PTW	Helmet wearing law
		Law on helmet standards
		Safety effect of helmet
	Red light running	Safety cameras/red light cameras
		General police enforcement
	No specific risk factor targeted	Fines and penalties
		Demerit point system
		General police enforcement and patroling, no specific violation
Education and voluntary trainings/programs	Children/pre-school, primary school	Pedestrian
		Cycling
		Road safety, general
	Adolescents/secondary school	Pedestrian
		Cycling
		Road safety, general

Topic	Subtopic	Specific countermeasure
	Young/novice	Driving
		PTW riding
		Road safety, general
	Elderly	Pedestrian
		Cycling
		Driving
		PTW riding
		Road safety, general
	General population	Usage and fitting of child restraint
		Pedestrian
		Cycling
		PTW riding
		Driving
		Hazard Perception
		Adverse conditions (weather, light)
		Unsafe, risky behaviour
		Rewarding programs
		Road safety, general
	Professional drivers	Truck
		Bus, coach
		Car, van
		Road safety, general
Driver training and licensing	Formal pre-license training	Duration
		Content
		Test
	Graduated driver licensing and probation	General effect of graduated driving licenses
		Speed restriction
		Nighttime driving restriction
		Passenger restriction
		Other driving restriction
	Health requirements for initial registration	Private vehicles (car, motorcycle)
		Commercial vehicles (truck, bus, taxi)
	Required age for initial registration	Required age for initial registration
	Accompanied driving, riding	Accompanied driving, riding
	Offenders	FDA

Topic	Subtopic	Specific countermeasure
Fitness to drive assessment (FDA) and rehabilitation		Rehabilitation
		Alcohol interlock
	Young offenders, drivers	FDA
		Rehabilitation
	Medical referrals	Dementia
		Medical referral, other
	Elderly drivers	FDA (Screening)
	Professional drivers	FDA (Screening)
Awareness raising and campaigns *- Hot topic*	Speeding and inappropriate speed	Speeding and inappropriate speed
	Distraction	Distraction
	Driving under the influence (alcohol and drugs)	Driving under the influence (alcohol and drugs)
	Fatigue	Fatigue
	Seat belt	Seat belt
	Child restraint	Child restraint
	Helmet, protective clothing and visibility	Helmet, protective clothing and visibility
	Aggressive and unsafe behaviour	Aggressive and unsafe behaviour
	Campaigns in general	Campaigns in general

Table App.1.3: Infrastructure Risk Factors Taxonomy

Topic	Subtopic	Specific risk factor
Exposure	Traffic flow	Traffic volume
		congestion
		secondary crashes
		varying traffic composition
		distribution of traffic flow over arms at junctions
		absence of access control
Road type	Road type	Road type
Road surface	Road surface deficiencies (risk of ran-off road)	inadequate friction
		uneven surface
		ice, snow
		oil, leaves, etc.
Road environment	Poor visibility and lighting	poor visibility - darkness
		poor visibility - fog
	Adverse weather	rain
		frost and snow
		wind
Workzones	Workzones - *Hot topic*	workzone length
		workzone duration
		insufficient signage
Alignment deficiencies - Road segments	Horizontal/vertical alignment deficiencies - *Hot topic*	low curve radius
		absence of transition curves
		frequent curves
		densely spaced junctions
		poor sight distance - horizontal curves
		high grade
		vertical curve radius
		presence of tunnel
		poor sight distance - vertical curves
Cross-section deficiencies - Road segments	Superelevation / cross-slopes	superelevetion at curve
		cross-slope

Topic	Subtopic	Specific risk factor
	Lanes deficiencies	number of lanes
		narrow lanes
	Median / barrier deficiencies	undivided road
		narrow median
	Shoulder and roadside deficiencies	absence of paved shoulders - *Hot topic*
		narrow shoulder - *Hot topic*
		risks associated with safety barriers - *Hot topic*
		absence of clear-zone
		roadside obstacles - *Hot topic*
		sight obstructions (landscape, obstacles and vegetation)
		absence of sidewalks
		narrow sidewalks
Traffic control - Road segments	Poor road readability - *Hot topic*	absence of traffic signs
		misleading or unreadable traffic signs
		absence of road markings
		absence of rumble strips
Alignment-junctions	Interchange deficiencies	ramp capacity
		ramp length
		acceleration / deceleration lane length
		absence of channelisation
		poor sight distance
	At-grade junctions deficiencies	high number of conflict points - *Hot topic*
		type of junction - *Hot topic*
		skewness / junction angle - *Hot topic*
		poor sight distance - *Hot topic*
		Gradient - *Hot topic*
Traffic control - junctions	Rail-road crossings (risk of collision with train)	uncontrolled rail-road crossing
	Poor junction readability	uncontrolled junction
		misleading or unreadable traffic sign
		absence of road markings

Topic	Subtopic	Specific risk factor
		absence of marked crosswalks

Table App.1.4: Infrastructure Measures Taxonomy

Topic	Subtopic	Specific countermeasure
Exposure	Traffic flow	flow diversion
		2+1 roads
		reversible lanes
		one-way traffic
		ramp metering
		access control
	Traffic composition	HGV traffic restrictions
		creation of HGV lanes
Infrastructure safety management	Formal tools to address road network deficiencies *- Hot topic*	road safety audits implementation
		road safety inspections implementation
		high risk sites identification
		land use regulations improvement
	Speed management & enforcement	reduction of speed limit
		dynamic & weather-variant speed limits *- Hot topic*
		individual dynamic speed warning *- Hot topic*
		speed cameras
		section control
		speed humps
		woonerfs implementation
		narrowings implementation
		30-zones implementation
		traffic calming schemes
		school zones speed reduction measures
Road type	Road type	upgrade / downgrade road class
		upgrade road to motorway
		creation of by-pass road
Road surface	Road surface treatments	improve friction (type of surface)
		road re-surfacing to improve evenness
		ice prevention / winter maintenance

Topic	Subtopic	Specific countermeasure
Lighting	Visibility / Lighting treatments - *Hot topic*	installation of road lighting
		improvement of existing lightling
Workzones	Workzones - *Hot topic*	workzone signage installation
		workzone signage improvement
		workzone length treatment
		workzone duration decrease
Alignment - Road segments	Horizontal & vertical alignment treatments	creation of weaving area
		increase horizontal curve radius (curve re-alignment)
		implement transition curves (curve re-alignment)
		reduce number of curves (re-alignment)
		reduce tangent length
		sight distance treatments (horizontal alignment)
		reduce gradient (re-alignment)
		increase vertical curve radius (curve re-alignment)
		sight distance treatments (vertical alignment)
Cross-section - Road segments	Superelevation / cross-slopes treatment	superelevation improvement
		cross-slope improvement
	Lanes / ramps treatments	increase number of lanes
		create speed change lane
		increase lane width
	Median / barrier treatments	installation of median
		increase median width
		change median type
		implementation of rumble strips at centerline
	Shoulder & roadside treatments - *Hot topic*	shoulder implementation (shoulder type)
		increase shoulder width
		change shoulder type
		safety barriers installation
		change type of safety barriers

Topic	Subtopic	Specific countermeasure
		create clear-zone / remove obstacles
		increase width of clear-zone
		removal of sight obstructions
	Delineation and road markings at road segments	installation of chevron signs at curves
		road markings implementation
		implementation of edgeline rumble strips
		transverse rumble strips
	Sidewalks treatments	sidewalk installation
		increase of sidewalk width
	Cycle lanes	cycle lanes treatments
		cycle path treatments
		increase of cycle lane width
Traffic control - Road segments	Traffic signs treatments at road segments *- Hot topic*	traffic sign installation
		traffic sign maintenance
	Driver information and alert	variable message signs: incident / accident warning
		variable message signs: congestion / queue warning
		V2I schemes
Alignment-junctions	Interchanges treatments	convert at-grade junction to interchange
		increasing ramp width
		increaseing ramp curve radius (ramp re-alignment)
		increasing acceleration / deceleration lane length
		increasing lane width
	At-grade junctions treatments	channelisation
		sight distance treatments *- Hot topic*
		convert junction to roundabout
		convert 4-leg junction to staggered junctions
		improve skewness / junction angle *- Hot topic*
Traffic control - junctions	Rail-road crossings	rail-road crossing traffic sign
		automatic barriers installation

Topic	Subtopic	Specific countermeasure
	Traffic signs treatments at junctions	STOP / YIELD signs installation
		STOP / YIELD signs replacement
	Road markings at junctions	road markings implementation
		implementation of marked crosswalk
	Traffic signals treatments	traffic signals installation
		improve traffic signals timing
		implementation of pedestrian signal phase

Table App.1.5: Vehicle Risk Factors Taxonomy

Topic	Subtopic	Specific risk factor
Crashworthiness	Compatibility, Age & Underrun	LGV
		Passenger Cars
		Trucks / Bus
	Low Star rating (EuroNCap)	Passenger Cars
		Pedestrian
Injury mechanism	Risk for unbelted occupants	Trucks / Bus
	Risk of injury in case of fire	Trucks / Bus
	Risk of injury in Rollover	Passenger Cars
		Trucks / Bus
	Risk to be injured in frontal impact (driver, front passenger ,rear passenger)	Passenger Cars
	Risk to be injured in rear impact	Passenger Cars
	Side impact: risk to be injured following nearside/farside impact	Passenger Cars
	Submarining & abdominal injury risk	Passenger Cars
Protective equipment design	Safety Equipment	PTW / ATV
Relevant factors in crash data	Accident characteristics & injury level	Bicycles
		LGV
		Passenger Cars
		Pedestrian
		PTW / ATV
		Trucks / Bus
Technical defects / Maintenance	Technical defects	Passenger Cars
		PTW / ATV
		Trucks / Bus
Vehicle design	vehicle shape & Configuration	Pedestrian
		Trucks / Bus
Visibility / Conspicuity	Visibility, Conspicuity & Blind Spot issue	Bicycles
		LGV
		Pedestrian
		PTW / ATV
		Trucks / Bus

Table App.1.6: Vehicle Measures Taxonomy

Topic	Subtopic	Specific countermeasure
Crashworthiness	Frontal impact	Directive 96/79/CEE et ECE.R94
		EuroNcap (Full width & ODB)
		Frontal airbag
		PTW Airbag
		Seat belt (effectiveness) SBR and Load limiter included
		anti-submarining (airbags, seat bossage, knee airbzg, seatbel pretensionner,…)
	Side impact	Directive 96/27/CEE et ECE.R95
		Regulation UN R135 (Pole side-impact protection)
		EuroNCap (MBD & Pole)
		Side airbag (Head only Head + Thorax, Thorax + Abd + Pellvis, Farside airbag, curtain, ...)
	Rear impact	Regulation UN R32 (Behaviour of the structure in rear-end collision)
		Anti Whiplash (Seat, active headrest, …)
		EuroNCap (whiplash)
	Rollover	AirBag protection (Roof, curtains, …)
		RollOver protection system
	Pedestrian	Pedestrian protection (Active bonnet, pedestrian airbag, EuroNCap, …)
		Pedestrian regulation
	Child	Child Restraint System (usage, fitting, misuse, ISOFIX, EuroNCap, …)
	PTW	Helmet + Protective equipment (use & performance)
	Cyclist	Helmet + reflective equipment + lighting (usage + performance)
	HGV	Underrun protection (Front / Side + Lateral Side Guards / Rear)
Active safety / ADAS - *Hot topic*	Longitudinal	Emergency Braking Assistance system
		Autonomous Emergency Braking AEB (City, interurban)
		Autonomous Emergency Braking AEB (Pedestrians & cyclists)
		Emergency Stop Signal (ESS)
		Braking system PTW (ABS, Combined braking system, …)ABS (PTW)
		Collision Warning
		Intelligent Speed adaptation + Speed Limiter + Speed regulator
		Adaptive Cruise Control (ACC & ACC Stop & start)

Topic	Subtopic	Specific countermeasure
	Lateral control	Electronic Stability Control (ESC)
		Lane Departure Warning (LDW) + Lane Keeping Assist (LKA) + Lane Centering System
	Driver assistance	Drowsiness and Distraction Recognition
		Alcohol Interlock (ALC)
	Visibility enhanced	Enhanced Headlights (automated, adaptive, advanced system, …)
		Night Vision
		Vehicle backup camera - Reversing Detection or Camera systems (REV)
		Blind Spot Detection
		Blind Spot mirror - Direct vision and VRU detection (VIS) for HGV
	Technical defects	ISO 26262 (road vehicles - functional safety)
		Tyre Pressure Monitoring and Warning
		Vehicle inspection
		Regulation ECE R13 (braking systems)
	Connected	Vehicle to Vehicle communication
Tertiary Safety	Post-Crash	eCall
		Rescue Data Sheet & Rescue code
		ECE R100 (Battery electric vehicle safety)
		Event Data Recorder

Table App.1.7: Post Impact Care Measures Taxonomy

Topic	Subtopic
Ambulances/helicopters	response time
	specialized ambulances
	helicopter rescue
Extraction from vehicle	extraction from passenger car
	extraction from LGV
	extraction from truck
	extraction from bus
Pre-hospital medical care	care on scene vs move to hospital
	ATLS/PHTLS
	mobile medical teams, people in the team (specialist nurses, physicians,…) and level of education
Triage and allocation to trauma facilities	triage
	trauma care organisation/regionalisation of trauma care/network of hospitals to chose appropriate hospital
	protocols for multiple casualty crashes
First aid training drivers	First aid training drivers

APPENDIX 2 - THE SAFETYCUBE ACCIDENT SCENARIOS TAXONOMY

Accident scenarios

Accident scenario	sub-scenario / pre-crash configuration
Pedestrian Accident	pedestrian crossing road out of crossing path
	pedestrian crossing road on crossing path at straight stretch
	pedestrian crossing road in front of junction
	pedestrian crossing road behind junction
	pedestrian moving along the road
	vehicle reversing
	pedestrian sitting or lying on the ground
	pedestrian – changing mode (e.g. driver getting off the car)
	other pedestrian configuration
Bicyclist Accident	Bicycle alone
	Crossing configuration, Cyclist coming from farside (C1)
	Crossing configurations, Cyclist coming from nearside (C2)
	Same direction, Vehicle turning farside (T1)
	Opposite direction, Vehicle turning farside -T2)
	Opposite direction, Vehicle turning nearside (T3)
	Cyclist coming (nearside) farside,
	Vehicle turning (nearside) farside (T4)"
	Same direction, Vehicle turning nearside (T5)
	Same direction, cyclist ahead (L1)
	Same direction, cyclist ahead and changing lane (L2)
	Opposite direction, Cyclist turning nearside (FAR SIDE) (On)
	Dooring accident
	Other (Re)
Single vehicle accident	The vehicle leaving the road nearside - with rollover
	The vehicle leaving the road nearside - with object collision (tree, pole, wall, ...)
	The vehicle leaving the road nearside - without rollover / object collision
	The vehicle leaving the road farside - with rollover
	The vehicle leaving the road farside - with object collision (tree, pole, wall, ...)
	The vehicle leaving the road farside - without rollover / object collision
	The vehicle leaving the road - other configurations
	Collision with parked vehicle
	Collision with lost load
	Collision with animals on the road

