FESTA

D2.6: Socio-economic impact assessment for driver assistance systems

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List of abbreviations

BCR	Benefit Cost Ratio
CBA	Cost Benefit Analyses
FOT	Field Operational Test
IRR	Internal Rate of Return
NPV	Net Present Value
OEM	Original Equipment Manufacturer
WTP	Willingness-To-Pay

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1. Executive Summary

This deliverable provides further advice on the methodology for socio-economic assessment of ICT based systems, within the Field Operational Tests (FOTs) being part-funded by the European Commission. It can be treated as a supplement to Chapter 9 of the FESTA Handbook.
Use of a consistent methodology in the FOTs will maximise the comparability of the results across regions, ICT systems and individual FOTs. The goal of this deliverable is therefore to provide concise advice on how to carry out a socio-economic impact assessment, addressing issues likely to arise and giving references to more detailed guidance elsewhere, plus examples of good practice in existing (web) documents.

Topics covered by this document include:

- the assessment framework;
- the approach to specific stakeholders as part of the wider picture;
- scope of the assessment - which impacts should be included;
- analysis methods for specific impacts;
- financial analysis;
- data needs.

Data will be one of the keys to success for the FOTs. This deliverable provides advice on which data will need to be collected during the FOT itself, i.e. 'FOT-specific data' (with implications for the design of FOTs), as well as generic data needed to carry out a socio-economic assessment. The latter include values for accident and casualty reduction.
This advice will be useful for: clients commissioning FOTs; consortia drawing up proposals for FOTs; and organisations carrying-out FOTs. It is assumed that a specialist in the area of socio-economic impact assessment will carry out the analysis - so a full "tutorial" on socio-economic assessment is neither feasible nor necessary in this deliverable. We will refer to this specialist as the “analyst”.
The advice was prepared by a group of European experts in the area of stand-alone and cooperative vehicle ICT systems and socio-economic impact assessment. Their experience was enriched by a literature review of over twenty state-of-the-art sources, covering methodologies and applications in studies and FOTs from Europe, Australia and the United States. Taking into account the findings of those studies and the experience of the team, an assessment methodology was specified: cost-benefit analysis (CBA) was chosen as the overall framework for assessment.

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2. Background

2.1. Cost-benefit assessment in Field Operational Tests

FESTA is a Support Action whose purpose is to determine the methodology and structure for Field Operational Tests (FOTs) of ICT-based systems for mobility. These Field Operational Tests will be part-funded by the European Commission and an integral part of each FOT will be a socio-economic assessment at a European level. This deliverable focuses on defining the methods for that socio-economic assessment. Many parts of the deliverable will also be relevant to FOTs conducted at a national or regional level within Europe or to FOTs conducted outside Europe.

As for data collection and storage, experimental methods, analyses, etc (see other FESTA deliverables), a consistent methodology for socio-economic assessment will maximise the comparability of the results across regions, ICT systems and FOTs.

In the past, the impact assessment of FOTs focussed on a narrow set of impacts of interest. Few looked at the stakeholder or supplier perspectives; some measured benefits but not (social) costs; very few started out with an impact table and formally identified what the expected “main effects” of the systems investigated would be; and some did not carry out a socio-economic impact assessment.

The goal of this document is to provide recommendations on how to carry out a socio-economic impact assessment, by giving clear, practical advice on how to do it. It will address the possible breadth of impacts that can be considered and the available resources for carrying out the assessment. This advice contains references to examples of good practice in existing (web) documents.

Our advice will be useful for a variety of parties: the organisations conducting the FOTs, including the socio-economic impact assessment specialist; the client commissioning the FOTs; and the consortia drawing up proposals for the FOTs. This chapter assumes that a “professional” in the area of socio-economic impact assessment will carry out the analysis. This information on socio-economic assessment is not meant as a “tutorial”.

What is a socio-economic impact assessment?
The socio-economic impact assessment investigates the impacts of a technology on society. Ideally a socio-economic impact assessment provides the decision maker with relevant information in a concise format. What information is relevant depends upon the decision makers’ objectives and their fundamental approach regarding social cost-benefit analysis (CBA), which is monetary unit-based, versus multi-criteria assessment (MCA), which is objective-based. Thus, the specific choices of which effects to account for depend on the client, the stakeholders, and the ICT system itself. For example, an ICT system such as Lane Departure Warning is expected to primarily reduce unintended lane departures and thus accidents, fatalities and injuries. It has primarily a safety benefit, but it will also help reduce accident related congestion. Speed Alert, which helps the driver maintain a safe speed, not only reduces speed-related accidents and thus accident-related congestion, but it also can have a positive environmental effect in terms of reduced emissions. It is conceivable that other ICT systems have positive direct impacts on safety, but the positive impact is partially negated by an increase in the number of kilometres driven, which is has a negative impact on the environment.

Performance assessments of ICT systems have already been carried out during several EU-research projects (e.g. ROSEBUD, SEISS, eIMPACT). These research projects had all a prognostic character and therefore tried to determine the future impact of such systems. During those assessment processes different impact hypotheses were proposed. Hence, the studies provided an ex-ante analysis. But the validity of such results can be criticised because prospective conclusions are always associated with a relatively high degree of uncertainty and risk. It is therefore vague whether the expected effects really will occur. This is the dilemma of all future oriented socio-economic evaluations.

For some time, there has been an increasing demand in the research literature for carrying out CBAs using objective data from real life situations. This would enable an ex-post verification of the ex-ante calculations on the basis of a real world real experiment. Ex post-checking would be a significant step towards increased reliability and objectiveness of the evaluation. It would improve considerably the basis for political decisions.

The FOTs to which FESTA can be applied vary in terms of their potential impacts; thus one set of impacts that must be examined in all FOTs does not exist. However, a complete table of impacts can be examined, from which the relevant impacts can be identified.

In addition to cost-benefit analysis, additional analyses can be carried out. Depending on the stakeholders involved, additional analyses such as financial analysis and stakeholder analysis can be carried out, using the same set of inputs as for the CBA. Furthermore, if Willingness-to-Pay information is gathered, this provides a way of getting better evidence on the users' likely demand for the products.

Other issues addressed include the importance of scaling up the results from a small FOT sample to a national or EU level. These types of analyses need additional data on market penetration, usage and reliability.

Why carry out a socio-economic assessment?
Carrying out a socio-economic impact assessment produces a succinct, understandable summary of the findings of the FOT. An FOT often produces an enormous amount of information that that can be difficult to compare and synthesize. Without the socio-economic assessment, it is easy to get buried under all of the results. A socio-economic impact assessment provides a methodology for synthesis.

We advise analysts to take the following issues into consideration when carrying out the socio-economic assessment. It is important to plan the FOT so that the needed input for benefit-cost calculations is available from the FOT itself as well as other sources. Furthermore, it is necessary to make assumptions in carrying out the socio-economic assessment. It is important that all assumptions made in impact assessments, especially ex-ante estimates, are transparent. This makes it possible to update the results in the future with better knowledge about penetration rates, safety impacts, costs-unit rates, etc.

2.2. Process for coming to these recommendations

A group of European experts in the area of stand-alone and cooperative vehicle ICT systems and socio-economic impact assessment drew up the recommendations contained in this chapter. These experts have experience in applying a variety of impact analyses to both the types of ICT systems that can be examined in the EC FOTs, but also to other types of impact assessments, such as those to support road network investment decisions.

This experience was used and enriched by a literature review of over twenty state-of-the-art documents, covering methodologies and applications of cost-benefit analyses in studies and FOTs in Europe and in the United States. The methodological studies reviewed include the EU studies eIMPACT, SEiSS, HEATCO, COWI Study Cost-benefit assessment and prioritisation of vehicle safety technologies, REFIT, ROSEBUD (D7), ADVISORS, RAILPAG and FUNDING; the EU member states studies of OEI (the Netherlands) and NATA (UK); the FOTs including The Assisted Driver (Dutch FOT), Australian FOT, the US FOTs ACAS, Freightliner IVI, Mack IVI, ICC, RDCW,

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IVBSS, 100-Car Naturalistic Driving Study and Volvo IVI; and a CBA for ESP in Europe. Summaries of these studies appear in the appendix.

Combining the findings in these studies with the expertise of the team, a basic assessment methodology was identified: The assessment methodology consists of a CBA, to gauge the efficiency of the intervention relative to the status quo. Additional analyses to support decision making about deployment or impacts on stakeholders are also recommended. Finally, this deliverable advises that a systematic identification and measurement of the potential impacts of the ICT system to carry out a complete assessment of the benefits and costs.

2.3. *Structure of the reporting on socio-economic assessment*

This deliverable first informs the reader on the methods proposed for the socio-economic costs-benefit assessment, followed by the application of the method. Section 3 introduces the key principles for socio-economic impact assessment in FOTs, the possible impacts to be investigated, how to analyse the effects, and choosing the methods, scope and effects to take into account. Section 4 provides guidance for how to carry out the assessments, data needs, and presentation of results.

The appendix supplies the reviewed literature templates and provides additional links and sources for additional information.

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3. Key Principles for FOT socio-economic assessment

3.1. Methods for socio-economic impact assessment

In order to perform ex-post evaluations of FOT, suitable assessment methods must be available. Generally, the tools which are used for efficiency analyses can also be used for analysing the socio-economic impacts of systems tested in a FOT. The evaluation methods that can be used in the socio-economic assessment can be distinguished in two groups due to their evaluation perspective:

- Information to support decision of affected stakeholders is given by the general stakeholder analysis, financial analysis and the break-even analysis. The first two will be discussed in more detail.
- Information on the overall societal effects is provided by benefit-cost analysis. In this deliverable we will only focus on the first one.

Furthermore, we will discuss on willingness-to-pay information. This helps to provide insight on the users' likely demand for the products, and can serve as input for the analyses mentioned above.

3.1.1. Social Cost-Benefit Analysis

The cost-benefit analysis (CBA) is a widely-used and objective evaluation instrument. In general, a CBA compares the potential economic benefits across a set of impacts with all relevant potential costs deriving from the implementation of a technology (or measure). It can be used to assess the absolute efficiency of a new technology since it estimates benefits and costs in monetary terms by multiplying impact units by prices per unit. Hence, a CBA helps to point out if a proposed objective is economically or socially efficient and how efficient it is. As a result of the analysis, a quantitative relationship between the benefits and costs is calculated. The most common indicator expressing this relationship is the benefit-cost ratio.

CBA is based on welfare-economics where the increase of the overall economic production potential is used as a standard for evaluating a technology. The costs of this new technology are confronted with this overall economic or social effect. The benefits are defined in terms of productive resources saved within an economy.

In theory, the principle of allocative efficiency is determined by the situation that by introducing any kind of technology at least one individual is made better off and no individual is made worse off. This is called the Pareto optimum. Since a consequent application of this principle is impractical due to the impossibility of identifying winners and losers, a potential Pareto optimum, called the Kaldor-Hicks criterion, is generally applied. This criterion considers a new measure (technology) acceptable if the amount of gain by certain people is greater than the amount of loss suffered by others. Hence, a net-benefit needs to be reached, by compensating losses of others by winners of the measure. Therefore a measure may be efficient if some people incur losses as long as it generates enough benefits to compensate this. The Kaldor-Hicks criterion is commonly accepted and widely applied in welfare economics as well as in managerial economics. The criterion serves as the rationale in the CBA.

When applying a CBA to assess the economic efficiency of road safety technology, the evaluation of accident savings plays an important role. The new technology is typically aimed to reduce the number of accidents or the severity of them. Direct benefits are therefore represented by the avoidance of accidents and achieving mitigation of current accidents. Other savings of resources can also be appointed as benefits of the new technology.

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Some of these resources are:

- energy consumption (fuel, green driving)
- time use (improved traffic flow)
- vehicle operating costs
- emissions of air pollutants
- greenhouse gas emissions

Costs of a technology to improve road safety consist of amongst others:

- investment costs
- maintenance costs
- operating costs

In Figure 1 the basic steps in the methodological process for assessing the benefits and costs of safety technologies are outlined. In general a CBA is assessed as a four step process.

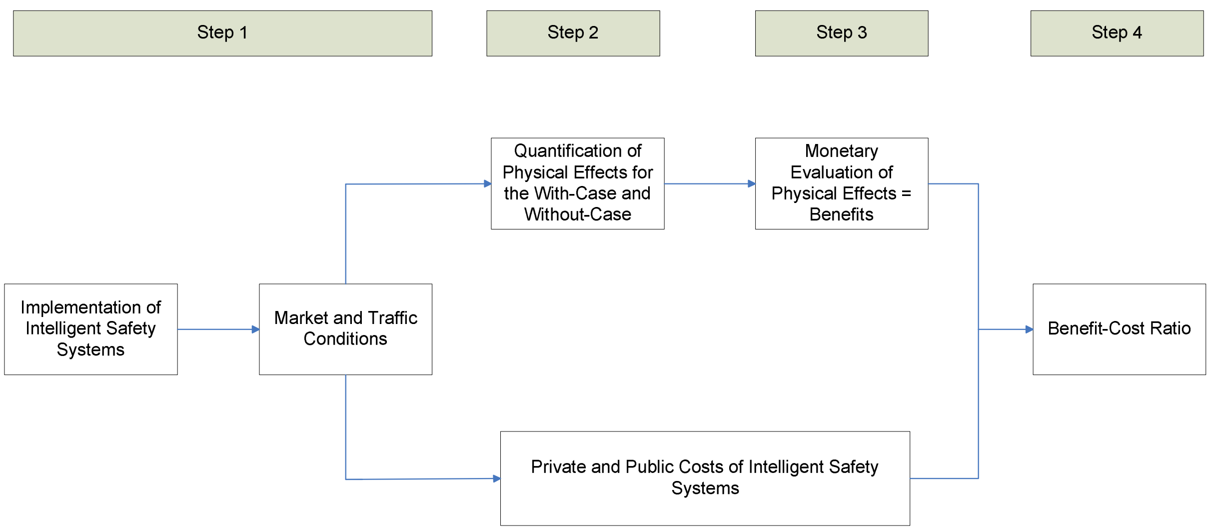

Figure 1: Methodological steps of CBA

- **Step 1**: Specify the general framework conditions for the analysis and define the relevant alternatives that will be compared in the analysis. For the CBA two cases are defined:
  - The “with-case”, which means that a road safety measure will be introduced.
  - The “without-case”, which assumes that there will be no implementation of the technology.
- **Step 2**: In the second step of the CBA the potential impacts of the traffic as a result of the technology is to be measured to each case. The traffic effects show how the economic factor resources such as time, energy and environment are affected. It thus determines whether the implementation leads to overall benefits or not.
- **Step 3**: In the third step the benefits are monetarized by valuing the annual physical effects with standardized cost-unit rates. This is necessary since the various parameters are measured in different quantity units. They must therefore be transformed in monetary units for them to be able to compare. The annual benefits over the effectiveness or life cycle of the technology will be summed up and then the total sum of benefits will be transformed by the discount rate to one actual value of social benefit for the starting data of the implementation. In addition to the monetarization of the benefits, the costs of the technology have to be determined. These comprise of the investment costs, operation costs and maintenance costs, and have to be discounted as well, to obtain a present value.

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- **Step 4**: The result of the economic evaluation is obtained in this fourth step. This is done by comparing the economic benefits with the costs. For this several measures can be calculated of which the most common one is the benefit-cost-ratio (BCR), ideally in net present value (NPV). With the BCR a technology is considered to be economic profitable, if the BCR is greater than one.

The previous outlined four step procedure illustrates how to require an absolute estimate of the benefits and costs associated with a ICT system. A CBA ensures an objective evaluation of the main socio-economic impacts of an ICT system. However, an implementation of a CBA requires a much higher differentiation and more detailed analysis of specific issues. For instance, use of different road types (highway, urban etc.) need different separate calculations to be performed. Likewise, the calculations must be performed twice when cars as well as heavy vehicles are taken account of. They differ for instance in their market deployment, vehicle mileage ad cost figures. In the end, a (weighted) average of the various calculations for different types of vehicles and roads is used to come up with the overall CBR for an ICT system. Furthermore, it is important to perform the evaluation for a number of different scenarios (based on policy, spatial etc.) to provide a range of benefit-cost ratios for each ICT system. These scenarios may differ for example on the market penetration rate of the ICT system which depends on the driving forces on the market.

3.1.2. Stakeholder analyses

The socio-economic assessment of an ICT system evaluates the macro-economic cost effectiveness, which results from different costs and benefits of these applications. In order to foster the market introduction of such applications, it is important to analyse benefits and costs with respect to their distribution between the different stakeholders which have interest in the market introduction of an ICT system or which are affected by these measures. For an ICT system there are a number of stakeholders: road users (users of the applications), manufacturers (OEM) and the society, which is affected possibly by a change in resource consumption.

The benefit-cost analysis displays the societal profitability only jointly for all impact components. Which kind of benefits results for the different stakeholders separately is not transparent in a conventional benefit-cost analysis. Such a differentiated display of the benefits for the different stakeholders should be carried out in order to improve acceptance of an ICT system and indicate arguments and reactions of these stakeholders. For this purpose, a separate breakdown of the benefit-cost analysis per stakeholder group is necessary. Each of them has an individual specific concern for these ICT systems. An example of four stakeholder groups and the approach they might take is described:

- *(Road-)users:* Users of a ICT system consider ideally the private-economic profitability of the ICT systems. As a result of the use of an ICT system, user costs can rise. For their purchase decision it is essential if these costs are exceeded by the benefits. These are calculated by looking at the individual savings of internal costs (e.g. time savings, operational costs). In the case of car owners, favourable insurance premiums due to fewer accidents are likewise relevant.
- *Manufacturers:* For OEMS and automotive companies, the question of commercial profitability of an ICT system emerges. Costs consist of development costs, manufacturing costs and production costs for vehicles. The costs face benefits resulting from increases in business volume and revenues due to the sale of an ICT system. The benefits must be identified beyond the scope of the CBA through separate calculations. For that purpose, market penetration rates of the ICT system, prices for the ICT system as well as production costs of the ICT system have to be known.
- *Society and public authorities:* Their benefits are gained through a diminishment of traffic costs by the ICT system such as a reduction of accidents (costs) and less emissions of CO_2 and pollutants. These reductions lead to a smaller loss of economic output and to less time

losses and a reduction in operational costs of cars. A second component of benefits (for the state) consists of higher tax revenues.
These result from production and sales of a ICT system. They may result from general taxes which arise because a ICT system helps to avoid accidents, so resources can be saved whereby a higher economic growth emerges. Expenditures on the other hand may rise due to encouragement spending and since certain communication infrastructure needs to be build.

- *Insurance companies:* They have interest in an ICT system because their business case is influenced. A ICT system reduces the accident frequency and severity which lessens the sum of damage to be regulated. This leads to an increase in profitability but also the decrease of damage also opens tolerances for reductions of premiums.

The aim of the stakeholder analysis is to divide and allocate benefits and costs of an ICT system on the various groups in interest. Insofar, stakeholder analysis is a method of separation and disaggregation with the CBA as the basis to work from. In addition to this, separate calculations to the CBA are carried out. Examples of applied methods are the financial analysis (see 3.1.3)
The stakeholder analysis gives differentiated information about the involvement of different groups and the (dis-)advantages from the applications of an ICT system. It is an instrument of political communication and able to convince the affected groups of the application of a ICT system and by that to broaden the acceptance and market penetration.

3.1.3. Financial analysis

This analysis can serve as an instrument to quantify the financial impacts of the application of an ICT system for a public authority. Amongst these impacts are revenues, expenditures and fiscal flow. Public authorities have a strong interest in projects with regard to fiscal budget effects. The budget-effects are of significant meaning for the political acceptance because the negative influences on the financial situation are a barrier of application. Aim of the financial analysis is to resolve if public expenditures which are transacted for a project can be refinanced from revenues. For that, cash flows are established which result from an ICT system.

The financial analysis is an additional calculation to the benefit cost analysis and considers monetary flow that is not included in CBA. CBA observes only real benefits and costs but no transfers as represented by cash flows. The financial analysis is only a matter of public's revenues and expenditures. These are important information for politicians who want to know which financial burdens result from a project and if these burdens are covered by revenues.

Also for the implementation of an ICT system the question of budget effects comes up, i.e. revenues and expenditures for public authorities.

Tax revenues result from the following flows:

- The investment costs for an ICT system raise prices for these ICT systems. Manufacturers face higher volumes of sales and for this reason an increase of value added tax.
- Higher prices mean higher profits for manufacturers so that the income tax or the corporation tax rises.
- In the production an ICT system lead to more employment and income of employees which results in higher wage taxes.
- The higher income causes an increase of consume expenditures and therewith a higher value added tax and higher consumption taxes.
- The application of an ICT system generates a saving of productive resources. That makes the potential gross domestic product rise. Macroeconomic growth is connected with higher tax revenues.

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Potential increases of public expenditures affect the following circumstances:

- A drop of tax revenues occurs if the implementation of an ICT system is induced by financial incentives (tax reduction).
- Expenditures increases for public authorities arise if for the technical operability of an ICT system certain infrastructure of information has to be established.
- Expenditure increases can also result from the emergence of administrative costs for the implementation of an ICT system.

The financial analysis means a confrontation of public revenues and expenditures. If actions of encouragement which require money should be warranted over future years, financial means per year have to be discounted to the present value.

For the determination of tax effects, average rates of taxation are evaluated for income, wage and corporation tax; then they are multiplied by tax assessment basis (profit, sum of salaries). Additional receipts from value added tax result from additional volume of sales of an ICT system producers multiplied by the average value added tax rate.

The increases of expenditures respectively the decreases of revenues of public authorities are detected by multiplication of tax remissions per vehicle by the rate of market penetration with an ICT system. Possible additional expenditures on infrastructure for an ICT system must be estimated from case to case.

3.1.4. The role of Willingness-to-pay information

The economic evaluation of ICT systems poses the basic problem of determining which method to use for the valuation of the benefits. The benefits that can accrue due to the use of ICT systems have been identified as a result of the use of the impact table. These include benefits such as improved comfort, improved journey reliability, reduced travel time, reduced emissions and the prevention of accidents (and injuries).The question is, what value do users / stakeholders attach to these benefits? One method of valuation that can be applied at this stage is the "willingness to pay" for these benefits.

