APPENDIX A. REVIEW OF EXISTING APPROACHES AND INITIATIVES

This appendix provides a review of national and international approaches for the efficiency assessment of road safety measures. In particular, the most important international initiatives for providing standardized and accurate methods or tools for the estimation of safety effects of road safety measures are presented. Furthermore, examples from the use and application of these (or other) methods and tools at national level are analyzed.

A.1. International approaches and initiatives

A.1.1. Handbooks and manuals

The Handbook of Road Safety Measures - Elvik et al (2009)

The handbook aims to provide a systematic overview of current knowledge regarding the effects of road safety measures, by presenting state-of-the-art summaries of current knowledge regarding the effects of 128 road safety measures. The types of measures that are included are road design and road equipment, road maintenance, traffic control, vehicle design and protective devices, vehicle and garage inspection, driver training and regulation of professional drivers, public education and information, police enforcement and sanctions, post-crash care and general purpose policy instruments.

More specifically, the handbook aims to provide answers to the following questions related to the type of measures which can be used to reduce the number of traffic crashes or the severity of injury in such crashes, the crash problems and types of injury that may be affected by the different measures, the effects on crashes and injuries of the various road safety measures, as well as their related effects on mobility and the environment. Moreover, the costs of road safety measures are examined, and the potential for cost-benefit evaluations of the measures is demonstrated.

It is also demonstrated that the safety effect of a measure may vary from place to place, depending on the design of the measure, the number of crashes at the spot, any other measures that have been implemented, etc. An attempt has been made to identify sources of variation in the findings of different studies and to try to form as homogeneous groups as possible when presenting estimates of the effects of measures on road safety.

In particular, the handbook seeks to develop objective knowledge about the effects of road safety measures by relying on an extensive and systematic search of literature and by summarising this literature by means of formal techniques of meta-analysis that minimise the contribution of subjective factors that are endemic in traditional, narrative literature surveys. A systematic framework has been used to assess the validity of the studies that are quoted. Moreover, the need to develop crash modification functions in order to describe systematic variation in the effects of road safety measures is stressed.

The criteria of study quality that have been applied to assess the road safety evaluation studies referred to in this handbook are to a great extent based on the validity framework of Cook and Campbell (1979). According to this framework, the quality of a study can be assessed in terms of four types of validity:

- Statistical conclusion validity; sampling technique, sample size, reporting of statistical uncertainty in results, measurement errors, specification of crash or injury severity
- Theoretical validity; identification of relevant concepts and variables, hypotheses describing the relationships between variables, knowledge of causal mechanisms
- External validity; generalisability of the results of a study
- Internal validity; basis for inferring a causal relationship between treatment and effect, statistical association between treatment and effect, clear direction of causality, dose-response pattern, specificity of effect, control of confounding factors.

The Highway Safety Manual

The Highway Safety Manual (HSM) aims to introduce a science-based technical approach and to provide tools for conducting quantitative safety analyses. This allows safety to be quantitatively evaluated alongside other transportation performance measures such as traffic operations, environmental impacts, and construction costs. In particular, the HSM provides a method to quantify changes in crash frequency as a function of cross-sectional features. With this method, the expected change in crash frequency of different design alternatives can be compared with the operational benefits or environmental impacts of these same alternatives.

The HSM provides the following tools:

- Methods for developing and evaluating a roadway safety management program, including the identification of hazardous sites, the diagnosing of conditions at the site, the evaluation of conditions and the identification of potential treatments, the prioritization and programming of treatments, and subsequently the evaluation of the crash reduction effectiveness of programmed treatments.
- A predictive method to estimate crash frequency and severity.
- A catalogue of crash modification factors (CMFs) for a variety of geometric and operational treatment types, developed using before/after studies that account for regression to the mean.

The HSM is organized into four parts:

Part A explains the relationship of the HSM to planning, design, operations and maintenance activities. Part A also includes fundamentals of the processes and tools described in the HSM.

Part B presents suggested steps to monitor and reduce crash frequency and severity on existing roadway networks. It includes methods useful for identifying improvement sites, diagnosis, countermeasure selection, economic appraisal, project prioritization, and effectiveness evaluation. Several new network screening performance measures are introduced to shift the safety analysis focus away from traditional crash rates, in order to deal with the major limitation associated with crash rate analysis i.e. the incorrect assumption that a linear relationship exists between traffic volume and the frequency of crashes.

Part C provides a predictive method for estimating expected average crash frequency of a network, facility or individual site, and it introduces the concept of safety performance functions (SPFs). The methods are provided for road segments and intersections for different facility types (rural two-lane roads, rural multilane highways, urban and suburban arterials).

Part D provides Crash Modification Factors (CMFs), allowing one to quantify the change in expected average crash frequency as a result of geometric or operational modifications to a site that differs from set base conditions. These concern roadway segments, intersections, interchanges, special facilities and road networks. These CMFs are claimed to be readily applicable to any design or evaluation process where optional treatments are being considered.

The HSM incorporates many, but not all geometric features. Moreover, the proposed models (SPFs) cannot explain crash causes. For instance, weather and driver behavior are not explicitly addressed in these models. Finally, in several cases the proposed models are very sensitive to the availability and quality of the necessary data.

