



# Thematic Network

**ROad Safety and Environmental Benefit-Cost and Cost-Effectiveness  
Analysis for Use in Decision-Making**

## **Framework for the assessment of road safety measures**

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## Framework for the assessment of road safety measures

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# 1 Introduction

It is a challenge to develop effective measures for improving road safety – especially when resources are scarce and economic means are limited. Nevertheless, a major target for European policy as well for as for national, regional and local decision makers is to improve road safety significantly.

To improve road safety is not an end in itself – it is an urgent social task. In the year 2002 about 50.000<sup>1</sup> persons were killed in accidents on European roads. In general economic terms the economic loss is very great; for example in Germany it amounts to over 30 billion Euro per year.

In order to help meet this challenge, ROSEBUD was funded by the European Commission as a thematic network to support users at all levels of government (European Union, national, regional, local) with information about road safety related efficiency assessment solutions. To this end, ROSEBUD brought together researchers, policy makers, decision makers and other relevant stakeholders into a co-operative network.

The European Union has the objective of halving the number of deaths on European roads by 2010. To achieve this it will be necessary to implement a range of effective road safety measures to the fullest extent. Reliable knowledge about the effectiveness of road safety measures is a prerequisite for this task. Efficiency assessment is a vital tool which should help policy-makers to set more effective priorities for road safety measures, and hence lead to a considerable reduction of accidents.

This document is a manual for the assessment of road safety measures. The following pages will provide you with an overview of how the efficiency of road safety measures can be assessed, which methodological principles are important, which knowledge and data are needed and available, and which barriers may hinder the process. A few basic principles for analysts are described. Finally, a short demonstration course is provided for the dissemination of this information. This document deals specifically with road safety and does not apply to other aspects of transport projects .

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<sup>1</sup> In the EU25.

## **2 How road safety measures are assessed**

This Section sets out to describe in layman's terms how efficiency assessment tools can be used to improve road safety. Although many aspects of these tools are technical and experts normally use technical terms to discuss and apply them, the underlying aims and concepts are general and can be understood by anyone. Those who are entrusted by society to take decisions about which road safety measures to implement will then be able to see how these tools can assist them in their task. The tools will not carry out the task for them; they provide crucial information which will help them to take the best decision, subject of course to constraints such as the resources available to them.

Roads and road transport play a central role in Western societies. Most of the goods needed for everyday life are transported by road, and the current generation has far greater opportunities for travel in the course of work and leisure than earlier generations. These advantages have, however, come at a cost. In addition to the obvious costs of building roads and vehicles and providing fuel, there are various less obvious costs: human and environmental. We focus here on the costs to society that are the result of road accidents: the human pain, grief and suffering and the material costs.

These costs existed before the modern era of motor transport: for example, large numbers of people were killed and injured in the 19<sup>th</sup> century while riding horses, or run down by horse-drawn vehicles. These days, however, society does not accept these costs passively, but introduces measures that attempt to reduce the number of accidents - or ideally to eliminate them. These efforts have achieved great success in most European countries, with the number of fatal or serious accidents falling at a time when the volume of traffic has grown rapidly. Nevertheless, the level of risk on the roads is still unacceptable, even in the safest countries, so much remains to be done to improve road safety.

Over the past decades, a large body of practical knowledge has been built up to show which measures are effective in which situations, and this helps greatly to develop new measures and programmes for improving road safety. The resources available, however, are rarely if ever sufficient to be able to do everything that is likely to reduce the number of accidents, so a decision must be made about which measures to implement.

This decision needs to take account of:

- the nature of the particular road safety problem being addressed
- the range of potential measures
- the resources available
- potential physical or political constraints

Each measure that is identified as being likely to address the particular problem is assessed in turn, taking account of:

- its predicted effects, including intended benefits such as casualty reductions but also potential drawbacks such as increased pollution or greater travel time
- possible variation of effects with the passage of time
- the costs of implementation

In the final stage of the assessment process, the benefits and costs of the alternative measures are compared. The alternatives are then ranked according to the ratio of benefits to costs, and the most highly ranked effective measure can be selected. This selection offers the highest overall level of benefit relative to the costs of implementation, and ensures that the available resources are used in the most effective manner.

The two main methods used to assess road safety measures are:

Cost Effectiveness Analysis (CEA)

Cost Benefit Analysis (CBA)

Full details of both methods are presented in Section 3, with information about how to choose the more appropriate when assessing a particular measure.

In the case of larger-scale measures, efficiency assessment can play an important part in developing the measure. Planning often takes many months if not years, and during this time information can be refined or new options can become available. Once the basic assessment framework has been established, the calculations can be readily updated and the implications assessed.

The problems being addressed in this report relate to road safety, so the estimation of the reduction of accidents and casualties that will be achieved by a particular measure is a crucial stage in the assessment. Road accidents are unpredictable events, so how can these benefits be predicted with any confidence? While it is true that individual accidents cannot be predicted, these are not random events and

research has identified various factors which make an accident more or less likely to occur. This makes it possible to predict how the existing pattern of accidents would change if a new measure were to be introduced. Nevertheless, it is important to monitor the new pattern of accidents after a measure has been introduced in order to check the accuracy of the prediction.

The use of the structured decision making process outlined above has many advantages:

- it is transparent: this is likely to increase public acceptance since the various stages in the process are documented and can be defended against criticism,
- it is comprehensive: all effects that may be predicted are brought together in a single framework,
- it is in accordance with the principles adopted by national Governments to ensure the best use of public money,
- the assessments can incorporate the best available knowledge about the effects of road safety measures
- the assessments incorporate public preferences: they include, for example, the results of surveys which have investigated the public's willingness to pay for improved road safety.

## 3 Efficiency assessment methodology

### 3.1 Introduction

Decision makers and politicians face many difficulties when deciding upon the implementation of road safety measures. They are obliged to choose those measures from a variety of measures that fit *best* in a certain situation, but it is not clear how the term 'best' should be defined. It is possible that those measures should be applied that entail the lowest costs. But success might also be gained if more expensive measures are implemented that have greater road safety benefits.

It is not enough to look on a measure's costs *or* on its benefits when deciding about its implementation. Both, costs and benefits, need to be jointly assessed and balanced against each other.<sup>2</sup> This ensures that the selection of road safety measures will follow principles of efficiency. The purpose of efficiency assessment is to provide information which supports this selection.

ROSEBUD will deal mainly with two closely related methods for efficiency assessment: cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA). Both represent economic evaluations of alternative resource use and measure costs in the same way. They differ in the analytical questions that can be answered. Within the CBA, all relevant costs and benefits are measured in monetary terms. On the other hand, costs are also measured in monetary terms within the CEA but benefits are expressed in non-monetary terms (e.g. number of saved lives). While the CBA can be used to assess the absolute efficiency of a measure (by monetizing all costs and benefits), the CEA can only be used to ascertain the effectiveness of a measure in accomplishing a particular objective (e.g. reduce the number of road accidents). In the following Sections the two methods will be presented and their differences and common features will be described.

### 3.2 Cost Effectiveness Analysis

Within a CEA two or more road safety measures can be screened and ranked according to their costs and effectiveness in accomplishing a particular objective (e.g. reduction of accidents). The combination of effectiveness and costs, helps the decision maker to ascertain

- o which measure provides a given level of effectiveness at the lowest cost or
- o which program provides the highest level of effectiveness for a given total cost.

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<sup>2</sup> A situation can be imagined where the road safety effects of a measure are 50 percent higher than the effects of the alternative, but triple costs will occur for the "more effective" investment. In such a case, the effectiveness in road safety per unit of implementation cost is twice as high for the "less effective" measure.

Unlike the CBA, the CEA expresses the benefits in physical impacts (e.g. reduction of accidents) rather than in monetary terms. Therefore the CEA will often be used in situations where

- o the efforts required to conduct a CBA (collection and editing of data etc.) will not be justified by the benefits that might be expected from implementing a measure,
- o the monetization of benefits will cause difficulties or is not possible,
- o a single objective will be pursued with the implementation of a measure (e.g. reduction of accidents) and it is not necessary or not sensible to assess other benefits as is done within a CBA.

### **Assessing Effectiveness**

To assess the effectiveness of a road safety measure, the goal of the measure has first to be defined and a means of quantifying its success has to be specified (e.g. reduction of accident severity, or reduction in the number of motorcycle accidents). An explicit definition is important to assure that the alternatives are assessed according to their success in achieving the objectives.

The measures' impacts on this pre-defined objective have to be appraised (in physical terms). Statements have to be made e.g. about the number accidents that can be avoided by implementing the measures. The estimated total impact of each measure are then compared with its costs.

The total impacts are expressed per unit of implementation cost, i.e. the number of accidents that can be avoided per unit of implementation cost is estimated. This allows the non-monetary benefits to be compared with the monetary costs.

### **Cost Estimation**

Besides the actual costs of implementing a measure, the total project costs include the costs of operation and maintenance that will occur at a later stage of the project. The total costs of the road safety measures have to be estimated.