Accident scenario	sub-scenario / pre-crash configuration
	Falling bus occupant without collision
	Falling PTW without collision with another participant
	Other configurations (e.g. fallen tree)
	Collision other obstacle, other impact
Head-on collision / Oncoming traffic	Head-on collision - overtaking
	Head-on collision - unintended lane change stable
	Head-on collision - unintended lane change instable
	Side collision with other participant oncoming - loss of control
	Other type of collision - unintended lane change instable
	Other oncoming traffic accident configuration
Rear-end collision / Same direction traffic	Standing vehicle (Rear-end collision while the vehicle ahead is standing)
	Breaking vehicle (Rear-end collision while the vehicle ahead is braking)
	Driving vehicle (Rear-end collision while the vehicle ahead is driving)
	Lane changing vehicle (Rear-end collision while at least 1 vehicle is changing lane)
	Side-swipe collision with other participant in same direction
	Other configurations (all configurations not included in the previous ones, e.g. overtaking, moving between lanes ...)
Junction accident (no turning)	No turning : participant required to yield crossing from nearside road
	No turning : participant required to yield crossing from farside road
	No turning : other
Junction accident (turning)	Turning : farside turn - other participant in direction (following or overtaking)
	Turning : farside turn - other participant in opposite direction
	Turning : farside turn - other participant from other road
	Turning : farside turn - both participant farside turning
	Turning : farside turn - other
	Turning : nearside turn - other road user in direction
	Turning : nearside turn - other road in opposite direction
	Turning : nearside turn - other road user from other road
	Turning : nearside turn - other
	Turning : other
Railway crossing	with barriers
	without barriers
	barriers unknown

Links between main accident scenarios and risks taxonomies

Accident Scenario	Taxonomy	Related risks
Pedestrian accident	Behaviour	Inappropriate speed
	Behaviour	Speeding
	Behaviour	Drunk driving or drunk riding (cyclists/mopeds)
	Behaviour	Distraction within vehicle or within the riding or walking situation
	Behaviour	Distraction outside vehicle (if car user)
	Behaviour	Distraction through state of mind and cognitive overload
	Behaviour	Inattention
	Behaviour	Reduced vision (Adaptation, visual field, visual acuity, Contrast perception)
	Behaviour	Disregard of right of way
	Behaviour	Children (4-12 years)
	Behaviour	Adolescents (12-18 years)
	Behaviour	Elderly (65+)
	Infrastructure	poor visibility - darkness
	Infrastructure	high number of conflict points
	Infrastructure	uncontrolled junction
	Infrastructure	misleading or unreadable traffic sign
	Infrastructure	absence of marked crosswalks
	Infrastructure	sight obstructions (landscape, obstacles and vegetation)
	Vehicle	Low Star rating (EuroNCap)
	Vehicle	Visibility, Conspicuity & Blind Spot issue
	Vehicle	vehicle shape & Configuration
Bicyclist accident	Behaviour	Using road lane dedicated to other road user or for other function
	Behaviour	Misjudgement of others / situation
	Behaviour	Adolescents (12-18 years)
	Behaviour	Drunk driving or drunk riding (cyclists/mopeds)

Accident Scenario	**Taxonomy**	**Related risks**
	Vehicle	Safety Equipment
	Vehicle	Prevalence of cyclists factors in crash data
	Vehicle	Visibility, Conspicuity & Blind Spot issue
	Vehicle	vehicle shape & Configuration
Single vehicle accident	Behaviour	Speeding
	Behaviour	Inapropriate speed
	Behaviour	Sensation Seeking
	Behaviour	Drunk driving or drunk riding (cyclists/mopeds)
	Behaviour	Not enough sleep
	Behaviour	Driven a long time
	Behaviour	Distraction within vehicle or within the riding or walking situation
	Behaviour	Distraction outside vehicle (if car user)
	Behaviour	Distraction through state of mind and cognitive overload
	Behaviour	Inattention
	Behaviour	Knowledge
	Behaviour	Young people (18 -24 years)
	Infrastructure	rain
	Infrastructure	frost and snow
	Infrastructure	wind
	Infrastructure	inadequate friction
	Infrastructure	uneven surface
	Infrastructure	poor visibility - darkness
	Infrastructure	poor visibility - fog
	Infrastructure	Visibility, Conspicuity & Blind Spot issue
	Infrastructure	roadside obstacles
	Infrastructure	sight obstructions (landscape, obstacles and vegetation)
	Infrastructure	Road type

Accident Scenario	Taxonomy	Related risks
	Infrastructure	low curve radius
	Infrastructure	absence of transition curves
	Infrastructure	frequent curves
	Infrastructure	densely spaced junctions
	Infrastructure	high grade
	Infrastructure	vertical curve radius
	Infrastructure	poor sight distance - horizontal curves
	Infrastructure	poor sight distance - vertical curves
	Infrastructure	absence of road markings
	Vehicle	Risk of injury in Rollover
Head-on collision / on-coming traffic	Behaviour	Risky overtaking
	Behaviour	Misjudgement of others / situation
	Behaviour	Wrong way driving
	Behaviour	Risk to be injured in frontal impact (driver, front passenger ,rear passenger)
	Behaviour	Not enough sleep
	Behaviour	Driven a long time
	Infrastructure	undivided road
Rear-end Colllision / Same direction traffic	Behaviour	Reduced vision (Adaptation, visual field, visual acuity, Contrast perception)
	Behaviour	Inapropriate speed
	Behaviour	Drunk driving or drunk riding (cyclists/mopeds)
	Behaviour	Distraction outside vehicle (if car user)
	Behaviour	Misjudgement of oneself
	Behaviour	Inattention
	Behaviour	Misjudgement of others / situation
	Behaviour	Headway distance
	Behaviour	Observation errors

Accident Scenario	Taxonomy	Related risks
Junction accident (no turning)	Behaviour	Misjudgement of others / situation
	Behaviour	Red light running
	Infrastructure	poor sight distance (at grade junctions deficiencies)
	Infrastructure	distribution of traffic flow over arms at junctions
	Infrastructure	type of junction
	Infrastructure	densely spaced junctions
	Infrastructure	high number of conflict points
	Infrastructure	uncontrolled junction
	Infrastructure	absence of road markings
	Infrastructure	absence of marked crosswalks
	Infrastructure	skewness / junction angle
	Infrastructure	gradient
Junction accident (turning)	Behaviour	Misjudgement of others / situation
	Behaviour	Red light running
	Behaviour	Disregard of right of way
	Behaviour	Elderly (65+)
	Infrastructure	type of junction
	Infrastructure	skewness / junction angle
	Infrastructure	poor sight distance (at grade junctions deficiencies)
	Infrastructure	uncontrolled junction
	Infrastructure	misleading or unreadable traffic sign
	Infrastructure	absence of road markings
	Infrastructure	absence of marked crosswalks
	Infrastructure	high number of conflict points
	Infrastructure	type of junction
	Infrastructure	skewness / junction angle

Accident Scenario	Taxonomy	Related risks
	Infrastructure	gradient
	Vehicle	Side impact: risk to be injured following nearside/farside impact
Railway crossing	Behaviour	Misjudgement of others / situation
	Infrastructure	uncontrolled rail-road crossing

Links between main accident scenarios and measures taxonomies

Accident scenario	Taxonomy	Related measures
Pedestrian accident	Behaviour	Distraction (Law and enforcement)
	Behaviour	Protective clothing (excluding helmet)
	Behaviour	Children/pre-school, primary school (education)
	Behaviour	Adolescents/secondary school (education)
	Behaviour	Elderly (education)
	Behaviour	General population (education)
	Behaviour	Campaigns in general
	Infrastructure	improvement of existing lightling
	Infrastructure	installation of road lighting
	Infrastructure	Night Vision
	Infrastructure	reduction of speed limit
	Infrastructure	speed cameras
	Infrastructure	section control
	Infrastructure	speed humps
	Infrastructure	woonerfs implementation
	Infrastructure	narrowings implementation
	Infrastructure	30-zones implementation
	Infrastructure	school zones speed reduction measures
	Infrastructure	traffic calming schemes
	Infrastructure	improve traffic signals timing
	Infrastructure	implementation of pedestrian signal phase
	Vehicle	Pedestrian protection (Active bonnet, pedestrian airbag, EuroNCap, ...)
	Vehicle	Pedestrian regulation
	Vehicle	Autonomous Emergency Braking AEB (Pedestrians & cyclists)
	Vehicle	Vehicle backup camera - Reversing Detection or Camera systems (REV)
	Vehicle	Blind Spot mirror - Direct vision and VRU detection (VIS) for HGV

Accident scenario	Taxonomy	Related measures
	Vehicle	Blind Spot Detection
Bicyclist accident	Behaviour	Helmet, cyclists (law and enforcement)
	Behaviour	Protective clothing (excluding helmet)
	Behaviour	Children/pre-school, primary school (education)
	Behaviour	Adolescents/secondary school (education)
	Behaviour	Elderly (education)
	Behaviour	Campaigns in general
	Infrastructure	cycle lanes treatments
	Infrastructure	cycle path treatments
	Infrastructure	increase of cycle lane width
	Vehicle	Helmet + reflective equipment + lighting (usage + performance)
	Vehicle	Helmet + Protective equipment (use & performance)
	Vehicle	Underrun protection (Front / Side + Lateral Side Guards / Rear)
	Vehicle	Autonomous Emergency Braking AEB (Pedestrians & cyclists)
	Vehicle	Vehicle backup camera - Reversing Detection or Camera systems (REV)
	Vehicle	Blind Spot mirror - Direct vision and VRU detection (VIS) for HGV
	Vehicle	Blind Spot Detection
	Vehicle	Night Vision
Single vehicle accident	Behaviour	Distraction (law and enforcement)
	Behaviour	Speeding (law and enforcement)
	Behaviour	Seat belt (law and enforcement)
	Behaviour	Young offenders, drivers (FDA)
	Behaviour	Young/novice (education)
	Behaviour	Campaigns in general
	Behaviour	Driving under the influence (alcohol and drugs) - Awareness reasing and campaigns
	Behaviour	Speeding and inappropriate speed (awareness raising and campaigns)
	Behaviour	Drunk driving/riding (law and enforcement)

Accident scenario	Taxonomy	Related measures
	Behaviour	Fatigue (awareness raising and campaigns)
	Behaviour	Helmet, cyclists (law and enforcement)
	Behaviour	Helmet, PTW (law and enforcement)
	Infrastructure	high risk sites identification
	Infrastructure	road safety audits implementation
	Infrastructure	road safety inspections implementation
	Infrastructure	increase horizontal curve radius (curve re-alignment)
	Infrastructure	implement transition curves (curve re-alignment)
	Infrastructure	reduce gradient (re-alignment)
	Infrastructure	reduce number of curves (re-alignment)
	Infrastructure	reduce tangent length
	Infrastructure	removal of sight obstructions
	Infrastructure	sight distance treatments (horizontal alignment)
	Infrastructure	sight distance treatments (vertical alignment)
	Infrastructure	increase vertical curve radius (curve re-alignment)
	Infrastructure	installation of chevron signs at curves
	Infrastructure	installation of median
	Infrastructure	installation of road lighting
	Infrastructure	increase lane width
	Infrastructure	increase median width
	Infrastructure	increase number of lanes
	Infrastructure	narrowings implementation
	Infrastructure	upgrade / downgrade road class
	Infrastructure	upgrade road to motorway
	Infrastructure	road markings implementation
	Infrastructure	implementation of edgeline rumble strips
	Infrastructure	shoulder implementation (shoulder type)
	Infrastructure	increase shoulder width

Accident scenario	Taxonomy	Related measures
	Infrastructure	change shoulder type
	Infrastructure	change type of safety barriers
	Infrastructure	create clear-zone / remove obstacles
	Infrastructure	increase width of clear-zone
	Infrastructure	safety barriers installation
	Infrastructure	sidewalk installation
	Infrastructure	increase of sidewalk width
	Infrastructure	individual dynamic speed warning
	Infrastructure	dynamic & weather-variant speed limits
	Infrastructure	reduction of speed limit
	Infrastructure	speed cameras
	Infrastructure	section control
	Infrastructure	speed humps
	Infrastructure	30-zones implementation
	Infrastructure	traffic calming schemes
	Infrastructure	school zones speed reduction measures
	Infrastructure	superelevation improvement
	Infrastructure	cross-slope improvement
	Infrastructure	improvement of existing lightling
	Infrastructure	woonerfs implementation
	Infrastructure	traffic sign installation
	Infrastructure	traffic sign maintenance
	Vehicle	AirBag protection (Roof, curtains, ...)
	Vehicle	Alcohol Interlock (ALC)
	Vehicle	Frontal airbag
	Vehicle	Drowsiness and Distraction Recognition
	Vehicle	eCall
	Vehicle	Electronic Stability Control (ESC)

Accident scenario	Taxonomy	Related measures
	Vehicle	Enhanced Headlights (automated, adaptive, advanced system, ...)
	Vehicle	Event Data Recorder
	Vehicle	Lane Departure Warning (LDW) + Lane Keeping Assist (LKA) + Lane Centering System
	Vehicle	Helmet + Protective equipment (use & performance)
	Vehicle	Helmet + reflective equipment + lighting (usage + performance)
	Vehicle	Night Vision
	Vehicle	Rescue Data Sheet & Rescue code
	Vehicle	RollOver protection system
	Vehicle	Seat belt (effectiveness) SBR and Load limiter included
	Vehicle	Tyre Pressure Monitoring and Warning
Head-on collision / on-coming traffic	Behaviour	Seat belt (law and enforcement)
	Behaviour	Helmet, cyclists (law and enforcement)
	Behaviour	Helmet, PTW (law and enforcement)
	Behaviour	Professional drivers
	Behaviour	Campaigns in general
	Infrastructure	2+1 roads
	Infrastructure	road markings implementation
	Infrastructure	installation of median
	Infrastructure	increase median width
	Infrastructure	change median type
	Infrastructure	implementation of rumble strips at centerline
	Vehicle	Frontal airbag
	Vehicle	PTW Airbag
	Vehicle	Seat belt (effectiveness) SBR and Load limiter included
	Vehicle	anti-submarining (airbags, seat bossage, knee airbzg, seatbel pretensionner,...)
	Vehicle	Child Restraint System (usage, fitting, misuse, ISOFIX, EuroNCap, ...)
	Vehicle	Helmet + Protective equipment (use & performance)

Accident scenario	Taxonomy	Related measures
	Vehicle	Helmet + reflective equipment + lighting (usage + performance)
	Vehicle	Underrun protection (Front / Side + Lateral Side Guards / Rear)
	Vehicle	Emergency Braking Assistance system
	Vehicle	Autonomous Emergency Braking AEB (City, interurban)
	Vehicle	Autonomous Emergency Braking AEB (Pedestrians & cyclists)
	Vehicle	Emergency Stop Signal (ESS)
	Vehicle	Braking system PTW (ABS, Combined braking system, ...)ABS (PTW)
	Vehicle	Collision Warning
	Vehicle	Intelligent Speed adaptation + Speed Limiter + Speed regulator
	Vehicle	Adaptive Cruise Control (ACC & ACC Stop & start)
	Vehicle	Drowsiness and Distraction Recognition
	Vehicle	Alcohol Interlock (ALC)
	Vehicle	Vehicle to Vehicle communication
	Vehicle	eCall
	Vehicle	Rescue Data Sheet & Rescue code
	Vehicle	Event Data Recorder
Rear-end Colllision / Same direction traffic	Behaviour	Campaigns in general
	Behaviour	Helmet, cyclists (law and enforcement)
	Behaviour	Helmet, PTW (law and enforcement)
	Behaviour	Professional drivers
	Behaviour	Seat belt (law and enforcement)
	Infrastructure	sight distance treatments (horizontal alignment)
	Vehicle	Adaptive Cruise Control (ACC & ACC Stop & start)
	Vehicle	Alcohol Interlock (ALC)
	Vehicle	Anti Whiplash (Seat, active headrest, ...)
	Vehicle	anti-submarining (airbags, seat bossage, knee airbzg, seatbel pretensionner,...)
	Vehicle	Autonomous Emergency Braking AEB (City, interurban)