The Rosebud Handbook

Within the activities of the Rosebud thematic network, a handbook titled "Examples of assessed road safety measures - a short handbook", was issued in July 2006 as the main outcome of the Rosebud project. The handbook includes information about various assessed road safety measures. The assessment methods used are cost effectiveness analysis (CEA) or cost-benefit analysis (CBA). In CEA, the costs of a measure are confronted with its effects; the effects of the measures are not expressed in monetary terms. On the contrary, in CBA the result of the evaluation is obtained by comparing costs with benefits. Economic evaluation of road safety measures using cost-benefit analysis is based on the costs incurred as a result of road crashes. Avoiding such costs represents the economic benefit of road safety measures. The benefit-cost ratio represents the economic advantage of the safety measures.

According to the benefit-cost ratio, measures are ranked as poor, acceptable and excellent. Measures from Rosebud consist of user related, vehicle related and infrastructure related measures.

The Handbook is available at
http://partnet.vtt.fi/rosebud/products/deliverable/Handbook_July2006.pdf

The CEDR Report

The Conference of European Directors of Roads (CEDR) has been promoting collaboration and exchange of information and expertise amongst its members since 1998. In particular, it aims to provide support to the activities of the Road Directors and their national road administrations, to promote a high level of common information, and to give assistance to the European Commission in the preparation of reports concerning the development of the Trans European Road Network (TERN).

The source of CEDR measures is the Final report of "Best Practice on Cost Effective Road Safety Infrastructure Investments", April 2008
(http://www.cedr.fr/home/fileadmin/user_upload/Publications/2008/e_Road_Safety_Investments_Report.pdf).

According to the report, the five most promising investments were identified (as a result of preliminary assessment and related ranking of investments) and selected for further in-depth analysis using the existing literature in conjunction with the results of Questionnaire 2 of the CEDR task group O7 (Road safety). These investments concern the following measures:

- Roadside treatment
- Speeding
- Junctions layout

- Junction traffic control
- Traffic calming

The FHWA Clearinghouse CMFs

The CMF Clearinghouse is home to a web-based searchable database of CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs. In addition to search functions, one can also submit CMFs to be included in the clearinghouse. CMFs are rated using a five star system for quality; five stars are needed for a CMF to be included in the HSM. Stars are applied based on a review of five criteria: study design; sample size; standard error; potential bias; and data source. The clearinghouse can be found at: http://www.cmfclearinghouse.org/sqr.cfm.

The Cochrane reviews

Cochrane Reviews are systematic reviews of primary research in human health care and health policy. They investigate the effects of interventions for prevention, treatment and rehabilitation. They also assess the accuracy of a diagnostic test for a given condition in a specific patient group and setting.

The Cochrane Injuries Group has been preparing Cochrane Reviews on the effectiveness of interventions for road safety, including slowing traffic speed, wearing helmets, and driver education. The findings of these Cochrane Reviews provide guidance on the effectiveness of interventions for road safety in the hope that governments, urban planners, and individuals will be encouraged to improve road safety as a matter of urgency.

http://www.thecochranelibrary.com/details/collection/691655/Safety-on-the-road.html

Countermeasures that work: A Highway Safety Countermeasure Guide For State Highway Safety Offices - 6th Edition (2011)

This Guide is intended to be a key reference to assist State Highway Safety Offices (SHSOs) in the USA selecting effective, evidence-based traffic safety countermeasures for major road safety problem areas. The Guide describes strategies and countermeasures that are relevant to SHSOs, summarizes their use, effectiveness, costs, and implementation conditions and includes references to the most important publications (research summaries and individual studies) in the field.

The Guide includes countermeasures related to the following road safety problems and research areas:

- Alcohol-impaired driving
- Seat-belt use and child restraints
- Aggressive driving and speeding
- Distracted and fatigued driving
- Motorcycle Safety
- Young drivers
- Older drivers
- Pedestrians

- Bicycles

Each section starts with a brief literature review on the road safety problem (e.g. the reader is often referred to the Cochrane reviews), followed by a presentation of the related strategies and countermeasures. More than 115 individual countermeasures are examined and typically one page is devoted to each countermeasure. In each case, the countermeasures are ranked in terms of their effectiveness on the basis of a rating in stars; the use, costs and time needed for implementation are also assessed. Effectiveness is measured by reductions in crashes or injuries:

- 5 stars - The measures are demonstrated to be effective by several high-quality evaluations with consistent results
- 4 stars - Demonstrated to be effective in certain situations
- 3 stars - Likely to be effective based on balance of evidence from high-quality evaluations or other sources
- 2 stars - Effectiveness still undetermined; different methods of implementing this countermeasure produce different results
- 1 star - Limited or no high-quality evaluation evidence

The use of the measures is ranked high (i.e. more than two-thirds of the states, or a substantial majority of communities), medium, or low (i.e. fewer than one-third of the states or communities). The implementation costs are ranked high (i.e. requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources), medium, or low (i.e. can be implemented with current staff, perhaps with training; limited costs for equipment, facilities, and publicity). Finally, the time to implementation is ranked long (i.e. more than one year), medium, or short (i.e. three months or less). A 'varying' option for the above rankings is also used in several cases.