The willingness-to-pay approach consists in estimating the value that individuals attach to benefits by means of surveys aimed at determining the amount of money that individuals would be prepared to pay in order to receive the benefit. Selected groups within the population are given a questionnaire describing situations in which the individual has the choice of spending a certain sum of money or exposing himself to a situation without the benefit of the ICT system. This approach is based on the preferences of those concerned. By adopting an approach focused on the specific benefit, it is possible to give the respondent the choice of getting the benefit against given sums of money and thereby obtain an indirect value of of the benefit. Figure 4 provides additional information about willingness-to-pay.

In the case of safety valuation, selected groups within the population are given a questionnaire describing situations in which the individual has the choice of spending a certain sum of money or exposing himself to risk of injury or death. By adopting an approach based on the prevention of accidents and damage, it is possible to balance a risk against given sums of money and thereby obtain an indirect value of human life and serious injury. To ensure that economic damage is also taken into account, the following are added to the value thus obtained: net lost output, medical costs, administrative costs, etc.; these latter costs are precisely the values of human capital. Logically, the willingness-to-pay approach yields values far higher than those based solely on the value of human capital. The willingness-to-pay approach can deliver therefore an imprecise valuation of the very parameter we are attempting to determine.

3.2. Scope of the assessment

The socio-economic impact assessment investigates the impacts of a technology on society. Ideally a socio-economic impact assessment provides the decision maker with relevant information in a concise format. The relevant comparison is between the benefits and costs between a base case, e.g., a scenario without the ICT system ("without-case") compared to those of the scenario with the ICT system ("with-case"). In preparing to carry out a socio-economic impact assessment, the analyst is faced with making choices about the impacts to be investigated in the analyses, the geographical scope of the assessment and the analyses to be carried out. This section will go deeper into the issues surrounding these choices. The chapter will conclude with guidance on how to make the choices and carry out the cost-benefit analysis.

Assessment scope and process implication
At the start of the socio-economic assessment, a view will need to be taken on the scope of the analysis. Ideally the assessment would include all impacts of the ICT system no matter how small that impact is: safety, mobility, efficiency and productivity, environmental, user acceptance and human factors, performance and capability, legal and implementation issues, and costs. However setting an unlimited such a broad scope for a socio-economic assessment will result in excessive data collection and analysis in terms of expense and time. Given that the purpose of the assessment is to firstly ensure that the implementation of the ICT system is economically beneficial and secondly to aid the choice between alternatives, the scope of the assessment often can be narrowed by excluding minor or insignificant impacts as long as the exclusion of these impacts will not bias the appraisal. An *impact table* such as Table 1 is extremely useful at the start to clarify which impacts have been considered and which - if any - have been ruled out as negligible or impossible to assess.

Geographical scope of assessment
The issue related to geographical scope is the ability to translate the findings of the FOT to a "higher" geographical level. The FOT is usually carried out at one or more locations, on a regional or national scale. However, the number of equipped vehicles and, if relevant, equipped roads, as well as the number of "equipped" kilometres driven, is usually a small percentage of the total vehicle fleet and the kilometres of roads. Therefore, in order to draw conclusions about the impacts and effectiveness of the ICT system tested, a "scaling up" of the results is needed in order to draw conclusions and in order to ensure transferability of the results. Chapter 9.5 of the FESTA Handbook and Deliverable 2.5 address the scaling up issues, which is to the national or European level. The availability of data plays a role in the decision to what level to scale up the results. Section 10.3 of the FESTA handbook and Section 4.2 of this document on data needs go into more detail to explain how to deal with this issue.

Goal Area / Objectives
Assess Safety Impacts • Determine if drivers drive more safely • Estimate crash reductions • Estimate crash reductions at full deployment • Determine if the implemented ICT system affects other crashes
Assess Mobility Impacts • Assess the direct effect on traffic flow • Assess the indirect effect of reduced crashes on mobility
Assess Efficiency and Productivity Benefits • Determine cost to deploy and maintain a ICT system • Estimate cost savings (positive or negative) with a ICT system • Conduct comprehensive benefit-cost analysis

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Assess Environmental Benefits • Assess effect of reduced crashes on environment • Assess effect of green driving
Assess User Acceptance & Human Factors • Determine usability of a ICT system • Determine if drivers perceive increased stress/workload • Determine perceived impacts on driver risks and vigilance • Determine perceptions of product quality, maturity, etc.
Assess a ICT system's Performance and Capability Potential • Characterize performance/functionality of components • Assess capability of components • Determine reliability and maintainability of components
Asses Product Maturity for deployment • Determine if costs are reasonable for motor carriers • Assess infrastructure investment needs • Determine availability of manufacturing capabilities • Assess need for modifications to ITS standards • Determine if a ICT system is suitable for widespread deployment
Address Institutional and Legal Issues • Identify and determine impact of institutional and legal issues

Table 1: Overview scope of assessment

3.3. Analysis of impacts

The analysis of impacts represents the most sophisticated part of the assessment. Figure 2 provides an overview over the most common effects (safety, mobility, environment, costs) which are considered in a FOT assessment. This assessment framework involves the distinction between direct and indirect effects (in safety mechanisms but also with respect to mobility effects, see below). It also implies the distinction between effects on internal and external costs. Mobility effects typically lead to lower internal costs of transport (i.e. time, fuel consumption) and also external costs (e.g. pollution, CO_2). The reduction of external costs is flagged out separately under environmental benefits because of its importance on the political agenda. The assessment can of course also consider wider economic effects (e.g. growth and employment effects of new technologies). However, given limited time and budget, it is useful to concentrate on the main impacts.

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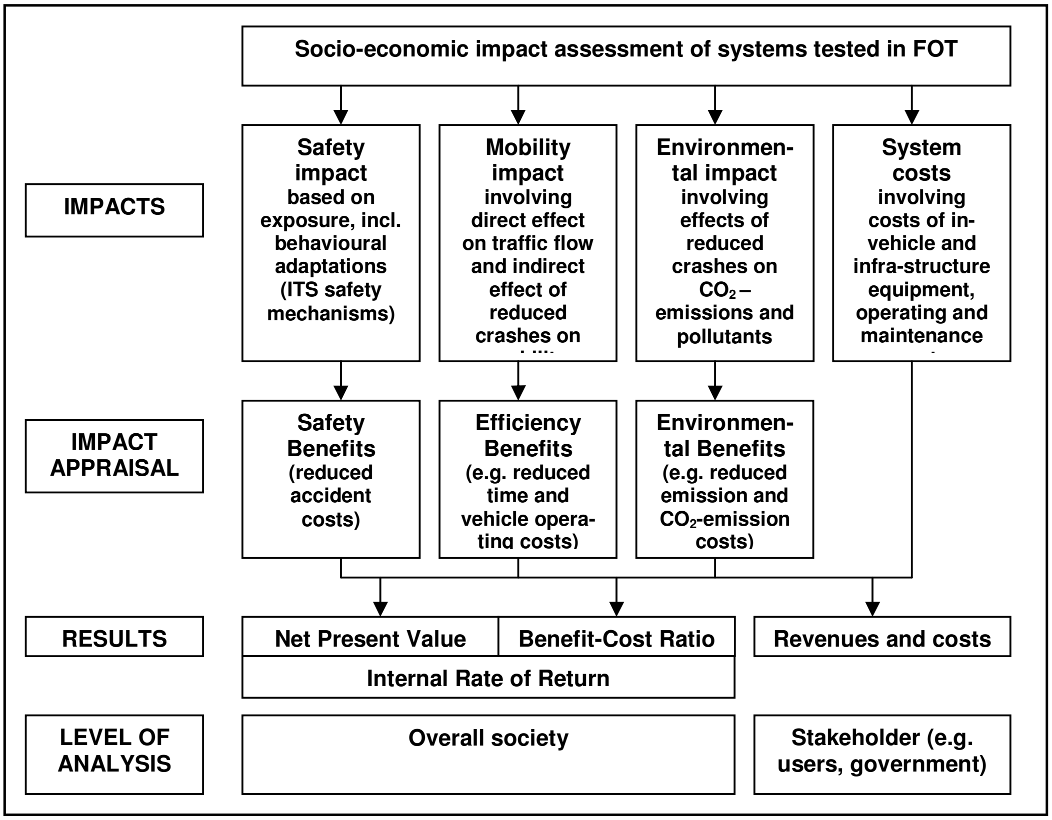

Figure 2: Scope of the impacts within socio-economic impact assessment

Safety benefits

The assessment of safety impacts has to consider several effects which can be combined to the overall safety benefit. Generally, objective data (accidents and their consequences) have to be used in order to estimate accident risks. Moreover, subjective information (driver behaviour) should also be integrated in the assessment plan. As an example and representing best practice, the Mack FOT puts the goals of the safety analysis as follows:

(1) Determine if driving conflict and crash probabilities will be reduced for drivers using the ICT system,
(2) Determine if drivers drive more safely using the ICT system,
(3) Determine reduction in crashes, injuries, fatalities if all fleets operating in the observed area were equipped with the ICT system,
(4) Determine if drivers using the ICT system have less severe crashes than drivers without the ICT system.

The first step collects sensor data from each vehicle within the FOT (e.g. braking force, steering angle). Based on earlier definitions the number of driving conflicts can be determined. Thus, two numbers for the driving conflicts – reflecting the with-case and the without-case – are available to calculate the risk ratio. This ratio reflects the number of driving conflicts in the with-case compared to the without-case. To provide an example: given a ICT system which maintains the safe distance to a predecessor vehicle, the number of driving conflicts due to close following will be reduced from 10 conflicts per 1,000 km to 5 conflicts per 1,000 km. Thus, the risk ratio equals 0.5 which indicates that driving with the ICT system is safer than without the ICT system. In general, a risk ratio below 1 indicates a safety benefit.

The benefit of lower exposure to accident risk will likely be modified based on adaptations of individual behaviour (second step). Behavioural adaptations can comprise e.g. adapting the following distance, adapting the speed variance, adapting the lane change behaviour (risky cut-ins or changing the lane without signalling it in advance).

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Examples for such behavioural changes can be found in the ITS safety mechanisms (eIMPACT). In this project, nine mechanisms have been introduced which lead to positive or even negative safety effects. In most cases, the motivation for behavioural adaptation is that the driver wants to avoid "public" warnings (noticeable to all passengers) and "education" by the ICT system.

The third step approaches the scaling-up from the FOT to a wider area (EU, nation, region). This process is subject to the procedure proposed in Scaling up (see chapter 9.5 of the FESTA handbook).

The last step leads to the prevention ratio. In-depth information of the accidents is used to calculate the mitigation effects of using the ICT system. Maybe the ICT system cannot avoid the accident but it can mitigate the accident consequences. This issue has to be considered in determining the effects for casualties.

Combining the steps 2 till 4 it is possible to calculate the prevention ratio. For this ratio the probability of having a crash (casualty) when having a driving conflict in the with-case is compared to the same probability of the without-case. In the above example the number of driving conflicts in the with-case was 5 and 10 in the without-case. Let us assume that out of the 5 driving conflicts 1 accident occurs and out of the 10 driving conflicts 3 accidents occur. Thus, the probability of having an accident due to a driving conflict is 0.2 in the with-case and 0.3 in the without-case. These values reflect the prevention ratios.

Efficiency benefits

Efficiency benefits are typically composed of two effects. They involve:

- Direct mobility effects resulting from a smoother traffic flow, e.g. where the ICT system allows traffic to re-route to avoid current congestion, or improves mean speeds by encouraging safe following behaviour,
- Indirect mobility effects resulting from reduced crashes e.g. reduced delays at incidents and accidents.

Direct mobility effects can play an important role in the socio-economic impact assessment. On the appraisal level, direct mobility effects are reflected in changes of time costs, fuel consumption costs and reliability changes. Because socio-economic impact assessment identifies quite commonly reductions of time costs as a major driver of the results, direct mobility effects are generally worthwhile to explore.

The investigation of direct mobility effects typically involves microscopic traffic flow simulation. A number of models (e.g. ITS Modeller, VISSIM, Paramics, DRACULA) are prepared to assess these impacts. Best practise, also concerning cross-validation of models, can be found in eIMPACT D4 (Wilmink et al., 2008) and Full Traffic (Technische Universiteit Delft, 2008). Typically, when traffic flow becomes more homogeneous, the standard deviation of the vehicle speed becomes lower. As a result, the average vehicle speed may increase or the infrastructure capacity improves. As a consequence, time costs and vehicle operating costs will decrease.

However, the realisation of those benefits is closely related to the likely market penetration. Mature ICT systems typically can produce such effects, ICT systems in the phase of market introduction typically can not. For internal efficiency it is therefore important to figure out at the beginning of the FOT assessment (when the scope is defined) whether direct mobility effects will be likely to appear or not.

Compared to the direct mobility effects, experience suggests indirect mobility effects are not restricted by conditions of market penetration. They can be realised in any case, as an add-on to the safety benefits. Indirect effects occur when the number – as well as the severity – of crashes is reduced. The benefits result from less congestion, therefore reducing journey times and fuel consumption. Typically, indirect traffic effects add up to about 10% of the safety benefits.

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Given the state of the art in traffic modelling, indirect mobility effects are assessed more frequently than direct mobility effects. Good practise on the appraisal of indirect mobility effects can be found, however, in recent European scale assessment studies (eIMPACT, COWI (2006)) and US American FOT assessments (Batelle Memorial Institute (2003), Volvo Trucks North America Inc (2007)). Some countries have methods specifically to address these effects (e.g. INCA in the UK) (see http://www.dft.gov.uk/pgr/economics/rdg/jtv/inca/).

Environmental benefits
Environmental benefits comprise lower CO_2- and air pollutants emissions. Noise also fits into this category but we would caution that noise should only be analysed where ICT systems are expected to make a significant difference between the two scenarios (with/without the ICT system) - consistent with the general principles set out for FOTs. CO_2- and pollutants emissions are both speed dependent, with CO_2-emissions directly linked to fuel consumption. Hence, there is a close relation to the mobility effects discussed above. The impact of CO_2 emissions is on a global scale, and is not linked to the particular country or area type where the CO_2 is emitted. The impact does, however, vary according the year in which the reduction (or increase) in emissions takes place – the impact becoming greater further into the future. Actually, mobility effects have impacts on both, efficiency and environmental benefits. However, because they are transmitted through the environment, and because they are largely externalities (i.e. their incidence is mostly on individuals other than the emitter) environmental benefits fill in an own category.

ICT system costs
ICT system cost estimation is an element within FOTs which is quite often rather neglected. ICT system promoters may not see costs as an impact. However from a socio-economic point of view, they are a (negative) part of the impact of ICT systems. Cost estimation should take care of the following aspects:
- Cost elements to include: The ICT system costs comprise the costs of in-vehicle, roadside infrastructure equipment and nomadic devices. Besides that, operating and maintenance costs have also to be considered. Examples of good practise for ICT system costs can be found in US American FOT assessments (Freightliner FOT, Mack FOT, Volvo FOT).
- Relevant size of costs: CBA applies a resource-based view. The exact costs that should be included in the CBA depends on the stakeholder. Section 4.1.1 "Cost Estimations, Relevant size of costs" addresses this issue.
- Process of cost estimation: Typically, cost estimation will be carried out by an expert group comprising of FOT internal staff and external industry experts. Section 4.1.1 "Cost Estimations, Process of cost estimation" addresses this issue.

3.4. Classification of assessment methods

Figure 3 gives a classification of socio-economic assessment methods, based on which of the elements are included, in particular:
- Whether a full set of impacts is addressed – for example, if a significant CO2 reduction can be anticipated, has it been included;
- Whether the assessment is from the social perspective only, or whether financial and stakeholder analyses are also given.

The recommendation is that the FOTs should be designed to be as complete as possible, both in terms of impacts and stakeholders views. The assessments in the FOTs reviewed are examples of good practice. However, they differ in the types of analyses carried out, as well as in the scope of the effects examined, with the exception of safety impacts.

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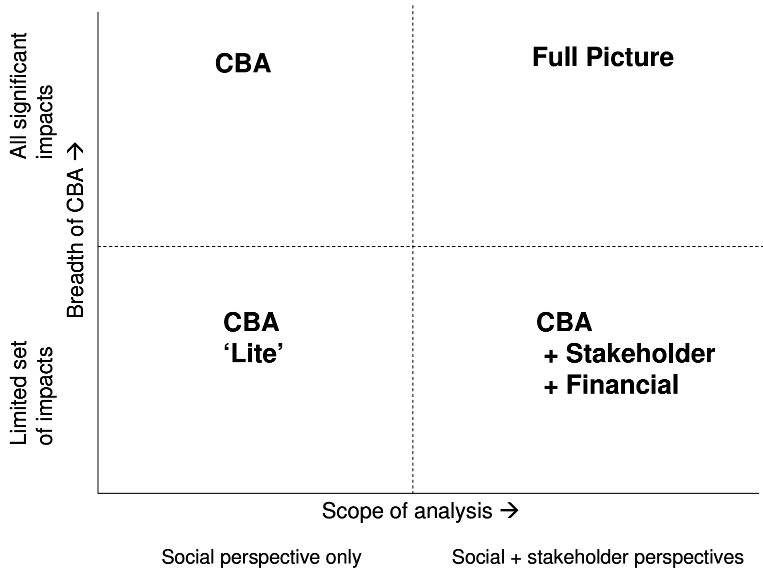

Figure 3: Classification of Socio-Economic Assessments

Figure 4 highlights another dimension in which assessment methods can be classified, namely whether or not they make use of case-specific Willingness-to-Pay (WTP) evidence. In the design of future FOTs, we recommend that clients and analysts consider WTP studies as a way of getting better evidence on the users' likely demand for the products. WTP can provide uniquely useful evidence on the value of the ICT system to consumers and producers. In absence of this, FOT's can refer to evidence in literature (market-based) as shown in Figure 4. WTP studies will, however, add to the cost and skill set required for FOTs, so the advantages and disadvantages will need to be weighed in each case.

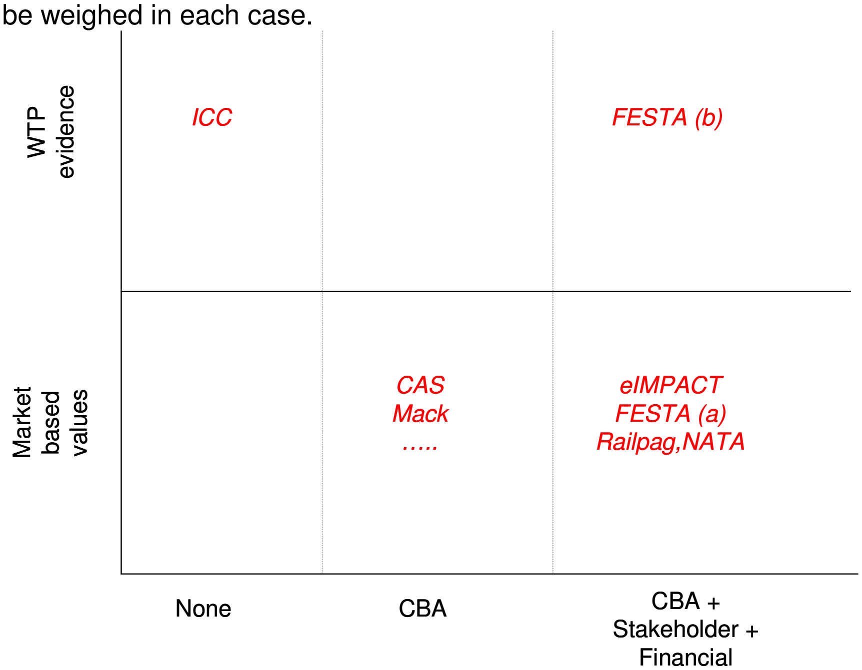

Figure 4: Assessments with/without ICT system-specific WTP evidence

We note that past FOTs generally relied on market-based values (e.g. CAS and Mack), although the ICC FOT did make use of specific WTP evidence, and as such is a useful reference. Also, we note that most previous assessment guidelines, including eIMPACT, assume that literature-based values will be used. Here, we leave the option open and recommend that clients and analysts decide at the inception phase of the FOT whether or not to go down the WTP route.

3.5. Making a choice

The analyst faces choices in setting up and carrying out the analyses. The choices will be influenced by the priorities identified by those setting up the FOT, as well as budget and time constraints. The following briefly discuss the most important factors of choice.

Methods
- Basic choice is the CBA, which summarises benefits and costs at societal level
- Stakeholder perspectives: makes use of the same input data as the CBA, but considers stakeholder-specific benefits, costs and financial analyses.

Identification of impacts
- Basic choices are the costs incurred and the main expected benefit(s), as identified by use of the impact table.
- Other impacts – both direct and indirect – can also be included, depending on the stakeholder perspective as well as the choices made elsewhere in the project, for example in hypothesis formulation, measurement methods and equipment and modelling capability.
- Willingness-to-Pay evidence, if also collected during the FOT, can be used to supplement the analysis methods above.

Geographical scope of assessment
This choice has far-reaching implications for data needs, cost unit route choices, etc.
Basic choice is the country level. In this case, the general data needs (see section 4.2.3) are limited to the country in question. EU-level analyses are preferred. These require substantially more general data from individual countries. Extra challenges in execution can be encountered due to differences in definitions or classifications

The following table (Table 2) outlines some more choices that the assessor has to make in choosing his needed form of CBA.

Criteria/CBA	**CBA "Lite"**	**"normal" CBA**	**CBA incl. financial + stakeholder analysis**	**Full picture**
Applicability of the method	Already in practice	Not in FOTs	Not in FOTs	Not in FOTs
Does it need to be adjusted for FOT application?	No	No	No	No
Desired outputs	CBA	CBA	CBA incl. financial + stakeholder analysis	CBA incl. financial + stakeholder analysis
Requirements for quality of FOT data (size of sample etc.)	Results should be transparent about statistical significance of the results			
Skills needed	Socio-economic application knowledge / experience			
Geographical scale	National or European			
Must fit "socio-economic impact assessment"	Yes			
Must address costs	Yes			
Targets main effects	Yes			
Must either	Yes	Yes	Yes	Yes

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address whole life cycle of the vehicle or must amortize costs to produce annual figure				
Clear distinction needed between user benefit and revenue to supplier	No	No	Yes	Yes
Discounting is important for social CBA calc and user benefits	Yes	Yes	Yes	Yes
Address the congestion effects of incidents	Maybe	Yes	Maybe	Yes

Table 2: Overview scope on each CBA

3.6. Presenting Results

3.6.1. Summary Tables

For the **social CBA**, we recommend reporting:

- safety benefit (€M);
- other benefits to road users (€M) – mainly time savings, operating cost savings and reliability gains;
- environmental benefits (€M) – including climate change, regional and local air quality effects; noise; and other impacts;
- revenue to operators (€M) – there may be multiple operators, including infrastructure and service operators – each will want to know the impact on themselves (financial), although for the social CBA these revenues may be aggregated;
- costs to operators (€M) – including capital, maintenance and operating costs;
- revenue to automotive OEMs (€M);
- costs to automotive OEMs (€M);
- revenue to government (€M) – including tax revenue changes;
- Costs to government (€M) – including investments in R&D, implementation of ICT systems.