Accident scenario	Taxonomy	Related measures
	Vehicle	Blind Spot Detection
	Vehicle	Braking system PTW (ABS, Combined braking system, …)ABS (PTW)
	Vehicle	Child Restraint System (usage, fitting, misuse, ISOFIX, EuroNCap, …)
	Vehicle	Collision Warning
	Vehicle	Drowsiness and Distraction Recognition
	Vehicle	eCall
	Vehicle	Emergency Braking Assistance system
	Vehicle	Emergency Stop Signal (ESS)
	Vehicle	EuroNCap (whiplash)
	Vehicle	Event Data Recorder
	Vehicle	Frontal airbag
	Vehicle	Helmet + Protective equipment (use & performance)
	Vehicle	Intelligent Speed adaptation + Speed Limiter + Speed regulator
	Vehicle	Night Vision
	Vehicle	PTW Airbag
	Vehicle	Regulation UN R32 (Behaviour of the structure in rear-end collision)
	Vehicle	Rescue Data Sheet & Rescue code
	Vehicle	Seat belt (effectiveness) SBR and Load limiter included
	Vehicle	Underrun protection (Front / Side + Lateral Side Guards / Rear)
	Vehicle	Vehicle to Vehicle communication
Junction accident (no turning)	Behaviour	Campaigns in general
	Behaviour	Professional drivers
	Behaviour	Helmet, cyclists (law and enforcement)
	Behaviour	Helmet, PTW (law and enforcement)
	Behaviour	Seat belt (law and enforcement)
	Infrastructure	convert junction to roundabout
	Infrastructure	improve skewness / junction angle

Accident scenario	Taxonomy	Related measures
	Infrastructure	sight distance treatments
	Infrastructure	transverse rumble strips
	Infrastructure	convert at-grade junction to interchange
	Infrastructure	increasing ramp width
	Infrastructure	increaseing ramp curve radius (ramp re-alignment)
	Infrastructure	increasing acceleration / deceleration lane length
	Infrastructure	increasing lane width
	Infrastructure	improvement of existing lightling
	Infrastructure	installation of road lighting
	Infrastructure	traffic signals installation
	Infrastructure	improve traffic signals timing
	Infrastructure	road markings implementation
	Vehicle	Blind Spot Detection
	Vehicle	Child Restraint System (usage, fitting, misuse, ISOFIX, EuroNCap, ...)
	Vehicle	eCall
	Vehicle	Event Data Recorder
	Vehicle	Frontal airbag
	Vehicle	Helmet + Protective equipment (use & performance)
	Vehicle	Helmet + reflective equipment + lighting (usage + performance)
	Vehicle	Night Vision
	Vehicle	PTW Airbag
	Vehicle	Rescue Data Sheet & Rescue code
	Vehicle	Seat belt (effectiveness) SBR and Load limiter included
	Vehicle	Vehicle to Vehicle communication
Junction accident (turning)	Behaviour	Campaigns in general
	Behaviour	Elderly (ducation)
	Behaviour	Elderly drivers (fitness to drive)

Accident scenario	Taxonomy	Related measures
	Behaviour	Helmet, cyclists (law and enforcement)
	Behaviour	Helmet, PTW (law and enforcement)
	Behaviour	Seat belt (law and enforcement)
	Infrastructure	channelisation
	Infrastructure	convert 4-leg junction to staggered junctions
	Infrastructure	convert junction to roundabout
	Infrastructure	implementation of marked crosswalk
	Infrastructure	improve skewness / junction angle
	Infrastructure	increasing ramp width
	Infrastructure	increaseing ramp curve radius (ramp re-alignment)
	Infrastructure	increasing acceleration / deceleration lane length
	Infrastructure	increasing lane width
	Infrastructure	road markings implementation
	Infrastructure	traffic signals installation
	Infrastructure	improve traffic signals timing
	Infrastructure	implementation of pedestrian signal phase
	Infrastructure	STOP / YIELD signs installation
	Infrastructure	STOP / YIELD signs replacement
	Infrastructure	installation of road lighting
	Infrastructure	improvement of existing lightling
	Vehicle	Adaptive Cruise Control (ACC & ACC Stop & start)
	Vehicle	anti-submarining (airbags, seat bossage, knee airbzg, seatbel pretensionner,…)
	Vehicle	Autonomous Emergency Braking AEB (City, interurban)
	Vehicle	Braking system PTW (ABS, Combined braking system, …)ABS (PTW)
	Vehicle	Child Restraint System (usage, fitting, misuse, ISOFIX, EuroNCap, …)
	Vehicle	Collision Warning
	Vehicle	Directive 96/27/CEE et ECE.R95

Accident scenario	**Taxonomy**	**Related measures**
	Vehicle	eCall
	Vehicle	Emergency Braking Assistance system
	Vehicle	Emergency Stop Signal (ESS)
	Vehicle	EuroNCap (MBD & Pole)
	Vehicle	Event Data Recorder
	Vehicle	Helmet + Protective equipment (use & performance)
	Vehicle	Helmet + reflective equipment + lighting (usage + performance)
	Vehicle	Intelligent Speed adaptation + Speed Limiter + Speed regulator
	Vehicle	Regulation UN R135 (Pole side-impact protection)
	Vehicle	Rescue Data Sheet & Rescue code
	Vehicle	Underrun protection (Front / Side + Lateral Side Guards / Rear)
	Vehicle	Vehicle to Vehicle communication
	Vehicle	Seat belt (effectiveness) SBR and Load limiter included
	Vehicle	Side airbag (Head only Head + Thorax, Thorax + Abd + Pellvis, Farside airbag, curtain, ...)
Railway crossing	Behaviour	Campaigns in general
	Infrastructure	traffic sign installation
	Infrastructure	traffic sign maintenance
	Infrastructure	improvement of existing lightling
	Infrastructure	installation of road lighting
	Infrastructure	rail-road crossing traffic sign
	Infrastructure	automatic barriers installation
	Vehicle	eCall
	Vehicle	Event Data Recorder
	Vehicle	Rescue Data Sheet & Rescue code
	Vehicle	Seat belt (effectiveness) SBR and Load limiter included
	Vehicle	Vehicle to Vehicle communication

APPENDIX 3 - LINKS BETWEEN RISK FACTORS, MEASURES AND SERIOUS INJURIES (MAIS 3+)

Within WP7, risk factors relevant regarding serious road injuries where investigated, following a two step approach. The first step concerned the selection of groups of casualties that were of special interest from a (burden of) non-fatal serious injury perspective. Four groups of casualties were selected: cyclists, 0-17 year olds, spinal cord injuries and knee/lower leg fractures. In the second step, these groups were further analysed using in depth data. It was determined in which types of crashes MAIS3+ casualties are present and which contributing factors are present in the crashes.

For the selected casualty groups in combination with risk factors, the DSS was searched for relevant measures. In some cases the recommendation returned from the search terms was not always absolutely specific, for example, recommendations relating to Pedestrians with vision obstruction may include general countermeasures for vision obstruction involving other vulnerable road users as there was no disaggregation between pedestrians, cyclists or PTW users.The information contained in the recommendations column is not exhaustive as there will be in most instances other countermeasures that could provide a variety of road safety effects. What the recommendations column does contain however is scientifically verified results for a range of different measures for road users, infrastructure and vehicles.

The table contains three columns, these are:(i) column one covering the group selected through the 'step 1' process, (ii) column two covering the specific risk factors determined through the in-depth analysis process and related to the specific groups and (iii) column three which contains the scientific overview for the specific recommendations taken from the Decision Support System. The information contained within the recommendation column covers three broad aspects, these are (i) the name of the recommendation as it appears in the SafetyCube DSS, (ii) the colour code applied to the specific recommendation to identify whether it is **Effective**, **Probably effective** or an **Unclear result**[1] and (iii) a short description of the recommendation (if necessary) and an overview of the scientific findings behind the effectiveness of the recommendation.

Group of casualties	Risk factor/crash type	Recommended measures
Cyclists 0 - 17 yrs	Collisions while crossing or turning	**Channelisation** **Effective** Channelisation of junctions is a physical measure of road safety to improve safety at intersections by traffic flow separation, sight improvement and the simplification of driving patterns and right of way rules. In general, channelisation of junctions seems to reduce accident frequency. Differences between the effectiveness of different types of channelisation of junctions like left-turn lanes or right-turn lanes are however difficult to quantify.
		Road safety audits **Probably effective**. It can be seen that road safety audits and inspections measures can have a positive effect on road safety. In a minority of cases their impact can be seen as inconclusive (or has isolated negative effects), but results still indicate an overall crash mitigation.

[1] The SafetyCube DSS also includes a further categorisation of 'ineffective' however these appear in limited numbers in the DSS and do not provide additional knowledge into suitable countermeasures.

Group of casualties	Risk factor/crash type	Recommended measures
		Road safety inspections implementation Probably effective. It can be seen that road safety audits and inspections measures can have a positive effect on road safety. In a minority of cases their impact can be seen as inconclusive (or has isolated negative effects), but results still indicate an overall crash mitigation.
		Identification of high risk sites (accident black spots) Probably effective. It can be seen that high risk site treatment measures have an overall positive effect on road safety. In a minority of cases the impact of the countermeasure may remain unverified or could show an isolated negative effect.
		Convert junction to roundabout Probably effective. Evidence from studies on this countermeasure presents mainly positive effects, however in some instances roundabouts may lead to higher crash rates for cyclists.
		Convert 4-leg junction to staggered junction Probably effective. The conversion of 4-leg junctions to staggered T-junctions appears to reduce injury crash occurrence, especially when the amount of side road traffic is high. At sites where the latter is low, an increase in crash occurrence is seen. However, although there were different results for different exposures, staggering junctions has mainly positive effects on road safety
		Traffic signal installation (for uncontrolled junctions) Probably effective It can be seen that the installation of traffic signals have a mostly positive effect on road safety. Results show that the countermeasure does efficiently change road safety levels in most cases.
		Improve skewness / junction angle Unclear result. The improvement of skewness or junction angle refers to the redesigning of junctions. Junctions are described as skewed when roads are not crossing at a right angle (90 degrees). Thus, improving skewness concerns the geometric layout of the junction. The improvement of skewness or junction angle may reduce crash occurrence and might also have positive effects on driving performance, but reported effects are not statistically significant.
	Vision obstruction	**Sight distance treatments** Effective. Sight distance treatments at junctions seem to reduce crash occurrence. In addition, mostly positive effects on driver behaviour (e.g. decrease in drivers' speed) can be seen, in addition intended sight obstructions might have positive effects on driver behaviour.
		Education – Pedestrian skills training for children Probably effective There is some evidence, including a meta-analysis, that behaviour based education/training for children in pedestrian skills can improve the skills that children require to cross the road. However, some studies had mixed results and those with follow up results suggested that the benefit of training may reduce over time.
	Judging vehicle speed and/or path	**Installation of section control & speed cameras** Effective. Results for this countermeasure consistently show that section control and fixed speed cameras have favourable effects on the number of crashes that occur [all road users]
		General road safety campaigns Probably effective There is some indication that campaigns are beneficial for road safety on various levels. Meta-analyses show an association with accident reduction, increased safe behaviours and risk awareness. However, no such effect was seen with behaviours such as drink-driving or safety relevant attitudes.

Group of casualties	Risk factor/crash type	Recommended measures
		Furthermore, the evidence is drawn from studies that vary strongly, mainly regarding the design of the evaluated campaigns.
		Education of children, pre-school and primary school Probably effective There is some evidence, including a meta-analysis, that behaviour based education/training for children in pedestrian skills can improve the skills that children require to cross the road. However, some studies had mixed results and those with follow up results suggested that the benefit of training may reduce over time. *[N.B. although the literature behind this recommendation is based on pedestrians it is probable that the countermeasure could also be applicable to cyclists]*
	Experience/behaviour	**Education – Pedestrian skills training for children** Probably effective There is some evidence, including a meta-analysis, that behaviour based education/training for children in pedestrian skills can improve the skills that children require to cross the road. However, some studies had mixed results and those with follow up results suggested that the benefit of training may reduce over time. *[N.B. although the literature behind this recommendation is based on pedestrians it is probable that the countermeasure could also be applicable to cyclists]*
		General road safety campaigns Probably effective There is some indication that campaigns are beneficial for road safety on various levels. Meta-analyses show an association with accident reduction, increased safe behaviours and risk awareness. However, no such effect was seen with behaviours such as drink-driving or safety relevant attitudes. Furthermore, the evidence is drawn from studies that vary strongly, mainly regarding the design of the evaluated campaigns.
PTW users 0 - 17 yrs	Collisions while crossing or turning	**Road safety audits** Probably effective. It can be seen that road safety audits and inspections measures can have a positive effect on road safety. In a minority of cases their impact can be seen as inconclusive (or has isolated negative effects), but results still indicate an overall crash mitigation.
		Road safety inspections implementation Probably effective. It can be seen that road safety audits and inspections measures can have a positive effect on road safety. In a minority of cases their impact can be seen as inconclusive (or has isolated negative effects), but results still indicate an overall crash mitigation.
		Identification of high risk sites (accident black spots) Probably effective. It can be seen that high risk site treatment measures have an overall positive effect on road safety. In a minority of cases the impact of the countermeasure may remain unverified or could show an isolated negative effect.
		Convert junction to roundabout Probably effective. Evidence from studies on this countermeasure presents mainly positive effects, however in some instances roundabouts may lead to higher crash rates for cyclists.
		Convert 4-leg junction to staggered junction Probably effective. The conversion of 4-leg junctions to staggered T-junctions appears to reduce injury crash occurrence, especially when the amount of side road traffic is high. At sites where the latter is low, an increase in crash occurrence is seen. However, although there were different results for different exposures, staggering junctions has mainly positive effects on road safety
		Traffic signal installation (for uncontrolled junctions) Probably effective

Group of casualties	Risk factor/crash type	Recommended measures
		It can be seen that the installation of traffic signals have a mostly positive effect on road safety. Results show that the countermeasure does efficiently change road safety levels in most cases.
		Improve skewness / junction angle Unclear result The improvement of skewness or junction angle refers to the redesigning of junctions. Junctions are described as skewed when roads are not crossing at a right angle (90 degrees). Thus, improving skewness concerns the geometric layout of the junction. The improvement of skewness or junction angle may reduce crash occurrence and might also have positive effects on driving performance, but reported effects are not statistically significant.
Pedestrians 0 – 17 yrs	Vision obstruction while crossing	**Sight distance treatments** Effective Sight distance treatments at junctions seem to reduce crash occurrence. In addition, mostly positive effects on driver behaviour (e.g. decrease in drivers' speed) can be seen, in addition intended sight obstructions might have positive effects on driver behaviour.
		Education – Pedestrian skills training for children Probably effective There is some evidence, including a meta-analysis, that behaviour based education/training for children in pedestrian skills can improve the skills that children require to cross the road. However, some studies had mixed results and those with follow up results suggested that the benefit of training may reduce over time.
		Implementation of marked crosswalks Unclear result The safety impact of marked crosswalks remains somewhat unclear, especially the impact on pedestrian crash rate. Some studies find no significant effects of marked crosswalks on the number of crashes, while some find significant increases in the number of crashes at some locations or for some groups of road users. However, a significant reduction in crash severity is consistently found in literature
Drivers in collision with a road user 0 – 17 yrs	Speed	**Installation of section control & speed cameras** Effective. Results for this countermeasure consistently show that section control and fixed speed cameras have favourable effects on the number of crashes that occur [all road users]
		Reduction of speed limit Effective Speed and road safety are inversely correlated. In that context, speed limit reduction has a significant positive impact on road safety. Studies observed a decrease of fatal crashes, of serious injuries, and also of other kind of injuries. The effects seem larger for a high level of initial speed than for a low level. No evidence of negative effects of speed limit reduction has been found. However, some studies lack statistical analyses and should be considered with care
		Installation of Speed Humps Effective Studies on the safety effects of speed hump installation show that accident rates and vehicle speeds are reduced when installed. In half of the analysed studies, the results were significant. In the other half of the studies, no statistical analysis was undertaken, so it is not known whether these results were significant. However, what is clear is that none of the results showed that speed humps resulted in increased speeds or accident rates. Hence, it can be concluded that installing speed humps reduces road safety risk
		Implementation of 30km/h (20mph)-Zones Effective The results from the available literature show that, overall, vehicle speeds and accident/casualty rates reduce when 30km/h (or 20mph) zones are implemented. Where available, the results are statistically significant for a variety of conditions. However, two of five studies did not undertake a statistical analysis, but many of the non-significant results showed speed