To make future costs and present costs comparable, future costs have to be discounted to a chosen base year (e.g. present time basis) or the total project investments have to be converted to annual costs<sup>3</sup>. This ensures that the implementation costs for all safety measures will be compared with a common basis and that differences in the duration of the measures will not affect the comparison.

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<sup>3</sup> The costs (and benefits) have to be calculated and estimated for the whole lifespan of a measure. The correct determination of a measure's lifespan is very important for the quality of the evaluation results. The lifespan generally is determined by the economic life.

## Combining cost and impacts

When both the costs and the impacts of road safety measures have been estimated, they can be combined to express the cost-effectiveness of a project.<sup>4</sup> Within the CEA the cost-effectiveness is expressed with the cost-effectiveness ratio (CER). The cost-effectiveness ratio of a measure is obtained by dividing its effectiveness (E) by its costs (C):

$$\text{CER} = E/C$$

It is interpreted as the units of effectiveness that are obtained for each unit of cost that is incurred (e.g. in Euro). The higher the ratio the more effective is a safety measure.

The CER has to be calculated for every measure in the selection. A comparison between ratios of various measures can be done to ascertain the *relative* efficiency of the measures in the selection. The measures can be ranked according to their contribution to the achievement of the pre-defined objective. But, unlike a CBA, a CEA cannot ascertain whether a project should be undertaken or not. There are no well-defined thresholds that indicate when a measure becomes inefficient. Therefore, within a CEA the *absolute* efficiency of a measure (e.g. the benefits of a measure exceed its costs) cannot be estimated. This can only be done within a CBA.

Even if a CEA cannot show whether a road safety project is a worthwhile investment, there are several issues that might cause decision makers to prefer a CEA to other modes of assessment.

1. The CEA is much easier to calculate than the CBA. A road safety project's benefits can be measured in physical terms (like numbers of accidents). Within a CBA these benefits have to be transferred to economic values. Therefore the CEA can be calculated with less information (e.g. on crash costs, on mobility effects) than the CBA.
2. The CEA is an effective evaluation tool for screening and ranking alternative investment projects, but is less complex than other modes of economic assessment (less time consuming, reduced data needs). This makes a CEA applicable for the economic assessment of smaller investments or local road safety measures.
3. A CEA can be used for highlighting a measure's impacts on a pre-defined objective. Within a CEA the costs of a road safety measure will only be compared with its road safety impacts. A CBA, however, takes into account other macroeconomic impacts in addition to road safety (e.g. impacts on mobility and the environment). Therefore, the importance of safety aspects within the assessment is reduced relative to other impacts.

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<sup>4</sup> It has to be assured that the dimensions of costs and effectiveness are the same, i.e. if the costs are considered as annuities, the road safety impacts also have to be displayed in annual effects.

### 3.3 Cost Benefit Analysis

#### 3.3.1 Definition

The Cost-Benefit Analysis (CBA) aims to find whether a proposed objective is economically efficient and how efficient it is (and if alterations in the objective could make it more efficient). Various measures of efficiency are used to perform a CBA;:

- the *net present* value of the project;
- the *cost-benefit ratio*;
- the *internal rate of return*.

#### Net present value

The net present value of a project is defined as the difference between the monetary value of all the benefits of a specific intervention and the value off all the costs required to realize them. Different benefits are usually added to obtain total benefits while negative benefits (e.g. increased travel time) are subtracted.

The cost term usually describes the implementation costs of a measure, expressed in terms of the opportunity cost from a social point of view.

#### Cost-benefit ratio

It is defined as:

$$\text{Cost-benefit ratio} = \frac{\text{Present value of all benefits}}{\text{Present value of implementation costs}}$$

There is a simple definitional relationship between net present value and cost-benefit ratio: when the net present value is positive, the cost-benefit ratio is greater than 1.0; the bigger the ratio, the higher the benefits .

#### Internal rate of return

It is defined as the interest rate that makes the net present value equal to zero.

The internal rate of return is compared to some critical rate (e.g., a long-term market interest rate); if it is greater than this rate, then the project is 'good'.

The Cost-benefit analysis is particularly useful in those areas of policy making where:

- there are multiple policy objectives (e.g. safety, environment and mobility);
- some objectives are in conflict (which is well-known in the case of safety or environment versus mobility);
- the objectives refer to goods that do not have market prices (which actually is the case for aspects of safety, environment and mobility)

CBA is necessary if different levels of injury severity are to be considered.

### **3.3.2 General assessment frameworks**

In many countries frameworks have been developed to assess road infrastructure investments and very often, they also include the monetized impacts of new road infrastructure investments on road safety. Well known examples for these assessment tools are among others

- from Germany: “Bewertungsverfahren der Bundesverkehrswegeplanung” (BVWP), “Empfehlungen zur Wirtschaftlichkeitsuntersuchung von Straßen” (EWS-97, previous “Richtlinie zur Anlage von Straßen-Wirtschaftlichkeitsuntersuchungen” RAS-W) etc;
- from United Kingdom: Cost-benefit analysis for the economic appraisal of road schemes (COBA), Economic assessment of road schemes in Scotland (NESA) Guidance on the New Approach to Appraisal (GNATA)/Guidance on the Methodology for Multi-Modal Studies (GOMMMS) etc;
- from USA: Surface Transportation Efficiency Analysis Model (STEAM) etc.

The German BVWP is based on road network analysis modules containing e.g. traffic volumes, road lengths, road capacities etc. It considers base cases and improvement cases which are analysed by the models as a basis for the economic task of the cost-benefit-analysis. The traffic development in Germany is simulated and forecasted. Interdependencies between investment projects are considered, too.

The economic evaluation of road safety impacts for the cost-benefit analysis is based on the costs incurred as a result of road accidents. Avoiding such costs represents an economic benefit of a road infrastructure investment. In the assessment method of the German BVWP the accident costs calculated by the Federal Highway Research Institute BAST were applied. The calculation of the road safety benefits of a road infrastructure investment is based on the number of accidents, road type specific accident rates and cost figures for accidents and personal injuries. All statistical categories of accidents with personal injury and property damage only are included. The accident reduction potential is calculated as the difference between the

accident frequencies in the with- and the without-case. Subsequently, the reduction potential is monetized by applying the above mentioned cost figures.

**COBA** (Cost Benefit Analysis) is a computer cost-benefit analysis programme for the economic assessment of roads schemes in the United Kingdom. It is a part of the British Design Manual for Roads and Bridges. The COBA computer program is developed to compare the costs and benefits of a wide variety of road investments. It is normally required for a priority ranking of projects. The first step of the COBA appraisal is to define the alternative options which are to be appraised. These are the so-called “Do-Minimum”-base case and all “Do-Something”-alternatives. COBA is principally concerned with estimating the effect of a road related improvements on the users of the road system, including the costs of accident. As in other cost-benefit-tools the user or public costs are balanced against the construction and maintenance costs. A comparison is made between the costs before and after the improvement.

In Sweden cost-benefit-analysis is also one of the instruments to support decision-making in transport planning. The Swedish National Road Administration is applying the **EVA** model for cost-benefit-analyses in the planning process of the long-term transportation plan to balance and prioritise measures. EVA is a computer model in Swedish language. Calculations in EVA are based on official statistics and state road data base. Traffic safety is one of the valued components of the EVA tool, i.e. beside time values, vehicle and transport costs, environmental costs of emissions, maintenance and investment costs and comfort costs, accident costs are considered, too. Fatalities as well as different levels of injuries and property damages are monetized.

In the United States of America the Federal Highway Administration (FHWA) developed an enhanced version of its own Sketch Planning Analysis Spreadsheet Model (SPASM) called **STEAM** - Surface Transportation Efficiency Analysis Model. This model was developed in order to provide an analytical tool for estimating impacts of multi-modal transportation alternatives and cost-effectiveness evaluation of alternatives in a system planning context. The main objective of STEAM is to provide a framework for estimating impacts of multi-modal transportation alternatives and assessing their overall merits.

All these examples should demonstrate that assessment tools are already applied to calculate the social and economic efficiency of new road investments. Nevertheless, none of these tools are specialised on road safety related assessment. All these tools had been developed to assess new road investments considering a very large variety of relevant components. The effects of new road investments on road safety are included in this variety.

### 3.3.3 Performing CBA

The cost-benefit analysis of road safety measures can be structured as follows:

- Define units according to the road safety measure (e.g. accident types)
- Determine other parameters (e.g. duration of the measure, interest rates)
- Estimate effectiveness of relevant safety measure in terms of the number of (target) unit accidents it can be expected to prevent – per unit implementation of the measure, e.g., km/h speed reduction, hours of traffic control or money into campaign of a specific type<sup>5</sup>.
- Estimate additional effects of the measure on, e.g., noise or air pollution.
- Estimate the costs of implementation and maintenance of the measures.
- Investigate the monetary values of all relevant effects (e.g. fatalities and injuries, emissions, travel time, mobility, noise).
- Estimate the benefits of measures.
- Convert all costs and benefits to present time basis (or an annual basis) by discounting.
- Calculate the cost- benefit-ratio.
- Carry out additional analysis (sensitivity analysis or break-even-analysis).
- Report and present results.