Source: http://www.nhtsa.gov/staticfiles/nti/pdf/811444.pdf

Austroads Road Safety Engineering Toolkit (www.engtoolkit.com.au)

The Road Safety Engineering Toolkit is a reference tool for road engineering practitioners in state and local governments in Australia and New Zealand. It outlines best-practice, low cost, high return road environment measures to achieve a reduction in road trauma. The Toolkit seeks to reduce the severity and frequency of crashes involving road environment factors. The Toolkit draws together existing road safety engineering knowledge as far as possible into one Toolkit for easy access by practitioners. The presented knowledge has been updated with recent experience from local and state government agencies, and with the results of comprehensive road safety research reviews. The Toolkit is considered a 'living' document including updates and revisions, so that more recent safety 'wins' are captured and disseminated.

International Road Assessment Programme (iRAP) Road Safety Toolkit (http://toolkit.irap.org/)

The Road Safety Toolkit provides information on the causes and prevention of road crashes that cause death and injury. Building on decades of road safety research, the Toolkit helps engineers, planners and policy makers develop safety plans for car occupants, motorcyclists, pedestrians, bicyclists, heavy vehicle occupants and public transport users. It is aimed primarily at users in developing countries. It has been translated into French, Spanish and Mandarin.

A.1.2. Research projects

The PROMISING project

The PROMISING project is aimed at developing measures that reduce the risk of injury to vulnerable and young road users as much as possible in a non-restrictive way. It was commissioned by the European Union and was coordinated by the SWOV Institute for Road Safety Research.

PROMISING project measures come from the WP5 "Cost-benefit analysis of measures for vulnerable road users", July 2001. Cost-benefit analysis was carried out for a number of measures.

The ROSEBUD thematic network

ROSEBUD (Road Safety and Environmental Benefit-Cost and Cost-Effectiveness Analysis for Use in Decision-Making) is a thematic network funded by the European Commission to support users at all levels of government (European Union, national, regional, local) with road safety related efficiency assessment solutions for the widest possible range of measures.

ROSEBUD examined the factors affecting the quality of the efficiency assessment of a safety measure, which in turn depends on the quality of the available values of safety effect. The latter were found to depend on a number of factors, including the availability of values, the validity of the data, the variability of the effect, the local versus general effects, and the changeability of the effect.

The recommendations include ways to systematize the values of safety effects, mainly by documenting the effects on the basis of either a meta-analysis or traditional literature surveys, and by providing for theoretical effects based on known relationships between risk factors and crashes. They also include criteria for examining the local findings on safety effects of road infrastructure improvements.

http://ec.europa.eu/transport/road_safety/pdf/projects/rosebud.pdf

The SUPREME project

The SUPREME research project was funded by the European Commission and its goal was to collect, analyse, summarise and publish best practices in road safety in the Member States of the European Union as well as in Switzerland and Norway. The target audiences of the project are decision and policy makers at all levels, from European to local, as well as the scientific community and practitioners in the field. The aim was to provide users with specific information on outstanding safety measures with a view to implementation in other countries or at the European level.

SUPREME measures come from the final report and are mainly from Part C of "Handbook for measures at the Country level", and Part D of "Handbook for measures at the European level", both from June 2007. The evaluated safety measures described are ranked as best, good or promising practices in the following areas:

- Licensing
- Policy
- Enforcement
- Campaigns

- Infrastructure interventions
- Safety equipment
- Data analysis
- Post impact care

The measures within the SUPREME research project were collected through a questionnaire sent to experts working for international or European organisations, NGOs, interest groups and industries. The information collected through the questionnaires was supplemented by additional research from the authors.

According to the SUPREME project, "best practice" measures were scientifically proven to lead to a reduction of road crashes and/or deaths and serious injuries, had a positive cost-benefit ratio and were expected to lead to the effects' sustainability and/or to public acceptance. Measures were rated as "good" when the available information on the above criteria was not sufficient to assess if they were the best practice in their category because of a clear lack of systematic evaluations of implemented measures. Measures that have not yet been implemented at the European or international level but have proven to be successful in one or more Member States were rated as "promising".

The Road Safety Engineering Risk Assessment Project

Funded by Austroads, this program of research began in 2002 on a relatively limited scale, but formed a substantial part of the Austroads road safety research program from 2004 to 2007. The results were intended to provide road authorities with more effective methods and tools to reduce road crashes and injuries. This has included assessment of the effectiveness of commonly used road safety measures, as well as reviews of other associated issues required as part of an economic evaluation for road safety. A total of 11 reports were published based on this research (available from www.austroads.com.au), as well as 15 newsletters (the 'risk reporter' newsletter series is available from www.arrb.com.au).

A.1.3. Other

The IRTAD Annual Reports

The source of IRTAD measures is the "IRTAD -Road Safety Annual Report 2009", which includes road safety data from 27 member countries. This report summarizes the recent road safety measures (2007-2009) as well as the National Road safety targets and strategies without always indicating their effectiveness.

Technical Assistance in support of the Preparation of the European Road Safety Action Programme 2011-2020

COWI is a northern European consulting group which undertakes studies within the fields of engineering, environmental science and economics.

The source of COWI study measures is the final report of "Technical Assistance in support of the Preparation of the European Road Safety Action Programme 2011-2020", January 2010, carried out for the European Commission DG-TREN. The main sources of this report are ERSO, ETSC, EuroRAP, The Global Status Report on Road Safety -Time for Action of WHO, IRTAD and national sources.