Group of casualties	Risk factor/crash type	Recommended measures
		reductions and lower accident/casualty rates. This suggests that, overall, 30km/h zones do improve safety
		Fines, demerit point system and general patrolling **Licence suspension** - Effective Studies indicate that licence suspension (or licence revocation) is an effective measure for reducing violations and crashes of (repeat) offenders. **Increasing traffic fines** - Probably effective There is evidence that higher fines are associated with less traffic violations, but effects may be limited in time and place **Demerit point systems** - Probably effective There is some indication that Demerit Point Systems can reduce road safety risk, however in practice the effects wear off rather quickly.
		Awareness raising and campaigns – Speeding Probably effective Results show that anti-speeding campaigns can have significant positive effects on road safety (behaviour). However, some campaigns are combined with enforcement activities others do not indicate long-term effects or do not take other indirect effects into account like changes in traffic
		Implementation of Traffic Calming Schemes Probably effective The results from the available literature showed that overall, accident and casualty rates reduce when calming schemes traffic are installed and these results are statistically significant. However, the studies included in all 3 meta-analyses and Yannis et al. (2003) are fairly dated (1980s/1990s), and without newer studies to support the findings, it is unclear whether these results would have been replicated if more recent studies/data had been available. Also in Høye (2014), none of the primary studies were controlled for regression to the mean, so the effects found may be over-estimated. However on balance, it appears that traffic calming schemes do improve safety
		Intelligent speed adaptation/speed limiter/speed regulator Probably effective The effects of speed adaptation devices in cars are mostly positive in reducing crash frequency, vehicles' mean speed and drivers exceeding the speed limit. Furthermore, the coded studies encompass several topics and have good levels of quality and consistency. However, there are a number of findings which cannot be strongly supported due to lack of statistical tests
	Distraction	**Autonomous Emergency Braking AEB (City, interurban)** Effective The bibliographic review on the effectiveness of AEB city & interurban suggests that the colour code Green (effective) should be given. While no studies were found dealing with AEB interurban, five studies were found dealing with AEB city and all suggesting that it has a positive effect on road safety.
		Autonomous Emergency Braking AEB (pedestrians & cyclists) Effective The bibliographic review on the effectiveness of AEB pedestrian & cyclist suggests that the colour code Green (effective) should be given. All studies establish that AEB pedestrian & cyclist has (or would have) a positive effect on road safety.
		Law and Enforcement -Distraction: Laws restricting the mobile phone use and enforcement of driving while using the mobile phone Unclear result. The effects of implementing laws and increasing enforcement against mobile phone use while driving are mixed. To date, studies have shown positive, positive without statistical evaluation, non-significant and even negative effects.

Group of casualties	Risk factor/crash type	Recommended measures
	Observation	**Education - Hazard perception training** Effective The results from the available literature indicate that hazard perception training/education can significantly improve the hazard perception skills of drivers as well as reduce accident rates and speeds. As most of the studies performed statistical analyses, and the vast majority of the results were statistically significant, there is evidence that hazard perception training brings about enhanced hazard avoidance skills. Consequently, drivers who have undertaken hazard perception training are less likely to cause accidents or drive with high speeds, thus it can be concluded that hazard perception training reduces road safety risk

Group	Risk	Recommendation
Cyclist (all ages)	Collisions while entering or crossing a priority road	**Channelisation** Effective Channelisation of junctions is a physical measure of road safety to improve safety at intersections by traffic flow separation, sight improvement and the simplification of driving patterns and right of way rules. In general, channelisation of junctions seems to reduce accident frequency. Differences between the effectiveness of different types of channelisation of junctions like left-turn lanes or right-turn lanes are however difficult to quantify.
		Road safety audits Probably effective. It can be seen that road safety audits and inspections measures can have a positive effect on road safety. In a minority of cases their impact can be seen as inconclusive (or has isolated negative effects), but results still indicate an overall crash mitigation.
		Road safety inspections implementation Probably effective. It can be seen that road safety audits and inspections measures can have a positive effect on road safety. In a minority of cases their impact can be seen as inconclusive (or has isolated negative effects), but results still indicate an overall crash mitigation.
		Convert 4-leg junction to staggered junction Probably effective. The conversion of 4-leg junctions to staggered T-junctions appears to reduce injury crash occurrence, especially when the amount of side road traffic is high. At sites where the latter is low, an increase in crash occurrence is seen. However, although there were different results for different exposures, staggering junctions has mainly positive effects on road safety
		Traffic signal installation (for uncontrolled junctions) Probably effective It can be seen that the installation of traffic signals have a mostly positive effect on road safety. Results show that the countermeasure does efficiently change road safety levels in most cases.
		Traffic sign installation; traffic sign maintenance Effective On the basis of both study and effect numbers, the installation and maintenance of traffic signs appear to have positive effects on road safety. There are cases when the impact is inconclusive, but these instances are in the minority. Furthermore, the coded studies encompass several topics and have good levels of quality and consistency. For the reasons mentioned above, the overall impact of traffic sign installation and maintenance is characterized as effective
		STOP/YIELD signs installation or replacement: Unclear result From studies on the effects of the installation or replacement of stop/yields signs at junctions it appears that only the installation of two-way stops and four-way stops significantly reduces crash occurrence. Installing one-way stops might reduce crash occurrence, but reductions were not statistically significant. This

Group	Risk	Recommendation
		applies also to the installation of yield signs. The replacement of stop signs by yield signs however appears to significantly increase crash occurrence
		Traffic signal reconfiguration: Unclear result On a basis of both study and effect numbers, traffic signal reconfiguration measures have an unclear effect on road safety. The positive effects do not outnumber the negative ones by a safe (large) margin, and many outcomes are either not directly related to road safety or are not statistically significant *[topic addresses pedestrian crossing phase which may have parallels with a cyclist crossing phase]*
	Vision issues while crossing	**Sight distance treatments** Effective Sight distance treatments at junctions seem to reduce crash occurrence. In addition, mostly positive effects on driver behaviour (e.g. decrease in drivers' speed) can be seen, in addition intended sight obstructions might have positive effects on driver behaviour.
	Single vehicle cycle crashes	**Increase shoulder width:** Probably effective Several studies have found a positive effect of increasing shoulder width on road safety. However, for some circumstances (e.g. injury and property damage only shoulder related crashes on multilane roads) significant negative estimates were found *[results are typically for motorised vehicles but parallels could be drawn for cycles]*
		Law and Enforcement -Distraction: Laws restricting the mobile phone use and enforcement of cycling while using the mobile phone Unclear result. The effects of implementing laws and increasing enforcement against mobile phone use while driving are mixed. To date, studies have shown positive, positive without statistical evaluation, non-significant and even negative effects.
		Cycle lane treatments; increase of cycle lane width Unclear result According to existing research, the installation of a cycle lane may have a positive or negative effect on road safety. A not physically separated cycle lane could reduce injury accidents for cyclists. The effect is greatest at road intersections. On the other hand, a physically separated cycle track may increase the number of accidents, particularly cycle accidents at intersections.
	Legal (disobeying signs/signals, alcohol, drugs)	**Effectiveness of Road Safety Campaigns** Probably effective There is some indication that campaigns are beneficial for road safety on various levels. Meta-analyses show an association with accident reduction, increased safe behaviours and risk awareness. However, for other outcome variables such as drink-driving or safety relevant attitudes, no such effect was found. Furthermore, meta-analysed studies vary strongly, mainly regarding the design of the evaluated campaigns.
		Awareness raising and campaigns – Driving under the influence Probably effective There is some indication that drink-driving campaigns have a positive impact on attitudes towards drink-driving and even on the related accident occurrence. There is less evidence of the effectiveness of designated driver programmes.

Group	Risk	Recommendation
Road users sustaining spinal cord injuries	Rollover occurrence for passenger vehicles	Electronic stability control Effective Results consistently show that the Electronic Stability Control (ESC) system reduces road safety risk. ESC is mandatory in many countries supported by the many indicators that prove ESC to be beneficial.

Group	Risk	Recommendation
	Roof strength for passenger vehicles and movement of occupant	**Rollover protection system** Unclear result A number of studies from the U.S. show that there is a relationship between roof crush and injury severity in rollover crashes. However no literature is available on the effectiveness of certain measures to reduce roof crush.
		Seatbelt Effective The recommendation for the use of 3-point seat belt measure is affective, referring to the unanimous and high positive effect regarding prevention of injuries and fatalities during a crash for which this type of occupant safety system is designed.
	High levels of crush and intrusion	**EuroNCAP frontal impact** Effective EuroNCAP publishes safety performance data continuously. Vehicle crash performance has steadily improved after the introduction of EuroNCAP tests. The scientific literature contains positive evaluations of EuroNCAP's contribution to improved frontal impact protection. There is no doubt that the introduction of the consumer test programmes and the regulations have caused the manufacturers to compete and improve their vehicles' safety features.
	Impacts with road/off road surface or road side furniture	PTW protective equipment Probably effective International literature indicates that the use of Powered Two Wheeler protective equipment in the form of motorcycle specific jackets, trousers, gloves and boots provides a protective effect, reducing the level of injury sustained in the event of a collision.

Group	Risk	Recommendation
Road users sustaining knee/lower leg injuries	PTW users in collisions with vehicles	PTW protective equipment Probably effective International literature indicates that the use of Powered Two Wheeler protective equipment in the form of motorcycle specific jackets, trousers, gloves and boots provides a protective effect, reducing the level of injury sustained in the event of a collision.
	Vehicle occupants in collision with fixed objects	**Lanekeeping systems** Unclear result Some literature was found on Lane departure warning systems, no relevant literature evaluating the effect of Lane keeping assist systems was found. The available literature mostly describes the benefit of LDW systems by identifying the target population (share of crashes that could have been addressed by a LDW system). Little is known however about the number of cases where LDW would have been effective.
	PTW uses in impact with road infrastructure/surface/guardrail	**PTW protective equipment** Probably effective International literature indicates that the use of Powered Two Wheeler protective equipment in the form of motorcycle specific jackets, trousers, gloves and boots provides a protective effect, reducing the level of injury sustained in the event of a collision.
	Vehicle passengers striking facia panels	**EuroNCAP frontal impact** Effective EuroNCAP publishes safety performance data continuously. Vehicle crash performance has steadily improved after the introduction of EurpoNCAP tests. The scientific literature contains positive evaluations of EuroNCAP's contribution to improved frontal impact protection. There is no doubt that the introduction of the consumer test programmes and the regulations have caused the manufacturers to compete and improve their vehicles' safety features.
	High levels of crush and intrusion	**EuroNCAP frontal impact** Effective EuroNCAP publishes safety performance data continuously. Vehicle crash performance has steadily improved after the introduction of EurpoNCAP tests.

Group	Risk	Recommendation
		The scientific literature contains positive evaluations of EuroNCAP's contribution to improved frontal impact protection. There is no doubt that the introduction of the consumer test programmes and the regulations have caused the manufacturers to compete and improve their vehicles' safety features.
		Frontal impact regulation (ECE R94) Probably effective Most results in the literature estimate safety benefits between generations of cars or according to certain types of impacts, this masks the effect of one specific regulation or the progress due to the rising effect of consumer test programs. All results or estimations for this measure fail to consider the requirements of the active safety devices or the possible migration of the type of impacts due to their generalisation on future vehicles; therefore it is not possible to conclude whether this recommendation is fully effective.

APPENDIX 4 - QUALITY ASSURANCE CHECKLISTS

Checklist for expert synopsis quality assurance review

	Sufficient? (Yes/No)	Explanation (in case No)
Study selection and prioritizing		
The most relevant search terms are included		
Most relevant database(s) is/are searched		
Selection of studies is transparent		
All obvious studies that should be included are included (expert judgement)		
Summary		
Assigned colour code is supported by main findings presented in summary		
Abstract reflects main contents of summary		
Background information in the summary provides sufficient introduction to risk factor/measure studied		
Overview of results in summary provides a clear picture of the main findings		
Analysis methods are adequately described and potential biases/limitations are clearly mentioned		
Conditions for transferability of the effect estimates are mentioned		
All results presented in the summary are valid and logical		
The summary sufficiently reflects the current state of knowledge (expert judgement)		
Overall advice		
In your view, is the summary of the synopsis (in its current state) of sufficient quality to be included in the online Decision Support System		

Checklist for coded study review

	Yes/No
Is the abstract of the study available?	
Are all the study design fields filled?	
Are there any display problems (e.g. weird characters)? Is the information in the correct place?	
Is the outcome variable field filled? Is the outcome variable clearly defined?	
Is the exposure variable field filled? Is the exposure variable clearly defined?	
Is the effect estimator field filled? Is the effect estimator clearly defined?	
Is there enough information to distinguish between the different effects?	
Are the effects estimated filled in and of reasonable value?	
Are the comments/conclusions filled for all effects?	