One of the greatest problems in cost-benefit analysis is to obtain valid and reliable monetary valuations of all relevant impacts. This objective is rarely, if ever, fully realised. It is therefore often relevant to carry out a cost-effectiveness analysis in addition to, or instead of, a cost-benefit analysis.

Due to the difficulty of deriving monetary values of all the relevant impacts, it may be useful to divide the application of CBA for road safety measures into 'maxi-CBA' and 'mini-CBA'.

The maxi-CBA is to be understood as a complete analysis involving the best available inputs and estimates of costs and benefits. The mini-CBA, on the other hand, involves a simpler estimation of main costs and benefits<sup>6</sup>.

Average values can be used to perform a mini-CBA, both for effects and economic values; therefore it could be used to perform preliminary assessments of road safety measures when resources are not available for a full analysis.

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<sup>5</sup> It is also possible to define units of implementation, e.g. „one section of a road“, „one area“, „one vehicle“etc.

<sup>6</sup> But the safety effects and implementation and maintenance costs have always to be included.

A maxi-CBA, on the other hand, should be more of a state-of-the-art analysis: it will be more complete (covering all relevant effects) and the estimates of costs and effects will make use of all available information, taking into account all circumstances. This will be more time-consuming and costly than a mini-CBA. It would serve as confirmation after a measure has passed the first selection phase. Ideally, a maxi-CBA would be carried out for larger infrastructure and safety projects.

### **3.3.4 Valuation of impacts of road safety policies in CBA**

The most difficult part of a cost-benefit analysis is often to obtain theoretically correct and empirically valid and reliable monetary valuations of all relevant impacts. Literally hundreds of studies have been made to determine the value of goods that do not have market prices, like the reduction of environmental pollution and reduced accident risk.

The valuation of a non-marketed good should be based on the willingness-to-pay of the potential purchasers of the good. In order to estimate the willingness-to-pay for a non-marketed good (with no linkage to consumption of market goods), a hypothetical market is set up, in which people are asked to state their willingness-to-pay for a certain amount of the good, or choose between various options that provide different amounts of the good.

The results of a detailed survey of practice in estimating road crash costs in EU and other countries that was made by an international group of experts as part of the EU COST-research programme is briefly presented to illustrate describe the complexity of evaluate road crash costs in cost-benefit analysis,. The project report contained recommendations about the cost items that ought to be included in estimates of road crash costs and the methods for estimating the various cost items.

Five major cost items were identified:

- a. Medical costs
- b. Cost of lost productive capacity (lost output)
- c. Valuation of lost quality of life (loss of welfare)
- d. Cost of property damage
- e. Administrative costs

These five major cost elements can be divided into two main groups. The first group includes all the cost items for which market prices normally exist (a, b, d, and e). The other group consists of cost item c for which a market price does not exist. Only in the past ten or fifteen years has any motorized country tried to estimate the monetary value of lost quality of life.

The cost of traffic delays (or travel time) can also be considered but even in this case the monetary value is difficult to estimate because the purpose of the trip will affect its value. Working trips will normally have a higher monetary value than leisure trips.

The monetary value of time is estimated according to an opportunity cost approach: individuals are assumed to value their time according to what they could earn by working an additional unit of time.

### **3.3.5 Uncertainty**

All the difficulties related to correctly estimating the impact of road safety measures represent sources of uncertainty in the assessment of these measures. Elvik and Amundsen identify the following sources of uncertainty:

- Uncertainty in the definition of the target group of crashes or injuries affected by each road safety measure.
- Random variation in the number of crashes or injuries affected by each road safety measure.
- Incomplete and variable reporting of crashes or injuries in official crash statistics.
- Random variation in the estimated effect of each road safety measure on the number or severity of crashes or injuries.
- Unknown sources of systematic variation in the effects of each road safety measure on the number or severity of crashes or injuries.
- Incomplete knowledge with respect to how the effects of each road safety measure are modified when it is combined with other road safety measures to form a strategy consisting of several measures affecting the same group of crashes or injuries.
- Uncertain estimates of the social costs of crashes or injuries and the value of preventing them.
- Uncertainty with respect to the duration of the effects of each measure on crashes or injuries.

It is not possible to meaningfully quantify of all these sources of uncertainty with the current state of knowledge, also because road safety measures can be innovative (with uncertain effects).

A practical way to deal with uncertainties is to prepare three scenarios: a 'golden mean' realistic/conservative scenario, an optimistic/upper scenario, and a pessimistic/lower scenario. This may highlight the fact that economic analysis cannot provide exact estimates but rather probable intervals.

### 3.4 Questions and answers

Decision makers face many problems and difficulties when confronted with the need to evaluate safety measures in a monetary way, and this section deals with some of those. Questions are listed that might arise when carrying out a monetary assessment of road safety measures, and the aim is to provide appropriate answers.

This section cannot deal with all of the problems and difficulties associated with the monetary evaluation of measures, but those that will be covered are felt to be the most pressing.

#### **When will evaluation tools (like CBA or CEA) be needed?**

Most measures that are invented to improve road safety do contribute to this primary goal. But at the same time the measures evoke costs (for implementation, maintenance etc.) In times of scarce financial resources and strict financial budgets for the implementation of road safety measures has to be made sure that the money will be spent on those measures that are efficient in terms of costs and benefits.

To find out whether a measure with a great impact on road safety can also guarantee efficiency on the cost side, costs and benefits have to be compared to each other. Within a CBA both – costs and benefits – will be transformed into monetary values. As a result the cost-benefit-ratio will be achieved. It gives evidence of the absolute efficiency of a measure.<sup>7</sup> The CEA represents a simpler form of a CBA. Within a CEA the safety effects (benefits) will not be monetized, but opposed in physical terms (numbers of casualties prevented) to the costs of a measure. This shows the cost-effectiveness of a measure (but does not prove its absolute efficiency).

Another need for the use of evaluation tools arises from the fact that in most cases several measures can be implemented to avoid a certain safety risk. Out of a tool of possible measures has to be selected that one, that does fit best in this situation. By monetizing the costs and benefits, different types of safety measures become comparable to each other. According to the cost-benefit-ratio can be chosen the most efficient measure in a certain situation.

#### **How can you compare different types of effect, such as casualty reductions, greater pollution and changed travel times?**

A road safety measure might also have effects that are unrelated to road safety, e.g. environmental or mobility effects). Decision making on a national or regional level implies that all effects of a measure are taken into account, not only the safety effects. All effects have to be weighed against each other to make sure that the measure will be efficient. Therefore, it will be important to include other significant effects (aside from road safety) in the evaluation of a road safety measure.

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<sup>7</sup> Within a CBA not only safety effects can be opposed to the costs of a measure. Also other effects (on pollution, on mobility etc.) can be taken into account for the efficiency analysis.

Among the monetary assessment methods a CBA is able to include multiple effects (safety effects, environmental issues, mobility effects etc.) in the analysis by monetizing them. Those effects need to be measurable and to have an economic value. By expressing effects in monetary units (e.g. in Euro), different aspects can be compared within the CBA. The monetization of impacts will be done using predefined values for the impacts (e.g. valuation of time by cost rates for labour time costs and time costs for leisure activities).<sup>8</sup> The monetized benefits and the costs of road safety measures will be set against each other. The cost benefit ratio is the final result; this measures the absolute efficiency of each measure.

A CEA cannot be used to weigh safety against other policy objectives or to compare safety effects for different levels of crash severity. This can only be done within a CBA. Within a CEA, the effects of a measure are expressed in non-monetary terms (e.g. number of saved lives per unit implementation cost). The safety benefit per Euro of project investment is highlighted: the higher the ratio, the more safety-effective the measure.

### **How can you compare a cost in 2005 with a benefit in 2010?**

The investment in road safety measures will generally not cause a simultaneous accumulation of costs and benefits; rather, today's investment in road safety will lead to future benefits. This brings the following problems.

- o A common reference time has to be chosen for the realisation of costs and benefits. The most common choice is the base year of the introduction of the new safety measure.
- o Future costs and benefits have to be discounted to the chosen reference time. The purpose of discounting is to put all present and future costs and benefits in a common metric (present value). This is necessary because a Euro today is considered to be worth more than a Euro in five years time, even if inflation is excluded, because today's Euro can be invested to yield a higher value in future. In the macroeconomic evaluation methodology for the Federal Transport Infrastructure Plan 2003 in Germany, the discount rate is 3%. The discount rate is based on the average of the expected long-term productivity growth in Germany. In other cases the interest rates of risk-averse long-term state securities are taken as discount rates (about 4% in Germany).<sup>9</sup> In the European guide to cost-benefit analysis of investment projects a social discount rate of 5% is determined.<sup>10</sup>
- o The level of the chosen discount rate can affect the assessment. A low discount rate favours projects with long-term benefits and short-term costs. When evaluating alternative projects, a sensitivity analysis using a range of discount rates can determine the importance of the discount rate to the relative assessment of the projects.