Tabulation of the social CBA is shown in Table 3. All entries are at Present Values. A common base year (for prices and discounting) aids comparison across different technology options. RAILPAG (EIB, 2005) has a more detailed breakdown by stakeholders (an 'SE Matrix'), which some analysts may find helpful in presenting the social CBA.

In the FOTs, we recommend always presenting the Net Present Value (NPV), as shown at the foot of Table 3.

In cases where the public sector expects to contribute to the development or implementation of the ICT system, we recommend also presenting a Benefit-Cost Ratio with respect to public sector support, which HEATCO (Bickel *et al*, 2006: 41-2) identifies in use by the EC, UK and Switzerland:

$$BCR = \frac{NPV}{PV(PublicSectorSupport)}$$

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The calculation of the benefit-cost ratio (BCR) is delicate issue in CBA. On one hand the BCR is a very powerful measure, because it applies to the common situation where investment budgets are limited and maximum value for money is required (making best use of a scarce resource). On the other hand the definition of 'costs' (the denominator) can be problematic. As a general rule, the BCR is useful when the denominator is defined in the same way for all options being compared – for example, NPV per unit of central government budget (which would be a BCR of interest to central government). Our recommendation of a BCR with respect to Public Sector Support broadens this to the budget for public expenditure as a whole. This avoids creating an incentive to manipulate the BCR by shifting costs to local and regional government.

Table 3: Social CBA tabulation

Group	*Impact*	*€M (2008 base)*		
		2015	*2025*	*Present Value (Total)*
Consumers	Safety benefits	289	299	3715 *a*
	Other road user benefits	574	606	603 *b*
	Environmental benefits	63	66	58 *c*
	…			*d*
Producers	Revenue	723	780	8520 *e*
	Costs	248	233	-8311 *f*
Government	Revenue	3	4	34 *g*
	Costs	12	14	-379 *h*

Net Present Value (NPV) = *Σa..h*	4240

Notes: sign – all negative impacts on the Group affected are shown with a negative sign, thus Costs appear with a negative sign; 2008 base – indicates appraisal at constant general prices using 2008 CPI, and with 2008 as the base year for discounting in the Present Value column.

In the example shown in Table 3, the BCR with respect to public sector support will be 4240/(379-34) = 10.3, which indicates a high social return from each € of public funds contributed.

Another useful breakdown for safety-related ICT systems will be to show how the benefits are shared between accident cost components, and between injury severities. Figure 5 gives an example.

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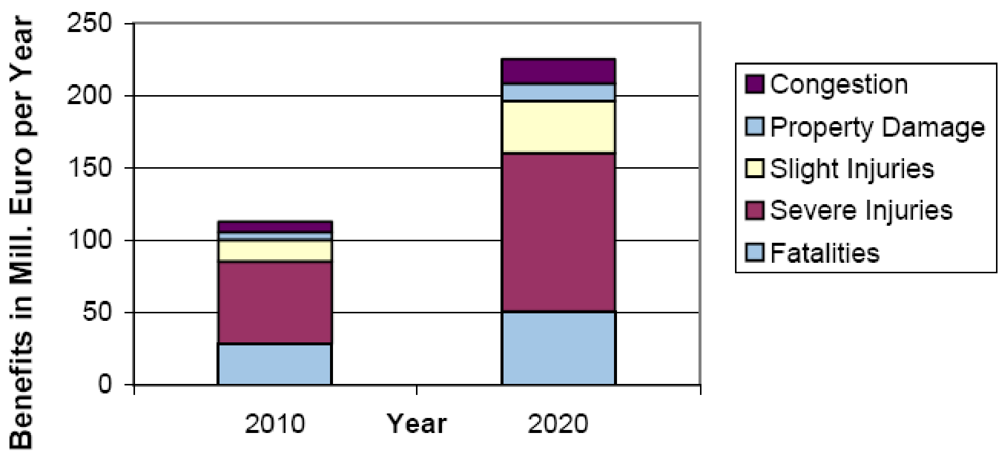

Source: Assing *et al* (2006), Fig. 54

Figure 5: Breakdown of Safety and Other Benefits (example)

The results of the financial analysis may be presented in a number of ways. Firstly, an Internal Rate of Return (IRR) is used to reduce a series of financial flows to a single figure indicating the performance of the project. We recommend that financial IRRs are reported for all FOTs.

Of key interest will be the IRR from the point of view of *specific stakeholders* (or stakeholder types). The IRR for vehicle OEMs will influence their decision about investing in the technology. Similarly, the IRR for infrastructure operators and service operators will influence their decisions – particularly where these are commercial operations.

Hence the key information will be in the form:

IRR_{OEMs} = ____ %
$IRR_{RoadAuthorities}$ = ____ %

Further IRRs should be reported where there are other stakeholders with a commercial interest, for whom significant impacts are expected.

Tables such as those used by WebTAG (DfT, 2005) also provide a useful series of snapshots of the financial impact. In this case, in order to be meaningful the tables should relate to *specific stakeholders* or stakeholder types, e.g. vehicle OEMs or road authorities.

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Table 4: Financial Analysis Tabulation

Financial Impacts – Vehicle OEMs					
Year	*Phase*	*€M (2008 base)*			
		Investment	*Other costs*	*Revenues*	*Net*
1 *(e.g. 2011)*	Development	-108			-108
2	Development	-157			-157
3	Development	-128			-128
4	Development	-163			-163
5	Market (first year)	-43	-50	73	-20
10	Market	-9	-80	144	55
20	Market	-6	-130	372	236

Notes: sign – all negative impacts on the Group affected are shown with a negative sign, thus Costs appear with a negative sign; 2008 base – indicates appraisal at constant general prices using 2008 CPI.

The financial results can be taken a stage further by reporting the breakeven point in terms of sales or market penetration (Figure 6), or the target price – down to which the ICT system must be engineered in order to achieve financial viability (Figure 7). The demand is expressed in terms of willingness to pay (WTP).Graphical presentations may be useful in these cases.

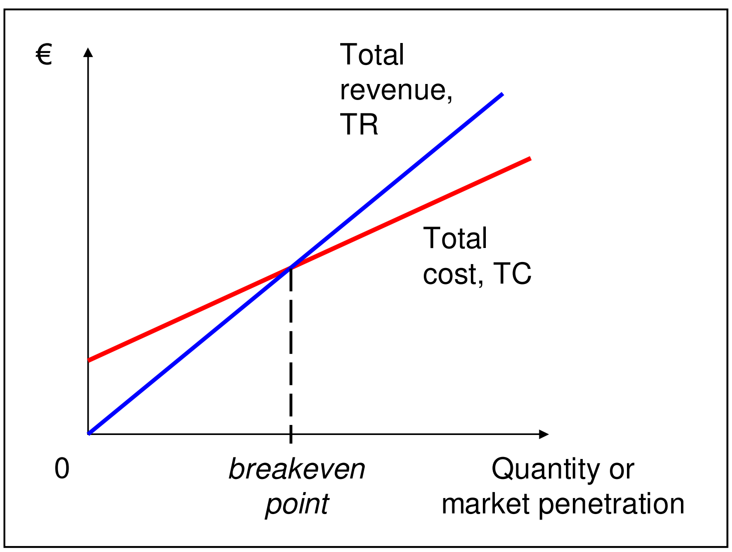

Figure 6: Breakeven Point

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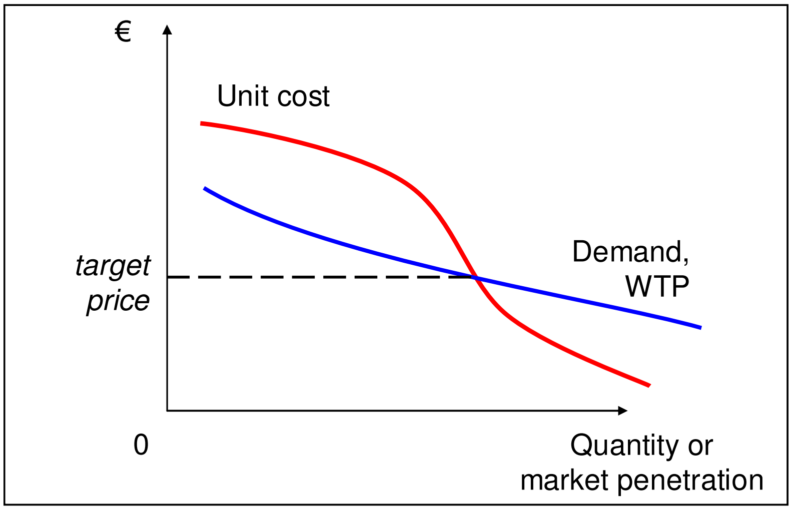

Figure 7: Target Price

The **stakeholder analysis** reporting will vary with the analytical methods used. For example, in the TAC Safe Car Project, Monash University used subjective questionnaire methods to investigate users' acceptance of several ICT systems including ISA (Regan *et al*, 2006) – see Figure 8.

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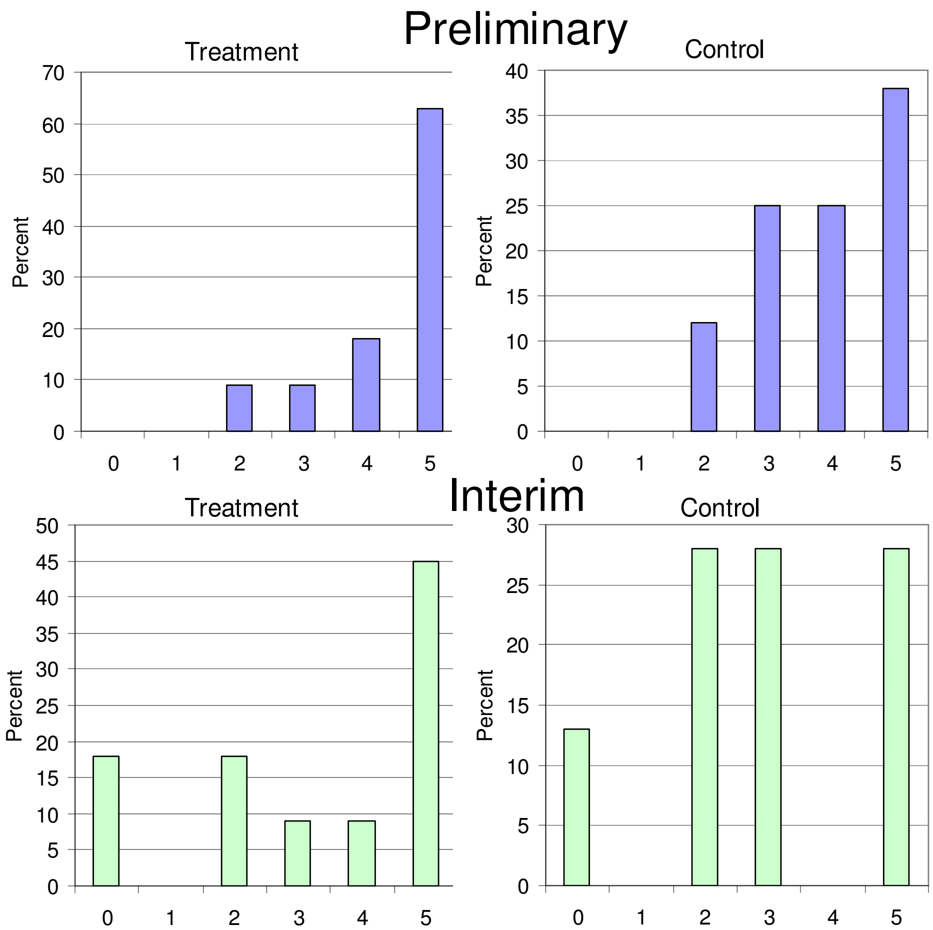

"To what extent will the ISA system be of use to you?" Percentage of responses in each category for the treatment group and the control group (0=no use; 5=always of use)".

Source: Regan *et al* (2006), Fig. 7.1

Figure 8: Acceptability Results in the TAC Safe Car Project

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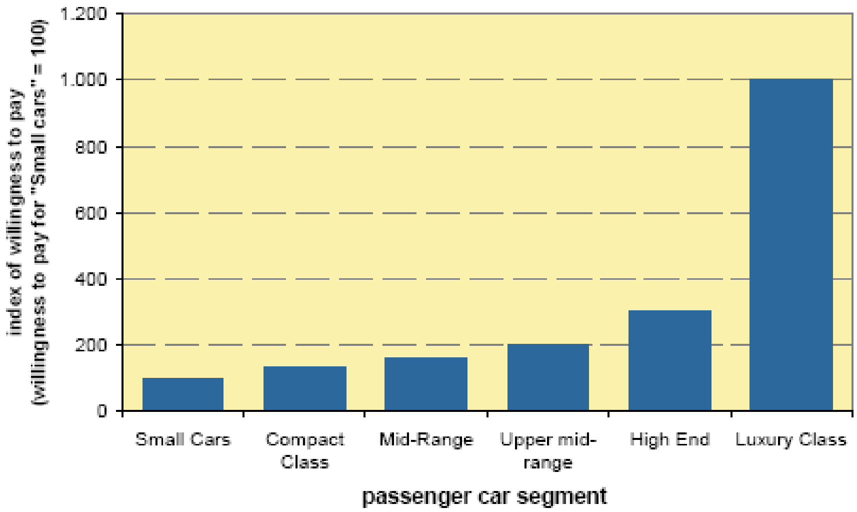
Another useful form of stakeholder analysis from the User perspective is Willingness-to-Pay evidence, as shown here (Figure 9).



Source: Assing et al (2006) p119, citing McKinsey & Company, Technische Universität Darmstadt – Institut für Produktionsmanagement, Technologie und Werkzeugmaschinen, Verband der Automobilindustrie (VDA), HAWK 2015 – Knowledgebased changes in the automotive value chain, Frankfurt 2003)

Figure 9: Willingness-to-Pay Results for New Vehicle Technologies

For the vehicle OEMs and both infrastructure and service operators:

- where they are commercial bodies, a *financial analysis* will provide the most important stakeholder information;
- Where they are public sector agencies, a *financial analysis* may need to be combined with an assessment against their public service objectives – however, in some cases the overall social CBA will serve this purpose, depending on the approach taken by the agencies involved.

3.6.2. Supporting evidence

It is good practice to make available and to collate and store supporting evidence to back up the results of the socio-economic assessment. Doing so promotes better-informed decision-making and provides an audit trail. This means that the following should be available to the decision maker:

- reports detailing the social CBA, financial analysis and stakeholder analysis;
- the basis for key intermediate steps of the analysis including functional assessment results from the FOT, forecasts of market penetration over time, tools and techniques used in the socio-economic assessment, economic parameters used, and any detailed breakdowns of results which have been produced but are not part of the core results;
- Mechanisms by which the decision maker can probe the findings, such as a consultant's representative or expert advisor with knowledge of the work.

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4. Carrying out the assessment

4.1. Overall assessment

4.1.1. CBA

The socio-economic impact assessment within FOT of Intelligent Vehicle Safety ICT systems should be based on (social) cost-benefit analysis since it is the most widespread, common accepted and practised method for analysing socio-economic impacts. It is clear that CBA accounts for all benefits and all costs on society level without regard to whom the benefits and costs accrue. As discussed earlier, CBA follow a four-step-process involving framework and preparatory work, measuring impacts, appraising impacts in a common monetary value and confronting the discounted society benefits with the costs of the policy measure. However, this process leaves also some room for shaping the individual steps of the process. Based on the earlier argumentation we recommend considering the following issues.

CBA framework

– Definition of the cases to be compared: With-case [do something] against without-case [do nothing])

– Base year and time horizon of the assessment: CBA can be performed for the whole life cycle of the considered an ICT system (for practical reasons identical with average vehicle lifetime) or only for selected target years. This decision depends on information needs (interest in development of effects over time or snapshot projections of benefit ad costs for one or few pre-selected target years)

– Geographical scope of the assessment: Because of data availability the geographical scope should be congruent to existing statistical reporting ICT systems. Reference only to the local area where the FOT takes place is insufficient for this reason and because the results of different FOTs need to be compared. This implies however that the socio-economic impact assessment has to undergo a scaling up procedure before the CBA in order to project the impacts from the FOT itself on to a larger area. The most practical appears to be assessment at the national level (assuming "nationwide deployment"). However, it is even more useful to provide results on a European level. The European perspective is important when the effects of FOTs in different member states should be compared or when policy measures are planned or considered to ensure a European scale deployment (e.g. eCall).

– Discount rate: The discount rate ensures that benefits and costs are expressed for a common base year. A discount rate of 3% (real) is recommended as a default (see 'Other economic parameters' in section 4.2.3).

– Deployment scenario: It has to be estimated which share of new vehicles or which share of the total vehicle fleet will be equipped with the ICT system in the target years and over the assessment period as a whole [depends on answer to 'Base year and time horizon' issue above]. For life cycle assessment it is also necessary to estimate the development of the equipment (technical capabilities, costs).

– Impact table: The impact table serves as an instrument to expedite identification of impacts. It is aimed to ensure that the FOT team and the group responsible for the socio-economic impact assessment are fully aware of the complete impacts of the ICT system.

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For efficiency reasons and likely budget constraints (competing FOTs and competing assessment issues within a FOT) it is necessary to concentrate the analysis on the significant impacts - impacts expected to be negligible, or impossible to analyse within the resources available, should be flagged as such in the impact table. Concerning the ICT system, safety is the relevant impact by definition. Direct and indirect mobility impacts and environmental impacts are typically also addressed. ICT system costs will always be relevant.

Impact assessment (incl. cost estimation)

Impact measurements represent an essential input to the cost-benefit assessment. We would normally expect most of these to feed through from the FOT experiment to the scaling-up procedure (Chapter 8 of FESTA Handbook) to the CBA inputs. In particular, accident prevention and ICT system costs at the national / EU levels should be delivered this way. Impacts on mobility and environment will typically require additional analysis at the CBA stage (although in a well designed FOT experiment, it may be possible to gather data specifically on any expected sources of benefit - e.g. reduced variability of traffic speeds or reduced fuel consumption (see the TAC Safe Car FOT)). The analysis of different FOT assessment has revealed some evidence on best practise for impact measurement. The requirements for CBA can be provided as a sort of output specification. This makes sure that the socio-economic impact assessment will be provided with the appropriate input data for carrying out the assessment. In terms of an output specification the following elements have to be put in place:

- Accident and traffic performance database: see the section on generic data for more details;

- Effectiveness of the ICT system (in preventing accidents, mitigating accident consequences, reducing congestion etc.): these values represent key output of the FOT which have to be provided to the socio-economic impact assessment. The effectiveness of the system may differ by type of vehicle in which it is used, for example, passenger cars vs. goods vehicles. For this reason, the analysis may require that the impacts are distinguished by vehicle type;

- Procedure for scaling up the effects to nationwide/European level: FOT should involve different European test sites in order to reflect the different driving and traffic conditions in the EU. Each FOT assessment represents valuable information standing for its own. However, it is useful and necessary to combine the findings to an overall European picture. This will be done by scaling up the effects from the FOT to the national and European level and

- Cost estimations.

Cost estimation is an element within FOTs which is quite often rather neglected. In a narrow sense, costs do not represent an impact. However, it is considered in this place because of practical and methodological reasons (in a broader assessment view, e.g. performing MCA, costs would also represent an element equal to safety impacts and mobility impacts). Cost estimation should take care of the following aspects:

– Cost elements to include (what to include?): The relevant elements are the investment costs (cost character: initial, at the beginning of the life cycle) of the vehicle equipment and – if applicable – of infrastructure investment (e.g. roadside units). Besides that, operating and maintenance cost (cost character: permanent over life cycle) should be also estimated.

– Relevant size of costs: CBA applies a resource based view. This means looking at potential savings of productive resources and on the other hand at the resources necessary to achieve this effect. The implication for cost estimation is that only the input of productive resources is relevant and not potential market prices. The convention proposed e.g. by eIMPACT is to stick to the cost price (the price of the ICT system which the vehicle manufacturer pays to its

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supplier) plus a mark-up which is allowed for in-vehicle implementation. On the contrary, market prices are relevant for user centred analyses (see section 4.1.2). Generally, in the face of limited evidence it is useful to apply the “Factor 3” rule of the thumb. It means that in the automotive industry market prices for an ICT system differ from the costs prices by factor 3.

– Process of cost estimation: Typically, cost estimation will be carried out by an expert group comprising of FOT internal staff and external industry experts. To avoid conflicts with confidentiality and the like, it appears sometimes helpful to introduce rough estimations to the group instead of working from blank sheets. Guidance to rough estimations fro investment and O&M costs can be applied from an US-American database on ITS costs and benefits (www.itscosts.its.dot.gov).

Impact valuation

- *Methodological base for impact valuation*: The general objective of this step is to provide unit values for the physical impacts. Several methods compete in the field of impact appraisal. They can be subdivided in objective approaches (e.g. damage costs, avoidance costs) and subjective approaches (e.g. willingness-to-pay). In European member states, different practises and preferences exist for impact appraisal. A lot of surveying and standardisation efforts have been made by projects like HEATCO (Bickel *et al*, 2006) to come to common European base. As a general recommendation, it can be stated that unit values for CBA should be based on objective approaches. However, willingness-to-pay information can largely contribute to a higher quality of the assessment when analyses for the users are carried out.

- *Good practise on unit values*: see eIMPACT, HEATCO and the handbook on external costs of transport.

- *National or European unit values*: This decision corresponds with the geographical scope. Assessment on national level will typically make use of national cost unit rates. For European scale assessment both options (different national or European average values) are possible. HEATCO shows a broad discussion of the pros and cons of the options. For European scale assessment, we recommend to use European average values.