APPENDIX 5 - LIST OF MASTER KEYWORDS SEARCHABLE THROUGH THE DSS KEYWORD ENTRY POINT

Master Keywords	Number of links with database keywords
2+1 ROADS	2
30-ZONES	5
AAP	2
ABS	3
ACC	3
ACCELERATION / DECELERATION LANES	6
ACCESS CONTROL	5
ACCIDENT PREDICTION	3
ACCIDENT SEVERITY	6
ACCIDENT TYPE	1
ACTIVE ACCELERATOR PEDAL	2
ACTIVE HOOD LIFT SYSTEM	1
ADAPTIVE CRUISE CONTROL	3
ADAS	5
ADD	5
ADHD	5
ADMINISTRATIVE LICENSE REVOCATION	1
ADOLESCENTS	14
ADVANCED DRIVER ASSISTANCE SYSTEMS	5
ADVERTISING SIGNS	6
AEB	8
AESTHETIC STREETS	1
AGE	4
AGEING	21
AGGRESSION	19
AGGRESSIVE DRIVING	2
AIRBAGS	11
ALCOHOL	52
ALCOHOL INTERLOCK	10
ALERTING SYSTEMS	3
ALIGNMENT	18
ALR	1
ALZHEIMER'S DISEASE	2
AMBULANCES	10
ANGER	19

Master Keywords	Number of links with database keywords
ANGLE CRASH	3
ANIMALS	1
ANTILOCK BRAKES	3
ANXIETY	6
AREA TYPE	30
ARTERIAL ROADS	4
AT-GRADE JUNCTIONS	8
ATTENTIONAL DEFICIT HYPERACTIVITY DISORDER	5
ATTITUDES	7
AUTONOMOUS EMERGENCY BRAKING	8
AWARENESS	3
AWARENESS RAISING	35
BAC LIMITS	10
BARRIERS	16
BEHAVIOURAL ADAPTATION	2
BENEFIT-COST ANALYSIS	8
BICYCLE LANES	7
BICYCLISTS	35
BIOMECHANICS	1
BLACKSPOTS	9
BLIND SPOTS	3
BLOOD ALCOHOL CONCENTRATION	10
BODY REGIONS	1
BRAIN INJURIES	2
BRAKE ASSIST SYSTEM	1
BRAKE RESPONSE	8
BRAKES	5
BREATH TESTING	4
BUILT-UP AREAS	20
BUS LANES	1
BUSES	12
BY-PASS ROADS	4
CAMERAS	20
CAMPAIGNS	35
CANNABIS	4
CAR SIZE	2
CARDIOPULMONARY RESUSCITATION	2
CARGO SECURING	1

Master Keywords	Number of links with database keywords
CARS	13
CELLPHONE USE	24
CHANNELISATION	3
CHEST INJURY	1
CHEVRON SIGNS	5
CHEVRONS	1
CHICANES	1
CHILD PEDESTRIANS	4
CHILD RESTRAINT SYSTEMS	12
CHILD SEATS	12
CHILDREN	23
CLEAR ZONE	10
CLIMATE	6
CLOSE FOLLOWING	12
CLOSE FOLLOWING BEHAVIOUR	3
COACHES	1
COGNITIVE IMPAIRMENT	11
COGNITIVE WORKLOAD	22
COLLISION AVOIDANCE	7
COLLISION WARNING	7
COMMENTARY DRIVING	2
COMMERCIAL VEHICLES	10
COMMUNITY DESIGN	1
COMPATIBILITY	4
COMPENSATORY BEHAVIOUR	2
COMPLIANCE	1
CONFLICTS	8
CONGESTION	9
CONNECTIVITY	1
CONSPICUITY	8
CONVERSATION WITH PASSENGER	2
COOPERATIVE SYSTEMS	8
COST-BENEFIT ANALYSIS	8
CPR	2
CRASH CUSHIONS	14
CRASH PREDICTION	3
CRASH SEVERITY	43
CRASH TEST	2

Master Keywords	Number of links with database keywords
CRASH TYPE	1
CRASHWORTHINESS	4
CROSSROADS	3
CROSS-SECTION	3
CROSSWALKS	14
CRS	12
CUBIC CAPACITY	2
CULTURE	8
CURVES	20
CYCLE LANES	7
CYCLISTS	35
DARKNESS	11
DAYLIGHT	5
DAYTIME RUNNING LIGHTS	2
DELIVERY/SALES WORKERS	1
DEMENTIA	2
DEMERIT POINT SYSTEM	3
DEMOGRAPHICS	4
DEPRESSION	2
DIABETES	9
DILEMMA ZONE	1
DISCOMFORT GLARE	1
DISEASES / DISORDERS	46
DISTANCE ADVANCE WARNING	1
DISTRACTION	70
DRINKING AND DRIVING	52
DRIVER EDUCATION	2
DRIVER TRAINING	2
DRIVERS	14
DRIVEWAYS	1
DRIVING PERFORMANCE	2
DRIVING UNDER THE INFLUENCE	82
DRL	2
DRUGS	45
DSDS	2
DUI	82
DYNAMIC SPEED DISPLAY SIGNS	2
DYNAMIC SPEED LIMITS	6

Master Keywords	Number of links with database keywords
DYNAMIC SPEED WARNING	5
E-BIKE	3
E-CALL	2
ECE-R-14	1
ECE-R-16	1
ECE-R-44	1
ECE-R-66	1
ECE-R-80	1
EDR	1
EDUCATION	16
EJECTION	2
ELDERLY	21
ELECTRIC BIKE	3
ELECTRIC VEHICLE	1
ELECTRONIC STABILITY CONTROL	8
EMERGENCY BRAKE ASSIST	3
EMERGENCY MEDICAL SERVICES	19
EMOTIONS	28
EMS	18
ENFORCEMENT	58
ENTERTAINMENT SYSTEMS	4
ENVIRONMENT DESIGN	6
ENVIRONMENTAL FACTORS	14
ENVIRONMENTAL STREET	1
EPILEPSY	1
ERRORS	7
ESC	8
EURONCAP	2
EVENT DATA RECORDER	1
EXPERIENCE	14
EXPOSURE	8
EXTRACTION FROM VEHICLE	4
FATAL CRASHES	14
FATIGUE	18
FDA	3
FINES	16
FIRE	10
FIRE BRIGADE	3

Master Keywords	Number of links with database keywords
FIRE DETECTION SYSTEM	1
FIRE SUPPRESSION SYSTEM	1
FIRST AID	5
FIRST AID TRAINING	8
FITNESS TO DRIVE ASSESSMENT	3
FLEET OPERATIONS	1
FOG	5
FOLLOW DISTANCE	14
FOLLOWING BEHAVIOUR	3
FORECASTING	1
FOREIGN DRIVERS	1
FOUR-LEGGED JUNCTIONS	3
FREEWAYS	36
FRICTION	16
FRONT PASSENGERS	3
FRONTAL CRASH	9
GDL	16
GENDER	6
GEOMETRIC DESIGN	18
GRADE	8
GRADE SEPARATION	2
GRADIENT	8
GRADUATE LICENSING	2
GRADUATED DRIVING LICENSE	14
GUARDRAILS	16
HANDHELD	5
HANDS-FREE	3
HEAD AND NECK INJURY	2
HEAD INJURY	6
HEAD RESTRAINTS	3
HEADLIGHTS	3
HEAD-ON COLLISION	9
HEADWAY	10
HEADWAY DISTANCE	7
HEALTH	3
HEARING IMPAIRMENT	6
HELICOPTERS	6
HELMETS	7

Master Keywords	Number of links with database keywords
HGV	26
HIGH RISK SITES	9
HIGHER EDUCATION STUDENTS	1
HIGHWAYS	36
HMI	1
HNISS	2
HOME ZONES	2
HOSPITALS	4
HOURS OF SERVICE REGULATIONS	6
HUMAN MACHINE INTERFACE	1
HYPERACTIVITY	5
ICE / SNOW / FROST	11
IGNITION LOCK	10
IMPACT AREA	3
IMPAIRED DRIVING	88
INATTENTION	22
INCIDENTS	2
IN-DEPTH ACCIDENT DATA	2
INJURY MECHANISM	4
INJURY SEVERITY	43
INTELLIGENT SPEED ADAPTATION	4
INTELLIGENT TRANSPORT SYSTEMS	5
INTERCHANGES	17
INTERLOCK	10
INTERSECTIONS	19
IN-VEHICLE DATA RECORDERS	1
IN-VEHICLE SPEED LIMITER	1
ISA	4
ISO	2
ITS	5
IVIS	7
JUNCTION ANGLE	5
JUNCTION DENSITY	4
JUNCTIONS	22
KNOWLEDGE	9
LAND USE	2
LANE DEPARTURE WARNING	1
LANE KEEPING	5

Master Keywords	Number of links with database keywords
LANE KEEPING ASSIST	1
LANE WIDTH	13
LANES	36
LATERAL CONTROL	5
LATERAL IMPACT	1
LAWS	23
LDW	1
LEFT-TURN CRASHES	11
LEFT-TURN LANES	8
LEVEL JUNCTIONS	8
LGV	21
LICENSE RENEWAL	1
LICENSE REVOCATION	2
LICENSE SUSPENSION	3
LICENSING	43
LIGHT GOODS VEHICLES	21
LIGHT TRUCKS	21
LIGHTING	19
LOAD	1
LOAD LIMITER	2
LONGER COMBINATION VEHICLES	1
LOSS OF CONTROL	1
LOW COST ENGINEERING MEASURES	1
LOW COST ENGINEERING TREATMENTS	1
LOWER EXTREMITY INJURY	2
LSD	1
MAIN ROAD	1
MAINTENANCE	2
MAIS	3
MAJOR ROAD	2
MCI	1
MEDIAN BARRIER	5
MEDIANS	15
MERGE / DIVERGE AREAS	14
META-ANALYSIS	8
MID-BLOCK CROSSING	4
MILD COGNITIVE IMPAIRMENT	1
MINOR ROAD	1

Master Keywords	Number of links with database keywords
MOBILE PHONE USE	24
MOOD	1
MOPEDS	29
MOTORCYCLE ABS	1
MOTORCYCLE AIRBAGS	2
MOTORCYCLES	30
MOTORWAYS	36
MULTIPLE-LEGGED JUNCTION	1
MUSIC	4
NATURALISTIC DRIVING	2
NEAR-MISS	1
NECK INJURY	5
NIGHT	8
NIGHT VISION	1
NIGHTTIME CURFEW	5
NIGHTTIME RESTRICTIONS	5
NOVICE DRIVERS	11
OBSERVATION ERROR	2
OBSTACLE FREE ZONE	3
OBSTACLES	12
OBTACLE FREE ZONE	7
OCCUPANT PROTECTION	5
OFFENCES	28
OLDER PEOPLE	21
ONE-WAY ROADS	1
ON-ROAD TEST	5
OPERATING DEVICES	7
OVERTAKING	8
PARENTS	4
PARKINSON'S DISEASE	1
PASSENGER CARS	13
PASSENGERS	5
PASSING	8
PASSING MANOEUVRES	3
PAVEMENT	10
PAVEMENTS	13
PEDELEC	3
PEDESTRIAN AIRBAGS	1

Master Keywords	Number of links with database keywords
PEDESTRIAN CRASHES	9
PEDESTRIAN CROSSINGS	16
PEDESTRIAN DETECTION	1
PEDESTRIAN SIGNAL	3
PEDESTRIANS	22
PENALTIES	16
PENALTY POINT SYSTEM	3
PERCEPTION	4
PERIODIC TECHNICAL INSPECTION	1
PERIODICAL TECHNICAL INSPECTION	5
PERSONAL FACTORS	13
PERSONALITY	13
POLICY	2
POST IMPACT CARE	2
POWERED TWO-WHEELERS	30
PRECIPITATION	4
PRE-HOSPITAL MEDICAL CARE	15
PRE-LICENSE TRAINING	1
PRIMARY ROAD	1
PRIVATE ROADS	1
PROFESSIONAL DRIVERS	41
PROTECTIVE CLOTHING	7
PROTECTIVE EQUIPMENT	5
PTI	6
PTW / ATV	30
PUBLIC TRANSPORT	1
RAIL-ROAD CROSSING	15
RAIN	4
RAISED CROSSWALKS	1
RAISED JUNCTIONS	2
RAMPS	15
REACTION TIME	2
REAR IMPACT	9
REAR-END COLLISION	9
RECIDIVISM	11
RED LIGHT CAMERAS	8
RED LIGHT RUNNING	11
REFLECTIVE CLOTHING	1

Master Keywords	Number of links with database keywords
REGULATIONS	9
REHABILITATION	13
RESCUE	3
RESIDENTIAL AREAS	6
RESPONSE TIME	2
RESTRAINT SYSTEMS	31
RESTRICTIONS	1
REVERSIBLE LANES	1
REVERSING ASSISTANT SYSTEMS	3
RIDERS	30
RIGHT ANGLE CRASHES	2
RIGHT TURN CRASHES	6
RISK PERCEPTION	3
RISK TAKING	22
ROAD LENGTH	1
ROAD MAINTENANCE	2
ROAD MARKINGS	34
ROAD RAGE	14
ROAD SAFETY AUDITS	5
ROAD SAFETY INSPECTIONS	3
ROAD SIGNS	24
ROAD SURFACE	22
ROAD TYPE	4
ROADSIDE	26
ROADWORKS	14
ROADWORTHINESS	1
ROLLOVER CRASH	5
ROUNDABOUTS	4
RSA	5
RUMBLE STRIPS	7
RUN-OFF-ROAD CRASHES	5
RURAL AREAS	12
RURAL INTERSECTIONS	1
RURAL JUNCTIONS	1
SAFETY-IN-NUMBERS	2
SANCTIONS	16
SCHOOL BUSES	1
SCHOOL LESSONS	1

Master Keywords	Number of links with database keywords
SCHOOL ZONES	7
SCREENING	9
SEAT BELT	25
SEAT BELT INTERLOCK	1
SEAT BELT REMINDER	1
SECONDARY CRASHES	4
SECONDARY ROAD	1
SECTION CONTROL	1
SEMI TRUCK	1
SENIORS	21
SENSATION SEEKING	12
SERIOUS INJURY	14
SHARED SPACE	2
SHOULDER WIDTH	3
SHOULDERS	22
SIDE COLLISIONS	9
SIDE IMPACT	8
SIDE-IMPACT PROTECTION	1
SIGHT DISTANCE	5
SIGHT OBSTRUCTION	10
SIMULATOR TRAINING	2
SINGLE CARRIAGEWAY	1
SINGLE-VEHICLE CRASHES	6
SITUATION AWARENESS	3
SKEWNESS	5
SKID RESISTANCE	13
SKILLS	9
SLEEP	16
SLEEP APNEA	7
SLOPE	8
SMOKE	2
SOCIAL COST	1
SPEED	34
SPEED	1
SPEED CAMERAS	8
SPEED HUMPS	10
SPEED LIMITER	4
SPEED LIMITS	22

Master Keywords	Number of links with database keywords
SPEED MANAGEMENT	55
SPEEDING	7
SPINE INJURY	2
STAGGERED JUNCTION	3
STEERING PERFORMANCE	1
STOP SIGNS	4
STRESS	11
STROKE	1
STUDENTS	1
SUBMARINING	1
SUDDEN BRAKE WARNING SYSTEM	1
SUNLIGHT	7
SUPERELEVATION	1
SUSTAINABLE INFRASTRUCTURE	1
SUV	3
T INTERSECTIONS	4
T JUNCTIONS	4
TAILGATING	15
TAILLIGHTS	3
TECHNICAL DEFECTS	2
TEENAGERS	14
TERTIARY SAFETY	1
TESTING	12
TEXTING	3
THORACIC INJURY	3
THUNDERSTORM	1
TIME-TO-COLLISION	1
TIRES	2
TOLL AREAS	2
TRACTORS	5
TRAFFIC CALMING	20
TRAFFIC COMPOSITION	2
TRAFFIC CONTROL	6
TRAFFIC FLOW	24
TRAFFIC ISLANDS	1
TRAFFIC LIGHTS	37
TRAFFIC SIGNALS	37
TRAFFIC SIGNS	26

Master Keywords	Number of links with database keywords
TRAILERS	5
TRAINING	38
TRANSITION CURVES	6
TRANSPORTATION OF PATIENTS	1
TRANSVERSAL RUMBLE STRIPS	2
TRAUMA CARE	17
TREES	8
TRIAGE	5
TRUCKS	26
TUNNELS	10
TURNING LANES	1
TWO LANE ROAD	3
TWO-VEHICLE ACCIDENTS	1
TYRES	4
UNCONTROLLED JUNCTION	10
UNDERRUN	1
UNDIVIDED ROAD	3
UPGRADE ROAD	2
URBAN AREAS	20
URBAN FREEWAY	2
URBAN INTERSECTIONS	2
URBAN JUNCTIONS	2
V2I	5
V2I	3
VANS	21
VARIABLE MESSAGE SIGNS	5
VEHCILE PERFORMANCE	1
VEHICLE AGE	1
VEHICLE MAINTENANCE	5
VEHICLE MASS	7
VEHICLE SHAPE	5
VEHICLE SIZE	7
VEHICLE STABILITY	2
VEHICLE STRUCTURE	5
VEHICLE-TO-INFRASTRUCTURE COMMUNICATION	8
VIOLATIONS	28
VISIBILITY	39
VISUAL IMPAIRMENT	18

Master Keywords	Number of links with database keywords
VMS	5
VULNERABLE ROAD USERS	142
WEATHER	22
WHIPLASH	**2**
WIND	**5**
WINDSCREEN	**1**
WINTER MAINTENANCE	**11**
WOONERFS	**2**
WORK ZONES	**14**
YOUNG DRIVERS	**15**
ZEBRA CROSSING	**9**