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<sup>8</sup> For the German Federal Transport Infrastructure Plan 2003 the cost of 3,83 Euro/hour of travel time reduction was applied for non-business related traffic. A certain amount of reduction of travel time that can be realised with an investment in infrastructure will produce correspondent monetary benefits. (See also: FMTBH, 2002)

<sup>9</sup> FMTBH, 2002, p. 35

<sup>10</sup> European Commission, Guide to Cost-Benefit Analysis of Investment Projects, Brussels 2003

- o Rates of inflation (the loss in the value of money over time) will rarely be included in CBAs for the public sector. Estimations of future costs and benefits will be used that are expressed in terms of base year's prices. Consistent with this approach, the discount rate used in the CBA represents the time value of money after adjustment for inflation ("real interest rate").

**Is the role of the decision maker simply to "rubber stamp" the measure which ranks most highly in the efficiency assessment?**

Politicians and decision makers might fear an increasing trust in the results of monetary assessments. They worry about becoming redundant in the decision making process about the introduction of road safety measures. But this fear is not justified. A cost-benefit or a cost-effectiveness ratio can only inform about the (economic) efficiency of a measure. But the process of decision making about the implementation of a road safety measure goes far beyond the economic terms. Factors like the users' acceptance of a measure, implementation strategies (e.g. involvement of citizens concerned by a measure), financing considerations, regional specifications or political interests can rarely be included in the monetary assessment. Therefore the future role of a decision maker will not be to rubber stamp the measure which ranks most highly in the efficiency assessment, but to debate if there are factors besides the economic terms that influence the result and should not be neglected. It becomes clear that monetary efficiency assessment is no substitute for political dialogue and the process of decision making, but it can help to increase the transparency and objectivity of decision making.

**If a measure has not been applied before in my country, can knowledge gained abroad of this measure be used for the assessment?**

Road safety measures have been applied in many countries around the world, in many cases with monetary assessments. Some of the tools and the data (e.g. crash data) gained during these assessments have been published and can be used to assist further assessments.

- o Databases for monetary assessment have already been set up in some countries. They contain data and results of evaluation studies that have been performed in various fields of application. Many countries also have developed evaluation tools that can be used for the monetary assessment of measures in multiple situations.<sup>11</sup> A review of international experiences with road safety measures and data on safety effects was published recently by the European Transport Safety Council (ETSC, 2003).
- o But it has to be checked whether the data used in other countries can be easily applied to the specific application. In particular, there is still a need to harmonise national accident data (e.g. the definitions of serious and slight injuries).
- o To ease problems of data availability, there should be a European approach to set up and maintain a database that can support monetary assessments of road

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<sup>11</sup> Examples for evaluation tools are COBA, STEAM, or BVWP 2003

safety measures. A system should be established so that the relevant data<sup>12</sup> can be automatically ordered<sup>13</sup> and collected, also checked for reliability and applicability.

### **How can you assess an innovative measure, i.e. one that has not been tried before?**

For monetary valuation, the impacts of measures have to be expressed in monetary terms. If the measure has not been implemented before, it is rarely possible to use values based on experience, but these measures can nevertheless be assessed by monetary methods. The missing input data for the calculation have to be supplied another way. The expected impacts of a road safety measure (in terms of reduced crashes or crash severity) can be modelled by computer simulations, conclusions by analogy etc. and quantified by the use of crash costs. To make sure that the simulation of impacts has been reliable, the theoretical derivation of impacts and values can be validated by field tests and test runs. A sensitivity analysis can additionally be done to assess the reliability of the result.

### **If efficiency assessment depends upon knowledge gained from previous measures, will its use stifle innovation?**

Monetary assessment often relies on knowledge gained from previous measures. But this does not inevitably impede the implementation of new, innovative road safety measures.

- o Values based on experience cannot be used in the case of new, innovative measures, so missing input data for the calculations have to be supplied another way. This can be done e.g. by computer simulations, conclusions by analogy or back up data, but inevitably monetary assessment of new, innovative measures is more complicated. However, there is no general, methodological barrier against the assessment, so its use cannot act as a barrier to innovation. On the contrary, monetary assessment sometimes demonstrates the economic efficiency of a new, innovative measure and facilitates its implementation.
- o It cannot be taken for granted that measures, having once been assessed positively, should also be considered as efficient from the economical point of view in other situations. The efficiency of a measure has to be proven for every implementation. Where different measures can be chosen for implementation, the cost-benefit or cost effectiveness ratio gives evidence which measure should be preferred - provided that each measure is assessed to the same standard.

When an established measure is valued more highly than a new, innovative one, this should not be interpreted as a hindrance to innovation. It should rather be understood that the established measure will suit better than the innovation in this concrete situation and will provide a greater benefit.

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<sup>12</sup> E.g. on safety effect values or implementation costs of the measure.

<sup>13</sup> E.g. for various groups of crashes and severity levels, for different geographical levels (local, national or European).

- o To ensure that innovation will not be stifled by the use of monetary assessments, the common objective must be to improve the assessment methodology continuously and to further develop the evaluation tools. An example for the successful enhancement of the assessment methodology has been the inclusion of the benefits of carbon dioxide reduction in the monetary assessment for the German Federal Transport Infrastructure Plan. This helped also to push the development and implementation of those measures that aimed to reduce carbon dioxide emissions.

**CBA relies on forecasting changes over a number of years. Forecasts are inevitably uncertain, how is this uncertainty taken into account?**

Although a CBA is intended to minimise uncertainty, it cannot eliminate it, and therefore must take account of it. There are many sources of uncertainty in road safety projects (e.g. variation in the estimated effects of the measure, uncertain duration of effects, uncertain forecasts of traffic volume, economic development etc.). The forms of uncertainty can be included in the calculation in several ways.

- o Different scenarios can be calculated. A 'golden mean' realistic/conservative scenario that is characterised by a high occurrence probability is supplemented by an optimistic/upper scenario (highest benefits, lowest costs) and a pessimistic/lower scenario (lowest benefits, highest costs). The benefits and costs will be monetized for every scenario. The cost-benefit ratios and net present values of all scenarios show the range of possible results. The 'golden mean' scenario can serve as a benchmark for the most probable result. But if the cost-benefit ratio for the pessimistic/lower scenario is less than one, the project should perhaps be removed from consideration.
- o Confidence intervals of the effects can be displayed and taken into account. Confidence intervals can usually be calculated for the expected impacts of a road safety measure. Therefore, the range of values can be shown and the reliability (in statistical terms ) of the results will increase.
- o A sensitivity analysis can examine how the outcome of a CBA changes with the input factors, assumptions etc.. Within a sensitivity analysis the calculations will be done for an optimistic/upper, a pessimistic/lower and a 'golden mean' value for input factors or for different kinds of assumptions. A single factor can be varied, all other factors remaining constant, or all factors can be varied. The results of the calculations (net present values, cost benefit-ratios) can then be compared in monetary or graphical manner. In decision making it is important to know whether this type of variation can influence project rankings or profitabilities.

### **If I have a fixed budget, how do I decide whether to spend it on one large scheme or on several smaller ones?**

Monetary assessment methods can be used to spend a fixed budget on the most efficient measures (in economic terms). The results of the monetary evaluation (cost benefit-ratio, net present value) give evidence of the efficiency of a measure.

If there is a choice between a large investment and several smaller ones, the monetary assessment has to be carried out for every available measure, and the choice made by comparing the results of the assessments. But it is not enough to compare just the net present values or the amount of road safety impacts (in terms of accident reductions) of the single measures, for this will certainly prefer the large investment.

Rather the cost-benefit-ratios of the single measures have to be compared. The ratio describes the amount of benefits of a measure in relation to its costs. By ranking small measures according to their ratio (until the amount of the fixed budget will be exploited) can be found a set of highly efficient measures. The accumulated net present value of this set of small measures has to be compared to the net present value of the large investment. Is the accumulated net present value higher than the single one of the large investment, the set of smaller measures will exploit the fixed budget in the most efficient way. This procedure can guarantee that smaller projects with a high efficiency get the chance for implementation.

### **Is choice or ranking of projects the only application of road safety related assessment?**

Many countries compile programmes of road safety measures and targets for improving safety (e.g. percentage of fatalities to be saved by a certain year). The programmes are based on a range of strategies and rarely on full ex-ante evaluations of the measures considered. If applied, CBAs and CEAs are most often used for setting priorities for safety measures within the framework of a national or local safety program.

But the assessment of road safety measures should not only be a single process at a certain stage in the process (normally at the beginning) or only to create a single programme. The application of CBAs and CEAs allows the results of systematic monitoring of road safety activities to be assessed.

Monitoring road safety is an essential step in a systematic evaluation process. The observation of safety plans or programmes should comprise the systematic recording of the activities and actions and of the development of the accident and performance indicators.

After comparing road safety plans with the reality, decision makers have the chance to steer the activities in a new direction if necessary, and CBAs and CEAs should be the basis for these decisions.