Results

Cost-benefit analyses can produce different results. It represents good practise to calculate the Net Present Value (NPV) by summing up all discounted values of benefits (plus sign) and costs (minus sign). Moreover, Benefit-Cost Ratios (BCR) are a very common expression of ICT system profitability which can be calculated by dividing the total benefits by the total costs. It is also practical (see time horizon) to calculate “snapshot” BCR for target years. In this case, the costs will be transformed to annual values (using discount rate) and will be confronted to the target year benefits. For FOT, we recommend to calculate both figures, NPV and BCR.

4.1.2. Stakeholder analysis for users

In contrast to CBA, only particular benefits and costs are relevant for particular stakeholders. The reduction of exhaust and CO2 emissions are not benefits to users, unless they are charged for it (through vehicle-taxes or –tolls). The costs of in-vehicle equipment do not represent costs to the government, unless the government agrees to pay for a share of this. The consequence is that ICT systems which are profitable on society level (NPV, BCR) will not be deployed when a relevant stakeholder group is economically impaired. Hence, it is necessary to include stakeholder perspectives in the FOT socio-economic assessment.

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Practically, stakeholder analyses make also use of accounting costs and benefits, but on the level of the individual stakeholder group.

This implies the following:

- Cost and benefits must be investigated according to their stakeholder relevance. Safety benefits (reduced accident and casualty risks) for instance are relevant to users (and to insurance companies as well).
- The appraisal of the impacts can be different. Users face market prices when considering the investment in an ICT system (see factor 3 rule of thumb). For benefit evaluation the implication is to use market values if available (e.g. fuel consumption: station prices (incl. taxes) instead of net prices). Otherwise, willingness-to-pay approaches have their justification here because they are better suited to reflect individual preferences.

Further adaptations to the CBA approach involve the use of a different discount rate (reflecting private sector interest rates) and the use of a different result measure (fair market price for a pre-defined annual vehicle mileage or the critical (break-even) mileage for a given market price).

4.1.3. Internal Rate of Return

The internal rate of return (IRR) of a project is the interest rate that will generate an NPV of zero. In an equation, this is

$$\sum_{t=0}^{T} \frac{B_t - C_t}{(1+i_{IRR})^t} = 0 \text{, with}$$

i_{IRR} internal rate of return.

The stakeholder for whom the IRR is calculated compares the IRR with a target rate. This target rate depends for each stakeholder. For public authorities as a stakeholder the target rate will be less than for private investors as stakeholders.

The last clause mentions the advantage of the IRR-concept in contrast to the BCR-approach. In the BCR-approach choosing the right discount rate is not possible. Critics will always be there who assume another discount rate would be better. In the IRR-concepts no discount rate is used. Each stakeholder has to define a target value for comparison on his own.

The IRR-concept is works well for a snapshot analysis, i.e. the analysis is done for only one year. However if the analysis is done for a period of time (e.g. 2010 till 2020) the IRR-concept might lead to doubtful results. The IRR may not be unique. This is the case if the project has a net benefit stream that changes sign more than once. For example, the net benefit starts out negative, then turns positive and ends negative. The result is that there may be two IRRs, both of which are equally valid.

Another problem of the IRR concept is that the target rate might change during the period under investigation. Consider the case the stakeholder has a target value in the first halve of the period of 5 % and of 8 % for the rest of the period.

The last mentioned problem is the absence of comparability. Consider two ICT systems. The first ICT system works only for a short period, the second ICT system works for a long period. In this case the IRR might lead to a preference of the wrong project. The “winner ICT system” out of the NPV-analysis may be another than out of the IRR-analysis.

In any case, a calculated BCR or IRR should be accompanied by an NPV.

The IRR-concept can be modified for comparing reasons. For his approach, the cash flow streams are subtracted. With the new cash flows the modified IRR is calculated. If the IRR is above the trigger rate, the project with the larger cash flow is the better project.

4.2. Data Needs

4.2.1. Overview of Data Needs

The data needed to carry out a socio-economic assessment for an FOT are extensive, and fall into two broad categories:

- FOT-specific data which will be gathered during the FOT itself – note that this includes some data that need to be gathered specifically to carry out a socio-economic assessment, so are part of the design of the FOT; and
- generic data, which play a role in:
    - scaling up the results from the experimental situation of the FOT to the national or EU level;
    - Reaching a socio-economic assessment, based on the FOT data scaled-up to national or EU level.

These data are used throughout the socio-economic assessment process outlined in section 4.1.1.

The following two sections outline the FOT-specific and generic data likely to be needed. Recommendations on ensuring data quality and validity are given in section 4.2.4. Management of the data for socio-economic assessment is covered in section 4.2.5.

4.2.2. FOT-Specific Data

The key items of FOT-specific data likely to be needed are:

- accident rates (or risks) with and without the ICT system in place for the FOT sample – these will need to be differentiated by all the key drivers of accident rates (risks) in the FOT sample (e.g. road type; driver type; traffic conditions...) so that accurate extrapolations can be made to the whole network;
- market penetration forecasts;
- usage, reliability and compliance;
- other driving behaviour data;
- attitudinal and acceptance data;
- costs of the ICT systems.

Accident Rates

Accident rates (or risks) will be needed with and without the ICT system in place for the FOT sample. These may need to be derived from data on unsafe behaviours if the sample is too small to contain a significant number of actual accidents, although this is likely to be done as part of the Performance Indicators in any case.

One approach to estimating the impact on accident rates uses the *effectiveness rate* (% of relevant crash type avoided) as in the CAS Benefits Study (NHTSA Benefits Working Group, 1996). The

data underpinning the effectiveness rate was drawn from a selection of the most current studies (in 1996). Different data was used for each of the three CAS systems tested.
Common themes were: identification of crash scenarios or crash sub-types; causal factors associated with these scenarios/sub-types; estimated effect of CAS systems on the causal factors; implications for effectiveness rate.

More sophisticated FOT studies will aim to produce data on *accident severity* as well as accident rates[1]. Since accident severity is determined by the severity of the most serious casualty only, a complementary item of data would be any expected change in the number of casualties per accident. In the Australian FOT, for example, Regan *et al* (2006) measured time spent buckled-up and time before buckling-up. This was used to input to injury severity estimates.

Regan *et al* (2006) also observed driving speeds with and without safety ICT systems active. These were used with Nilsson's power method (2004) to provide crash reduction estimates. In the RDCW FOT, UMTRI *et al* (2006) analysed the impact on driver behaviour using objective data including response to LDW alerts and lateral acceleration through curves (with/without CSW). In the Volvo Truck IVI FOT (Volvo Trucks North America *et al,* 2007), engineering data were collected onboard the tractors to evaluate the dynamic state of the vehicle (e.g., speed), the conditions in which the vehicle was driven (e.g., following a vehicle at highway speed), the driver's actions (e.g., braking or turning), and the functions of technologies (e.g., alarm sounded by the VORAD® Collision Warning System). Additionally, the ICC Evaluation (USDoT, 1999), used video data from a forward-looking camera mounted on the vehicle to assist with the performance analysis (safety and traffic effects).

Whichever approach is used to estimate accident rates and accident severity, the analysis will need to take account of any *options* in the implementation path. For example, in the Freightliner FOT study (Batelle Memorial Institute, 2003) there were four possible deployment groups (HazMat tankers; all tankers; tractor trailers; all large trucks) – input data will be required for each of these options.

Multiple scenarios may also be needed to enable *sensitivity testing*. That is, where there is uncertainty over accident rates/severity or other key variables, this can be handled through 'what if' scenarios based on combinations of the possible outcomes. Thus in the Freightliner FOT there were 24 scenarios in total, made up of four implementation options * three possible effectiveness levels (baseline/best case/worst case) * two possible ICT system cost outcomes.

There may also be some value in having *spatially differentiated data,* and being able to link behaviour to *traffic conditions.* So for example, the Full Traffic FOT used GIS to localise the drivers throughout the FOT, which then allowed the researchers to differentiate between urban/non-urban driving (roughly 50%/50% of the driving time in this FOT) and congested/intermediate/free-flow conditions (35%/19%/46% in this case). Similarly, in the Volvo Truck IVI FOT, the location of the vehicle in the United States and the driving conditions were logged at all times.

Market Penetration

This needs to be a profile over time showing the % of the fleet (and sub-fleets) in which the ICT system has been fitted. If there is expected to be any heterogeneity which could affect the total safety impact (e.g. if market penetration is expected to be higher in rural areas than urban), data on this needs to be presented.

In the literature, SEiSS (VDI/VDE-IT, 2005 and Baum *et al,* 2006) gives particular attention to market penetration.

[1] the CAS Benefits Study assumed that there was no effect on severity

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Usage, Reliability and Compliance

Although the study made assumptions about *usage, reliability* and *compliance* rather than gathering data, the CAS Benefits Study (NHTSA, 1996) did draw attention to these important factors in the out-turn effectiveness of ICT systems. Usage refers to the % of drivers (or of driving time) for which ICT systems installed on the vehicle will be switched-on and active.
Reliability refers to the likelihood that that ICT systems will operate without failure, technically. Compliance refers to the % of occasions on which the driver's behaviour complies with warning or indication provided by the ICT system.

Other Driving Behaviour Data

Regan *et al* (2006) collected data on fuel purchases and matching odometer readings (data was actually collected by experimental subjects), which enabled them to estimate fuel consumption and CO_2/NO_x/HC emissions. In the Full Traffic FOT, fuel consumption and emissions were inferred from speed and acceleration data using a standard model from the literature (TU Delft, 2008).

Attitudinal and Acceptance Data

Regan *et al* (2006) gathered attitudinal and acceptance data using questionnaires administered at various times throughout the study. This was analysed and reported with implications for user acceptance of the ICT systems.

UMTRI *et al* (2006) gathered subjective data on driver perceptions including: scores on the Van der Laan scale of acceptance; perceived usefulness (utility) of ICT systems; and a synopsis of focus group views. These were used to analyse consumers' willingness to purchase, amongst other indicators.

The ACAS FOT (USDoT, NHTSA, 2006) gathered subjective data based on driver surveys including, amongst others: ease of use; ease of learning; advocacy; perceived value; the HUD; and driver performance. These data were cross-referenced against the demographic characteristics of the drivers.

In the Volvo Truck FOT, Battelle conducted a survey of drivers as a two-part interview process. The first survey (Phase I) focused on driver expectations for the new safety technologies installed on selected Volvo trucks, and the second survey (Phase II) focused on driver experiences using the technologies.

Costs of ICT Systems

These will need to include in-vehicle equipment, infrastructure-based equipment and other costs, and including both investment and ongoing maintenance and operating costs. Sources of this data will include the ICT system suppliers and vehicle OEMs. It is good practice to have some independent verification of these costs, since they will play such an important role in most socio-economic assessments.

In some FOTs, data has been gathered which inputs directly into the maintenance and operating cost calculations, e.g. in the Volvo Truck FOT, fleet operations records originating with the fleet operator or the truck manufacturer were collated. They included drivers' information, vehicle/driver tracking, maintenance/repair, and ICT systems status/performance/operations.

Where the assessment period is longer than the expected service life of the equipment, replacement costs should be included (e.g. in the Freightliner FOT one round of replacement was included since the service life was 10 years and the assessment period 20 years) (Battelle Memorial Institute, 2003).

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4.2.3. Generic Data

The key items of generic data likely to be needed are:

- national and EU-level network, fleet and traffic data, which are used in scaling-up the findings from the FOT to the level of political interest;
- speed-flow relationships or network models, which allow journey times and costs to be derived from changes in flows;
- evidence on accident costs, used to measure the benefits of accident reduction and changes in accident severity;
- evidence on values of time savings and vehicle operating cost savings, used to measure the benefits of changes in traffic flow;
- emissions factors and values for the damage caused by emissions of greenhouse gases, air pollutants and noise;
- Other economic parameters such as the social discount rate.

National and EU Level Network, Fleet and Traffic Data

The International Road Traffic and Accident Database, IRTAD (ITF, 2008) contains traffic data for the EU27. This includes vehicle kilometres on the total road network, vehicle kilometres on motorways, and vehicle kilometres on urban roads. Vehicle kilometres on rural roads can be derived; some data are missing.

ProgTrans European Transport Report (latest version: 2007/08) can be used as a valid source for forecasts. It contains vehicle stock and vehicle kilometres for 1) cars, 2) buses and coaches and 3) goods vehicles. Generally, the report covers past, present (incl. short-term forecasts for the next years) and future (longer term for selected target years). In the 2007/08 report the following years are covered: 1995, 2000, 2005, 2006, 2007, 2008, 2015 and 2020. Geographically, they cover EU-27 by member state plus some more (Norway, Switzerland, Croatia, Turkey, Belarus, Russia, Ukraine plus China, Japan and the USA).

Accident data (accidents, fatalities, severe and slight injuries) for base scenario: National databases are available. At the EU-level, the collection and compilation of accident data as a basis for the safety impact assessment is a challenge, especially when specific target accidents are going to be explored. Several EU-projects are dedicated to harmonizing accident databases, See TRACE (www.trace-project.org) or SafetyNet (http://www.erso.eu/safetynet/content/safetynet.htm) for more information. Forecasts of road safety are needed. An example can be found in eIMPACT "Impact Assessment of Intelligent Vehicle Safety Systems", in which accident trend estimates for 2010 and 2020 for the EU-25 are presented.

More detailed network specifications (e.g. infrastructure equipment) may be required for some ICT systems: the presence/absence of beacons, signalisation. Basic figures (e.g. share of Trans-European Road Network equipped with dynamic traffic management) are available from the eSafety Forum Implementation Roadmap Working Group (2005).

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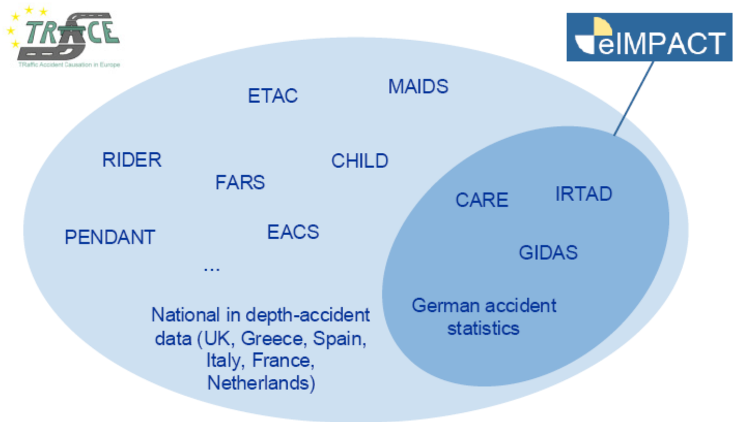

Speed Flow Relationships or Models

Although these are strictly much more than just 'data', it is worth highlighting the key role they play in socio-economic assessment of transport ICT systems. Many of the effects of new ICT systems will be mediated through changes in traffic flow on the network – for example, advanced warning systems allow drivers to change route to avoid hazards, but the net effect on travel times and costs is dependent not only on the behaviour of the individual, but on the behaviour of large numbers of individuals and the interaction with the limited capacity of the network. Hence, at the very least, knowledge of speed-flow relationships is needed to understand the consequences of shifting traffic across the network.

HCM (2000) and FGSV (2001) are sources of speed flow relationships. Network models or strategic transport models incorporate this data and have much wider functionality. The fact that these models are very expensive to develop and maintain means that they tend not to be developed for one socio-economic assessment in isolation. Instead, part of the socio-economic assessment process is usually to identify models already existing which can provide the necessary functionality.

Accident Costs

The HEATCO project (Bickel et al, 2006) was designed specifically to provide harmonised cost estimates for socio-economic assessment in Europe. We recommend that the HEATCO accident cost values are used in the FOTs, and we provide one additional piece of evidence to fill a gap in HEATCO which is a generic dataset on the costs of 'damage only' accidents.

Two of the main issues in this field are:

- an apparent inconsistency between 'willingness-to-pay' (WTP) methods and 'cost of damage' or 'human capital' methods as a basis for values – empirically, WTP methods can produce significantly higher values for fatalities in particular (see Assing *et al,* 2006: Table 16); and
- Double-counting of casualties' lost future consumption, which is included in both lost future output and WTP to reduce accident risk.

HEATCO addresses these issues by specifying a common framework in which the different elements of accident costs measured by each method can be reconciled.

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For example, 'human capital' methods do not capture people's full valuation of safety risk, whilst WTP-based values do not capture the *external* resource costs of accidents (e.g. healthcare costs borne by the state)
but often do double-count lost future consumption, as already noted. The HEATCO framework includes:

- property damage;
- medical costs;
- administration costs
- lost output;
- welfare losses due to casualty reduction.

As a result, the HEATCO values for fatalities are neither as high as the US NHTSA's willingness-to-pay values cited by Assing *et al*, nor are they as low as the NHTSA's cost-of-damage values. They are broadly in line with 'best practice' European values used in cost-benefit analysis, and the differences can generally be understood by examining the differences in the underlying measurement methods.

Other important functions of the HEATCO values are to provide:
- a common unit of account in the face of taxes and subsidies – HEATCO values are provided at the factor cost unit of account (Bickel *et al,* 2006: 52);
- a common price base year;
- a common currency, €, for European-level assessments.

The HEATCO accident values are expressed as values per casualty saved. These values do include the full set of accident costs, per casualty.

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Country	Fatality	Severe injury	Slight injury
	(€2002, factor prices)		
Austria	1,760,000	240,300	19,000
Belgium	1,639,000	249,000	16,000
Cyprus	704,000	92,900	6,800
Czech Republic	495,000	67,100	4,800
Denmark	2,200,000	272,300	21,300
Estonia	352,000	46,500	3,400
Finland	1,738,000	230,600	17,300
France	1,617,000	225,800	17,000
Germany	1,661,000	229,400	18,600
Greece	836,000	109,500	8,400
Hungary	440,000	59,000	4,300
Ireland	2,134,000	270,100	20,700
Italy	1,430,000	183,700	14,100
Latvia	275,000	36,700	2,700
Lithuania	275,000	38,000	2,700
Luxembourg	2,332,000	363,700	21,900
Malta	1,001,000	127,800	9,500
Netherlands	1,782,000	236,600	19,000
Norway	2,893,000	406,000	29,100
Poland	341,000	46,500	3,300
Portugal	803,000	107,400	7,400
Slovakia	308,000	42,100	3,000
Slovenia	759,000	99,000	7,300
Spain	1,122,000	138,900	10,500
Sweden	1,870,000	273,300	19,700
Switzerland	2,574,000	353,800	27,100
United Kingdom	1,815,000	235,100	18,600

Source: Bickel et al (2006), Table 0.10.

Table 5: Values for Casualty Reduction

To apply these values, analysts will require further data:

1. Forecasts of accidents with and without the technology in place – based on the FOT findings and the results of the scaling up process.
2. If these forecasts do not address unreported accidents, then factors for the number of unreported accidents given the number of reported accidents can be found in HEATCO (Bickel *et al,* 2006, Table 5.1).
3. Growth in the values over time – an elasticity of 1.0 with respect to GDP per capita, thus a 2.0% annual increase in GDP per capita would imply a 2.0% annual increase in the values of accident reduction.
4. Damage only accident values. Table 5: Values for Casualty Reduction only includes values for injury accidents. As Baum *et al* (2007) shows, savings in damage only accidents can make up a large proportion of the benefits from ICT safety systems. Damage only accident costs have been valued with cost unit rates of 1,500 EUR up to more than 10,000 EUR per accident.

This bandwidth exists manly because of different statistical definitions of property damage only accidents in different European member states. The research done in HEATCO suggests that the central value is approximately 2,150 EUR.

National level assessments may wish to take advantage of the most recent safety valuation evidence at national level. For multi-national assessments it will be important to ensure that any national evidence is checked for consistency across boundaries, and conversions made if necessary (e.g. in terms of base year, unit of account, cost elements included, measurement methodology, etc).

For EU-level assessments, consistency across countries and comparability between assessments will be important, which makes the use of a harmonised set of values (as above) more attractive. If the harmonised values are found not to provide the detail which the analyst wants – e.g. if differentiated accident costs by road type or user type are expected to be a key requirement for a particular assessment – then it may be appropriate to vary the values above, based on more detailed information (for example, the accident cost data included in national level assessment guidelines).

Values of Time Savings and Vehicle Operating Costs

Values of travel time savings will be needed to assess the benefits of improved traffic flow due to the ICT systems. HEATCO Tables 4.6-4.8 provide suitable values for working and non-working passenger trips, and for freight transport (Bickel *et al,* 2006: 73-75). These values increase with GDP per capita, at an inter-temporal elasticity of 0.7.

Sometimes there will be an impact on reliability, not only expected (mean) travel times, and in these cases we recommend using the reliability ratios set out in HEATCO Table 4.3 to value changes in the standard deviation of journey time.

Vehicle operating cost savings are also likely to arise from changes in traffic flows. The traffic models used to predict traffic flow responses to ICT systems will typically be capable of predicting changes in Vehicle Operating Costs, and the fine network detail in these models usually makes it more logical to calculate these cost savings within the model, rather than attempting to do so based on model outputs. As a result, standard values are not offered for these impacts by HEATCO (see Bickel *et al,* 2006: 135-140).

Environmental Values

When ICT systems bring about changes in traffic flows, or more efficient driving styles for example, the impacts on the environment may be valued using data available for the EU27 countries. The key environmental values relate to:

- air quality;
- CO_2 emissions; and
- noise.

The principal sources of air pollution from surface transport are emissions from vehicles and emissions from electricity generation plants. HEATCO provides values for both sources of emissions (Bickel *et al,* 2006, Tables 6.2,6.4). Values for particulate (smoke) emissions are differentiated between urban and non-urban locations, due to their very localised impact pathway. Other air pollutants are valued uniformly at country level.

The impact of CO_2 emissions is on a global scale, and is not linked to the particular country or area type where the CO_2 is emitted.

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The impact does, however, vary according the year in which the reduction (or increase) in emissions takes place – the impact becoming greater further into the future. HEATCO provides a shadow price of CO_2 by year of emissions (Bickel *et al,* 2006, Table 6.12) which should be applied to all forecast changes.

The impact of noise changes may be quantified using the HEATCO values for road, rail and aircraft noise in each member state (Bickel *et al,* 2006, Table 6.9).

Other Economic Parameters

Discount rates are required for socio-economic assessment. In line with HEATCO, we recommend using a risk-free social time preference rated for the countries to which the assessment would apply. If a default discount rate at the EU level is required, we would recommend using 3% per annum (real).