APPENDIX 6 - SAFETYCUBE DSS GLOSSARY

Term	Short Description	Long Description
AADT	Annual Average Daily Traffic (AADT). The total volume of vehicle traffic of a highway/ road for a year divided by 365 days	AADT is used by local and national transport authorities to forecast issues such as maintenance needs and expenditure. It is measured using either automated traffic counters or observers who record traffic. Automated traffic counters can either be permanently embedded into a road and traffic data collected 365 days a year or portable traffic sensors can be attached to the road to record shorter terms, typically 12-14 days.
Abbreviated Injury Scale	Abbreviated Injury Scale (AIS) is an anatomical-based consensus derived, coding system created by the Association for the Advancement of Automotive Medicine to classify and describe the severity of injuries.	The Abbreviated Injury Scale (AIS) is an anatomical-based consensus derived, coding system created by the Association for the Advancement of Automotive Medicine to classify and describe the severity of injuries. The system provides a seven number code which describes three aspects of the injury plus an additional severity score which represents the threat to life associated with the injury. The first three aspects describe in turn, the body region, the type of anatomic structure and the specific injury type while the severity score uses a scale of 1 to 6 with 1 being a minor injury and 6 being maximal (currently untreatable).
Accident Modification Factor	Accident modification factor. It is a measure of the safety effectiveness of a particular treatment, countermeasure or design element . Also referred to as Crash Modification Factor.	A CMF consists of a multiplier applied to the crashes that occurred before the implementation of the measure. A CMF is used to estimate the number of crashes that will occur when the measure is implemented and is a measure of the expected effect.
ADAS	Advanced Driver Assistance System (ADAS) is a vehicle control system that use vehicle sensors to identify driving conditions that should be addressed by the driver.	The systems can present warnings or automatically intervene to improve vehicle stability or safety. The simplest ADAS systems are the anti-lock braking systems (ABS) and Electronic Safety Programs (ESP) that can control the vehicle brakes to maintain vehicle stability. Advances systems like Forward Collision Warning (FCW) detect the proximity of forward vehicles to warn the driver or adjust vehicle speed to avoid collisions.
Advanced Driver Assistance System	Advanced Driver Assistance System (ADAS) is a vehicle control system that uses vehicle sensors to identify driving conditions that should be addressed by the driver.	The systems can present warnings or automatically intervene to improve vehicle stability or safety. The simplest ADAS systems are the anti-lock braking systems (ABS) and Electronic Safety Programs (ESP) that can control the vehicle brakes to maintain vehicle stability. Advances systems like Forward Collision Warning (FCW) detect the proximity of forward vehicles to warn the driver or adjust vehicle speed to avoid collisions.
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Term	Short Description	Long Description
ASECAP	European Association of Operators of Toll Road Infrastructures (ASECAP)	-
BAC	Blood Alcohol Concentration (BAC). The amount of alcohol in blood is used as an indicator if a person is intoxicated. The amount of alcohol in blood is usually expressed as percent Blood Alcohol Concentration (BAC)	BAC is often measured by the percent of milligrams of alcohol per millilitre of blood (e.g. BAC=0.1 would mean 1milligram of alcohol per 1 milliner of blood). However, the exact measurement of BAC varies slightly across countries. The larger the BAC level, the greater the association with a clear deterioration of reaction time and control . Many countries dictate a BAC level at which driving is unsafe and therefore against the law, but this also varies between countries.
BCR	Benefit-to-Cost Ratio (BCR). Ratio of benefits over costs.	The benefit-to-cost ratio (BCR) is an often used indicator in cost-benefit analysis. If the benefits are greater than the costs, a measure is cost-effective and would have a BCR value higher than 1.
Before-after Study	Before-after studies are a form of Repeated Measures Experimental study. The critical property of before and after studies is that the order of the repeated measurements is fixed, i.e., outcomes are always measured first without and then with exposure.	-
Benefit-to-Cost Ratio	Benefit-to-Cost Ratio (BCR). Ratio of benefits over costs.	The benefit-to-cost ratio (BCR) is an often used indicator in cost-benefit analysis. If the benefits are greater than the costs, a measure is cost-effective and would have a BCR value higher than 1.
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Break-even	Measure threshold cost value at which benefits and costs are equal.	The break-even costs indicate the maximal costs that one unit of a measure can have to still be economically efficient. The break-even cost can also be calculated if no measure cost information is available.
BRRC	Belgian Road Research Center (BRRC)	-
Burden of Injury	The impact of an injury. It is often quantified in terms of Disability Adjusted Life Years (DALYs) or Quality Adjusted Life Years (QALYs) .	-

Term	Short Description	Long Description
CARE	Community database on Accidents on the Roads in Europe (CARE). It is the European centralised database on road accidents which result in death or injury across the European Union (EU).	The main objectives of CARE are to enable (i) identification and quantification of road safety problems; (ii) evaluation of the efficiency of road safety measures; (iii) analyses to determine the relevance of Community actions and facilitate the exchange of experience in this field. It currently contains data from across 32 countries in Europe from between 13 and 23 years. It includes data on all accidents reported by police (over 25 million) on public roads with at least one motor vehicle and at least one person injured. It contains more than 100 common variables and more than 1000 values by accident.
Case-Control Study	In a case-control design, the investigator identifies two populations: one with an outcome of interest ("cases") and one without the outcome of interest ("controls"). In each population for which exposures are measured the association between exposure and outcomes is determined.	Case-control studies are a form of Analytical Observation Study. In the case-control design, one starts from different outcomes in the population and studies differences with respect to the distribution of exposure levels (outcome -> exposure). The fact that outcomes are defined as grouping variables is a critical distinct feature of the case-control design and is especially advantageous when the natural occurrence of the targeted outcomes is rare. The main quality of case-control designs is that they allow the collection of much more exposure data on rare outcomes.
CBA	Cost-Benefit Analysis (CBA). Monetary evaluation of costs and benefits of a certain measure	A cost-benefit analysis (CBA) allows the joint evaluation of the effectiveness of measures in reducing crashes of different severity and to provide information on the socio-economic return of countermeasures. Therefore a monetary value is assigned to each type of benefit that results from the measure. The sum of these monetary values is compared to the costs of the measure.
CEA	Cost-Effectiveness Analysis (CEA). Number of crashes prevented by the measure per unit cost of implementing the measure.	In a cost-effectiveness analysis (CEA) a road safety measure can be evaluated as the number of crashes prevented by the measure per unit cost of implementing the measure. The necessary information to conduct this analysis is the effectiveness of a measure per unit of implementation, the cost of implementing the measure and a definition of a unit of implementation.
CEDR	Conference of European Road Directors (CEDR) is an organisation of European national road administrations that promotes Excellence in the Management of Roads	-
CI	Confidence Interval (CI). Estimated range of values which is likely to include an unknown population parameter.	In statistics, a confidence interval (CI) is a type of interval estimate (of a population parameter) that is computed from the observed data. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter. If a corresponding hypothesis test is performed, the confidence level is the complement of the level of significance; for example, a 95% confidence interval reflects a significance level of 0.05.If it is hypothesized that a true parameter value is 0 but the 95% confidence interval does not contain 0, then the estimate is significantly different from zero at the 5% significance level. The desired level of confidence is set by the researcher. Most commonly, the 95% confidence level is used.
CMF	Crash modification factor (CMF). It is a measure of the safety effectiveness of a particular treatment, countermeasure or design element . Also referred to as Accident Modification Factor.	A CMF consists of a multiplier applied to the crashes that occurred before the implementation of the measure. A CMF is used to estimate the number of crashes that will occur when the measure is implemented and is a measure of the expected effect.

Term	Short Description	Long Description
Coded Studies	In SafetyCube, for each topic (risk factor or measure), the results of each study found in the literature review were coded into a template which aimed to capture relevant information from each study in a manner that this information could be uniformly reported and shared across topics.	Examples of information coded from each study includes: - Road system element (Road User, Infrastructure, Vehicle); - Level of taxonomy so that users of the DSS will be able to find information on topics they are interested in; - Basic information of the study (title, author, year, source, origin, abstract; - Road user group examined; - Study design; - Measures of exposure to the risk factor / measure; - Measures of outcome (e.g. number of injury crashes); - Type of effects; - Effects (including corresponding measures e.g. confidence intervals); - Limitations; - Summary of the information relevant to SafetyCube.
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Term	Short Description	Long Description
Coding Template	In SafetyCube, for each topic (risk factor or measure), the results of each study found in the literature review were coded into a template which aimed to capture relevant information from each study in a manner that this information could be uniformly reported and shared across topics.	Examples of information coded from each study includes: - Road system element (Road User, Infrastructure, Vehicle); - Level of taxonomy so that users of the DSS will be able to find information on topics they are interested in; - Basic information of the study (title, author, year, source, origin, abstract; - Road user group examined; - Study design; - Measures of exposure to the risk factor / measure; - Measures of outcome (e.g. number of injury crashes); - Type of effects; - Effects (including corresponding measures e.g. confidence intervals); - Limitations; - Summary of the information relevant to SafetyCube.
Cohort Study	Cohort studies start with the identification of a target population which is not associated with a certain negative outcome. This population (or a sample; "panel") is then followed over time while monitoring the occurrence of the outcome of interest.	Cohort studies are a form of Analytical Observation Study. In cohort studies investigators start from different a priori exposure levels in the population and monitor differences in outcomes (exposure -> outcome). Cohort studies start with the identification of a target population which, at a given initial point in time, is not associated with a certain negative outcome (e.g., not injured in a traffic accident). This population (or a sample; "panel") is then followed over time while monitoring the occurrence of the outcome of interest.
Colour Code	In SafetyCube, a colour code is used to indicate how important the risk factor or safety measure is, in terms of its effect on safety based on the results of the literature search for each risk factor/measure.	For risk factors, the colour codes are red (increased risk), yellow (possible increase risk but inconsistent results), grey (no conclusion possible) and green (does not increase risk). For measures, the colour codes are green (reduces safety risk), light green (possible reduction in risk but inconsistent results), grey (no conclusion possible) and red (does not reduce safety risk and might even increase it).
Community database on Accidents on the Roads in Europe	Community database on Accidents on the Roads in Europe (CARE). It is the European centralised database on road accidents which result in death or injury across the European Union (EU).	The main objectives of CARE are to enable (i) identification and quantification of road safety problems; (ii) evaluation of the efficiency of road safety measures; (iii) analyses to determine the relevance of Community actions and facilitate the exchange of experience in this field. It currently contains data from across 32 countries in Europe from between 13 and 23 years. It includes data on all accidents reported by police (over 25 million) on public roads with at least one motor vehicle and at least one person injured. It contains more than 100 common variables and more than 1000 values by accident.

Term	Short Description	Long Description
Confidence Interval	Confidence Interval (CI). Estimated range of values which is likely to include an unknown population parameter.	In statistics, a confidence interval (CI) is a type of interval estimate (of a population parameter) that is computed from the observed data. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter. If a corresponding hypothesis test is performed, the confidence level is the complement of the level of significance; for example, a 95% confidence interval reflects a significance level of 0.05.If it is hypothesized that a true parameter value is 0 but the 95% confidence interval does not contain 0, then the estimate is significantly different from zero at the 5% significance level. The desired level of confidence is set by the researcher. Most commonly, the 95% confidence level is used.
Conference of European Road Directors	Conference of European Road Directors (CEDR) is an organisation of European national road administrations that promotes Excellence in the Management of Roads	-
Conflict	Conflicts refer to a situation where there is an increased risk of a collision occurring between at least two road users which leads to some sort of emergency action being taken by at least one road user, leading to either a collision or a 'near miss'.	-
Cost-Benefit Analysis	Cost-Benefit Analysis (CBA). Monetary evaluation of costs and benefits of a certain measure	A cost-benefit analysis (CBA) allows the joint evaluation of the effectiveness of measures in reducing crashes of different severity and to provide information on the socio-economic return of countermeasures. Therefore a monetary value is assigned to each type of benefit that results from the measure. The sum of these monetary values is compared to the costs of the measure.
Cost-Effectiveness Analysis	Cost-Effectiveness Analysis (CEA). Number of crashes prevented by the measure per unit cost of implementing the measure.	In a cost-effectiveness analysis (CEA) a road safety measure can be evaluated as the number of crashes prevented by the measure per unit cost of implementing the measure. The necessary information to conduct this analysis is the effectiveness of a measure per unit of implementation, the cost of implementing the measure and a definition of a unit of implementation.
Cost-Utility Analysis	Cost-Utility Analysis (CUA). Health impact per unit cost of a measure.	In a cost-utility analysis (CUA) a road safety measure can be evaluated by balancing the measure cost with its health impact. The impact of a measure on the health of traffic casualties can be expressed in Quality Adjusted Life Years (QALY) and/or in Years of Life Lost (YLL) avoided
Countermeasure	Any intervention that is taken to reduce the risk, the frequency or the consequences of road accidents. In SafetyCube, 'measure' and 'countermeasure' are used interchangeably.	Measures can have a direct influence on the risk or the frequency of an accident occurring, on the consequences of the accident (e.g. severity), or more indirectly by influencing a Safety Performance Indicator (SPI) which itself has a causal link to crashes or severity (e.g. speed).
Crash Modification Factor	Crash modification factor (CMF). It is a measure of the safety effectiveness of a particular treatment, countermeasure or design element . Also referred to as Accident Modification Factor.	A CMF consists of a multiplier applied to the crashes that occurred before the implementation of the measure. A CMF is used to estimate the number of crashes that will occur when the measure is implemented and is a measure of the expected effect.