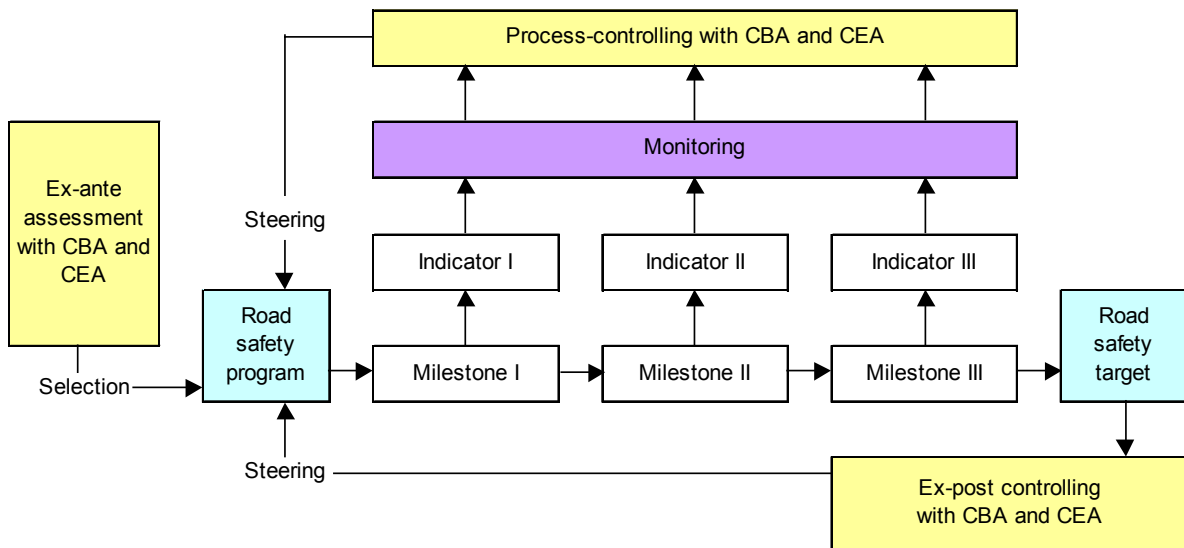


Figure 1: Possible scheme of a systematic evaluation of road safety activities

The whole process could be divided into 3 steps:

- Monitoring and controlling of implementation (controlling I)  
After identifying all responsible institutions, the milestones for implementation should be defined (targets of the measures, their beginning, implementation steps and completion). The plan and reality should be compared at successive milestones. This should identify any problems or barriers to implementation.
- Monitoring and controlling of the measure effects (controlling II)  
As described above, target variables and indicators should be defined and the expected effects should be compared with the results reached in reality. At this step, measures with unsatisfactory results or (unintended) side-effects should be identified.
- Monetary evaluation of the outcomes (controlling III)  
A comparison of ex-ante and ex-post CBAs and CEAs should be made. This step should identify the efficiency or inefficiency of road safety activities. The budget planning of the next years should depend on the results of this monitoring and controlling step.

All steps provide the decision-maker with information to replan, to reorganise, to steer the road safety activities. Especially, controlling II and III enable funds to be allocated to profitable safety activities and away from low-yielding ones.

**Democratic politicians who face re-election may tend to favour measures with short-term benefits; can the efficiency assessment take account of this preference?**

To make costs and benefits of measures with different time horizons comparable to each other, in a monetary assessment all effects are discounted to a common base year. This means that effects that occur later weigh less heavily than effects that occur sooner. The discounting of effects, therefore, considers the appearance of costs and benefits of a measure at different points in time.

Attention has to be drawn to the discount rate. The choice of the discount rate is decisive for the valuation of short-term and long-term costs and benefits. A high discount rate favours projects with long-term costs and near-term benefits. On the other hand a low discount rate favours projects with long-term benefits and near-term costs.

The methodology of the CBA contains adjusting devices to consider a time preference within the assessment. But the question comes up if a preference for short-term benefits of politicians generally should be regarded within the assessment (in either direction: for or against the politician's preference). The choice of the discount rate should rather be determined by other factors (long-term interest rates, inflation rates, risk components).

**Are there guidelines about the maximum percentage of a scheme budget that it is worth spending on an efficiency assessment?**

There are no precise guidelines about the maximum percentage of a scheme budget that is worth spending on an efficiency assessment.

But it is obvious that the expenses for the efficiency assessment should be in due proportion to the project scale and especially to the financial budget that is underlying the implementation process of the safety measure. It cannot be the objective to conduct a detailed monetary assessment for a small regional measure that exhausts nearly half of the project's financial budget.

Therefore, for every assessment has to be verified that the project details (characteristics, scale, financial resources etc.) require a detailed monetary assessment. In those cases where a detailed analysis can not be afforded, other techniques have to be regarded (e.g. a "Mini"-CBA, where detailed time- and cost-consuming assessments and calculations are substituted by rough estimations with average values for effects and economic valuations and approximate data on the measure's costs).

**Is it possible that there are significant effects which cannot be included in CEA or CBA, and if so how should they influence the final decision?**

In a monetary assessment only those effects (benefits and disbenefits) can be regarded that do have an established monetary value. CBA deals only with benefits and costs that can be expressed in monetary terms. The monetary benefits will be opposed to the costs of a measure. By comparing costs and benefits the macroeconomic efficiency of a project can be proven.

But a project can also cause effects than can not be expressed in monetary terms. Benefits or disbenefits of such kind will be for example:

- Effects – perhaps in case of an infrastructural measure – on urban development (urban planning objectives, quality aspects, aesthetics etc.),
- Environmental hazards of a measure (e.g. endangerment of biological reserves),
- Social aspects and equity considerations (e.g. effects on personal income distribution, effects on social structures and surroundings),
- (User) acceptance of a measure.

Mostly, it will not be possible to find monetary values for such (dis-)benefits. This will generally keep them out of the evaluation process. However, it has to be taken care, that important non-monetary benefits or disbenefits will not be left out of the assessment. The efforts to include non-monetary effects into the assessment should of course strongly depend on the importance of these aspects relative to other effects, the dimensions of the project and political considerations. But if such effects are considered to be relevant for the evaluation of a measure, it should be sought for a possibility to include them in the assessment. In rare cases it might be possible to establish monetary values for the effects (by rough estimations). In other cases a non-monetary assessment, that accounts for political objectives, social and environmental aspects etc, can be done additionally to the monetary assessment.

The example of the German Transport Infrastructure Plan 2003 demonstrates that also non-monetary effects and objectives can be included in the macroeconomic assessment of infrastructure projects. Additional to the monetary evaluation within a CBA the transport projects will undergo an environmental risk assessment and a regional impact analysis that go far beyond the aspects that can be included monetarily in the CBA.<sup>14</sup>

### **How can the economic assessment of crashes be done?**

When doing the economic assessment of crashes, different types of crashes have to be distinguished (fatality, severe injury, slight injury, property damage only). Crash costs have to be calculated for each category of accident. The total crash costs arise as the sum of different cost components:

- human losses: loss of life or injury suffered personally by the victim and the pain and grief of the victim and the victim's relatives,
- lost gross output of production from the casualties,

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<sup>14</sup> Federal Ministry of Transport, Building and Housing, Federal Transport Infrastructure Plan 2003, Basic features of the macroeconomic evaluation methodology, Berlin 2002, p. 35

- o direct and indirect costs of restitution (medical aid, post treatment, police, administrative costs of insurances etc.)

In the EU member states different evaluation methods are used. Differences arise from the question whether the damage costs should be estimated or the willingness-to-pay approach should be applied to evaluate the crash costs. Within the damage cost approach the damages arising from casualties and fatalities are accumulated, within the willingness-to-pay method the cost calculation is based on the amount of money a victim is willing to pay for not being hurt. The most appearing difference within the two approaches is, that the evaluation of human losses in the willingness-to-pay approach leads to significantly higher valuations than the damage-cost approach. Both approaches have weaknesses. The damage costs approach, for example, may cause significant problems by applying different damage costs due to the individual's contribution to productivity (depending on whether it is a full- or a part-time employee, an employee or an unemployed etc.). The willingness-to-pay approach may fail because of divergences between the hypothetical and the real situation. The information state of the respondent will match the information state of a real market participant only by chance. This may lead to wrong or over-/under-estimated cost rates.

It ought to be the future objective to harmonize the European assessments and to create a consistent standard for the estimation of crash costs throughout Europe. Methodical differences that are practised in Europe by using two approaches for cost calculations, may lead to irritations of users and can reduce creditability and acceptance of the results in the public scene.

## 4 Knowledge and Data

This chapter deals with the knowledge and data elements which are required in order to perform an efficiency assessment (CBA/ CEA) of a safety-related measure.

### 4.1 Safety effects

The quantification of the effects of measures aimed at reducing crashes represents a critical point for the application of the CBA and CEA techniques to road safety. The major source of knowledge on safety effects are evaluation studies of past treatments.

The most common form of a safety effect is the percentage reduction of crashes following the treatment (sometimes called the crash reduction factor). The quality of the efficiency assessment of a safety measure (i.e. a prediction of the crash reduction likely to be attained) depends on the *quality* of the available values of safety effect. The latter depends on a number of factors, such as:

- The availability of values: do data exist (values of crash reduction factors) relevant to the type of measure considered and applied at the particular type of site?
- Validity of data: were the effects estimated properly, i.e. accounting for confounding factors that may have influenced the results?
- Variability of the effect: if there is a range of results for similar treatments, what is the best estimate of the effect of the intended measure?
- Local versus general effects: how to combine the evaluation results attained under local conditions (in a country, region, authority) with a more general experience on the subject (e.g. safety effects known from international practice)?
- Changeability of the effect: how can we handle a situation where the safety effect is not stable but depends on traffic volumes?