GDP growth data for the members of the EU27 (required for updating values of accidents, etc, over time) is available from Eurostat (ec.europa.eu/eurostat).

ICT system Costs

ICT system costs will vary greatly and on the whole will be ICT system-specific.

However, where costs are hard to obtain or commercially confidential, or where independent verification is required, a limited number of sources of generic cost data are available. The US ITS database is a particularly valuable source. Additionally, SEiSS (VDI/VDE-IT, 2005) has a literature review on ICT system costs.

4.2.4. Data quality and validity

The EC ROSEBUD project provided the following guidance as part of a "professional code for analysts" (BASt *et al,* 2005: 46):

> *"Data* has to be attributed correctly to its sources, especially when different data sources like national or international accident databases or in-depth databases are used. Where and how estimations were made to fill data gaps needs to be documented. Regression models should be used to generate future time series; trend extrapolations can replace them where available data are insufficient for regressions".

In addition, we would recommend that:

- the principles of statistics apply – statistical tests should be used wherever possible to determine if hypotheses about ICT system impacts are supported by the FOT evidence, and sample sizes should be chosen to obtain statistically significant results;
- when scaling-up from the FOT to the national or EU27 level, a methodical approach based on the key drivers of safety/other significant outcomes identified in the FOT should be used;
- confidence intervals as well as mean data should be recorded for key variables – note that confidence intervals are given in HEATCO for the various economic parameters recommended;
- we have noted the need to recognise the uncertainty in the data using sensitivity analysis – if analysts wish to take a more advanced approach and use Monte Carlo simulation or related techniques (for example to derive a probability distribution on NPV or BCR) that would be welcome as it simplifies the outputs seen by the decision-makers, although it does place an additional burden on the analysts;
- known problems with the data should be acknowledged and acted upon, e.g. UMTRI *et al* (2006) excluded a proportion of drivers whose trials were invalidated (in that case 9/87 drivers), and some trips by the remaining drivers.

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Well known problems with the omission of unreported accidents from data have prompted Bickel *et al* (2006, Table 5.1) to provide adjustment factors for different accident severities and types.

Record keeping and data storage are important. This includes qualitative/subjective data, and evidence gathered during deliberative studies (e.g. UMTRI *et al* (2006) ensured that focus group evidence was captured on video and by a court stenographer).

Finally, the US NHTSA observes that “[t]he validity of any experimental test results depends on the experimental condition effects that were placed on the drivers” (NHTSA, 1996: 36). Care is needed, therefore, when extrapolating data from short-term experiments to long-term term adjustments in behaviour and demand for ICT systems – e.g. the CAS Benefits Study found that “a better estimation of the safety benefits… can be achieved as more relevant test data are gathered especially from long-term, large-fleet field operational tests” (pC-8).

4.2.5. Data management

UMTRI *et al* (2006) and others have considered and reported on their Data Archive procedures. The amount of data input to and output by socio-economic assessments will be sufficiently large to justify making specific arrangements for storage and management.

For socio-economic assessment, Excel is an extremely powerful tool – both for data storage and analysis. The main exceptions are very detailed CBA studies based on a full network model, where the number of origin-destination pairs can conflict with the size limits on Excel spreadsheets. In these cases, plain text data files may be used, and both input and output files should be stored as part of the wider data archive.

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5. Conclusions

The goal of this document is to provide clear, practical advice on how to carry out a socio-economic impact assessment. This advice covered all aspects related to methods, stakeholder issues, types of analyses, assessment scope, impact assessment, presenting results and data.

Cost estimation for equipment (in-vehicle, infrastructure and nomadic devices), and the projection of how these costs develop in the future period covered by the CBA, is a challenge. All FOTs will need to estimate these in order to carry out the CBA. We suggest that advice, guidance or recommendations be addressed at the European level either in a project such as FOT-NET or through an eSafety Working Group.

A solution to come up with this estimation for the costs would be the following approach: develop a procedure, acceptable for the market's anti-trust authorities, that gives enough insight into the different costs structures (for the various equipment). This can be accomplished by choosing one trusted independent party that will start off with an initial cost structure overview, and then polishes it with help of the feedback of the other market parties. This way, an overview of the cost structures is created with which every party is satisfied.

In the future, we expect revised versions of FESTA to appear. This has to do with the fact that the CBA must be tailored to the particular characteristics of the ICT system tested in the FOT. FOTs are specific for the characteristics of the ICT systems that are being tested, research questions that need to be answered and the relevant stakeholder perspectives that are part of the particular FOT. The application of the CBA to these systems will provide new information that will lead to improvements in CBA in FOTs.

Furthermore, the source of information for the recommendations in this document is based primarily on experience with applications to in-vehicle systems. When applying CBA to cooperative and nomadic systems, new challenges with respect to defining the cost and benefits will be encountered, leading to refinements in the socio-economic impact assessment methodology.

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Annex 1.

The appendices contain the summary and the details of about 20 studies reporting the socio-economic impacts of ICT systems from different research angles:

- **Socio-economic impact assessment studies** typically investigate the impacts of a system for a future time horizon. These prospective studies make use of an ex-ante impact assessment, often based on literature review, simulation work and expert estimation. They are often comprehensive in scope but they do not involve, or only to a limited extent, data from real-life conditions.
- **Transport appraisal guidelines** or **scoping studies** in this area are very much focused on the appraisal part of the impacts. They dig deep into methodology and practise of appraisal, also involving proposals for standardisation. Their detriment is that they are not developed specifically for safety evaluation.
- **Field Operational Test assessment studies** typically assess the impacts of one or more system functions. FOT evidence can lead to a quantum leap in the impact assessment because FOT produce measured data about effects. Therefore, the assessment can rely on ex-post measurement data.

Study			**Main Focus**				**Impacts**				
Name	**Year**	**Geograph. Scope**	**Methodology**	**Case Studies**	**Application**	**FOT Assessment**	**Safety**	**Mobility – Direct**	**Mobility – Indir.**	**Environmental**	**System Costs**
eIMPACT	2006-08	EU	X		X		X	X	X	X	X
SEiSS	2005	EU	X	X			X	(X)	X	X	X
ECORYS / COWI	2006	EU			X		X		X	X	X
ROSEBUD	2005	EU	X	X			X	(X)	(X)	(X)	X
ADVISORS	2000	EU			X		X	X	X	X	
HEATCO	2006	EU	X				X		X	X	
RAILPAG	2005	EU	X	X							
FUNDING	2007	EU			X						
NATA	2003-08	UK	X								
Full Traffic	2008	NL			X	X	X	X	X	X	
TAC Safe Car	2006	AUS			X	X	X	X		X	
Freightliner FOT	2003	USA			X	X	X		X		X
Mack FOT	2006	USA			X	X	X		X		X
Volvo FOT	2007	USA			X	X	X		X		X
IVBSS	2007	USA			X	[X]	[X]				
RDCW FOT	2006	USA			X	X	X				
ACAS FOT	2006	USA			X	X	X				
ICCS FOT	1999	USA			X	X	X				X
CAS Benefits	1996	USA			X		X				

Annotation: (…) … addressed as an option […] … subject to future reports

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Table 6: Summary of reviewed socio-economic impact assessment studies

Name of the study /project/guideline	eIMPACT
Full title (if applicable)	Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems (IVSS) in Europe
Relevant deliverable	D3,
Publication Year	2007
Partners	TNO, UOC, DAB, CRF, BMW, BOSCH, PTV, VTT, BASt, RWS, CDV, MOVEA, IMC
Funded by/prepared for	EU
Project Reference	027421
Web address	www.eimpact.eu

Methodology - general	Main focus: e.g. methodological development, application study	D3 is a methodological development based on SEiSS. D6 is an application study
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Cost-benefit-analysis / stakeholder-analysis
	Client and type of client	European Commission DG INFSO and MEDIA
	Verification of methodology by case studies (if applicable): yes/no	Yes: ACC. The methodology is used in D6 for the twelve considered IVSS
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Two scenarios for different penetration rates (status quo and incentives), time horizon is 2010 and 2020, geographical scope: EU 25
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Sensitivity analyses for each of the considered systems, stakeholder analyses and financial analyses for some systems, macroeconomic impacts and distributional impacts for one system

Input data - system specific data	
	Data 1
(a) Short description of data needed	System costs
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	No
(c) Sources / Collection method	Experts guess
(d) Step in Method where data is used	Determining the costs and determining the benefits
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	penetration rates (fleet and mileage)	Infrastructure requirement and costs
(b)	No	No
(c)	Experts guess	Experts guess and studies
(d)	Determining the costs and determining the benefits	Determining the costs
(e)		
	Data 4	*Data 5*
(a)	Lifetime	Discount rate
(b)	No	No
(c)	Standard values out of literature review	Standard values out of literature review

(d)	Determining the costs	Determining the costs
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	Accident data forecast
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Time series of the accident data for EU 25
(c) Sources / Collection method	Regression based on CARE database
(d) Step in Method where data is used	Determining the safety effects
(e) Any other relevant information (e.g. availability; geographical scope ...)	Accident data time series for countries which are not included in CARE

	Data 2	*Data 3*
(a)	Vehicle stock	Vehicle mileage
(b)	No	No
(c)	ProgTrans (2008): European Transport Report 2007	ProgTrans (2008): European Transport Report 2007
(d)	Determining the costs	Determining the benefits
(e)		
	Data 4	*Data 5*
(a)	Distribution of Level of Services	Functions for determining the fuel consumption, CO2 exhaust and other pollutants
(b)	Newest available data (no time series available)	Newest available data and updating factors for future
(c)	INFRAS/IWW (2004): External costs of Transport, Zürich/Karlsruhe	FGSV (1997): Empfehlungen für Wirtschaftlichkeitsuntersuchungen an Straßen, EWS, Köln
(d)	Determining of traffic benefits	Determining of traffic benefits
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	Safety impact estimation
		Simulation of traffic flow for a few IVSS, scaling up to network level
		System costs estimation
		Market penetration (fleet and mileage) forecasts
		Vehicle operating cost estimation, infrastructure operating cost estimation
		Cost-unit rates for safety and traffic effects
		CBA
		Stakeholder on end-user level, on OEM level, on Insurance level, financial analysis, macroeconomic.
		Impacts, distributional impacts

Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP	Benefits, Costs, Benefit-cost-ratio, safety effects (no. of fatalities and of injuries), traffic impacts
		Stakeholder acceptability on user, OEM and on insurance level
		Financial impacts, macroeconomic impacts, distributional impacts

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	Employment change Accessibility indicators	
Other data issues	Data quality and validity (information or guidance)	Data quality depends on the chosen assumptions
	Data management	
	Presentation of summary output data / results	Yes, in D6
Relevant items for FOT	FOT explicitly addressed: yes/no	No
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Scaling up procedure is used for determining the traffic impacts
	Problems encountered	
Additional comments	Approach of eIMPACT can be used for FOT.	

Name of the study /project/guideline	SEiSS
Full title (if applicable)	Exploratory Study on the potential socio-economic impact of the introduction of Intelligent Safety Systems in Road Vehicles
Relevant deliverable	Final Report
Publication Year	2005
Partners	VDI/VDE-IT GmbH, Institute for Transport Economics at the University of Cologne
Funded by/prepared for	European Commission, DG Information Society and Media
Project Reference	n.a.
Web address	www.vdivde-it.de (project website no longer maintained), report is stored in www.esafetysupport.org/en/esafety_activities/related_studies_and_reports

Methodology - general	Main focus: e.g. methodological development, application study	Development of assessment methodology (main focus) and verification of the proposed methodology by exemplary case studies
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Cost-benefit analysis
	Client and type of client	European Commission
	Verification of methodology by case studies (if applicable): yes/no	Yes, case studies: Safe Following (based on ACC), Lane Departure Warning / Lane Change Assistance, eCall
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	All case studies show results for EU-25, eCall case study demonstrates the potential (100% penetration) based on 2002 accident situation, other case studies come up with results for the years 2010 and 2020 based on estimated market penetration
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Methodology for stakeholder analyses (e.g. break-even analyses for users, financial analysis) and wider economic impacts is also included in the report
Input data		

- system specific data	
	Data 1
(a) Short description of data needed	System costs
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Investment costs, operating & maintenance costs (if applicable) of both, vehicle and infrastructure
(c) Sources / Collection method	Literature survey (European R&D projects, ITS cost database (US DOT), Consultant reports)
(d) Step in Method where data is used	Calculation of system costs
(e) Any other relevant information (e.g. availability; geographical scope ...)	---

	Data 2	*Data 3*
(a)	Market penetration	System specification
(b)	in % of all vehicles (stock penetration)	Specification of technology on functional level, must enable to identify the target accidents, has also implications for the level of detail in accident data (generic, data 1)
(c)	Literature survey (European R&D projects, Consultant reports)	Technical experts, description
(d)	Calculation of system costs, also determination of benefits	Determination of benefits (safety and traffic)
(e)	---	---
	Data 4	*Data 5*
(a)	Collision probability depending on shift forward of driver reaction	Mitigation of accident consequences (eCall)
(b)	Per accident type	Fatal → severe, severe → slight
(c)	Enke (1979), Literature	E-Merge (2004), D6.3 Compiled evaluation results
(d)	Determination of safety benefits	Determination of safety benefits
(e)	---	Estimation for three countries: Germany, the Netherlands, UK

Input data - generic data	
	Data 1
(a) Short description of data needed	Accident data
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Minimum information: number of accidents with personal damage, number of fatalities, severe and slight injuries, better to have additional information on accident types in order to identify the size of the target accidents, when available information on property damage only (PDO) accidents
(c) Sources / Collection method	CARE Database
(d) Step in Method where data is used	Safety benefits
(e) Any other relevant information (e.g. availability; geographical scope ...)	in SEiSS the information on accident types was introduced by studies carried out on the CARE database

	Data 2	*Data 3*
(a)	Vehicle stock	Vehicle mileage
(b)	Per country	Per country
(c)	ProgTrans (2004), European Transport Report 2004	ProgTrans (2004), European Transport Report 2004
(d)	Determination of costs	Determination of benefits
(e)	---	---
	Data 4	*Data 5*
(a)	Cost unit rates for appraisal of safety impact	Cost unit rates for appraisal of accident caused congestion
(b)	Per fatality, per severe injury, per slight injury	Per fatality, per severe injury, per slight injury
(c)	European Commission (2003), COM (2003), 448	ICF Consulting, Cost-Benefit Analysis of Road Safety

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		Improvements, London 2003.
(d)	Calculation of safety benefits	Calculation of indirect traffic benefits
(e)	EU-25 default values	---

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	Safety impact estimation based on accident avoidance and mitigation of consequences, number of accidents / fatalities / severe injuries / slight injuries avoided for target years 2010 and 2020
		Traffic flow impacts not considered (because of the limited nature of the case studies within SEiSS), hence no estimation of accessibility, time, vehicle operating costs, emission costs…
		System costs based on in-car and infrastructure investment, O&M costs negligible
		Market penetration on stock level based on literature
		EU-25 as geographical reference, no need for scaling up
		CBA includes safety impacts, indirect traffic impacts (reduction of accident caused congestion) and system costs
		Stakeholder analysis is described from methodol. point of view, no verification by case studies

Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Benefits and costs for target years 2010 and 2020 (ACC, LDW&LCA), benefits and costs for range of safety impacts (low-high) and in-vehicle costs (low-high) (eCall)
		No information about net present value
		Benefit-cost ratios for 2010 and 2020 (ACC, LDW&LCA), for two scenarios (potential based on 2002 data) confronting high cost with low impacts and vice versa (eCall)
		No other output available

Other data issues	Data quality and validity (information or guidance)	Case studies provide a good estimation based on desk research
	Data management	n.a.
	Presentation of summary output data / results	In tables and graphs (composition of benefits)

Relevant items for FOT	FOT explicitly addressed: yes/no	No
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	No
	Problems encountered	No

Additional comments	Case studies are separately published as journal article: Baum, H., Geißler, T., Grawenhoff, S., Schulz, W.H., Cost-Benefit Analyses of Intelligent Vehicle Safety Systems – some empirical case studies, in: Zeitschrift für Verkehrswissenschaft, Vol. 77 (2006), No. 3, pp. 226-254.

Name of the study /project/guideline	ECORYS COWI
Full title (if applicable)	Cost-benefit assessment and prioritisation of vehicle safety technologies: Final report
Relevant deliverable	Cost-benefit assessment and prioritisation of vehicle safety technologies: Final report
Publication Year	2006

Partners	COWI (DK), ECN (NL), Ernst & Young Europe (B) and Consultrans (ES), ECORYS Nederland BV (NL)
Funded by/prepared for	European Commission - DG TREN
Project Reference	TREN-ECON2-002
Web address	

Methodology - general	Main focus: e.g. methodological development, application study	Application of cost-benefit assessment to vehicle safety technologies
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Cost-benefit analysis was applied, when data was available (13 of 21 systems). Break-even analysis was applied when data was missing (4 of 21). **The study specifically mentions using the SEiSS methodology and HEATCO results. A number of minor changes were made to SEiSS accommodate the requirements of the COWI study.**
	Client and type of client	EC: DG TREN
	Verification of methodology by case studies (if applicable): yes/no	Yes, the methodology is applied to 21 vehicle safety technologies, based on existing literature, data and knowledge.
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	The study made use of scenarios (market penetration for the do-something and the do-nothing scenario); it accounted in-factory installation of systems and systems that can be retrofitted. ; the time horizon was 20 years (for the year 2025). The geographic scope was the EU-25.
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Sensitivity analyses were carried out (as a function of penetration rate)

Input data - system specific data	
	Data 1
(a) Short description of data needed	Scenario for implementation: do-nothing vs. do-something scenario
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Development of penetration rate for the system, At the EU-25 level, although this is not explicitly mentioned. This is an estimate for every year to the end-of-appraisal year.
(c) Sources / Collection method	Literature review
(d) Step in Method where data is used	Step 3: scenario for implementation
(e) Any other relevant information (e.g. availability; geographical scope ...)	For Overall EU-25, although this is not explicitly mentioned

	Data 2	*Data 3*
(a)	Definition of relevant accidents	Technology assessment: effectiveness of technology in terms of reduced collision probability and / or severity of accidents
(b)	Identify relevant accidents targeted by system. Accident data is used. This study used the CARE database (a community database on reported road accidents resulting in death of injury. It contains no statistics on material damage accidents. See appendix A for more details. The study used the years 1993-2002 when possible or data for 2002 only.	• Percentage reduction collision probability, resulting in reduction of fatalities, server end slight injuries. • Accident severity matrix for shift from fatalities to…, sever injuries to… and slight injuries to….
(c)	CARE database; on-line access is restricted to expert users (in 2005)	Literature review
(d)	Step 1: definition of relevant accidents	Step 2: technology assessment
(e)	CARE is available on-line to expert users. Scope is roughly EU-	

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	15, with some gaps by country and with some inconsistent definitions	

Input data - generic data	
	Data 1
(a) Short description of data needed	Forecasting of vehicle stock: passenger cars and heavy goods vehicles (>3.5 tons) in the EU-25
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Number of passenger cars, at the EU-25 level from the start to target year. Number of heavy goods vehicles, in the EU-25.
(c) Sources / Collection method	ANFAC for passenger cars for EU-25. TÜV for heavy goods vehicles for the EU-15; data for NMS not available. The size of the fleet in the NMS is estimated on the basis of the fleet data for the EU-15 and data on the number of newly registered HGV > 3.5 tones, which is available for EU-23 from the ACEA website).
(d) Step in Method where data is used	Step 3: Scenario for Implementation
(e) Any other relevant information (e.g. availability; geographical scope ...)	Data is not readily available. Calculations and estimates need to be made to scale up informationto the EU-25.