Term	Short Description	Long Description
Cross-Sectional Study	In a cross-sectional design the investigator "cuts through" a target population at a specific moment in time and looks at the level of exposure and the outcome for each sampled member.	Cross-sectional studies are a form of Analytical Observation Study. In cross-sectional designs the distribution of exposure and outcome is considered simultaneously (exposure <-> outcome). Typical examples are in-depth accident databases containing information on outcomes (e.g. injuries) but also the exposure to risk factors (e.g., road conditions, sobriety, pre-accident speed, …) and measures (seat-belt use, ABS, …).
CUA	Cost-Utility Analysis (CUA). Health impact per unit cost of a measure.	In a cost-utility analysis (CUA) a road safety measure can be evaluated by balancing the measure cost with its health impact. The impact of a measure on the health of traffic casualties can be expressed in Quality Adjusted Life Years (QALY) and/or in Years of Life Lost (YLL) avoided
DALY	Disability Adjusted Life Years (DALY). Measure to quantify the burden of injury	A generic measure to quantify the burden of disease or injury, including both loss of quantity of life (premature mortality) and quality of life due to a disease or injury.
Disability Adjusted Life Years	Disability Adjusted Life Years (DALY). Measure to quantify the burden of injury	A generic measure to quantify the burden of disease or injury, including both loss of quantity of life (premature mortality) and quality of life due to a disease or injury.
Driving Under the Influence	Driving under the influence (DUI) of a psychoactive substance (alcohol and drugs, either recreational or prescription).	-
DSS	Decision Support System (DSS)	A Decision Support System is an information system that supports organisational decision-making activities and helps people within an organisation to come to decisions about issues or problems that may fluctuate over time and circumstances. In SafetyCube, the Decision Support System has been developed to support decision makers and policy makers in road safety and road practitioners in their decisions to improve safety on the roads.
DUI	Driving under the influence (DUI) of a psychoactive substance (alcohol and drugs, either recreational or prescription).	-
E3 - Economic Efficiency Evaluation	Economy Efficiency Evaluation (E3) is a procedure developed within SafetyCube to calculate the economic efficiency of a measure. The economic efficiency is the balance between the effects of a measure and its implementation costs .	Within the SafetyCube-project an Economic Efficiency Evaluation (E3) calculator has been developed. This tool facilitates conducting a CBA. All necessary input information can be filled in by the user. Monetary values of the benefits (the prevented crashes or casualties) for different severity categories are provided by the tool. Using this information, the economic efficiency of the measure is calculated by the E3 calculator in terms of the NPV, the BCR or, in case there is no information on the measure costs, the break-even cost.
EC	The European Commission (EC) is an organisation within the European Union whose main responsibilities are to advise on legislation, implement decisions and managing the everyday business of the EU.	-

Term	Short Description	Long Description
Empirical Bayes	Empirical Bayes (EB) methods can be used to correct for bias or inaccuracies in data. For example in road safety, The empirical Bayes estimate of the expected number of accidents is a weighted average of the model-predicted number of accidents and the recorded number of accidents.	The Empirical Bayes (EB) method for road safety estimation utilises two sources of data regarding safety to develop estimates that are site-specific and thus account for the site-specific characteristics that influence the number of accidents. The two sources of data are: 1. A model-based estimate of the number of accidents expected to occur on a site with known values for all independent variables included in the accident prediction model. 2. The number of accidents recorded on a site during the same period as used to develop the accident prediction model.
ERSO	The European Road Safety Observatory (ERSO) is the output from the SafetyNET project and provides knowledge, data and links to researchers and policy makers on a wide range of road safety topics.	ERSO is the output from the SafetyNET project and aims help policy makers, researchers and road safety advisors find their way into the European road safety world by providing knowledge, data and links on a wide range of road safety topics. All information on ERSO is scientifically founded, easy to read, ready to use and written by renowned road safety experts. [http://erso.swov.nl/index.html]
ETSC	The European Transport Safety Council (ETSC) is an independent non-profit making organisation dedicated to reducing the numbers of deaths and injuries in transport in Europe.	ETSC is an independent non-profit making organisation dedicated to reducing the numbers of deaths and injuries in transport in Europe. ETSC provides an impartial source of expert advice on transport safety matters to the European Commission, the European Parliament, and Member States. It is independent, maintained through funding from a variety of sources including membership subscriptions, the European Commission, and public and private sector support for various activities. ETSC seeks to identify and promote effective measures on the basis of international scientific research and best practice in areas which offer the greatest potential for a reduction in transport crashes and casualties [http://etsc.eu/]
EU	The European Union (EU) is an association of currently 28 European nations formed in 1993 for the purpose of achieving political and economic integration.	The EU's origins can be traced back to the European Coal and Steel Community (ECSC) and the European Economic Community (EEC), both of which were formed in the 1950's. EU policies aim to ensure the free movement of people, goods, services, and capital within the internal market, enact legislation in justice and home affairs, and maintain common policies on trade, agriculture, fisheries, and regional development.
EuroNCAP	New Car Assessment Programs (EuroNCAP)	NCAP programs are used to provide consumer information on the safety performance of vehicles. The tests are decided by the organisation and are not mandatory for selling vehicles. The NCAP test protocols tend to me more stringent than government regulations and provide safety performance rating. "EuroNCAP" is the system applied in Europe while the US National Highway and Traffic Safety Administration publishes "NCAP" information. Many other countries have individual NCAP programs.
European Commission	The European Commission (EC) is an organisation within the European Union whose main responsibilities are to advise on legislation, implement decisions and managing the everyday business of the EU.	-
European Directives	European Legislation that address the performance of vehicles sold in the European Union	European Directives related to vehicle safety are harmonised with the UN-ECE regulation agreement the EU member states. Essentially all safety regulations listed in the European Directives are identical to the UNECE

Term	Short Description	Long Description
		regulations. For example UN-ECE Regulation 94 and European Directive 96/79/EC both describe the same frontal test procedure.
European Road Assessment Programme	European Road Assessment Programme (EuroRAP) is an international non-profit organisation which aims to save lives through safer roads across Europe.	EuroRAP has developed a programme of systematic assessment of risk to identify limitations which can be addressed through the introduction of road improvement measures. One way this is done is by rating roads (in the same way the EuroNCAP rate cars) for their levels of safety designed into the roads for all road user types.
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European Union	The European Union (EU) is an association of currently 28 European nations formed in 1993 for the purpose of achieving political and economic integration.	The EU's origins can be traced back to the European Coal and Steel Community (ECSC) and the European Economic Community (EEC), both of which were formed in the 1950's. EU policies aim to ensure the free movement of people, goods, services, and capital within the internal market, enact legislation in justice and home affairs, and maintain common policies on trade, agriculture, fisheries, and regional development.
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Exposure	Exposure, in the context of road safety, either refers to exposure to risk factors or exposure to countermeasures.	Exposure, in the context of road safety, either refers to exposure to risk factors or exposure to countermeasures. In the latter case, it might sound more natural to speak of "implementation of countermeasures" (e.g., roundabouts) or "use of countermeasures" (e.g., helmets), but using "exposure" helps to see commonalities with designs in studies on risk factors and the epidemiological literature.
Extraction	Extraction relates to the need for intervention to remove an occupant from a crashed vehicle.	Extraction broadly takes two forms, but, can be defined as the need to remove a portion of the vehicle or to bend or force a vehicle component or structure away from an occupant in order to remove them from the vehicle.

Term	Short Description	Long Description
Extrication	Extrication relates to the need for intervention to remove a vehicle from around a casualty when normal means of exit are not possible or not advisable after a road traffic collision and to help avoid further injuries to the casualty in the vehicle.	Generally, extrication is undertaken by the fire service once the scene has been made safe, an initial medical assessment of the casualty has been undertaken by the medical team and the vehicle has been secured to prevent unexpected movement. The first stage of extrication is to provide an opening in the vehicle to allow the medical team inside the vehicle to better assess the casualty and begin care. The next stage involves removing a section of the vehicle (normally roof or door) to allow the safe removal of the casualty. The final stage is the removal of the casualty from the vehicle.
Federation Internationale de l'Automobile	The Federation Internationale de l'Automobile (FIA) is the governing body of motor sport and promotes safe, sustainable and accessible mobility for all road users across the world.	-
FIA	The Federation Internationale de l'Automobile (FIA) is the governing body of motor sport and promotes safe, sustainable and accessible mobility for all road users across the world.	-
Forgiving Roads	A forgiving road is a road which is designed to help avoid driver errors from resulting in any serious injuries or a collision at all.	A forgiving road is one which is designed so that if a driver/rider was to make an error which led to a potential loss of control, then the design of the road would help the driver to regain control and avoid a collision from occurring. Or if a loss of control does occur, the roadside is designed so that no serious injuries should occur from any impacts the vehicle has on the roadside (i.e. the road or roadside is 'forgiving' of the error which the driver experienced).
Full Bayes	Similar to an Empirical Bayes, but it is thought to need less data for non-treated reference sites, it better accounts for lack of certainty in the data used, and it provides more flexibility in selecting crash count distributions.	-
German In-Depth Accident Study	The German In-Depth Accident Study (GIDAS) is one of the largest road accident investigation studies in Germany and across Europe.	Since 1999, the GIDAS study has collected approximately 2000 accidents per year in the Hannover and Dresden areas of Germany.
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Heavy Goods Vehicle	Heavy Goods Vehicle (HGV) is any truck with a gross combination mass (GCM) of over 3,500 kilograms/3.5 tonnes. This includes the UNECE vehicle categories N2 and N3.	-

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HGV	Heavy Goods Vehicle (HGV) is any truck with a gross combination mass (GCM) of over 3,500 kilograms/3.5 tonnes. This includes the UNECE vehicle categories N2 and N3.	-
Hot Topic	Risk factors or measures of greatest interest identified through consultation with relevant stakeholder groups.	A selection of topics which have attracted particular attention by road safety researchers and stakeholders as critical areas for action and / or further research in recent scientific and policy documents. These factors have been given particular emphasis and priority in the SafetyCube analysis.
Injury Severity Score	Injury Severity Score (ISS), a medical score to assess trauma severity	ISS is used to define the term major trauma: A major trauma (or polytrauma) is defined as the Injury Severity Score being greater than 15.
Intelligent Speed Adaptation	Intelligent Speed Adaptation (ISA) is a system which ensures that a vehicle does not exceed either a legal speed limit or an advisory safety limit.	ISA can be implemented either passively by alerting the driver to the excessive speed via a visual, auditory and/or tactile cues and allowing the driver to alter their speed themselves, or actively, where the vehicle intervenes and automatically reduces the speed to within the legal/safe limit.
Intelligent Transport Systems	Intelligent Transport Systems (ITS) is the combination of Information Technology and telecommunications to help improve safety, mobility and efficiency	ITS can apply to all modes of transport, but more often it is relevant to road transportation modes. It can include vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technology.
International Road Assessment Programme	The International Road Assessment Programme (iRAP) is the same as EuroRAP, but is concerned with assessing road safety all over the world.	iRAP is an international non-profit organisation which aims to save lives through safer roads across the world. iRAP has developed a programme of systematic assessment of risk to identify limitations which can be addressed through the introduction of road improvement measures. One way this is done is by rating roads (in the same way the EuroNCAP rate cars) for their levels of safety designed into the roads for all road user types.
International Road Traffic Accident Database	The International Road Traffic Accident Database (IRTAD) contains crash and traffic exposure data from over 32 countries.	The data is aggregated by country and year from 1970 and is sourced from national data providers from each participating country. Linked to the database is the IRTAD group, which consists of road safety experts from a variety of professional backgrounds.
International Transport Forum	The International Transport Forum (ITF) is part of the OECD (Organisation for Economic Cooperation and Development) which acts as an advisory body for transport policy.	It is an intergovernmental organisation with 59 member countries which covers all transport modes. It aims to raise the profile of transport policy and garner a better awareness the role transport plays in areas such as economic growth and sustainability.
In-Vehicle Information Systems	In-vehicle Information Systems (IVIS) is a collective term for systems/tools that provide information to a driver within their vehicle.	Examples of In-Vehicle Information Systems include specialised traffic information/navigation systems, mobile phones, text messaging, email, vehicle diagnostics, and, in some situations, warning systems and emergency help systems.

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Longitudinal Study	A longitudinal study is an observational research method in which data is gathered for the same subjects repeatedly over a period of time (often months or years).	-
MAIS	Maximum Abbreviated Injury Scale (MAIS) is the maximum of the AIS scores for each region of the body, and is frequently used for assessing overall severity.	The MAIS (Maximum AIS) is the maximum of the AIS scores for each region of the body, and is frequently used for assessing overall severity. It does not necessary have a linear relationship with the probability of death.

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Matched Case-Control Study	In a "matched case-control" study, the investigator makes assumptions about a number of relevant secondary characteristics (age, sex, etc.) and equates cases and controls with respect to these variables. This can be done on a one-to-one/one-to-many basis or at the group level.	-
Maximum Abbreviated Injury Scale	Maximum Abbreviated Injury Scale (MAIS) is the maximum of the AIS scores for each region of the body, and is frequently used for assessing overall severity.	The MAIS (Maximum AIS) is the maximum of the AIS scores for each region of the body, and is frequently used for assessing overall severity. It does not necessary have a linear relationship with the probability of death.
Measure	Any intervention that is taken to reduce the risk, the frequency or the consequences of road accidents. In SafetyCube, 'measure' and 'countermeasure' are used interchangeably.	Measures can have a direct influence on the risk or the frequency of an accident occurring, on the consequences of the accident (e.g. severity), or more indirectly by influencing a Safety Performance Indicator (SPI) which itself has a causal link to crashes or severity (e.g. speed).
Meta-Analysis	A meta-analysis statistically combines the quantitative results of a number of comparable studies with the aim to come to one, weighted estimate of the effect that has greater statistical power than the individual results.	Meta-analysis is the statistical analysis of a set of numerical research results for the purpose of developing a weighted mean result and identifying sources of systematic variation in individual results. Meta-analyses are normally part of systematic literature reviews, and the results of meta-analyses are normally reported in terms of one or more summary estimates of effect. The most commonly applied technique in road safety is the inverse variance technique. There are two models for inverse-variance meta-analysis: (i) the fixed-effects model and (ii) the random-effects model. (i) The fixed-effects model is based on the assumption that the variation in individual results consists of sampling variance only (random variation only occurs within studies), i.e. there is one true effect and all variance is fully explained in terms of the sampling random variation within studies. This is rarely appropriate as there are usually differences between studies e.g. due to the environment they are conducted in. However, if studies are conducted in the same environment and with the same sort of participants, this would suggest there should be a single true effect and a fixed-effects model should be used. (ii) The random-effects model is based on the assumption that there is systematic between-study variation in results (random error occurs both within and between studies), i.e. the true effect could vary from study to study, variation greater than sampling variance accounts for the difference in effect. For example, variation in effect may be due to variation in the age of participants or difference between geographical regions. If there is a lot of between-study variation (e.g., significant Q statistic, high I^2), a random-effects model of meta-analysis should be adopted.

Term	Short Description	Long Description
Metadata	Metadata is the summary of information about data. In SafetyCube, metadata includes information such as title, author, date, abstract, keywords.	-
NCAP	New Car Assessment Programs (NCAP) are used to provide consumer information on the safety performance of vehicles.	In NCAP, the tests are decided by the organisation and are not mandatory for selling vehicles. The NCAP test protocols tend to me more stringent than government regulations and provide safety performance rating. "EuroNCAP" is the system applied in Europe while the US National Highway and Traffic Safety Administration publishes "NCAP" information. Many other countries have individual NCAP programs.
Net Present Value	Net Present Value (NPV). Difference between monetarized benefits and costs of a measure, taking into account time differences in costs and benefits.	The net present value (NPV) is determined by subtracting the costs from the benefits of a measure. Discounting is used to bring costs made at different points in time to the same present value. It is sometimes advised to use the net-present value rather than the benefit-cost ratio as a decision rule in cost-benefit analysis
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Observational Study	In observational studies, there is no intervention whatsoever, neither by researchers nor by any other party. The natural occurrence (distribution) of exposure and outcome is studied. Observational studies can be "analytical" or "descriptive".	In observational studies, the natural occurrence (distribution) of exposure and outcome is studied. "Analytical" observational studies look at the relationship between different exposures and different outcomes. "Descriptive" observational studies typically involve risk factors, rather than countermeasures, and merely describe the presence (or distribution) of exposure to risk factors in either an accident/injury or no-accident/injury population. Three families of analytical-observational designs can be distinguished: cross-sectional, cohort and case-control.
Organisation for Economic Cooperation and Development	The Organisation for Economic Cooperation and Development (OECD) is an intergovernmental organisation which aims to promote policies that will improve the economic and social well-being of people around the world.	-
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Outcome	Outcomes typically concern accidents or injuries and in particular, their (absolute/relative) numbers, types and severities.	Outcomes typically concern accidents or injuries and in particular, their (absolute/relative) numbers, types and severities. Apart from such direct indicators of road safety, variables like driving skills (e.g., expert rating), attitudes towards safe behaviour (e.g., willingness to drink and drive) or even physiological (e.g., eye-movements, electro encephalogram) and physical measures (e.g., km/h) can also be considered as outcomes, since they are known or can reasonably be assumed to influence accidents or injuries (numbers/types/severities).
Over triage	The orientation of too many traumas to the most advanced care structures in order to not lose a potentially major trauma patient	-
Percentage Reduction	Percentage Reduction (PR). The reduction in percentage of the number of crashes due to the measure.	Percentage reduction = Crash reduction factor (CRF) = (1- θ) θ= Effectiveness = Crash Modification Factor (CMF) = ratio of crashes after and before a certain measure.
Post impact care	A strategy which aims to reduce the severity of injury consequences once a road traffic crash has occurred	-
Powered Two Wheelers	(PTW) include any form of road transport which are powered by an engine or battery (e.g. moped, scooter, on-road and off-road motorcycles).	-
PPP	Purchasing Power Parity (PPP). Purchasing power parity means equalising the purchasing power of two currencies by taking into account the costs of living.	The purchasing power of a currency refers to the quantity of the currency needed to purchase a given unit of a good, or common basket of goods and services. Purchasing Power Parities are the rates of currency conversion that equalize the purchasing power of different currencies, they are price relatives that show the ratio of the prices in national currencies of the same good or service in different countries. For example, if one converts the price of a consumer good in Europe to US dollars using market exchange rates, relative purchasing power is not taken into account, and the validity of the comparison is weakened. By adjusting rates to take into account local purchasing power differences, known as PPP adjusted exchange rates, international comparisons are more valid.
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QA	Quality Assurance (QA) is a systematic process to ensure that a product meets specified requirements.	In SafetyCube, QA is carried out on all project deliverables to ensure that it meets a high level of quality before publication.
QALY	Quality Adjusted Life Years (QALY) measures for the quality of life	The difference between a QALY and a DALY is that a QALY measures the quality of life in health gain, whereas a DALY measures the health loss in the quality of life. QALY is usually used when considering options for health treatments.
Qualitative	Qualitative data/research refers to using measures of 'types' to describe a situation or outcome. In accident analysis, examples of qualitative data include case studies, questionnaires or observational studies.	-
Quality Adjusted Life Years	Quality Adjusted Life Years (QALY). Measure for the quality of life	The difference between a QALY and a DALY is that a QALY measures the quality of life in health gain, whereas a DALY measures the health loss in the quality of life. QALY is usually used when considering options for health treatments.
Quality Assurance	Quality Assurance (QA) is a systematic process to ensure that a product meets specified requirements.	In SafetyCube, QA is carried out on all project deliverables to ensure that it meets a high level of quality before publication.
Quantitative	Quantitative data/research refers to using measures of counts and values measured in numbers. In accident analysis, this would be number of accidents or injuries, for example.	-
Quasi-Experimental Study	Quasi-experimental studies are a form of Experimental study, but lacks random assignment, which is normally found in experimental studies.	Quasi-experimental designs imitate experimental designs by having a control group in which a measure is not introduced or a risk factor is not present. The difference is that the control group is chosen on the basis of external circumstances (e.g., whether a local politician had decided to build a roundabout or not); there is no random assignment of subjects to it.