### 4.2 Number of crashes affected by the measures

The number of crashes affected by a measure multiplied by the value of the safety effect provides for the number of crashes likely to be prevented by the measure. Considering the number of crashes affected, there are two basic alternatives.

1. When a safety measure is chosen for a specific crash site (area, population), the implementation unit is known. The number of crashes affected by a measure depends on two factors: the statistics of crashes observed at the site over the last few years and the target crash group of the measure.

The target crashes are usually obvious as they are dictated by the nature of safety-related measures. Examples of target crash groups associated with different safety measures are given in Table 1. The definitions were given by Elvik (1997a), within the framework for a CBA of the Dutch road safety plan.

In most cases, a safety treatment is considered for a site with a 'bad safety record', i.e. with a bad record of crashes occurring at the site. Due to random fluctuations of crashes on the one hand, and the phenomenon of 'selection bias' (Hauer, 1997) on the other, the annual number of crashes in the 'before' period should be estimated on a 3-5 year basis (and not on the last year which would attribute a higher crash-saving potential to the measure than it actually has).

2. When a safety measure is considered for implementation within a large-scale road safety program, a typical 'unit' of implementation should first be defined, and then the number of target crashes expected to occur per year for a typical unit, should be estimated.

In the case of infrastructure improvements, the appropriate unit will often be one junction or one kilometre of road. In the case of area-wide or more general measures, a unit may be a typical area or a certain category of roads. In the case of vehicle related measures, one vehicle will often be a suitable unit or, in the case of legislation introducing a certain safety measure, the percentage of vehicles equipped with this safety feature or complying with the requirement. As far as education or training is concerned, the number of trained pupils according to a certain training scheme may be a useful unit of implementation (Elvik, 1997a). For police enforcement, it may be a kilometre of road with a certain level of enforcement activity (e.g. the number of man-hours per kilometre of road per year); in the case of public information campaigns - the group of road users, which is supposed to be influenced by the campaign.

For example, an economic model developed for the Israeli safety programme was based on estimates of savings in severe crash injuries, which could be attained due to the implementation of the programme (Hakkert and Gitelman, 1999). Considering each field of the program's activity, three stages were completed: (1) definition of target crash groups; (2) evaluation of the expected safety effect of the treatments; (3) definition of the scope of implementation which is attainable during the program.

Description of measure	Target group of accidents
Cycle lanes in urban areas	All accidents on affected roads
Roundabouts	All accidents in affected junctions
Blackspot treatment	All accidents at treated blackspots
Truck lanes on rural roads	Accidents involving trucks on rural roads
New road lighting	Accidents in darkness on unlit roads
Upgrading road lighting	Accidents in darkness on lit roads
Shoulder rumble strips	Ran-of-road accidents on rural roads
Extending 30 km/h roads	All accidents in areas changed into 30 km/h zones
Reduced speed limit on 80 km/h roads	All accidents on affected roads
Lowered speed limits at junctions	All accidents in affected junctions
System of optimal speed limits	All accidents on all roads where speed limit is changed
Speed reducing measures at pedestrian crossings	Accidents at pedestrian crossings
Upgrading pedestrian crossings	Accidents at pedestrian crossings
Prohibiting mopeds from using cycle tracks	Accidents involving mopeds on cycle tracks
Law requiring use of daytime running lights	Multi party daytime accidents involving cars
Extra high mounted brake lights	Rear end collisions
Driver side airbags	Frontal impacts involving cars
Rear seat belts mandatory	Injuries to rear seat occupants in cars
Speed limiters on mopeds	All accidents involving mopeds
Speed limiters on heavy vehicles	All accidents involving heavy vehicles
Speed limiters on all cars	All accidents involving cars
Provisional licensing and demerit point system for new drivers	Accidents involving new drivers in the first two years of driving
Raising minimum licensing age for moped riders	Accidents involving new moped riders in the affected age groups
Reforming licensing age system for motor vehicles	Accidents involving drivers in the affected age groups
Child pedestrian training	Pedestrian accidents involving children in the affected age groups
Increased speed enforcement	All accidents during period of enforcement
Increased enforcement of drinking and driving	Accidents involving drinking drivers during period of increased enforcement
Increased seatbelt enforcement	Injuries to car occupants not wearing seatbelts
Extending automatic enforcement	All accidents on roads subject to automatic speed enforcement
License withdrawal for drinking and driving	Accidents involving drinking drivers

*Table 1: Examples for definitions of target accident groups: target accident groups for safety measures for the Dutch road safety plan. Source: Elvik, 1997*

Regarding the third stage, two types of activity were defined: national (e.g., 'enhancing the use of safety restraints in cars') where potential injury savings were estimated using average nationwide indices; and variable, i.e. those activities whose scale and sites of application depended on a marginal cost-benefit analysis. The latter type included the road environment and enforcement measures, where the evaluation concerned:

- o five categories of geographic units, i.e. one-kilometer road sections and junctions in urban and rural areas (as potential black-spots), and rural sections of variable length (as candidates for creating forgiving roadside conditions);
- o three variants of treatment, i.e. improvement of road infrastructure only, intensive speed enforcement only or both measures combined. For each geographic unit, the most cost-effective variant was chosen.

To avoid any possible bias caused by regression-to-the mean, estimates of the number of crashes that can be prevented by road related measures should be based on crash rates representing the typical level of safety for various categories of road elements and road types (Elvik, 1997a).

Two more factors are essential to estimate the reduction in the of number of crashes:

- o the measure may already be implemented to a certain extent. For example, in some countries the initial level of wearing safety belts in cars is rather high, therefore a public information campaign on the issue will have only a limited effect on the number of casualties. Similarly, black-spot treatment measures are widely applied in many European countries; there is some initial level of police enforcement etc. As a result, the actual safety potential of a measure will depend on the local conditions.
- o the same crashes can be influenced by several kinds of treatments. A combined effect of these measures will be lower than a direct sum of the initial values (e.g. Elvik, 2001).

ETSC (2003) provides examples of accounting for the implementation scale of safety measures. For example, the reduction of fatalities following the compulsory introduction of DRL in the EU was estimated as:

- o the number of fatalities (observed)
- o the average 90%-use of DRL
- o the 40% of the DRL relevant crashes
- o the 20%-effect of DRL for fatalities,

where both the scope of use and the share of relevant crashes were stated based on the analysis of crash and behaviour data in different countries. According to the estimate, 2,827 fatalities per year are expected to be saved in the EU.

Another measure was the promotion of Random Breath Testing (RBT) in the EU countries. Having considered the data on alcohol involvement in fatal crashes, the level of drink-driving in traffic and the current level of RBT in different countries, two basic sets of assumptions were applied (ETSC, 2003):

- o 3% drink-drivers (in traffic) and 30% alcohol related fatalities;
- o 2% drink-drivers and 40% alcohol related fatalities.

Three forms of safety effect were considered:

- o a 9% reduction in all fatalities;
- o a 30% decrease in alcohol related fatalities (as was found in Norway, following a tripling of the enforcement level in low frequency RBT areas);
- o a 25% decrease in alcohol related fatalities (as was observed in a Dutch study in the city of Leiden where the RBT was doubled).

According to these estimates, a reduction of 2,040-2,500 fatalities per year is expected in the EU.

### **4.3 Existing road accident databases**

One of the problems which complicate decision making at the international level is absence of relevant international data on road accidents and traffic. Today, the following international databases on road safety exist:

#### **IRTAD database**

This database is operated by the Joint Transport Research Centre (JTTC) of OECD/ECMT, currently located at BAST although its transfer to Paris is planned. The data from 29 OECD member states are included. In this database, also separate data for the territory of both former German states, for Great Britain proper and for Northern Ireland. All data are aggregated<sup>15</sup>. Killed numbers are recorded for the 30-days term after accident, if necessary by applying correction factors. In addition to

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<sup>15</sup> I.e. only total numbers, not data on individual accidents.

the main accident indicators<sup>16</sup> exposure data<sup>17</sup> are also included in the database. The data are registered from 1970<sup>18</sup>.

The data can be obtained on-line on the www-address <http://irtad.bast.de><sup>19</sup>. General access for selected data is possible on the www-address

<http://www.bast.de/htdocs/fachthemen/irtad/english/englisch.html> .

## **CARE database**

CARE is the European road traffic accident database created and operated in the framework of the European Commission - General Directorate for Energy and Transport. It is the only existing database with disaggregated data<sup>20</sup> at the EU level, which should serve for the detailed analysis of the accidents at both national and international level, and for creation of both national and European traffic safety policy.

The widely used IRTAD database contains only total numbers of accidents and injured, with no data on individual accidents or injured persons. CARE, however, is disaggregated database, involving data on killed and injured persons with accident type and circumstance for all registered accidents. This gives more flexibility, allows more complex information to be received. FARS is a similar system operated at the federal level in the USA (see below).