According to the report, the enforcement of rules on speed, drunk driving, and seat belt wearing in EU25 is provided as a quantitative ranking (scale 0-10) and a qualitative ranking (good/ improving/ need to do more). The effectiveness of helmet wearing enforcement and child restraints is also provided. In addition, infrastructure interventions concerning engineering actions such as formal audits on new roads, regular inspections on existing roads, and EuroRAP assessment (risk mapping or star rating) are also included.

Roads are assessed according to: the separation of directions (how well the medians are treated), the design standard and frequency of intersections, how well the roadsides are protected, how the edge of the carriageway is treated, and the occurrence of fatalities for pedestrians and cyclists.

Concerning the education and campaign measures of the safety measures, the COWI study presents the most common campaigns on speed, seatbelts, alcohol, helmets, young drivers and school children education.

As for trauma management, the COWI study presents the performance for several countries according to the Safetynet study ranking (high level, medium level, low level, relatively low level).

I-cars network, thematic group on impact assessment measures

http://www.icarsnetwork.eu/en/thematic_groups/tg3_-_impact_assessment_methods/ This project provides an overview of impact assessment studies (all types of studies, from expert judgement to crash studies) for intelligent vehicle systems. The objective of the project is to exchange experience regarding the use of different methods of impact assessment and socio-economic evaluation with the goal of leading to more reliable methods with higher predictive validity.

A.2. Existing national approaches and initiatives

Australia

Crash Reduction Factors (CRFs) form the basis of decision making for many policy and infrastructure improvements within Australia. A solid body of evidence has been established over many years on this topic. This is particularly strong for road infrastructure improvements, with less information available for behavioural and vehicle-based improvements.

National guidance has been produced on the treatment of crash locations (Austroads 2009) and this provides information on the use of CRFs. This guidance is used across Australia and New Zealand.

Various robust evaluations have been conducted in Australia on the effect of infrastructure improvements, particularly those treatments at high crash locations (i.e. blackspot programs). These evaluations have occurred at national and state levels, and cover a range of CMFs. Numerous studies on individual treatments have also been conducted on an ad-hoc basis. The predominant methodology for Australian research has been to use before and after studies with a control group. A 3-5 year before and after period is generally selected to minimise the effect of regression to the mean.

Numerous studies have also been undertaken on safety initiatives relating to vehicle improvements and behavioural programs. Information on these aspects of safety is less coordinated than for infrastructure safety improvements.

Various summaries on this research have been published within international journals. However, much of the research is not, and resides in published or unpublished reports and conference proceedings.

Several relevant research products on this topic from Australia have been developed as part of the Road Safety Engineering Risk Assessment research program. The first is titled *Road Safety Engineering Risk Assessment, Part 6: Crash Reduction Factors* (Turner et al., 2010). The objectives of the project were to improve crash reduction estimates associated with various road design features or safety measures (termed 'issues') in different environments, and to provide more objective analysis methods for use by road authorities in assessing relative risk. The report examines 47 different treatments. A second report titled *Road Safety Engineering Risk Assessment, Part 2: Crash Risk Migration* (Styles et al., 2010) provides an overview of the effect known as crash risk migration (CRM). The report is intended to build an understanding of the potential for CRM to occur as a result of road safety treatments. It is also intended to inform current approaches to evaluating road safety risk. In particular, evaluation approaches generally examine the extent to which a safety issue at a treatment site can be addressed, without considering the possibility that some treatments may impact crash rates at other locations. The report focuses on situations where CRM may occur as a result of traffic redistribution. A further study examines the issue of treatment life, or how long engineering treatments can be expected to deliver a road safety benefit (*Road Safety Engineering Risk Assessment Part 4: Treatment Life for Road Safety Measures*, Turner & Comport, 2010).

The research program also led to the development of a rating scale that assigns a level of robustness to individual studies according to the research methodology that was used. This scale ranks research from 1 (poor quality research) to 5 (high quality). A level of confidence in the robustness for the CRFs associated with various treatments has been developed (a rating of high, medium and low). This rating is based on the number of studies, the robustness of their methods indicated by the rating scale, the consistency of the results, the recentness of the study, and the transferability of the research.

Research needs where there is either a low level of confidence or where there is no adequate research have been identified. A method to prioritise these gaps in knowledge has been developed. This is based in part on the economic cost of not knowing accurate information about the treatment.

In addition, research has been conducted on the cumulative effect of more than one engineering treatment at a site. A formula has been developed to estimate the aggregated benefit. This research found that only 1 in 5 treated sites had just a single treatment. A combination of treatments had been used at most of the sites examined.

A national guidance document is currently being prepared on evaluation methodology for the development of CRFs. This will cover different issues to consider when evaluating road safety engineering measures, as well as methodology options. This document has been produced with reference to this current OECD/ITF report to ensure that future research is compatible with international efforts on this topic.

Austria

In general, the efficiency results from the Handbook of Road Safety Measures are used.

A large examination was carried out from the KfV, concerning the efficiency analysis of remedial measures at high risk sites. The measures were classified in four different groups. A statistical assessment showed the appropriate significance of three different testmodes. Eventually, a cost-benefit analysis showed the potential of the different measures for Lower Austria.

It was found that possible savings by reconstruction measurements are 3 percent − thus, in Lower Austria €23 million of social costs could be saved.