	Data 2	*Data 3*
(a)	Forecasting the safety situation in the EU-25: • change in crash and casualty rates, do-nothing scenario • forecast of veh-km and the vehicle fleet	Definition of relevant accidents
(b)	• Forecast of vehicle-km for passenger and goods transport, for the EU-25, for target years (2002, 2010, 2020) Source: SEiSS study (2005) • Change in crash and casualty rates due to improved roads and vehicles (source: ICF). This data may be different for different countries or regions. Critical for safety calculations as the continuous increase in traffic partly offsets the expected decline in crash and casualty rates.	Identify relevant accidents targeted by system. Accident data is used. This study used the CARE database (a community database on reported road accidents resulting in death of injury. It contains no statistics on material damage accidents. See appendix A for more details. The study used the years 1993-2002 when possible or data for 2002 only.
(c)	See (b) Also: Relationship between traffic and accident changes: Transportøkonomisk Institutt (1977): road safety handbook www.toi.no.	CARE database; on-line access is restricted to expert users (in 2005)
(d)	Step 3: Scenario for Implementation	Step 1: definition of relevant accidents
(e)	The ICF and SEiSS studies may need to be updated. The ICF data is available for the EU-15, Greece, Portugal and Spain	CARE is available on-line to expert users. Scope is roughly EU-15, with some gaps by country and with some inconsistent definitions
	Data 4	*Data 5*
(a)	Basic assumptions & cost-unit rates	
(b)	Discount rate: 5% Time horizon: Result year country-specific values or EU-averaged values? (this analysis uses EU-averaged values unit cost rates (euros / fatality or injury, Accidents)	
(c)		
(d)		
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts	Steps:
		1. Definition of relevant accidents
		2. Technology Assessment: **Market Penetration forecasts**

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	estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	3. Scenario for implementation: share of vehicles with technology. This implicitly takes into account passenger vs heavy goods vehicles. 4. Effects on Accidents: **Safety Impacts estimation** 5. Net Benefits **Monetarization of safety impacts, property damage and congestion** 6. Cost Assessment: **implementing, operating and maintaining the safety system. The costs appear to differ from the type of cost used in SEiSS and eIMPACT** 7. Economic cost-benefit assessment: **CBA and sensitivity analysis**
Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Benefit cost ratio
Other data issues	Data quality and validity (information or guidance)	
	Data management	
	Presentation of summary output data / results	
Relevant items for FOT	FOT explicitly addressed: yes/no	No
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	---
	Problems encountered	
Additional comments		

Name of the study /project/guideline	ROSEBUD
Full title (if applicable)	Road safety and Environmental Benefit-Cost and Cost-Effectiveness Analysis for Use in Decision Making
Relevant deliverable	D7
Publication Year	2005
Partners	BASt (DE), DITS (IT), KuSS (AT), TRL, (UK), UOC (DE), CDV (CZ), SWOV (NL), TOI (NO), TRI (IL), VTT (FI), VTI (SE), KTI (HU), CETE (FR), NTUA (GR)
Funded by/prepared for	European Commission, DG Energy and Transport
Project Reference	GTC2/2000/33020
Web address	www.rosebud-eu.org

Methodology - general	Main focus: e.g. methodological development, application study	Thematic network covering assessment methodology (main focus), compilation of existing assessments of road safety measures and verification of the methodology by case studies
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Cost-benefit analysis Cost-effectiveness analysis
	Client and type of client	European Commission
	Verification of methodology by case studies (if applicable): yes/no	Yes, 11 case studies (reported in another deliverable - D6): e.g. ABS for motorcycles, daytime running lights, 2+1 roads, section control, compulsory helmet regulation for cyclists
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Case studies and compiled examples of road safety measures assessments have various geographical scope, mostly the focus is local or national, by nature also the data needs and sources are different
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Analysis of barriers to use efficiency assessment tools (fundamental [resulting from theoretical base], institutional [resulting from inst. Settings], technical [resulting from the assessment process itself, incl. data needs], implementation oriented [related to the implementation of cost-effective measures])

Input data - system specific data (here: measure specific data, not included in D7)	
	Data 1
(a) Short description of data needed	Implementation costs
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Investment costs, operating & maintenance costs (if applicable) of both, vehicle and infrastructure
(c) Sources / Collection method	---
(d) Step in Method where data is used	Calculation of implementation costs
(e) Any other relevant information (e.g. availability; geographical scope ...)	---

	Data 2	*Data 3*
(a)	Market penetration	Description of the measure
(b)	---	---
(c)	---	Technical experts, description
(d)	Calculation of system costs, also determination of benefits	Determination of benefits (safety and traffic)
(e)	---	---
	Data 4	*Data 5*
(a)	---	---
(b)	---	---
(c)	---	---
(d)	---	---
(e)	---	---

Input data - generic data → D7 does not deal with data itself, it states some principles for data quality and management, input data specific to case studies will not be reported here because of the different scope of the case studies	
	Data 1
(a) Short description of data needed	Accident data
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	---

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(c) Sources / Collection method	---
(d) Step in Method where data is used	---
(e) Any other relevant information (e.g. availability; geographical scope ...)	---

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	Safety impact estimation as essential element
		Optional: traffic flow impacts, incl. travel time and fuel consumption changes, pollution effects and global warming effects
		System costs estimation as essential element
		Market penetration in some case studies relevant (where implementation is market based)
		no need for scaling up because of different geographical scope of the case studies
		General recommendation of CBA, in case of one-dimensional impact (e.g. only fatalities) cost-effectiveness analysis is also possible and requires less information (valuation of impacts), coverage of effects: "mini CBA" confronts safety benefits with implementation costs, (full) CBA does also include impacts such as travel time and fuel consumption changes, pollution effects and global warming effects
		Effects beyond the scope of CBA/CEA (e.g. wider economic impacts) should be mentioned

Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Snapshot benefits and costs
		Mostly no information about net present value
		Benefit-cost ratios, additional classification: BCR < 1: poor, 1 ≤ BCR < 3: acceptable, BCR > 3: excellent, classification presumably corresponds with threshold (BCR ≥ 3) of the German Federal Transport Infrastructure Investment Plan 1992 (threshold for classification as urgent demand)
		No other output available

Other data issues	Data quality and validity (information or guidance)	Guidance is provided by the following principles ("professional code for analysts", p. 46): 1) Database: Data has to be attributed correctly to its sources, especially when different data sources like national or international accident databases or in-depth databases are used. Where and how estimations were made to fill data gaps needs to be documented. Regression models should be used to generate future time series; trend extrapolations can replace them where available data are insufficient for regressions. 2) Estimation of safety impact: The most important step of any road safety related assessment is the estimation of the accident reduction potential. Many different techniques are available to derive an accident reduction potential, e.g. field studies, meta analyses, surveys or expert judgements. Independent from the chosen approach analysts must give reasons why this approach was chosen and document how the chosen technique was applied. 3) Appraisal: In many European countries official values are available to assess the above mentioned effects. Analysts should avoid creating their own figures where official values exist. Where official figures are not appropriate the analyst should raise the problem and carry out a sensitivity analysis

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		with the official and unofficial values. Where official values are missing analysts should use available figures from other countries, but taking account of welfare differences between countries, e.g. by using weights like income per capita.
	Data management	n.a.
	Presentation of summary output data / results	In tables
Relevant items for FOT	FOT explicitly addressed: yes/no	No
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Partly, the ROSEBUD partners have developed a training course on CBA/CEA for road safety measures. This may be interesting and helpful for FOT teams who are unexperienced in socio-economic assessment but obliged to perform a CBA or mini CBA within their FOT. The demo course is also documented in D7.
	Problems encountered	No
Additional comments	The ROSEBUD Thematic Network is more or less a scoping study of existing assessments for road safety measures. It defines also minimum requirements for performing efficiency assessment (CBA/CEA) and tests these requirements in a broad range of case studies.	

Name of the study /project/guideline	ADVISORS
Full title (if applicable)	Action for advanced Driver assistance and Vehicle control systems Implementation, Standardisation, Optimum use of the Road network and Safety
Relevant deliverable	D6.1 "Integrated Multi criteria Analysis for Advanced Driver Assistance Systems"
Publication Year	2000
Partners	BIVV, AUTh, BASt, VTT, Siemens, SWOV, JDR, Achmea, Trail, VTI, RUG, CRF, IAT, NTUA, CDV, TRL
Funded by/prepared for	EU DG TREN
Project Reference	GRD1 2000 10047
Web address	http://www.advisors.iao.fraunhofer.de/

Methodology - general	Main focus: e.g. methodological development, application study	Development and application of multi criteria analysis (MCA) for the socio-economic assessment of ADAS
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Main focus on MCA, short exemplary cost benefit analysis (CBA) of ACC
	Client and type of client	EU-Commission
	Verification of methodology by case studies (if applicable): yes/no	Yes - ACC
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	CBA: calculations were performed for urban context (Flemish region), 30-year time frame
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Sensitivity tests, stakeholder analysis

Input data - system specific data	
	Data 1

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(a) Short description of data needed	MCA: weights for different system specifications	
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)		
(c) Sources / Collection method	Expert estimation	
(d) Step in Method where data is used		
(e) Any other relevant information (e.g. availability; geographical scope ...)		
	Data 2	Data 3
(a)	CBA: penetration rate of system	CBA: system costs are not considered
(b)	In % of whole vehicle-stock, 30-year time frame	no
(c)	Own calculation	no
(d)	For determination of total system costs	no
(e)	Maximum penetration rate 75%	no
	Data 4	Data 5
(a)	CBA: safety impact of ACC	
(b)	In % of relevant accidents regarding a 100% penetration rate	
(c)	University of Minnesota	
(d)	Calculation of economic savings of accident prevention	
(e)		

Input data - generic data		
	Data 1	
(a) Short description of data needed	MCA-rating of different weight parameters	
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Data gained during project lifetime	
(c) Sources / Collection method	questionnaire	
(d) Step in Method where data is used	Ranking of different criteria	
(e) Any other relevant information (e.g. availability; geographical scope ...)		
	Data 2	Data 3
(a)	CBA: cost-unit-rates for travel time savings	CBA: cost-unit-rates for different emissions
(b)	€ per person and per hour for 2002	€ per tonne of pollutant
(c)	taken from average hourly salary paid in Belgium	n.a.
(d)	Calculation of total travel time savings	Calculation of economic cost savings of emission reduction
(e)		

	Data 4	Data 5
(a)	CBA: number of relevant accidents	
(b)	Total number of accidents differentiated in light and severe casualties as well as fatalities	
(c)	Flemish Data, NIS 2002	
(d)	Calculation of economic accident costs	
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level	CBA: traffic flow changes were calculated with SATURN-model CBA: environmental effects were calculated with TEMAT-model CBA: no scaling up, only regional impact analysis

	Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	MCA: no scaling up
Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Benefits and cost were calculated for four different market penetration level for the year 2000 Overall ranking of different evaluation parameters in regard of certain system
Other data issues	Data quality and validity (information or guidance)	MCA-data (weights) were gained by experts and ranking based on questionnaires , CBA-data based on literature and own calculations
	Data management	
	Presentation of summary output data / results	Graphs and tables for the different rankings in regard of different policy scenarios
Relevant items for FOT	FOT explicitly addressed: yes/no	No
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	No
	Problems encountered	No
Additional comments	MCA more relevant for stakeholder analysis or deployment strategies.	

Name of the study /project/guideline	HEATCO
Full title (if applicable)	Developing Harmonised European Approaches for Transport Costing and Project Assessment
Relevant deliverable	D5: Proposal for Harmonised Guidelines
Publication Year	2006
Partners	IER, BUTE, COWI, SWECO, Ecoplan, EIT, Herry, ISIS, ITS, NTUA, Sudop, TNO, UBath, VTI
Funded by/prepared for	EU-FP6
Project Reference	HEATCO
Web address	http://heatco.ier.uni-stuttgart.de/

Methodology - general	Main focus: e.g. methodological development, application study	Harmonised European approach for CBA for TEN-T projects (transnational infrastructures)
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Cost-benefit analysis, not related to FOTs, but useful as a reference guide to CBA's

	Client and type of client	European Commission
	Verification of methodology by case studies (if applicable): yes/no	Yes, three case studies have been carried out, in the UK, Denmark and Greece
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	HEATCO contains recommendations, methods and key values for the assessment of impacts of transnational projects (TEN-T): - general issues (discount rate, time horizon, decision criteria, indirect economical effects, etc.) - effects on travel time and congestion - effects on traffic safety - effects on environment (air pollution, noise, global warming, etc.) - direct and indirect costs of infrastructure investments - vehicle operating costs The key values are available for each member state in the EU25, in most cases.
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Sensitivity analysis is recommended to be part of every CBA.

Input data - system specific data	
	Data 1
(a) Short description of data needed	no system specific data, because HEATCO does not aim to assess the effects of vehicle systems
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)		
(b)		
(c)		
(d)		
(e)		
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	Values of time and congestion
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	When using money values, HEATCO presses on using present values (discounting)
(c) Sources / Collection method	Transport models and calculation values as suggested in the report
(d) Step in Method where data is used	

(e) Any other relevant information (e.g. availability; geographical scope ...)		
	Data 2	*Data 3*
(a)	Environmental costs	Cost and indirect costs of infrastructure investment
(b)	When using money values, HEATCO presses on using present values (discounting).	
(c)	Transport models, transport emission models and calculation values as suggested in the report.	Expert judgement, and calculation values as suggested in the report (lifetimes, expenditure uplift).
(d)		
(e)	Some of this information is not quantitative, HEATCO contains suggestions how to handle qualitative and non-monetary values in a CBA.	
	Data 4	*Data 5*
(a)	Vehicle operating costs	Value of changes of accident risks
(b)		
(c)	Expert judgement	Transport models and calculation values as suggested in the report.
(d)		
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation	CBA, using inputs from other sources and methods, like traffic flow impacts, transport demand predictions, transport emission models, regional economic evaluations, etc.
	Traffic Flow Impacts estimation	
	System Costs estimation	
	Market Penetration forecasts	
	Scaling up to network level	
	Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation	
	Emissions cost estimation	
	CBA	
	Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	

Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Net present value Benefit cost ratio Effects on GDP and employment Accessibility indicators, accident risk changes Environmental impacts: emission effects, global warming, noise impacts

Other data issues	Data quality and validity (information or guidance)	
	Data management	
	Presentation of summary output data / results	

Relevant items for FOT	FOT explicitly addressed: yes/no	No

	Findings relevant for / applicable to FOT, e.g. scaling up procedure	HEATCO gives guidelines how to apply a proper CBA, more or less prescribed by EC
	Problems encountered	

Additional comments	

Name of the study /project/guideline	RAILPAG Railway Project Appraisal Guidelines
Full title (if applicable)	"
Relevant deliverable	"
Publication Year	2005
Partners	European Commission; European Investment Bank (EIB)
Funded by/prepared for	European Commission; European Investment Bank (EIB)
Project Reference	'RAILPAG'
Web address	http://www.railpag.com/

Methodology - general	Main focus: e.g. methodological development, application study	Appraisal guidance.
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Socio-economic impact (CBA) for whole society, and for stakeholders (using an 'SE Matrix').
	Client and type of client	Type: EIB is an International Financial Institution (IFI), similar to The World Bank.
	Verification of methodology by case studies (if applicable): yes/no	Yes – 10 case studies given (http://www.railpag.com/index.php?mod=cstudy&act=view).
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Do-Minimum scenario versus with-project scenario.
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Financial analysis. Simple indicators for non-monetised impacts (colour-coded green for mild effects; yellow for moderate; and red for those which may have significant weight in the decision).

Input data - system specific data	
	Data 1
(a) Short description of data needed	Multimodal passenger and freight flows, journey times, costs.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Forecast years suitable for the project's time horizon.
(c) Sources / Collection method	Demand and network supply models – passenger and freight.
(d) Step in Method where data is used	User Benefit estimation; Operating cost and revenue estimation.
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Project specific cost data: investment, operation	

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	and maintenance.	
(b)	Forecast years suitable for the project's time horizon.	
(c)	Engineering / feasibility study estimates.	
(d)	CBA; Financial Analysis.	
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	Cost-benefit values for time savings, safety, emissions, etc.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Suitable for the countries and markets involved, and the appraisal period / time horizon.
(c) Sources / Collection method	RAILPAG Appendix A for Safety and Emissions.
(d) Step in Method where data is used	User Benefit estimation; CBA
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Economic lifetimes of infrastructure elements.	
(b)		
(c)	RAILPAG Annex B	
(d)	CBA; Financial Analysis	
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	Investment costs.
		Maintenance and operating costs of the infrastructure.
		Vehicle operating costs.
		Journey times.
		Safety – "By convention, safety is treated separately from the other components of user benefits. Expected changes in accident rates for the different modes and alternatives are used to estimate economic benefits, multiplying them by the relevant unit values per accident and per casualty. These values consist of a part usually paid by users through insurance, which is thus internal to the transport system, and general expenditure from the public sector and suffering, which are externalities."
		Externalities, such as environmental externalities.

Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	ERR, NPV, B/C Ratio
		Stakeholder distribution of effects.

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Other data issues	Data quality and validity (information or guidance)	
	Data management	
	Presentation of summary output data / results	SE Matrix (appended below)

Relevant items for FOT	FOT explicitly addressed: yes/no	No.
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Yes – general framework for socio-economic assessment of rail projects.
	Problems encountered	Little detail on safety analysis.

Additional comments	

Name of the study /project/guideline	FUNDING
Full title (if applicable)	Funding Infrastructure: Guidelines for Europe – FUNDING
Relevant deliverable	Deliverable 3: Computing revenues from pricing and possible financing gaps
Publication Year	2007
Partners	Transport and Mobility Leuven; Katholieke Universiteit Leuven
Funded by/prepared for	European Commission
Project Reference	'FUNDING'
Web address	http://www.tmleuven.be/project/funding/FUNDING_D3%20final_01.pdf

Methodology - general	Main focus: e.g. methodological development, application study	Application: to compute the effects on revenue and welfare of different price mark-up scenarios to finance a TEN-T infrastructure fund.
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Welfare economics (CBA), modelling using TREMOVE.
	Client and type of client	European Commission
	Verification of methodology by case studies (if applicable): yes/no	Yes – method applied to multiple mark-up scenarios.
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Scenarios: subsidy and toll; subsidy and detailed toll; subsidy and detailed country-specific toll; subsidy and fuel tax. Moderate subsidy scenario / high subsidy scenario. Time horizon: 2020. Geographical scope: TEN-T network (linking EU25).
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	

Input data - system specific data	
	Data 1
(a) Short description of data needed	Not applied to safety systems.

(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	
(e) Any other relevant information (e.g. availability; geographical scope ...)	

Input data - generic data	
	Data 1
(a) Short description of data needed	Accident costs.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	External costs separated from total accident costs.
(c) Sources / Collection method	INFRAS/IWW (2000, *External costs and transport: Accident, environmental and* *congestion costs in Western Europe.* Zurich/Karlsruhe.
(d) Step in Method where data is used	Calculation of marginal external costs of transport per mode.
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Environmental costs.	Congestion costs.
(b)		
(c)	TREMOVE model, based on COPERT II for emissions estimation, EXTERNE for valuation.	TREMOVE model, based on speed-flow relationships from the SCENES model and the BPR functional form.
(d)	Calculation of marginal external costs of transport per mode.	Calculation of marginal external costs of transport per mode.
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation	Marginal external costs by mode and vehicle type, by time period, by geographical area.
	Traffic Flow Impacts estimation	Optimal toll levels estimated.
	System Costs estimation	
	Market Penetration forecasts	
	Scaling up to network level	
	Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation	
	Emissions cost estimation	
	CBA	
	Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	

Outputs	e.g. Snapshot Benefits and Costs	EU25 change in consumer surplus and producer surplus in year 2020.
	Net Present Value Benefit:Cost Ratio	Reduction in environmental costs by component by 2020.
	Financial rate of return Stakeholder acceptability incl. public	Change in tax revenues.
	GDP Employment change	
	Accessibility indicators	

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Other data issues	Data quality and validity (information or guidance)	
	Data management	
	Presentation of summary output data / results	
Relevant items for FOT	FOT explicitly addressed: yes/no	No.
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	External costs of accidents. Welfare economic framework, including funding considerations.
	Problems encountered	
Additional comments		

Name of the study /project/guideline	Transport Analysis Guidance (NATA) (www.webtag.org.uk)
Full title (if applicable)	Transport Analysis Guidance
Relevant deliverable	-
Publication Year	2003-2008
Partners	-
Funded by/prepared for	Department for Transport, London
Project Reference	'NATA'
Web address	www.webtag.org.uk

Methodology - general	Main focus: e.g. methodological development, application study	The Department for Transport's website for guidance on the conduct of transport studies. Contains top-level guidance, numerous detailed guidance documents, an archive of older material, and external links. Covers objective setting, option development, modelling and appraisal. The appraisal framework used in WebTAG is the 'New Approach to Appraisal' (NATA) developed in 1997 for the Roads Review (DETR, 1998) and since extended to other modes and applications. Reference: DETR (1998), *Understanding the New Approach to Appraisal.* London: DETR.
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	The appraisal framework is objective-led, and can be characterised as a multi-criteria framework. Criteria weights are not used, however. Instead the emphasis is on presenting a concise set of relevant information to the decision maker. Contains CBA elements - e.g. scheme costs; vehicle operating costs; revenues; safety benefits; other user benefits; noise costs; other emissions damage costs - which are presented in monetary terms as well as in physical units. Some impacts remain un-monetised, e.g. landscape and townscape; physical fitness; personal security (as distinct from accident risk). The 'New Approach to Appraisal' is the multi-criteria framework that brings all the analysis together.
	Client and type of client	Department for Transport. Type: central government department.
	Verification of methodology by case studies (if applicable): yes/no	Yes. AEAT *et al* (2004) examined the conduct and effectiveness of a series of major studies using the WebTAG/NATA methods, and found it generally satisfactory, indentified scope for improvements.

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		Reference: AEAT, ITS and John Bates Services (2004), *Evaluation of the Multi-Modal Study Process.* London: DfT.
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Do-something scenario represents the 'with project' state of the world; Do-minimum is a realistic 'without project' baseline - transport and demographic forecasting data is provided (TEMPRO) to help define the Do-minimum. Time horizon is flexible according to the expected economic life of the asset; in the case of long-lived infrastructure investment, recent changes to the advice have introduced a 60 year time horizon, and also a 3.5% discount rate, reduced from 6% (HMTreasury, 2003). Geographical scope is usually the UK, although devolved governments in Cardiff and Edinburgh have a remit to appraise impacts on Wales and Scotland respectively. Reference: HM Treasury (2003), *Green Book: Appraisal and Evaluation in Central Government'.* London: TSO.
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	The 'New Approach to Appraisal' does include consultation procedures as well as analysis, and does include financial appraisal as well as the multi-criteria framework results. The CBA elements of the framework are broken down by impact group (users (business and non-business), operators, and central and local government).

Input data - system specific data	
	Data 1
(a) Short description of data needed	Safety data: • for rail/air/shipping modes, estimates of accident numbers, and casualty numbers and severity, in the Do-Minimum and Do-Something scenarios; • for road safety, software also exists (COBA11) to predict accidents and casualties given road design and flows on the road (DfT,2006). Reference: DfT (2006), *Design Manual for Roads and Bridges Volume 13: The COBA Manual.* London: TSO.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Data must cover a sufficient time period to be able to interpolate/extrapolate credibly out to the time horizon - typically, at least two forecast years are used (one close to the opening year, another 10-15 years later).
(c) Sources / Collection method	Observed link/node accident data can be entered to override default data in COBA11. Collection method is not discussed.
(d) Step in Method where data is used	Throughout, but notably in Option Testing and Appraisal (see appended Figure 'The Study Process') – under the 'Safety' objective.
(e) Any other relevant information (e.g. availability; geographical scope ...)	Not discussed in the guidance.

	Data 2	*Data 3*
(a)	Other data: • a very wide range of data is needed on flows, times and costs across the network on all relevant modes - see WebTAG; • environmental assessment creates further data needs, e.g. properties exposed, pollution concentrations, land take; • economic analysis - wider economic benefits require regional GDP data; • social impacts - elements of WebTAG focus on the impacts on the young, old, disabled and deprived communities, and on the distributional impacts of projects - consequently scheme specific data on the impacted groups and areas is needed.	
(b)	Data must cover a sufficient time period to be able to	

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	interpolate/extrapolate credibly out to the time horizon - typically, at least two forecast years are used (one close to the opening year, another 10-15 years later).	
(c)	Various - see WebTAG.	
(d)	Throughout.	
(e)	Various - see WebTAG.	

Input data - generic data	
	Data 1
(a) Short description of data needed	Values for accident prevention
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Values per accident and per casualty, by casualty severity, by user class, by road type (for road accidents). A formula is provided to derive forecast values for future years (from 2005).
(c) Sources / Collection method	Values collated in DfT (2005), *Highways Economics Note 1*. Casualty values are based on Willingness to Pay - for methodology see Hopkin and Simpson (1995). Other costs (material damage, police and emergency services, healthcare, insurance administration, lost output) are based on a range of data.
(d) Step in Method where data is used	Option Testing and Appraisal - under the Safety Objective (typically at the Plan stage, when the intervention is being investigated in detail).
(e) Any other relevant information (e.g. availability; geographical scope ...)	Values are applied uniformly across the UK.