CARE involves at present data from 14 old member EU states (without Germany), but its extension to all 25 EU member states with Norway and Switzerland is being prepared. In addition to the main database involving source data from these countries (in the common agreed structure transformed from original national structures), supplementary data on population, vehicle park, drivers, road network, traffic volumes, safety measures etc should gradually be added.

Confidence in the individual data must be, of course, strictly assured. All outputs are created by the aggregation of source data by the selected parameters. The output is two-dimensional contingency table with utilization of row of filters for value selection. Individual variables involve all accessible information from EU member state accident statistic files. Comparability of data from different member states - definition, structure, quality, accuracy and underreporting – is a continual problem with the accident data. Individual variables are gradually being harmonized.

Observed variables include the number of accidents and casualties by injury severity (fatal, serious and slight) distributed by the age, sex, user type (driver, passenger, pedestrian), vehicle type, place, type, time and circumstances (lighting, weather) of the accident, vehicle age, driver practice etc. Where necessary, correction factors are applied to the number killed to take account of the 30-day definition.

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<sup>16</sup> Number of injury accidents, number of killed, injured and hospitalized, in distribution by the age of victims, user type, road type.

<sup>17</sup> Population number, motor vehicle number, road length, area of state and modal split of transport volumes to individual transport modes.

<sup>18</sup> Some data also monthly.

<sup>19</sup> Only for authorised members.

<sup>20</sup> Data on killed and injured with accident type and circumstances, disaggregated on individual accidents.

Database users are bodies at different levels in the state administration (with on-line access) - ministries of transport, public works, interior, justice, public health, statistical offices, local authorities, police; also hospitals, universities, research institutes, industrial institutions, professional associations, intergovernmental and nongovernmental international organizations.

Provision of national data must be authorised by the competent authorities. Delivery of standard reports is assumed to be free of charge for national administrations, for other users it will be charged.

A general review of the main CARE data is published at the www-address <http://europa.eu.int/comm/transport/care>.

### **ECE-UN database**

ECE-UN at present involves all European states (i.e. 36, including the smallest, excluding ex-USSR states), further ex-USSR states (15), Cyprus, Israel, USA and Canada (in total 55 states). The data are collected and incorporated in the database by means of representatives of individual states (ministries and statistical offices). The yearbook „*Statistics of Road Traffic Accidents in Europe and North America*“ is published with data from all member states (usually with a delay of 2 years).

The Intersecretariat Working Group for traffic statistics (IWG) comprises representatives of the secretariats of individual international governmental organizations ECE-UN, ECMT and Eurostat (EU). The IWG coordinates their statistical activities by means of common statistical questionnaires, because all of these bodies operate with similar datasets.

### **ECMT database**

ECMT at present involves all European states (i.e. 32, excluding the smallest and ex-USSR states), also European states of ex-USSR including Transcaucasian republics (10), also Morocco, USA, Canada, Australia, New Zealand, Japan and South Korea (in total 49 states). The data are collected and incorporated in the database by representatives of individual states (ministries and statistical offices). The yearbook „*Statistical Report on Road Accidents*“ is published every 2 years with data from all member states (usually with delay of 3 years).

ECMT resides in Paris in the same place as OECD. Their transport statistics activities are now combined in the Joint Transport Research Centre (JTRC) of OECD and ECMT.

These data are also published by the ECMT at the website <http://www.cemt.org/stat/accidents/index.htm>.

## **EU (Eurostat) database**

Eurostat (the statistical office of the EU, situated in Luxembourg) operates at present its own database for the 25 member states of the EU, including aggregate accident data. Correction factors for the number killed in individual countries are not used. The data are collected and incorporated in the database by representatives of individual states (ministries and statistical offices).

With respect to close cooperation of traffic statistics activities, Eurostat is also represented in the Intersecretariat Working Group for traffic statistics (IWG).

These data (for transport area, both states and regions) are accessible at the website

[http://epp.eurostat.ec.eu.int/portal/page?\\_pageid=0,1136162,0\\_45572076&\\_dad=portal&\\_schema=PORTAL](http://epp.eurostat.ec.eu.int/portal/page?_pageid=0,1136162,0_45572076&_dad=portal&_schema=PORTAL).

There is in addition a small yearly publication by the General Directory for Energy and Transport involving main road accident data, at the website [http://europa.eu.int/comm/dgs/energy\\_transport/figures/pocketbook](http://europa.eu.int/comm/dgs/energy_transport/figures/pocketbook).

## **FARS database**

The Fatal Accident Reporting System) is operated by the NHTSA (National Highway Traffic Safety Administration, in Washington, D.C.), within the US Department of Transport . This database includes disaggregate road traffic accident data (i.e. for individual accidents) for the USA (both total and separate states) and it is freely accessible on the www-address <http://www-fars.nhtsa.dot.gov> By means of input forms, it is possible to create queries with selections of conditions (possibly selecting from many variables related to the accidents, vehicles, persons and drivers) and immediately receive corresponding aggregated output in the form of one- or two-dimensional tables, or even lists of cases (without personal data). Also, it is possible to illustrate selected accident variables on the USA map.

## **Other accident databases**

In addition to the databases mentioned above, some other traffic accidents databases of both intergovernmental (e.g. WHO - www-address [http://www.who.int/topics/injuries\\_traffic](http://www.who.int/topics/injuries_traffic)) and nongovernmental organizations (IRF, IRU, ERSF) exist.

The problems with the international databases on road accidents and on road traffic may be summarised as follows: their reporting rate for national databases is poorly understood, and every country uses its own definitions which are not comparable with other countries. This allows data to be extracted which may not be comparable.

Every national database which feeds into the international databases has its own system for collecting data – the protocols on road accidents and their consequences differs from country to country; no common protocol is used to collect the data for the international databases.

Aside the road traffic accident databases mentioned above, there are databases on injuries, including road traffic, which are collected with the World Health Organisation (WHO) based on national medical data on injuries and deaths. These data are collected nationally by medical institutions and even at this level there is no consistency with data collected by the police. It is clear, for example, in the case of single cycle accidents, which are very much under reported by the police.

Existing international databases collect mostly basic data on road accidents and their consequences. Although data on traffic flow and the nature and operation of the vehicle fleet appear to be vital for road safety work and decision making, they are rarely collected .

There are problems with the age of the data – e.g. UN data published are at least two years old. The situation with CARE and IRTAD data is better.

#### **4.4 Implementation costs of measures**

The implementation costs are the social costs of all means of production (labour and capital) that are employed to implement the measure (ETSC, 2003).

The implementation costs are generally estimated on an individual basis for each investment project. As to road investment costs, the average cost rates to be used in master plans are measured on a per junction or per kilometre of road basis. Road maintenance costs are measured on a per kilometre of road per year basis.

The typical values of costs are essential to perform a CBA/CEA, especially at the preliminary evaluation stage. However, these values are usually not published, which increases the uncertainty of the evaluation results.

For the efficiency assessment of safety measures at different levels (national, regional, local), there is great interest in implementation costs applied to relevant conditions.

ETSC (2003) provides detailed specifications of costs of five 'promising' road safety measures for the EU: daytime running lights (DRL), random breath testing (RBT), audible seat belt reminder in the front seat of cars, use of EuroNCAP as an incentive for developing safer cars, road safety engineering (best practice guidelines).

For example, for the DRL introduction, the cost components are as follows: the price for a switch in a new vehicle = € 5 per unit; the price of retrofitting = € 50 per vehicle; maintenance and repair costs of automatic light switches = € 15 per vehicle; extra

fuel consumption due to the use of DRL = 1% - 2% (a more detailed consideration was applied for different vehicle types). Combining these assumptions with the number of vehicles in EU countries and their kilometers, the estimated present value costs were €23 billion for standard low beam headlights and €16 billion for special DR-lamps .

For the RBT, the costs included (ETSC, 2003):

- o costs of police personnel at the roadside (with 180 days/year, 6 hours/day, 15 tests/hour, i.e. 16,200 tests in one person-year; €100,000 per person-year);
- o equipment costs, where each personal device costs €750 and 20,000 mouthpieces costing € 0.25 each are needed per year, or €5,750 in total;
- o costs of publicity - € 2 million per country, where the low enforcement areas comprise 9 countries;
- o extra costs of administration of justice (with €1,000 per offender; 107,000-150,000 extra offenders per year).

Taking account of the number of breath tests to be taken annually, the net present value of the costs of the measure was estimated to be €185-228 million.

Considering the best practice road safety engineering, examples of low-cost infrastructure-related measures that have been recently introduced in Norway were presented. The implementation costs of these measures are given in *Table 3.9*. The values are typical for Norway and only illustrative for other countries (ETSC, 2003).

#### **4.5 Side-effects**

Road safety measures can produce three kinds of effects: safety, mobility, and environmental (ETSC, 2003). The mobility effects comprise changes in travel time and vehicle maintenance expenses; qualitative techniques for estimating the mobility effects of transportation projects are well developed and can be found in guidelines and computer programs for economic evaluations in transport, e.g. BVWP, EWS-97, RAS-W in Germany; TUBA, COBA, NESA in the UK; STEAM in the USA (WP 1, 2003).