Moreover, the KfV published a report in 2009 titled "Good and Promising Interventions for the Prevention of Injuries to Pedestrians and Two-wheelers - Inventory and Guidebook for the Health Sector". The aim of this "inventory and policy guide" was to build common knowledge on what is known to work in injury prevention when targeting vulnerable road users and falls in pedestrians (inventory), as well as to guide politicians, administrators and other stakeholders in the health care sector in the implementation of policies and practices (policy guide).

http://www.euroipn.org/apollo/reports/ANNEX%205.1%20ApolloGPGuideandInventory.pdf

Canada

Throughout Canada, several provinces use Collision Reduction Factors to evaluate the effectiveness of countermeasures. There are several resources that are used by practitioners to obtain these factors. These include:

- In Service Safety Reviews
- FHWA Reports
- Sources of general information such as ITE, TAC, TRB and AASHTO
- Specific provincial lists
- The Canadian Guide to In-Service Road Safety Review (TAC- January, 2004); Section 6.3 Countermeasures and Effectiveness (Tables 6.1 to 6.12)
- CRF's produced by the ICBC and the British Columbia Ministry of Transportation and Infrastructure
- Highway Element Investment Review (HEIR) Guidelines

Noteworthy is Ontario's Highway Element Investment Review (HEIR) Guidelines. HEIR are guidelines accompanied by an excel spreadsheet. The purpose of HEIR Guidelines is to help practitioners determine how to make the best investment in highway infrastructure. In this document there are equations whose purpose is to determine the safety benefits of highway improvements. The guidelines are accompanied by an excel spreadsheet that helps perform cost/benefit analyses of potential improvements to the highway.

CMF's are used within the HEIR Guideline calculations to help determine the overall benefit of safety measures. The change in frequency for different collision severities is calculated; this collision reduction value is then multiplied by a corresponding collision cost. The results of these calculations are used to determine total collision reduction benefits. This process is performed automatically in the HEIR accompanying excel spreadsheet.

Finland

Since 1995, practically all traffic safety effects of road improvements on public roads have been evaluated using an evaluation tool (TARVA) whose major feature is the use of CRFs. TARVA was created for the Finnish road administration by VTT.

In addition to using relevant CRFs, the emphasis is on appropriate evaluation of current safety situations and taking into account overlapping safety measures. The CRFs used are based on a Norwegian traffic safety handbook modified for local conditions. Cost/benefit ratios have been calculated for different safety measures - it was also found that the AADT on the site of improvement heavily influences it. The CRFs are also utilized while evaluating safety effects of traffic safety programs.

Literature: Peltola, H. (2007) Evaluating measures in order to achieve safety targets. Road Safety on Four Continents, Bangkok, Thailand 14-16 Nov 2007; Peltola, H. (2009) Evaluating road safety and safety effects using Empirical Bayesian method. 4th IRTAD Conference, Seoul, Korea, 16 - 17 Sept. 2009 http://internationaltransportforum.org/irtad/pdf/seoul/8-Peltola.pdf

TARVA (2010) - home pages at web: http://www.tarva.net/tarvaintro.asp

Germany

Road traffic safety work is an interdisciplinary task. In Germany the current practice in safety assessment incorporates infrastructure and vehicle technology as well as behaviour related measures. Safety assessment is done in both ex-post evaluations as well as in ex-ante evaluations.

Vehicle:

Recently, a lot of scientific work was done to evaluate the possible safety effects of vehicle systems. Research development started from simple vehicle safety systems, moved on to intelligent safety systems which work autonomously, and then included communication based cooperative systems to link vehicles with each other or together with infrastructure devices. Much of this work was done in the scope of EU-projects encompassing work on the methodological foundations of CBA, EU-level standardization of the assessment methods used, and socio-economic assessments of road safety measures and programs. The most important projects concerning vehicle safety systems are the following:

- The EU-project ROSEBUD (2003 – 2006) supported users at all levels of government (European Union, national, regional, local) with information about road safety related efficiency assessment (see section 3.2.2)
- The IMPROVER project funded by the EC (2004 – 2006) examined the impacts of light goods vehicles (LGV) on road safety, emissions and fuel consumption. The safety measures considered were speed limiters, electronic stability control, social rules (using digital tachographs), seat belt reminders or seat belt locks, professional fleet safety management, and an increase in the minimum age of drivers to 21 years.
- In the EU-project eIMPACT (2006 - 2008) the socio-economic effects of stand-alone and cooperative Intelligent Vehicle Safety Systems (IVSS), and their impact on traffic safety and efficiency were assessed. In addition to including a CBA, the project also addressed policy options to improve market deployment of the IVSS and included the views of stakeholders such as users, OEMs and insurance companies concerning the profitability of the systems.
- The iCars Network funded by the EC (2008 – 2010) (see section 3.2.3)

- The project SAFESPOT (2006-2010) aimed to develop co-operative safety systems (IVSS) with communication and information platforms. Within the subproject BLADE a comprehensive assessment and impact evaluation of IVSS was done. In this context, an integrated framework was used, which consisted of a CBA, sensitivity analysis and a complementary stakeholder analysis. The impacts considered in the assessment were safety, traffic flow and environmental effects of cooperative safety systems.
- The EU-project ASSESS (2009 – 2012) aims to develop a relevant set of test and assessment methods applicable to a wide range of integrated vehicle safety systems considering driver behavioral aspects, pre crash sensing performance and crash performance with a special focus on emergency brake assist systems.