Term	Short Description	Long Description
Randomised Study	Randomised studies are a form of Experimental study. In randomised trials, the researcher uses a random process of assigning treatments to the experimental units.	Every experiment relies upon selecting subjects (persons, vehicles, crossings, etc...) and placing them into groups, with the objective to form groups that are equal with respect to all characteristics except for the one under investigation. The random process implies that every possible allotment of treatments has the same probability. The purpose of randomisation is to remove selection bias and other sources of extraneous variation, which are not controllable.
Repeated Measures Study	Repeated Measures studies are a form of experimental study. In repeated measures experiments, different exposure levels are sequentially imposed to the same units of analysis (sample group). They may be "before and after" studies or "cross-over" studies.	-
Review-type analysis	In SafetyCube, a review-type analysis is where the data from a specific topic (i.e. measure or risk factor) is summarised using a qualitative summary table. A review-type analysis is undertaken in SafetyCube when either a met-analysis or a vote-count analysis is not possible (i.e. not enough detailed data).	-
Risk Factor	Any factor that contributes to the occurrence or the consequence of road accidents.	Risk factors can have a direct influence on the risk of an accident occurring, on the consequences of the accident (severity), or more indirectly by influencing a Safety Performance Indicator (SPI). All elements of the road system are potential crash risk factors.
ROR	A Run-Off-Road (ROR) collision refers to a type of single vehicle collision that occurs when the vehicle leaves the road and enters the roadside or central reservation.	Run-off-road collisions can often involve the vehicle impacting a roadside object, such as a tree, pole or a safety barrier, or it could result in the vehicle rolling over, or both. They can be a result of avoiding a collision with another vehicle, object or animal/human, or a loss of control (e.g. due to distraction, illness...) or incorrectly judging a curve.
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Safe System Approach	The Safe System approach is an approach to road safety management, where no level of death or serious injury is acceptable on the road transport network. Therefore in a safe system, a road user should be able to survive a crash with no serious injuries as long as the road was 'safe', the vehicle was 'safe' and the road user was travelling 'safely'.	In a Safe System, responsibility for the system is shared by everyone (e.g. vehicle manufacturers, road operators, road users, policy makers, road safety educators, enforcement officers, fleet managers….). The safe system is made up of four main components: Safer roads (segregating traffic and road users, limiting speed, self-explaining roads) Safer speeds (establish appropriate limits, enforce these limits, educate road users) Safer vehicles (passive measures such as airbags, seatbelts, padded interior; active safety measures such as ABS, crash avoidance systems…). Safer road use (using seatbelts, not speeding, not breaking the law (e.g. alcohol, drug use, phone use), education, school travel plan initiatives, encouraging motorised traffic reduction).
Safety Performance Function	Safety Performance Functions (SPFs) are crash prediction models.	SPFs are used to predict the average number of crashes per year at a location as a function of exposure and, in some cases, roadway or intersection characteristics (e.g., lane number, traffic control…)
Safety Performance Indicator	Safety performance indicators (SPI) are seen as any measurement that is causally related to crashes or injuries.	Safety performance indicators (SPI) are seen as any measurement that is causally related to crashes or injuries and is used in addition to the figures of accidents or injuries, in order to indicate safety performance or understand the process that leads to accidents. They also provide the link between the casualties from road accidents and the measures to reduce them. Safety performance indicators help illustrate how well road safety programs are doing in meeting their objectives or achieving the desired outcomes.
Self-Explaining Roads	Roads are self-explaining when they are in line with the expectations of the road user, eliciting safe behaviour simply by design.	Self-explaining roads are intended to provide information to road users on the course and the situation on the road ahead and aim at inducing an adequate driving behaviour by the road layout itself. Motorways are a good example of a self-explaining road, as road users will clearly know when they are on a motorway and therefore will know what to expect (e.g. speed limits, lane positioning, where to expect signage…).
Sensitivity analysis	Sensitivity analysis is a technique used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions	In SafetyCube, sensitivity analyses were carried out as part of the cost-benefit analyses of certain measures. It was based on some alternative assumptions about the effects of the measure. The purpose was to show to what extent benefit-to-cost ratios were sensitive to changes in the underlying effect estimates.
Serious road injury	Non-fatal road traffic casualty with an injury severity level of MAIS3+	The official EU definition is a non-fatal road traffic casualty with an injury severity level of MAIS3+ (MAIS: Maximum Abbreviated Injury Scale), i.e. an injury/injuries with an AIS (Abbreviated Injury Scale) score of 3 of higher (e.g. an open fracture of humerus). However, different other definitions are applied as well, like for example non-fatal casualties that are admitted to a hospital.
Simulation	Simulation or simulators involve simulating real world conditions using computer programming, in the case of accident analysis, road and driving conditions.	Simulation in accident analysis generally refers to a computer programme which is developed to mimic the actions of real road user to predict accident outcomes. Simulators in accident analysis generally involve individuals volunteering to drive a mock-up of a real vehicle and computer simulated road scene and under experimental conditions, and are observed/assessed through a series of road environments/conditions.

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Stakeholder	Project stakeholders are individuals, groups or organisations that have a professional interest in a given project and its results, in this instance, the SafetyCube project.	-
Synopsis	A summary of the major points of a particular subject. From a SafetyCube perspective each synopsis provides a synthesis of the findings for a specific risk factor or road safety measure which form the DSS.	Each synopsis contains: (1) A Summary consisting of a two-page document reporting the key aspects of the topic, the main results and transferability conditions. (2) A Scientific overview covering 4-5 pages including a short synthesis of the literature, describing the way the reported effects have been estimated and including a full analysis of the methods, results, and its transferability conditions. (3) Supporting documentation which contains 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.
Taxonomy	Taxonomy is the practice and science of classification - In the context of the SafetyCube project the taxonomy is a three level classification system describing risks and measures included in the DSS.	In the context of the SafetyCube project a taxonomy is used to identify relevant topics covering all aspects of infrastructure, vehicle and human risk factors, and structure them in a meaningful way (e.g. general topics, specific topics). The taxonomy is furthermore the basis for linking risk factors with their corresponding measures.
Time-Series Analysis	Time series analysis comprises methods for analysing a series of data points indexed (or listed or graphed) in time order, to extract meaningful statistics and other characteristics of the data.	Time-series models can be used both to assess risk factors, in particular those that vary over time (weather, daylight), and to evaluate the effects of road safety measures.

Term	Short Description	Long Description
Transportation Research Board	The Transportation Research Board (TRB) is a division of the National Research Council of the United States.	The Transportation Research Board serves as an independent adviser to the President of the United States of America, the Congress and federal agencies on scientific and technical questions of national importance. It manages transportation research by producing publications and online resources, including the TRID database, which is the largest online bibliographic database of transportation research.
Trauma centre	A hospital equipped and staffed to provide care for patients suffering from major traumatic injuries like road traffic crashes.	-
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Triage	Rapidly directing victims to appropriate health care facilities.	-
Under triage	The orientation of a seriously injured person to an inadequately equipped care facility.	-
UNECE Regulations	The United Nation Economic Commission for Europe (UNECE) Regulations are international vehicle regulations used to ensure a minimum performance levels for vehicle systems.	The UN-ECE Regulations address all aspects of vehicle design (lighting, emissions, safety, etc). There are different membership conventions that define which UN-ECE regulations must be applies by the relevant countries. European Countries as well as the European Commission participate in the rule making activities.
United Nation Economic Commission for Europe Regulations	The United Nation Economic Commission for Europe (UNECE) Regulations are international vehicle regulations used to ensure a minimum performance levels for vehicle systems.	The UN-ECE Regulations address all aspects of vehicle design (lighting, emissions, safety, etc). There are different membership conventions that define which UN-ECE regulations must be applies by the relevant countries. European Countries as well as the European Commission participate in the rule making activities.
Unmatched Study	In an unmatched study, the investigator does not equate cases and controls with respect to any variables.	-
V2I	Vehicle to Infrastructure (V2I) communication	V2I communication includes Intelligent Transport Systems which allow vehicles to share information with the components that support a country's highway system.
V2V	Vehicle to Vehicle (V2V) communication	V2V communication is wireless transmission of data between motor vehicles. Its aim is to prevent accidents by allowing vehicles in transit to send position and speed data to one another over an ad hoc mesh network.

Term	Short Description	Long Description
Variable Message Signs	Variable Message Signs (VMS) are electronic and intelligent display panels for road traffic management.	VMS allow text and graphic variable messages to be combined, resulting in a more effective means of controlling traffic and providing information to road users, for example, about special events, delays on the road ahead, variable speed limits and in urban areas, parking information.
Vehicle classifications	System describing the design and function of vehicles	Different organisations have definitions of vehicle types describing the type and function of different vehicles. There are two fundamental categories of vehicles to address cargo in terms of passenger or goods. Sub-categories describe the size of vehicles. There is an international definition used by the UN-ECE for vehicle standards. Vehicle classifications are used to define the vehicles that can be operated for each driver's license category.
Vehicle to Infrastructure	Vehicle to Infrastructure (V2I) communication	V2I communication includes Intelligent Transport Systems which allow vehicles to share information with the components that support a country's highway system.
Vehicle to Vehicle	Vehicle to Vehicle (V2V) communication	V2V communication is wireless transmission of data between motor vehicles. Its aim is to prevent accidents by allowing vehicles in transit to send position and speed data to one another over an ad hoc mesh network.
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Vote-count analysis	A standard vote-count analysis divides a collection of research studies into three categories: those with significant positive results, those with significant negative results, and those with nonsignificant results and the category containing the most studies is the one with the greatest effect.	For example, if the majority of studies examining a specific road measure found significant positive results (i.e. fewer accidents occurred when the measure was installed), then the treatment is considered to have a positive effect on safety. In SafetyCube, a vote-count analysis was undertaken if a meta-analysis was not possible (i.e. not enough detailed results to perform a meta-analysis).
VRU	Vulnerable Road User (VRU). Modes of transport that provide the least protection for the road user (i.e. pedestrian, cyclist, motorcyclist), or a certain age group/characteristic.	A group of road users can be defined as 'vulnerable' in a number of ways, such as by the amount of protection in traffic (e.g. pedestrians and cyclists) or by the amount of task capability (e.g. the young and the elderly). Vulnerable road users do not usually have a protective 'shell', and also the difference in mass between the colliding opponents is often an important factor. In crashes involving only vulnerable road users and no other road users, it is mainly the infrastructure that is important for the prevention and limitation of injury. (http://www.swov.nl/rapport/Factsheets/UK/FS_Vulnerable_road_users.pdf)

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Willingness To Pay	Willingness To Pay (WTP). Valuation method measuring the amount of money individuals are willing to pay for a risk reduction	In the willingness to pay (WTP) approach costs are estimated on the basis of the amount individuals are willing to pay for a risk reduction. This approach is used to estimate the economic value of lost life years and lost quality of life, since there is no market price for such impacts. The WTP can be based on questionnaires in which people, directly or indirectly, are asked how much they are willing to pay for more safety ('stated preferences'), or on actual behaviour, for example purchasing behaviour regarding safety provisions such as airbags ('revealed preferences'). The results of WTP studies are used to derive the value of a statistical life (VOSL), which is used to calculate human costs of fatalities. The WTP approach also applies to injuries. In WTP studies for injuries, the amount people are willing to pay for reducing the risk of getting injured is estimated, e.g. relative to the WTP for reducing fatal risk.
Work package	A Work Package (WP) is a group of related tasks within a project. Within SafetyCube, the project is divided into 8 Work Packages.	-
WP	A Work Package (WP) is a group of related tasks within a project. Within SafetyCube, the project is divided into 8 Work Packages.	-
WTP	Willingness To Pay (WTP). Valuation method measuring the amount of money individuals are willing to pay for a risk reduction	In the willingness to pay (WTP) approach costs are estimated on the basis of the amount individuals are willing to pay for a risk reduction. This approach is used to estimate the economic value of lost life years and lost quality of life, since there is no market price for such impacts. The WTP can be based on questionnaires in which people, directly or indirectly, are asked how much they are willing to pay for more safety ('stated preferences'), or on actual behaviour, for example purchasing behaviour regarding safety provisions such as airbags ('revealed preferences'). The results of WTP studies are used to derive the value of a statistical life (VOSL), which is used to calculate human costs of fatalities. The WTP approach also applies to injuries. In WTP studies for injuries, the amount people are willing to pay for reducing the risk of getting injured is estimated, e.g. relative to the WTP for reducing fatal risk.
Years Lived with Disability	Years Lived with Disability (YLD). Measure to quantify the loss of quality of life due to a disease or injury	Years lived with quality of life loss due to an injury, weighted for the severity of this impact on quality of life (expressed by a disability weight). Suppose that a road casualty suffers from an injury that results in a loss of life quality of 25% (disability weight 0.25) for 8 years. In this case the YLD of one casualty is 2 years: 8 years multiplied with 25% quality of life loss.

Term	Short Description	Long Description
Years of Life Lost	Years of Life Lost (YLL). Measure to quantify the loss of quantity of life (premature mortality) due to a disease or injury	-
YLD	Years Lived with Disability (YLD). Measure to quantify the loss of quality of life due to a disease or injury.	Years lived with quality of life loss due to an injury, weighted for the severity of this impact on quality of life (expressed by a disability weight). Suppose that a road casualty suffers from an injury that results in a loss of life quality of 25% (disability weight 0.25) for 8 years. In this case the YLD of one casualty is 2 years: 8 years multiplied with 25% quality of life loss.
YLL	Years of Life Lost (YLL). Measure to quantify the loss of quantity of life (premature mortality) due to a disease or injury	-