	Data 2	*Data 3*
(a)	Accident rates per road type, by traffic flow and vehicle mix.	Other data – a very wide and deep set of economic, environmental and social data is required in order to conduct a NATA appraisal. Indeed, the level of detail has sometimes been seen as problematic when appraising strategies as opposed to detailed plans (AEAT *et al*, 2004). Notable generic data items include: • values of travel time savings and vehicle operating cost formulae; • values for reductions in noise exposure; • agglomeration elasticities (for wider economic benefits).
(b)	-	-
(c)	Incorporated in the COBA11 software - DfT (2006), *Design Manual for Roads and Bridges Volume 13: The COBA Manual.*	WebTAG Units 3.5.6 and 3.3.4; ....
(d)	Throughout, but notably in Option Testing and Appraisal (see appended Figure 'The Study Process') - under the 'Safety' objective.	Option Testing and Appraisal (see appended Figure 'The Study Process').
(e)	-	
	Data 4	*Data 5*
(a)	Discount rate.	
(b)	-	
(c)	HM Treasury (2003).	
(d)	Option Testing and Appraisal (see appended Figure 'The Study Process').	
(e)	Standard social rate of discount = 3.5% per annum, falling to 3.0% after 30 years.	

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts	See figure appended: 'The Study Process'. Option Testing and Appraisal stage includes estimation of: traffic flow impacts; safety impacts; system costs; travel

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	estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	time, vehicle operating cost and reliability impacts; impacts on emissions; wider economic benefits. The results are presented using the NATA framework. Consultation is conducted alongside the analysis. Distributional and financial analyses are conducted.
Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Impact on the 5 NATA objectives (environment, safety, economy, accessibility, integration). Benefits and costs (where monetised). Benefit:cost ratio (partial). Financial NPV and annual cash flow. GDP and employment change. Distributional analysis.
Other data issues	Data quality and validity (information or guidance)	Guidance indicates that the data should be of sufficient quality to produce robust results.
	Data management	TUBA software carries out matrix-based user benefit estimation (and can store and present some other cost items and overall CBA results). Excel worksheets are provided to automate some calculations and store data, e.g. noise annoyance and valuation.
	Presentation of summary output data / results	Appraisal Summary Table is a standard format for the appraisal results. The full analysis on environmental impact, safety, economy, etc, lies behind the Appraisal Summary Table and is usually available to the decision maker on request. Standard tables also exist for the CBA (Transport Economic Efficiency Analysis) and financial sustainability results.
Relevant items for FOT	FOT explicitly addressed: yes/no	No.
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	The OD matrix based user benefit analysis (incorporated in TUBA and other proprietary software) is a useful tool for scaling up to the whole network level, particularly relevant for interventions which change the pattern of travel behaviour on the network.
	Problems encountered	One identified limitation of the WebTAG/NATA method (AEAT *et al,* 2004) is its reliance on network models to generate full user benefit results. This imposes a large fixed cost of analysis on any appraisal – except in those cases where a suitable model of the relevant network is maintained by the network authority and can be easily run to test the intervention being appraised.
Additional comments		

Name of the study /project/guideline	Full Traffic
Full title (if applicable)	Full Traffic – WP Dataloggers & WP Verkeersimpact
Relevant deliverable	
Publication Year	2008
Partners	Technische Universiteit Delft, Faculteit Civiele Techniek en Geowetenschappen, Afdeling Transport & Planning
Funded by/prepared for	
Project Reference	
Web address	

Methodology - general	Main focus: e.g. methodological development, application study	Carry out an objective analysis of the effects of driving with ACC and LDW on the individual driving behavior and on the general traffic flows.
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Based on a number of data collected during the FOT and, in some parts, on a simulation study, conclusions are drawn with respect to effects on driving behaviour, safety and fuel consumption/emissions. Most of the conclusions are done quite empirically.
	Client and type of client	-
	Verification of methodology by case studies (if applicable): yes/no	-
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	19 cars, equipped with both ACC and LDW, were used by experienced drivers (lease drivers) for a 5 month period. The first month counted as the reference month in which the systems were still disabled. Drivers could be localised after the FOT using GPS. They reached to almost the whole Netherlands during the FOT. Almost half of the time was spent in cities, whereas the other half was spent on the highways. The situation of the roads varied between congested (35%) to free-flow (46%).
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	-

Input data - system specific data	
	Data 1
(a) Short description of data needed	Collected data related to the vehicle-status and the ACC. Among these are speed, acceleration, speed-variation and ACC-status.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	Data collected during the FOT using a so-called CANbus.
(d) Step in Method where data is used	
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Collected data with the GPS. Among these are speed, speed limit, latitude/longitude and road type.	Collected data using the MobileEye such as headway/distance/angle to the predecessor, blinking light on/off, lateral position and lane width.
(b)		

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(c)	Data collected during the FOT using the GPS.	Data collected during the FOT using the MobileEye.
(d)		
(e)		
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)		
(b)		
(c)		
(d)		
(e)		
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	1) **Effects on driving behaviour**: Based on data such as the headway, acceleration, lane changing behaviour statements are made on the change in the overall driving behaviour when using the ITS systems.
		2) **Effects on throughput**: Statements are made by simply looking at some of the previously shown effects on driving behaviour as well as on studies done with simulation programs.
		3) **Effects on safety**: Again, some statements are made on the effects on the safety by simply looking at data such as the acceleration (hard braking moments), headway times and the usage of the blinking lights.
		4) **Effects on fuel consumption and emission**: Using a model from the literature, they've examined the fuel consumption (and related emission) calculated by data such as the speed and variation.

Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	1) **Effects on driving behaviour**: - 2) **Effects on throughput**: - 3) **Effects on safety**: - 4) **Effects on fuel consumption and emission**: -
Other data issues	Data quality and validity (information or guidance)	
	Data management	
	Presentation of summary output data / results	
Relevant items for FOT	FOT explicitly addressed: yes/no	
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Scaling up: Use of micro simulation.
	Problems encountered	
Additional comments		

Name of the study /project/guideline	TAC Safe Car Project
Full title (if applicable)	On-Road Evaluation of Intelligent Speed Adaptation, Following Distance Warning and Seatbelt Reminder Systems
Relevant deliverable	Final Report (Volume 1) and Appendices (Volume 2)
Publication Year	2006
Partners	Monash University Accident Research Centre Report authors Michael A. Regan *et al.*
Funded by/prepared for	Victorian Transport Accident Commission (TAC), Ford Motor Company of Australia
Project Reference	'Australian FOT'
Web address	http://www.monash.edu.au/muarc/reports/muarc253.html

Methodology - general	Main focus: e.g. methodological development, application study	Application: on-road evaluation.
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	No CBA, MCA or CEA. Estimate of aggregate Australian accident cost savings, using a method from Fildes, Fitzharris, Koppel and Vulcan (2002), ***for SRS only.*** Analysis of impact on: • driving performance and safety

		• fuel consumption and $CO2/NOx/HC$ emissions • driver attitudes and acceptance. Reference: Fildes BN, Fitzharris M, Koppel S and Vulcan AP (2002), *Benefits of Seat Belt Reminder Systems.* Report CR211a. Canberra: ATSB.
	Client and type of client	Types: public safety body; automotive OEM.
	Verification of methodology by case studies (if applicable): yes/no	Yes – custom applications to ISA, FDW and SRS.
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Main scenarios are: ISA; ISA and FDW; SRS; technology as now. Time horizon not explicitly addressed. Fildes *et al* (2002) use both 15 and 25 year fleet lives, argue that 15 years and 5% discount rate most appropriate. Geographical scope: individual road user; except Australian aggregate cost savings for SRS only.
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Analyses as above.

Input data - system specific data	
	Data 1
(a) Short description of data needed	Driving speeds with and without ISA or ISA+FDW active.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	For speed zones from 50km/h to 100km/h. Mean, median, max, SD, 85^{th} percentile speeds gathered.
(c) Sources / Collection method	Observed in on-road trials (n=13). Automatic data logging by vehicles used in the trial.
(d) Step in Method where data is used	Crash reduction estimates.
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Headway time.	Time before buckling up; time spent buckled up.
(b)	Mean, min and SD.	
(c)	Observed in on-road trials (n=13). Automatic data logging by vehicles used in the trial.	Observed in on-road trials (n=13). Automatic data logging by vehicles used in the trial.
(d)	Crash reduction estimates.	Injury severity estimates.
(e)		
	Data 4	*Data 5*
(a)	Fuel purchases and matching odometer readings.	Attitudinal & acceptance data.
(b)		
(c)	Observed in on-road trials (n=13). Purchase data collected by subjects.	Questionnaires administered at various times throughout the study.
(d)	Estimation of fuel consumption and $CO2/NOx/HC$ emissions.	Analysis of driver attitudes and acceptance.
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	Injury cost data.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	By injury severity, crash type, seating positions.

(c) Sources / Collection method	Source: Fildes, Fitzharris, Koppel and Vulcan (2002). Various data: data on medical costs, loss of earnings, loss of quality of life.
(d) Step in Method where data is used	Safety benefit estimation.
(e) Any other relevant information (e.g. availability; geographical scope ...)	Australia.

	Data 2	*Data 3*
(a)	Accident numbers Australia-wide.	
(b)	1996 data, disaggregated by injury severity, etc.	
(c)	ATSB (2002), *Road crash statistics, 1996.*	
(d)	Base data for Australia-wide safety benefit estimation (SRS only).	
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	Crash reduction estimates for ISA and FDW use Nilsson's power method (2004). Reference: Nilsson (2004), *Traffic safety dimensions and the power model to describe the effect of speed on safety,* Bulletin 221. Lund, Sweden: Lund University.
		Cost savings from SRS use Fildes *et al*'s HARM method (2002).
		Fuel consumption and emissions estimated using the PKE (Positive Kinetic Energy) model provided by Prof Harry Watson at Melbourne University.
		Driver attitudes and acceptance: for methodology see Chapters 5&7 of the TAC Safe Care Project Final Report.

Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Crash reduction estimates for ISA and FDW: % reduction in number of fatal and serious crashes.
		Cost savings from SRS: approx $335million per annum at the Australia level, 1996 base.
		Fuel consumption (l/100km) before/during/after introduction of ISA/FDW/ISA+FDW vs control.
		CO2/NOx/HC emissions (g/km) before/during/after introduction of ISA/FDW/ISA+FDW vs control.
		Driver attitudes and acceptance: perceived usefulness; effectiveness; social acceptability; affordability; usability.

Other data issues	Data quality and validity (information or guidance)	Limited reflection on quality of data gathered – 'issue would/would not have affected data quality'. NASA RTLX scales used to measure workload, since these scales have high face validity. Validity of self-reported behaviour results not examined, although validity of simulator method was verified.
	Data management	Report (Volume 2) covers data logging parameters, and the database used to store responses to the feedback line.
	Presentation of summary output data / results	Text + tables. Customised for this application.

Relevant items for FOT	FOT explicitly addressed:	Yes

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	yes/no	
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Method used to derive Australian level accident cost saving estimates for SRS.
	Problems encountered	Australian level results not derived for ISA or FDW.

Additional comments	

Name of the study /project/guideline	Freightliner FOT
Full title (if applicable)	Evaluation of the Freightliner Intelligent Vehicle Initiative Field Operational Test
Relevant deliverable	Final report
Publication Year	2003
Partners	Battelle Memorial Institute (FOT partners: Freightliner, University of Michigan Transport Research Institute, Praxair)
Funded by/prepared for	U.S. Department Of Transportation
Project Reference	DTFH61-96-C-00077 Workorder 7718
Web address	n.a.

Methodology - general	Main focus: e.g. methodological development, application study	Application study, FOT of the Roll Advisor and Control (RA&C) system, truck application
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Cost-benefit analysis
	Client and type of client	U.S. Department Of Transportation
	Verification of methodology by case studies (if applicable): yes/no	Application study, see above
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	In total 24 scenarios (4*3*2), scenarios cover different deployment groups (HazMat tankers, all tankers, tractor trailers, all large trucks), different effectiveness of system to prevent rollover crashes and single vehicle road departure (SVRD) crashes (Baseline 20%/33%, worst case 20%/20%, best case 33%/33%) and different costs (traction control system excluded: only RA&C / TCS plus RA&C), 20 years period (2000-2019), United States
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Deployment issues, sensitivity implicitly tested

Input data - system specific data	
	Data 1
(a) Short description of data needed	System costs
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	One-time start-up: equipment and installation costs, driver training costs Recurring: equipment replacement costs, service life (10 years, BC calculation period is set to 20 years), ongoing driver and staff training
(c) Sources / Collection method	Manufacturer information (interviews and site visits)
(d) Step in Method where data is used	Calculation of system costs
(e) Any other relevant information (e.g. availability; geographical scope ...)	Maintenance costs recorded in the FOT are marginal and therefore negligible

	Data 2	*Data 3*
(a)	System description	Effectiveness in preventing crashes
(b)	Describe functionality, identify addressable accidents	
(c)	Technical experts description	Estimation based on FOT data
(d)	Calculation of safety benefits	Calculation of safety benefits
(e)	---	---
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Input data
- generic data

	Data 1
(a) Short description of data needed	Accident data
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Accident types (rollover crashes, SVRD crashes) for different vehicle types (HazMat tankers, all tankers, tractor trailers, all large trucks)
(c) Sources / Collection method	Statistical data (GES, FARS) 1995-2000
(d) Step in Method where data is used	Determining safety impact
(e) Any other relevant information (e.g. availability; geographical scope ...)	United States

	Data 2	*Data 3*
(a)	Cost unit rates for safety impact and indirect traffic impact appraisal	Discount rate
(b)	Fatality, incapacitation injury, non-incapacitation injury, property damage, hazardous materials impacts, traffic delays, 1999 US$	---
(c)	Pacific Institute for Research and Evaluation	Literature, guidelines (U.S. Office of Management and Budget)
(d)	Calculation of safety benefits	Calculation of system costs
(e)		4% (recommended by economists), 7% (recommended by OMB)
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation	Safety benefits resulting from different exposure (to driving conflicts) and prevention (once a driving conflict occurs)
	Traffic Flow Impacts estimation	No traffic flow impacts investigated, however traffic delays included in benefits
	System Costs estimation	See section on data
	Market Penetration forecasts	Market penetration not explicitly addressed because e of nationwide deployment (100%)
	Scaling up to network level	Scaling up is done but only safety effects are considered
	Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation	No accessibility / time / comfort / VOC esimation
	Emissions cost estimation	Emissions and CO2 not recorded
	CBA	CBA for 24 scenarios, 20 years period (2000-2019)
	Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	No further socio-economic analyses
Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Net present values for benefits and costs
		Benefit-cost ratios for 24 scenarios
Other data issues	Data quality and validity (information or guidance)	No activations of RSC during the FOT, benefits included in CBA are therefore limited to Roll Stability Advisory Representative road network in Great Lakes states
	Data management	
	Presentation of summary output data / results	Yes, in tables and figures
Relevant items for FOT	FOT explicitly addressed: yes/no	FOT with 23 drivers in four states, FOT data collection in the period from Sept. 2000 to Dec. 2001, evaluation period began already in fall 1999 (tool development)
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Scaling up of the safety benefits from Praxair fleet (average 5.8 rollovers per year in a fleet of 650 trucks) to national level (HazMat tankers, all tankers, tractor trailers, all large trucks), Scaling up is done with precaution (same effectiveness for all deployment groups assumed)
	Problems encountered	No activations of RSC during the FOT, benefits included in CBA are therefore limited to Roll Stability Advisory
Additional comments	Methodology and study design similar to Mack FOT	

Name of the study /project/guideline	Mack FOT
Full title (if applicable)	Evaluation of the Mack Intelligent Vehicle Initiative Field Operational Test
Relevant deliverable	Final report
Publication Year	2006
Partners	Battelle Memorial Institute (FOT partners: Mack trucks, McKenzie Tank Lines)
Funded by/prepared for	U.S. Department Of Transportation
Project Reference	DTFH61-96-C-00077 Workorder 7721
Web address	n.a.

Methodology - general	Main focus: e.g. methodological development, application study	Application study, FOT of the Lane Departure Warning system (LDWS), truck application
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Cost-benefit analysis
	Client and type of client	U.S. Department Of Transportation
	Verification of methodology by case studies (if applicable): yes/no	Application study, see above
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	In total 16 scenarios (4*2*2), scenarios cover different deployment groups (HazMat tankers, all tankers, tractor trailers, all large trucks), different effectiveness of system to prevent rollover crashes and single vehicle road departure (SVRD) crashes (Baseline 20%/33%, worst case 20%/20%, best case 33%/33%) and different costs (750/1,500 US$), 20 years period (2005-2024), United States
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Deployment issues, sensitivity implicitly tested

Input data - system specific data	
	Data 1
(a) Short description of data needed	System costs
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	One-time start-up: equipment and installation costs, driver training costs Recurring: equipment replacement costs, service life (5 years, BC calculation period is set to 20 years), ongoing driver and staff training
(c) Sources / Collection method	Manufacturer information (interviews and site visits)
(d) Step in Method where data is used	Calculation of system costs
(e) Any other relevant information (e.g. availability; geographical scope ...)	Maintenance costs recorded in the FOT are marginal and therefore negligible

	Data 2	*Data 3*
(a)	System description	Effectiveness in preventing crashes
(b)	Describe functionality, identify addressable accidents	
(c)	Technical experts description	Estimation based on FOT data
(d)	Calculation of safety benefits	Calculation of safety benefits
(e)	---	---
	Data 4	*Data 5*
(a)		
(b)		

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(c)		
(d)		
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	Accident data
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application	Accident types (rollover crashes, SVRD crashes) for different vehicle types (HazMat tankers, all tankers, tractor trailers, all large trucks)
(c) Sources / Collection method	Statistical data (GES, FARS) 1999-2003
(d) Step in Method where data is used	Determining safety impact
(e) Any other relevant information (e.g. availability; geographical scope ...)	United States

	Data 2	*Data 3*
(a)	Cost unit rates for safety impact and indirect traffic impact appraisal	Discount rate
(b)	Fatality, incapacitation injury, non-incapacitation injury, property damage, hazardous materials impacts, traffic delays, 2000 US$, inflated to 2005 US$ with consumer price index	---
(c)	Pacific Institute for Research and Evaluation	Literature, guidelines (U.S. Office of Management and Budget)
(d)	Calculation of safety benefits	Calculation of system costs
(e)		4% (recommended by economists), 7% (recommended by OMB)
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation	Safety benefits resulting from different exposure (to driving conflicts) and prevention (once a driving conflict occurs)
	Traffic Flow Impacts estimation	No traffic flow impacts investigated, however traffic delays included in benefits
	System Costs estimation	See section on data
	Market Penetration forecasts	Market penetration not explicitly addressed because e of nationwide deployment (100%)
	Scaling up to network level	Scaling up is done but only safety effects are considered
	Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation	No accessibility / time / comfort / VOC esimation
	Emissions cost estimation	Emissions and CO2 not recorded
	CBA	CBA for 16 scenarios, 20 years period (2005-2024)
	Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	No further socio-economic analyses

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Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Net present values for benefits and costs Benefit-cost ratios for 16 scenarios
Other data issues	Data quality and validity (information or guidance)	Representative road network in Southeastern states
	Data management	
	Presentation of summary output data / results	Yes, in tables and figures
Relevant items for FOT	FOT explicitly addressed: yes/no	FOT with 22 drivers in Florida and neighbour states, FOT data collection over 12 months period
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Scaling up of the safety benefits from McKenzie Tanker fleet to national level (HazMat tankers, all tankers, tractor trailers, all large trucks), Scaling up is done with precaution (same effectiveness for all deployment groups assumed)
	Problems encountered	
Additional comments	Methodology and study design similar to Freightliner FOT	

Name of the study /project/guideline	**Evaluation of the Volvo Intelligent Vehicle Initiative (IVI) Field Operation Test (FOT)**	
Full title (if applicable)	Final report: Evaluation of the Volvo Intelligent Vehicle Initiative (IVI) Field Operation Test (FOT)	
Relevant deliverable	Volvo Trucks North America, Inc. (February 15, 2005). Volvo Trucks Field Operational Test: Evaluation of Advanced Safety Systems for Heavy Truck Tractors, Final report to U.S. Department of Transportation, Federal Highway Administration, Washington DC, Cooperative Agreement No. DTFH61-99-X-00102.	
Publication Year	2007	
Partners	FOT was conducted by Volvo Trucks North America Inc. and US Xpress Enterprises. Evaluated by Battelle and a team of subcontractors	
Funded by/prepared for	US Department of Transportation	
Project Reference		
Web address	http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14352.htm#TOC	
Methodology - general	Main focus: e.g. methodological development, application study	To determine the extent to which the intelligent vehicle safety systems (IVSS) can help drivers drive more safely and, thus, reduce the number of truck crashes, bodily injuries, and fatalities involving the subject vehicle population. IVSS is composed of the following three systems: - Collission Warning System (CWS) - Adaptive Cruise Control (ACC) - Advanced Braking Systems (AdvBS)
	Type of methodology: e.g. cost-benefit analysis, multi	The results of the FOT were extended to estimate the **safety benefits** to society if all similar vehicles and eventually all large

	criteria analysis, cost-effectiveness analysis	commercial vehicles operating in the U.S. were to be equipped with the technologies tested. The evaluation also assessed the benefits of these IVSS technologies in areas pertaining to other national ITS goals such as public mobility, efficiency and productivity, and environmental quality. A societal **benefit-cost analysis** was performed to determine if the costs to deploy, maintain, and operate these systems can be economically justified based on the total benefits to society. To asses the **driver acceptance**, driver perceptions of system performance and usefulness were also evaluated.
	Client and type of client	
	Verification of methodology by case studies (if applicable): yes/no	
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	

Input data - system specific data	
	Data 1
(a) Short description of data needed	**Engineering data** were collected **onboard** the tractors to evaluate the dynamic state of the vehicle (e.g., speed), the conditions in which the vehicle was driven (e.g., following a vehicle at highway speed), the location of the vehicle in the United States, the driver's actions (e.g., braking or turning), and the functions of technologies (e.g., alarm sounded by the VORAD® CWS).
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	Used in safety analysis
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	In an activity related to the Volvo IVI FOT, Battelle conducted a **survey** of drivers as a two-part interview process. The first survey (Phase I) focused on **driver expectations** for the new safety technologies installed on selected Volvo trucks, and the second survey (Phase II) focused on **driver experiences** using the technologies.	**Fleet operations records** are data originating with the fleet operator or the truck manufacturer. They include drivers' information, vehicle/driver tracking, maintenance/repair, and systems status/performance/operations.
(b)	The surveys involved contacting more than 300 drivers, approximately 200 of whom responded via computer-aided telephone interviewing. A total of 25 drivers took part in both Phase I and Phase II. The Phase I survey was conducted between October 22 and 27, 2001. The Phase II survey was conducted between March 29 and April 6, 2004.	
(c)		
(d)	Used in **driver acceptance assessment**.	Used in the **Benefit/Cost analysis**
(e)		
	Data 4	*Data 5*
(a)	As **inputs to the benefit-cost analysis**, the cost values for deploying and operating/maintaining the IVSS in the Volvo IVI FOT were determined through contacts with manufacturers and component suppliers. Other cost values, such as the dollar cost per crash and all of the cost	

	elements that feed into it (mobility, fatality, injury, lost productivity, etc.) were adapted from the Freightliner IVI FOT evaluation report, which in turn was based primarily on a review of the transportation economics literature.	
(b)		
(c)		
(d)	Used in the **benefit-cost analysis.**	
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	**Historical and FOT Crash/Incident Data:** This source included available databases on truck crashes and relevant incidents. Primary sources were public databases, such as the Fatality Analysis Reporting System (FARS) and the General Estimates System (GES), and reports of test vehicle crashes and incidents provided by US Xpress. The public databases were used in the safety benefit analysis to estimate the frequency and characteristics of relevant crashes without the IVSS technologies at a national level. The test fleet data were used to calibrate our models.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	**Annual rates** of crashes, injuries, and fatalities were based on averages for the **years 1999 through 2003**.
(c) Sources / Collection method	Historical population crash data came from the National Automotive Sampling System (NASS) General Estimates System (GES), and the corresponding fatality rates were derived from the Fatality Analysis Reporting System (FARS).
(d) Step in Method where data is used	*GES data* used in **safety analysis**.
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)		
(b)		
(c)		
(d)		
(e)		
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics,	**1) Safety analysis:** The applied safety analysis is all about a certain **Benefits equation**. As data input for this equation population statistics (GES) and the FOT data is used. The latter is applied using analytical models to calculate certain **prevention ratios** and **exposure ratios**. **Prevention ratios** are ratios of exposure to driving conflicts with and without an IVSS. Values of this ratio less than 1 indicate that an IVSS will reduce exposure to potential crash situations. **Prevention ratios** measure the efficacy of an IVSS at preventing crashes after a particular driving conflict has occurred. Again, if this ratio is less than 1, safety benefits can be inferred. A stepwise plan is introduced on how to collect and prepare specific data for these ratios. **2) Driver acceptance assessment**: Based on the data collected from surveys of the drivers on both expectations and experiences on the system.