Infrastructure:

Within the national project "Possibilities of faster realisation and prioritization of structural measures to improve road safety at black spots" a catalogue was developed which contains black spots with examples of measures for their elimination. In this catalogue, the efficiency (benefit-cost analysis) as well as the effectiveness (crash costs and impact of measures) were exemplarily described for different measures. In addition, every example was judged and examined, whether or not the effect of the measure is significant. The examples are to support crash commissions and decision makers assessing advantages and disadvantages of planned measures. An evaluation of the effectiveness and efficiency for 110 measures taken at black spots was possible.

Human behaviour:

In the past, different measures were scientifically accompanied and evaluated by ex-post analyses. Two behavioural measures were introduced recently: "Accompanied Driving from the Age of 17" and the "Ban on Alcohol for Beginners".

- Accompanied driving from the Age of 17: Germany has had no previous experience in preparing beginners for driving from an early age. Before introducing the model "Accompanied Driving from the Age of 17", there was an analysis of its effects in foreign countries and of the possibilities to adopt this model in Germany. In particular, experiences from Sweden, Canada and United States were investigated. The introduction of this model and its safety effects were evaluated in three studies that differed regarding their period and location of investigation. All three studies showed a double-digit decrease in driving offence and crash risk. Based on these results the model project will be converted into common law.

- Ban on Alcohol for Beginners: Even at low alcohol concentrations, young drivers and beginners already have a significantly higher crash risk. The introduction of a "Ban on Alcohol for Beginners" in Germany in 2007 was accompanied by a before and after comparison as well as by an analysis of international experience. The results of this study showed a significant decrease in alcohol related crashes in beginner drivers. Furthermore, there was also a decrease in the risk of committing driving offences. To strengthen these results the time period of the evaluation is to be expanded as soon as actual crash and offence data are available.

Greece

The evaluation of road safety measures in Greece is not routine within road safety decision making. A number of evaluations are available, mainly on the basis of research projects, but these are only occasionally used. The assessments mainly include infrastructure improvements, such as an evaluation of the upgrade of the interurban road network to motorways, and an evaluation of traffic calming and low-cost traffic engineering measures in urban areas (Yannis et al. 2005). An evaluation of speed and alcohol enforcement was also carried out, confirming that the intensification of enforcement was one of the main reasons for the significant improvement of road safety in Greece from 2003 onwards (Yannis et al. 2008). Some results from the evaluation of safety campaigns are also published by non-profit organizations (www.ioas.gr).

Furthermore, there are no official figures for crash costs but work is on-going to make the evaluation process more efficient. A complete assessment of the social costs of road crashes and related casualties, with particular emphasis on the estimation of human cost (i.e. the value of statistical life) is presented in Yannis et al. (2005), suggesting that the social cost of fatal crashes and their victims in Greece is considerably higher compared to the estimates of international publications (e.g. ROSEBUD, UNITE).

Ireland

In the past, safety assessment in Ireland was carried out mainly from the engineering perspective while behavioural assessments were left out. Current research is trying to correct this by also incorporating behavioural measures.

Japan

A policy referred to as "Management to produce results" is now being implemented in Japan. As part of the policy, road administrators are establishing a database with integrated data of traffic accidents, traffic and road conditions, so that a kind of CMF could be introduced, according to the process outlined below.

Collecting data

In Japan, separate administrative bodies are in charge of traffic safety. Initiatives taken to reduce traffic accidents are implemented by both road administrators and police agencies. Police agencies, which manage traffic, collect crash data. Road administrators consider countermeasures using crash data provided by police agencies in addition to traffic and road condition data. Two databases are being established. The first one is the "Integrated Accidents Database" and concerns trunk roads. The contents of this database are aggregated crash data, traffic and road conditions for 700 road sections, totalling 180 thousand kilometers. The second one is the "Database of Locations Implemented Measures", and includes descriptions of countermeasures implemented, crash data, and basic data concerning the road traffic environment of the locations where the countermeasures were implemented. This database concerns national roads and trunk local roads.

Analyzing data and establishing CMFs

Based on the "Database of Locations Implemented Measures", the effect on reducing traffic accidents for each type of countermeasure and the general effectiveness of the countermeasures implemented at each location were analyzed.

The establishment of CMFs requires adequate data collection. If additional data is needed during the CMF estimation process, further data collection will be initiated.

Continuous reviewing of CMFs

As the policy includes the PDCA (Plan, Do, Check and Action) management cycle, data will continue to be accumulated after the establishment of CMFs. These CMFs will be reviewed to improve precision after data is collected for several years in many locations.

Netherlands

The SWOV institute of road safety research uses crash reduction factors (CRFs) mainly to estimate the effects of future traffic safety measures. The effect of a certain measure is estimated on the basis of the crash reduction factor, the penetration level and the target group. A recent study discussed the CRFs of 30 traffic safety measures. The following criteria were applied to assess the quality of the evaluation studies that were analysed:

- Is the crash reduction factor based on a before and after study?
- Is there a control group?
- Are the appropriate statistical analyses performed and are they performed correctly?
- Is the number of crashes high enough?
- Is the crash reduction factor based on a Dutch evaluation study?

When available, CRFs from Dutch before and after studies are used (preferably with a control group). However, the number of 'good' evaluation studies is limited, because of the costs of data collection. When no CRFs based on Dutch studies are available, factors from other countries may be used, and in some cases these factors are adjusted (based on expert judgement) to the Dutch situation.

In some cases, CRFs from other countries cannot be applied. For example, this is the case in the evaluation of roundabouts, since the number of cyclists is much higher in the Netherlands compared to other countries.

Norway

Norway applies an abbreviated version of the Highway Safety Manual with new numerical estimates of measures. Norway also applies a five star system in the manual to describe the quality of the assessment / study.

Spain

In Spain, different steps are being taken towards the goal of establishing a procedure for systematically assessing the effectiveness and efficiency (cost-effectiveness) of road safety measures. This process is mainly led by the Ministry of Interior, responsible for the coordination of road safety policies, traffic management and enforcement, driving licences, vehicle registrations, education, training and awareness, and the Ministry of Public Works, responsible for the construction and maintenance of

roads and the public transport of goods and people. For any action to succeed, the involvement of departments at different levels —regional, provincial and local— shall prove essential.

Within the Ministry of Interior, the National Road Safety Observatory has, as one of its main tasks, the evaluation of the impact of road safety policies. This evaluation is generally carried out by external research centres and universities. During the past few years, the Observatory has promoted the evaluation of measures such as the penalty point system or the signposting of black spots. This will contribute to developing a set of national estimates of effectiveness (CMFs).

The Observatory has also promoted research about the value of preventing both fatal and non-fatal accidents in Spain. This research has been conducted by a team of University experts, and has been based on the so-called 'willingness to pay' approach, which is now regarded as the best option for computing public preferences for public investments. As a result of this research, the value of preventing a fatality in Spain has been estimated at 1.4 million euros, a value that is consistent with those from other countries also using the 'willingness to pay' approach. The publication and dissemination of the value of preventing a non-fatal accident will follow shortly. This research will allow Spain to comply with the prescriptions of the Directive 2008/96 on road infrastructure safety management, and will make it possible to use cost-benefit analysis for those measures where a crash modification factor is available.

Along with the Ministry of Interior, the Ministry of Public Works is also promoting the use of effectiveness estimates in the construction and operation of roads. At present, road safety must be explicitly considered during the planning, design, construction, operation and maintenance of roads. At the planning stage, the designer must analyse all factors that influence safety, such as the continuity of layout, and the density and design of junctions or facilities for pedestrians and cyclists. An assessment of the expected safety performance of the different options must be made, and safety must be used as a criterion for the final choice. At the stages of layout design and construction, the designer must consider the expected safety impact in the so-called 'safety appendix'.

Different tools are now being used for the safety assessment of roads. The Ministry of Interior published a manual called 'Recommendations for the economic evaluation and cost-benefit analysis of road projects'. These recommendations offer methods for estimating the expected frequency of accidents and victims for a given option. In addition, the Ministry has developed a system for monitoring the evolution of safety in those sites where safety measures have been implemented. This process comprises the registration of data such as the: identification and description of the site, description of the measure, cost of the measure, frequency of accidents during the 'before' period, and frequency of accidents during the 'after' period (typically five years).

The Ministry of Public Works has recently adopted Directive 2008/96, for the safety management of the Spanish trans-European network. According to the prescriptions of the Directive, several procedures for safety management shall be introduced, including road safety impact assessments and road safety audits for infrastructure projects, as well as safety ranking, management and inspections for the road network in operation.

In conclusion, a number of significant initiatives are now being undertaken in Spain regarding the evaluation of the impact of road safety measures and the application of efficiency assessment tools, such as cost-benefit analyses. This process should lead, in the medium and long term, to the consolidation of procedures for systematically assessing the impact of safety measures, both ex-ante (i.e. during the stage of planning) and ex-post (i.e. once the measure has been implemented). There are no national guidelines, nor is there a handbook for systematically collecting CMFs in Spain; the improvement of efficiency assessment tools is thus necessary.

Sweden

The Swedish Transport Administration requires all projects to apply the EVA-model to analyse safety effects in the preliminary and final design stages. The EVA-model operates as follows:

- Networks with and without proposed countermeasure are defined
- Traffic volumes including route choice are applied (car and truck volumes, pedestrian and bicycle flows only for intersections)
- Networks are divided into intersections and links
- Links are divided into homogenous sections by cross-section and speed limit. More specifically, in rural conditions they are classified per alignment class, roadside area type and type of wildlife area, and in urban areas per road function, traffic type and degree of separation of vulnerable road users
- "Normal" traffic safety results, SPFs, are given by the EVA-model for homogenous links (fatalities, injuries etc.)
- Crash cost is weighted with Swedish socioeconomic cost values
- Intersections are classified per number of arms and intersection type (lane layouts, degree of separation, traffic control, grade-separation)
- "Normal" traffic safety results, SPFs, are given in the same way as for links
- Fatalities are assumed to decrease by 2 percent per year and severe accidents by 1.5 percent due to improved cars, increase in safety belt use etc.
- The safety effect is given as the difference between the networks

The EVA link model gives injury type rate SPFs (e.g. fatalities per million vehicle-km) independently of traffic flow, mainly because traffic flow intervals for different cross-section types are rather narrow in Sweden.

EVA intersection models give injury type numbers (e.g. fatalities per year) due to major road traffic flow, secondary road traffic flow and flow of pedestrians and bicyclists. The weighting factors used include traffic volume for the crash data and a regression to the mean factor.