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	Distribution, Financials, Acceptability, etc	**3) Benefit/Cost Analysis**: The BCA, as applied to the Volvo IVI FOT, is a public-sector evaluation tool that compares all of a project's benefits to society to all of the deployment and maintenance costs. Benefits and costs are restricted to industry revenue outlays, industry costs, and industry avoided costs.
Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	**1) Crash reduction rates**
		2) Findings are organized according to four research objectives that evaluated driver perceptions of (1) system usability (including training, ease of use, and understanding of the system), (2) impact on workload and stress, (3) impacts on driving, and (4) product quality.
		3) Benefit/Cost Ratios
Other data issues	Data quality and validity (information or guidance)	
	Data management	
	Presentation of summary output data / results	
Relevant items for FOT	FOT explicitly addressed: yes/no	
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	
	Problems encountered	
Additional comments		

Name of the study /project/guideline	Integrated Vehicle-Based Safety Systems (IVBSS)
Full title (if applicable)	"
Relevant deliverable	Integrated Vehicle-Based Safety Systems: First Annual Report
Publication Year	2007
Partners	University of Michigan Transportation Research Institute (UMTRI)
Funded by/prepared for	National Highway Traffic Safety Administration (NHTSA), USDoT
Project Reference	'IVBSS'

Web address	http://www.its.dot.gov/itsweb/ivbss/docs/IVBSS_FirstAnnualReport_FINAL_October2007.pdf

Methodology - general	Main focus: e.g. methodological development, application study	Application – 4 year program developing IVBSS (Nov '05 – Sept '09). Phase II includes a field operational test (FOT) (Nov '07 – Sept '09).
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Analysis of FOT data is programmed for 2009, methodology is not yet determined. The focus appears to be on driver performance and driver acceptance (as in the RDCW FOT). It is not clear there will be any impact assessment beyond these issues, and the approach to scaling-up/aggregation is not discussed.
	Client and type of client	Type: public safety body.
	Verification of methodology by case studies (if applicable): yes/no	Yes – IVBSS, in future.
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Main scenarios expected to be with/without IVBSS.
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	As above.

Input data - system specific data	
	Data 1
(a) Short description of data needed	Not yet known.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	
(e) Any other relevant information (e.g. availability; geographical scope ...)	

Input data - generic data	
	Data 1
(a) Short description of data needed	Not yet known.
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	
(e) Any other relevant information (e.g. availability; geographical scope ...)	

Methodology - inputs → outputs	e.g. Safety Impacts estimation	Not yet known.
	Traffic Flow Impacts estimation	
	System Costs estimation	
	Market Penetration forecasts	

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	Scaling up to network level	
	Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation	
	Emissions cost estimation	
	CBA	
	Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	
Outputs	e.g. Snapshot Benefits and Costs	Not yet known.
	Net Present Value	
	Benefit:Cost Ratio	
	Financial rate of return	
	Stakeholder acceptability incl. public	
	GDP	
	Employment change	
	Accessibility indicators	
Other data issues	Data quality and validity (information or guidance)	Not yet known.
	Data management	Arrangements for a new, networked data management system (DMAS) are described in Ch 7.
	Presentation of summary output data / results	Not yet known.
Relevant items for FOT	FOT explicitly addressed: yes/no	Yes – in future.
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Scaling up omitted.
	Problems encountered	
Additional comments	"The goal of the IVBSS program is to assess the safety benefits and driver acceptance associated with prototype integrated crash warning systems" (p1). This opens the possibility of benefit measurement or aggregate-level safety impact measurement, but suggests the analysis will be limited to safety impacts. Although from an earlier research programme, the IVBSS website (http://www.its.dot.gov/itsweb/ivbss/ivbss_pubs.htm) also contains a relevant paper by the NHTSA Benefits Working Group (1996). We have reviewed this – see separate pro-forma.	

Name of the study /project/guideline	Road Departure Crash Warning System Field Operational Test (RDCW FOT)
Full title (if applicable)	"
Relevant deliverable	Road Departure Crash Warning System Field Operational Test: Methodology and Results Volume 1: Technical Report and Volume 2: Appendices
Publication Year	2006
Partners	University of Michigan Transportation Research Institute (UMTRI), Visteon Corporation, AssistWare Technology Inc
Funded by/prepared for	National Highway Traffic Safety Administration (NHTSA), Washington DC
Project Reference	'RDCW FOT'
Web address	http://deepblue.lib.umich.edu/bitstream/2027.42/49242/1/99788.pdf http://deepblue.lib.umich.edu/bitstream/2027.42/49242/1/99789.pdf

Methodology - general	Main focus: e.g. methodological development, application study	Application: field operational test.
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	No CBA, MCA or CEA. Analysis of impact driver behaviour, perceived usefulness, willingness to purchase. No aggregation (to local, regional or national levels).
	Client and type of client	Type: public safety body.
	Verification of methodology by case studies (if applicable): yes/no	Yes – applied to LDW (lateral drift warning), CSW (curve speed warning) and integrated LDW/CSW systems.
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Main scenarios are with/without systems in place.
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Analyses as above.

Input data - system specific data	
	Data 1
(a) Short description of data needed	Objective data on driver behaviour: response to LDW alerts and lateral acceleration through curves (with/without CSW).
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	Automatic on-vehicle collection.
(d) Step in Method where data is used	Analysis of impact on driver behaviour.
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Subjective data on driver perceptions: Van der Laan scale of acceptance; perceived usefulness (utility) of systems; synopsis of focus group views.	
(b)		
(c)	Questionnaires; focus group.	
(d)	Questionnaires throughout the study. Focus group after debriefing at end of study.	
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	[No aggregation, hence this type of data not used].
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	
(e) Any other relevant information (e.g. availability; geographical scope ...)	

Methodology	e.g. Safety Impacts	Analysis of impact on driver behaviour, by observing the difference in patterns of behaviour between week 1 of the FOT

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- inputs → outputs	estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	(no systems) and weeks 2-4 (systems in place). Analysis of perceived usefulness, willingness to purchase, using statistical analysis of questionnaire responses on 1-7 or 1-5 scales.
Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Lane-keeping measures with/without systems in place. Rate of alerts per 100km. Usefulness (utility) ratings on 1-5 scale, for different systems and user characteristics. Willingness to purchase on 1-7 scale, for different systems and user characteristics.
Other data issues	Data quality and validity (information or guidance)	Invalidated drivers (9/87) excluded; and some trips invalid and excluded (see Ch 5). Rate of successful data collection = 97% of all miles travelled. Focus group evidence captured on video and by a court stenographer. Completeness of data is considered (§5.1.3,5.2.2).
	Data management	Data Archive is described in Chapter 5 of the report.
	Presentation of summary output data / results	Custom: text and tables.
Relevant items for FOT	FOT explicitly addressed: yes/no	Yes.
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Method may be more transferable than findings.
	Problems encountered	Scaling up procedure omitted.
Additional comments		

Name of the study /project/guideline	Evaluation of an Automotive Rear-End Collision Avoidance System
Full title (if applicable)	Evaluation of an Automotive Rear-End Collision Avoidance System
Relevant deliverable	Automotive Collision Avoidance System Field Operational Test Report: Methodology and Results

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Publication Year	2006
Partners	
Funded by/prepared for	U.S. Department of Transportation; National Highway Traffic Safety Administration
Project Reference	
Web address	

Methodology - general	Main focus: e.g. methodological development, application study	The ACAS integrates forward collision warning (FCW) and adaptive cruise control (ACC) functions for light-vehicle applications. The FCW detects, assesses, and alerts the driver of a potential hazard in the forward region of the vehicle. The ACC provides automatic brake and throttle actuation in order to maintain speed and longitudinal headway control. Goals of the independent evaluation of the ACAS FOT were: 1. to characterize ACAS performance and capability 2. achieve a detailed understanding of the ACAS safety benefits 3. to determine the driver acceptance of ACAS
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	
	Client and type of client	
	Verification of methodology by case studies (if applicable): yes/no	
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	

Input data - system specific data	
	Data 1
(a) Short description of data needed	Objective data from the FOT, amongst others: - general characteristics of crash-imminent alerts - analysis of moving in-path target alerts - driver response to imminent alerts - driver inattention during crash-imminent alerts
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	Used in the performance/capability test
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Subjective data from the FOT, amongst others: - Missing and false targets - timing of FCW auditory alert - ACC auto brake response timing	Objective data from a system characterisation test conducted by an independent evaluator, amongst others: - late detection - out-of-path target rejection - ACC response time
(b)		

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(c)		
(d)	Used in the performance/capability test	Used in the performance/capability test
(e)		
	Data 3	*Data 4*
(a)	Objective crash data from the FOT including: - exposure and response to driving conflicts - involvement in severe near-crashes - unintended consequences Also the video data around these near-crash/conflict moments.	Subjective data based on driver surveys on amongst others: - ease of use - ease of learning - advocacy - perceived value - the HUD - driver performance As well as data on the demographic characteristics of the drivers.
(b)		
(c)		
(d)	Used in the safety analysis	Used in the statistical analysis in the driver acceptance determination
(e)		
	Data 5	*Data 6*
(a)	Operational data from the FOT Data Acquisition System on for things like: - characterized travel behaviour - alerts	
(b)		
(c)		
(d)	Used in the statistical analysis in the driver acceptance determination	
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	
(c) Sources / Collection method	
(d) Step in Method where data is used	
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)		
(b)		
(c)		
(d)		
(e)		
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

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Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	1) **Determining the ACAS capability**: Simple straightforward analysis of the above mentioned data on a number of topics: i. Sensor suite: characterize the performance of the forward-looking sensor in rejecting out-of-path targets and detecting closest in-path targets ii. Alert logic: examine the performance of the warning logic in alerting the driver to driving conflicts that might lead to rear-end crashes. iii. Automatic controls: assess the ability of ACC to maintain a pre-set longitudinal distance to the predecessor iv. Driver-Vehicle Interface: to review the system's capability of properly convey the visual and audible information to the driver
		2) **Determine ACAS safety benefits**: This assessment was performed in three areas: i. Driving conflict analysis: Using a general approach for estimating the safety benefits of a crash avoidance system is used to express these in terms of the number of rear-end crashes that might be avoided. ii. Near-crash analysis: Examination of the driver's exposure and response to severe near-crashes. iii. ACAS Driver impact analysis: Analysis driver performances by means of identifying positive and unintended negative effects of the system.
		3) **Determine driver acceptance**: Statements and overviews on everything around this topic were derived from the data using statistical analysis. This varied from using simple frequency response distributions and descriptive statistics, to applying Spearman's Rho test for means of confirming inter-relatedness of relevant survey items within themes (e.g. ease of use/learning). Also multivariate analysis of variance was used to determine if statistical differences existed between groups based on demographic characteristics (e.g. gender, age). Where normality was not assumed, they also applied Kruskal-Wallis tests.
Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	1) **Determining the ACAS capability**: Some statements on the mentioned topics from above.
		2) **Determine ACAS safety benefits:** i. Driving conflict analysis: Number of rear-end crashes that the system might prevent. ii. Near-crash analysis: Number of severe rear-end crashes that might be avoided. iii. ACAS Driver impact analysis: Statements on consequences of the ACAS on travel speed, time headway, lane position, distraction, and eyes-off road.
		3) **Determine driver acceptance**: Several diagrams and concluding statements are made on this topic based on the extensive statistical analysis.
Other data issues	Data quality and validity (information or guidance)	
	Data management	
	Presentation of summary output data / results	
Relevant items for FOT	FOT explicitly addressed:	

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	yes/no	
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	
	Problems encountered	

Additional comments	

Name of the study /project/guideline	Evaluation of the Intelligent Cruise Control System (ICCS)
Full title (if applicable)	Evaluation of the Intelligent Cruise Control System, Volume I – Study Results, Final Version
Relevant deliverable	Volume I – Study Results
Publication Year	1999
Partners	U.S. Department Of Transportation, Research and Special Programs Administration, John A. Volpe National Transportation Systems Center Cambridge
Funded by/prepared for	U.S. Department Of Transportation, NHTSA
Project Reference	DOT-VNTSC-NHTSA-98-3, DOT HS 808 969
Web address	n.a.

Methodology - general	Main focus: e.g. methodological development, application study	Application study, FOT
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	Evaluation of safety effects of the ICC-systems, evaluation of ICC systems and vehicle performance, user acceptance of the ICC system, and system deployment issues
	Client and type of client	U.S. Department Of Transportation, NHTSA
	Verification of methodology by case studies (if applicable): yes/no	Yes: ICC
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	108 volunteers drive ten ICC-equipped Chrysler Concordes; time horizon is July 1996 till September 1997, geographical scope: Michigan
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	Performance analysis for ICC, user acceptance of ICC and willingness to pay for ICC, system deployment issues

Input data - system specific data	
	Data 1
(a) Short description of data needed	Video data from a forward-looking camera mounted on the vehicle
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	n.a.
(c) Sources / Collection method	n.a.
(d) Step in Method where data is used	Performance analysis (evaluate safety effects, traffic effects etc)
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Digital data on ICC system and vehicle performance (e.g. velocity etc)	Questionnaire

(b)	n.a.	n.a.
(c)	On-board data acquisition system	Questionnaire
(d)	Performance analysis (evaluate safety effects, traffic effects etc)	Evaluate user acceptance of ICC
(e)		
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	Standard traffic engineering analysis
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Valid functions
(c) Sources / Collection method	n.a.
(d) Step in Method where data is used	Determining traffic effects
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Costs of ABS	
(b)	valid cost data	
(c)	n.a.	
(d)	Willingness to pay for ICC	
(e)		
	Data 4	*Data 5*
(a)		
(b)		
(c)		
(d)		
(e)		

Methodology - inputs → outputs	e.g. Safety Impacts estimation	Data of the headway, braking force and so on leads to safety effects on a qualitative level
	Traffic Flow Impacts estimation	Usage data had been acquired
	System Costs estimation	Data of acceleration levels leads to traffic effects on a qualitative level
	Market Penetration forecasts	Questionnaire for willingness-to pay
	Scaling up to network level	
	Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation	
	Emissions cost estimation	
	CBA	
	Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	

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Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	The traffic-relevant data should be published Willingness-to pay for ICC Only qualitative impacts
Other data issues	Data quality and validity (information or guidance)	Data is valid for states which are comparable to Michigan
	Data management	
	Presentation of summary output data / results	Yes
Relevant items for FOT	FOT explicitly addressed: yes/no	Yes
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Procedure is used to determine the fuel consumption and emissions, models are not transparent
	Problems encountered	n.a.
Additional comments		

Name of the study /project/guideline	Preliminary Assessment of Crash Avoidance Systems Benefits (ACAS Benefits)
Full title (if applicable)	"
Relevant deliverable	"
Publication Year	1996
Partners	NHTSA Benefits Working Group
Funded by/prepared for	National Highway Traffic Safety Administration (NHTSA), USDoT
Project Reference	'CAS Benefits Study'
Web address	http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//4423.pdf

Methodology - general	Main focus: e.g. methodological development, application study	Application – CAS (has the same three components as IVBSS, i.e. systems to address rear end collision, single vehicle road departure, lane change/merge).
	Type of methodology: e.g. cost-benefit analysis, multi criteria analysis, cost-effectiveness analysis	CBA. Analysis of aggregate safety impact.
	Client and type of client	Type: public safety body.
	Verification of methodology by case studies (if applicable): yes/no	A task force of Federal staff and support contractors were used to "develop safety benefits estimation methodologies and apply them to [CAS]" using the best information available from the literature.
	Short description using keywords: e.g. use of scenarios, time horizon, geographical scope	Main scenarios are: without CAS; with rear-end only; with road departure only; with lane change/merge only; and with full CAS. CAS benefits are treated as the sum of the individual system benefits. Time horizon is expected life of vehicle (varies by vehicle

		type). Discount rates 2%,4%,7% tested. Geographical scope: USA.
	Complementary analyses: e.g. sensitivity tests, stakeholder analyses, financial analysis	No.

Input data - system specific data	
	Data 1
(a) Short description of data needed	Effectiveness rate (% of relevant crash type avoided).
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Data was drawn from a selection of the most current studies in 1996. Different data was used for each of the three systems. Common themes were: identification of crash scenarios or crash sub-types; causal factors associated with these scenarios/sub-types; estimated effect of CAS systems on the causal factors; implications for effectiveness rate.
(c) Sources / Collection method	Wide range of study data including simulator and field studies – see NHTSA Benefits Working Group (1996), Ch 3-5.
(d) Step in Method where data is used	Analysis of aggregate safety impact.
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	Assumptions: • Market penetration = 100% • Usage = 100% • Reliability of systems = 100% • Compliance = 100% • Apart from crashes avoided, impact on crash severity = 0 These simplifying assumptions could and probably should all be replaced by evidence in an FOT, but serve the purpose of a 'Preliminary Assessment' when clearly stated.	
(b)		
(c)		
(d)	Analysis of aggregate safety impact.	
(e)		

Input data - generic data	
	Data 1
(a) Short description of data needed	US level data on accident numbers and characteristics (including crash type and associated injuries).
(b) Any requirements on the nature of the data (e.g. level of detail, year of collection & application)	Most recent (1994 data used).
(c) Sources / Collection method	NHTSA General Estimates System (GES), 1994. Collected from police reports.
(d) Step in Method where data is used	Analysis of aggregate safety impact.
(e) Any other relevant information (e.g. availability; geographical scope ...)	

	Data 2	*Data 3*
(a)	US accident and injury costs	
(b)	By severity. 1994 costs.	
(c)	Blincoe LJ (1996), *The Economic Cost of Motor Vehicle*	

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	Crashes, 1994. NHTSA Technical Report, Publication Number DOT HS 808 425.	
(d)	CBA.	
(e)	Data includes 'direct' costs but not 'humane costs' of pain, grief and suffering derived using WTP.	

Methodology - inputs → outputs	e.g. Safety Impacts estimation Traffic Flow Impacts estimation System Costs estimation Market Penetration forecasts Scaling up to network level Accessibility/Time/Reliability/ Comfort/Vehicle Operating Cost estimation Emissions cost estimation CBA Stakeholder Analysis: Macroeconomics, Distribution, Financials, Acceptability, etc	Safety impact assessment – effectiveness rates applied to aggregate accident number data. Safety benefit analysis – money values for accident and injury costs are applied to aggregate safety impact. Cost-benefit analysis – estimates of system cost provided by the 'task force' are used to compare with benefits, both at a society level (annual and Net Present Value) and at the level of the individual car purchaser. Implications for the target production cost of the devices are drawn from the findings on potential benefits.
Outputs	e.g. Snapshot Benefits and Costs Net Present Value Benefit:Cost Ratio Financial rate of return Stakeholder acceptability incl. public GDP Employment change Accessibility indicators	Aggregate safety impact – numbers of each crash type reduced. Safety benefits – in $ annually and per vehicle lifetime. Cost-benefit analysis - $NPV and per individual vehicle.
Other data issues	Data quality and validity (information or guidance)	Validity of assumptions and data is discussed. This is a preliminary study, likely to be overtaken by future research.
	Data management	
	Presentation of summary output data / results	Simple tabular format.
Relevant items for FOT	FOT explicitly addressed: yes/no	Input data includes some field test data, but "a better estimation of the safety benefits… can be achieved as more relevant test data are gathered especially from long-term, large-fleet field operational tests" (pC-8).
	Findings relevant for / applicable to FOT, e.g. scaling up procedure	Scaling up procedure.
	Problems encountered	Assumptions needed on market penetration, usage, reliability, compliance, and impact on accident severity.
Additional comments		

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