Normal safety performance could be changed using crash reduction / modification factors applied for car, wildlife or pedestrian/bicycle accidents. These crash reduction factors should be picked based on an engineering judgement from a countermeasures catalogue. The catalogue gives a mixture of quantitative and qualitative recommendations for a number of measures, based on research and crash statistics in Sweden and elsewhere (often the Norwegian Safety Handbook). A procedure similar to the HSM with statistical meta tests is not used.

Swedish safety research normally applies "with/without" comparisons (typically 5 to 10 years) at the same speed and traffic flow conditions or before-after studies with regression to the mean and control group corrections.

Literature: Manual cost-benefit analysis for investment projects in Transport Plan preparations 2008 (in Swedish), Swedish Road Administration 2008-06-28; Investment and rehabilitation measures - effects Chapter 6 Safety (in Swedish) Swedish Road Administration.2008:11 updated.

United Kingdom

The Department for Transport provides general guidance on evaluation http://www.dft.gov.uk/pgr/evaluation/evaluationlinks and specific evidence based guidance on road safety to local authorities and local level practitioners. For example, see the road safety good practice guide http://www.dft.gov.uk/pgr/roadsafety/laguidance/roadsafetygoodpracticeguide?page=2 and manual for streets http://www.dft.gov.uk/pgr/sustainable/manforstreets/

In addition to the above, TALs (traffic advisory leaflets) provide summaries of research on specific road related safety interventions http://www.dft.gov.uk/pgr/roads/tpm/tal/

Research on specific interventions is also available. For example, the effectiveness and impact of 20mph zones and limits is well evidenced over a long period of time using standard evaluations of case control before and after measures of impact on casualty numbers up to 3 years before and after. Increasingly, these evaluations are looking beyond impacts on casualty numbers alone and are also considering impacts on the environment, including health and social impacts, e.g. changes in modal choice with increased walking and cycling.

Individual measures are usually part of an integrated approach – the impact on users, vehicles and the road environment. It is also essential to consider the impacts of programmes of activity, e.g. the contribution of Local Safety Schemes to Casualty Reduction
http://www.dft.gov.uk/pgr/roadsafety/research/rsrr/theme5/rsrr108findings.pdf

Local authorities deliver the bulk of engineering interventions via funding provided mainly through Local Transport Plan allocations. This study was commissioned to help understand overall performance amongst peer authorities and across England as a whole. This study examines the performance of a large sample (408 in number) of the schemes from 2004/05 and quantifies what contribution these schemes made to casualty reduction.

Also, when looking at programmes and the transferability of measures and strategies, it is necessary to contextualize the geographical, socio-economic, cultural, political and legislation framework. This was the approach taken by the SUNFLOWER initiative in which the UK participated.

In addition to engineering focussed measures there are also education, training and publicity (ETP) interventions focussing on behaviour change. These can be evaluated at an individual intervention level or as part of a holistic programme.

For example, individual education interventions may be evaluated to assess impacts on skills, knowledge, attitudes and behaviours. In the UK, the child pedestrian training intervention Kerbcraft was piloted nationally in deprived areas. One hundred and fifteen pilot schemes were funded in 75 authorities across England and Scotland, in areas with high child pedestrian crash rates and high levels of deprivation. Effective ways of establishing and sustaining practical child pedestrian schemes were identified.
http://www.dft.gov.uk/pgr/roadsafety/research/rsrr/theme1/childpedestrianprojects/networkchildpedestrianhtml

One of the main challenges in undertaking impact evaluations of transport interventions is the ability to demonstrate that the observed outcomes and impacts have been caused by the intervention, thus ruling out the influence of external factors. DfT has produced guidance for evaluators to help choose an evaluation approach to achieve better attribution.

http://www.dft.gov.uk/pgr/evaluation/evaluationguidance/transportimpact/

In order to improve the access to and use of evidence and evaluation in local safety measures, a number of initiatives are underway:

- TAP - the Transport Advice Portal is a joint venture involving the Department for Transport (DfT) and the Chartered Institution of Highways and Transportation (CIHT). The technical library is a repository of core documents covering: legislation; TALs, good practice guidelines, general information, research and useful websites.

  http://tap.iht.org/

- DfT are in the process of developing a web based toolkit for the evaluation of education training and publicity type interventions.

United States

There are several initiatives in the U.S., most notably the production of the Highway Safety Manual (HSM). Because high quality CMFs are essential for effective use of the HSM, the FHWA manages a CMF Pooled Fund Study in which funds from multiple states are combined to invest in the research on CMFs for particular countermeasures. Because good quality research on CMFs is generally expensive, the selection of countermeasures to include in the pooled fund effort is very competitive. Additionally, many studies (recently completed or underway) sponsored by the National Cooperative Highway Research Program are developing CMFs.

In this framework, the Transportation Research Board published Circular E-C142, Methodology for the Development and Inclusion of Crash Modification Factors in the First Edition of the Highway Safety Manual. This circular can be found at: http://onlinepubs.trb.org/onlinepubs/circulars/ec142.pdf.

To ensure practitioners have access to as much information as possible, the Federal Highway Administration manages the CMF Clearinghouse online. The Federal Highway Administration also developed the *Guide to Developing Quality Crash Modification Factors* that is intended to provide clear, concise guidance to agencies interested in developing CMFs. The guide discusses the process for selecting an appropriate evaluation methodology and the many issues and data considerations related to the various methodologies. It is available online at the CMF Clearinghouse.