As many road safety measures affect the amount and/or speed of travel, they may also have impacts *on emissions and noise*. For example, DRL increases the use of fuel and the emission of exhaust gases. An estimate exists that the total costs of pollution due to fuel emissions in road transport in the EU amount to € 20 billion per year. As the additional fuel consumption due to DRL use for all vehicles is about 1%, the environmental effect of the measure will result in expenses of € 0.20 million per year (ETSC, 2003).

Considering the effects of setting different speed limits for rural roads, Elvik (2002) applied the official estimates of environmental impacts accepted in Norway and

Sweden (Table 2). These estimates were published by the highway authorities in both countries and are used for CBA of highway-related projects.

Unit of valuation	Norway in NOK (1 NOK= \$ 0.107 US)		Sweden in SEK (1 SEK= \$ 0.092 US)	
	Rural areas	Urban areas	Rural areas	Urban areas
Traffic noise per kilometre of driving	0.00	0.14	0.008	0.067
Traffic noise per bus or truck kilometer of driving	0.00	1.14	0.040	0.617
Emission of 1 kilogram of carbon dioxide (CO <sub>2</sub> )	0.37	0.37	1.50	1.50
Emission of 1 kilogram of nitrogen oxide (NO <sub>x</sub> )	33	66	60	72
Emission of 1 kilogram of volatile organic compounds (VOC)	33	66	30	50
Emission of 1 kilogram of sulphur dioxide (SO <sub>2</sub> )	18	70	20	118
Emission of 1 kilogram of particulate matter (PM <sub>10</sub> )	0	1700	0	3343

*Table 2: Monetary valuations of environmental impacts of speed choice in Norway and Sweden (national currencies; 1999 price level). Source: Elvik (2002)*

Cameron (2003) performed a similar evaluation for Australian rural roads. To consider the environmental impacts of changes in speed limits, Cameron applied the results of the EU MASTER project (Robertson et al, 1998) – estimates of the levels of emissions from a typical stream of vehicles traveling at a steady speed. The air pollution emission impacts *in grams per km* were estimated for carbon monoxide, hydrocarbons, nitrogen oxides and particulates, at each travel speed. Robertson et al's estimates have been recently updated, and carbon dioxide emission rates have been added, based on Kallberg and Toivanen (1998).

Emission factors	At initial speed, g/km	At final speed, g/km
Carbon monoxide CO	2.41	2.75
Hydrocarbons HC	0.43	0.49
Oxides of nitrogen NO <sub>x</sub>	1.54	1.61
Particles PM	0.034	0.040
Carbon dioxide CO <sub>2</sub>	239.1	257.1

*Table 3: Air pollutant emission coefficients (average), following the increase of 100 kph speed limit to 130 kph speed limit on rural freeways. Source: Cameron, 2003*

Air pollution cost estimates were provided as follows (in year 2000 A\$):

- o carbon monoxide - \$ 0.002 per kilogram;
- o hydrocarbons - \$ 0.44 per kilogram;
- o oxides of nitrogen - \$1.74 per kilogram,
- o particulates (PM10) - \$ 13.77 per kilogram,
- o carbon dioxide - \$ 0.022 per kilogram.

The impact of noise pollution from vehicles usually relates to the population living in the vicinity of roads who are exposed to noise in excess of 55 decibels. As the population living in the vicinity of the rural roads considered was negligible, noise pollution was ignored in this Australian study (Cameron, 2003).

## **5 Barriers to the use of efficiency assessment tools**

Efficiency assessment tools (EAT) support decision-making about the implementation of road safety measures. They can separate efficient measures from inefficient ones as well as rank measures according to their efficiency. But the use and the implementation of EAT within road safety policy faces limitations, restrictions and constraints. Barriers to the use of EAT can arise before and during the whole decision making-process. They can hinder the application of EAT or even prevent their use.

In this chapter, the most important barriers to the use of EAT for the implementation of road safety measures will be examined. The barriers are subdivided into different categories (clusters). The categories cover the whole decision-making process: from the institutional settings (independent from the EAT) to the technical requirements of the use and the methodology of EAT. In addition, the categories differ according to their importance for a monetary assessment of road safety measures: in some cases the use of EAT for monetary assessment is not possible.

Even if some categories of barrier (absolute and institutional barriers) continue to limit the field of application of EAT and will not be avoided or eliminated in the short term, other categories might easily be removed.

### **5.1 Types of barrier to the use of efficiency assessment tools for the implementation of road safety measures**

Monetary efficiency assessment tools that aim to support decision-making about the implementation of road safety measures and to select efficient measures are neglected or not used for a variety of reasons. It is possible, for example, that particular road safety measures have to be introduced hurriedly because of public or political pressure, so decisions about the implementation have to be taken rapidly. In this case, rough calculations will more or less substitute for intensive monetary assessment. Other reasons for not using EAT might include missing input data for the necessary calculations (e.g. because of lack of knowledge about relevant impacts), or decision-makers that lack the knowledge needed to conduct a monetary assessment. Additionally, conflicts of interest may arise and impede the application of EAT, or decisions may be taken without following the principles of efficiency but instead for political objectives (e.g. protection of particular groups of people, equity aspects). These examples demonstrate the wide variety of restrictions and constraints to the application and implementation of EAT.

To draw up the whole spectrum of possible barriers, the second work package of the ROSEBUD project investigated barriers to the use of EAT for the implementation of road safety measures. A survey was carried out to shed light on barriers that lead directly to the abandonment of monetary assessment for road safety measures. A questionnaire was developed and handed out to decision-makers and experts at different policy levels (regional, national, European) within the partner countries.

They were mainly asked about

- the current road safety policy in their countries,
- the use of formal efficiency assessment tools for setting priorities for road safety measures and
- the main reasons why formal efficiency assessment tools are not used as a stable element of road safety policy.

Also the relative importance of various barriers to the use of efficiency assessment tools was assessed. The result of the survey and the complementary desk research was a broad catalogue of barriers that continue to limit the applicability of monetary assessment methods for the implementation of road safety measures. The most frequently mentioned barriers (all policy levels, all partner countries) are

- rejection of the welfare-economic principles that underlie the EAT,
- rejection of the efficiency criterion as a measuring unit,
- rejection of the monetary valuation (e.g. of human lives),
- political opportunism in decision making, different political objectives (e.g. equity aspects),
- scarcity of resources (financial budget, time),
- lack of recommendations for using EAT,
- lack of practical EAT knowledge, difficulty of performing EAT, inadequate tools and guidance,
- lack of (political) responsibility and non-funded mandates,
- wrong timing of EAT in the decision making process,
- lack of knowledge about impacts or monetary values,
- unreliability of method or impact data, lack of impartial quality check,
- unsuitability of methods for certain kinds of measures and
- conflicts of interest or possible vested interests.

Barriers to the use of EAT derive from different aspects of making decisions about the implementation of road safety measures. On one hand, they might result from the monetary assessment tools themselves (e.g. theoretical background of the methods, practical use of the tools), on the other hand they might be based in the environment of the political decision making process (political interests and opportunism, conflicting policy objectives) or the institutional structures (unfunded mandates, lack of a mandate that requires efficiency assessments). In order to develop appropriate „counter measures“ and proposals for increasing the use of EAT it is not enough to simply know about the existence of such barriers; the aim must be to counteract the

emergence of such obstructions. This is helped by forming categories or clusters of similar barriers. Presumably, similar means can help to eliminate each barrier in a cluster. Several suggestions have been made within ROSEBUD for clustering barriers to the application of EAT.<sup>21</sup>

Four different clusters of barriers to the use of efficiency assessment tools (according to their nature or origin) were generated:

	<b>Cluster</b>	<b>Examples of barriers to the use of EAT</b>
A	Fundamental barriers = resulting from the theoretical basis of the assessment tools	- Rejecting principles of welfare economics - Rejecting efficiency as a relevant criterion of desirability - Rejecting monetary valuation of risk reductions
B	Institutional barriers = resulting from the institutional settings	- Lack of consensus on relevant policy objectives - Unfunded mandates and excessive delegation of authority - Wrong timing of EAT information in decision making
C	Technical barriers = resulting from the EAT itself (technical requirements, data needs)	- Lack of knowledge of relevant impacts - Inadequate monetary valuation of relevant impacts - Inadequate treatment of uncertainty
D	Implementation barriers = related to the implementation process of cost-effective measures	- Lack of power (related to unfunded mandates etc.) - Lack of incentives to implement cost-effective solutions - Lack of marketing of efficient policies (presentation)

*Table 4: Clusters of barriers to the use of efficiency assessment tools in road safety policy (Source: Rosebud, WP 2 Report, Oslo 2003, p. 13 ff.)*

In the first work package of ROSEBUD a main distinction was identified between barriers to use and to implementation.

- o Barriers to use are more or less comparable to categories A, B and C in the classification mentioned above. In work package 1 two items were stressed as important barriers to the use of EAT.
  - ⇒ Efficiency assessments of road safety measures are not mandatory (it is not even mandatory to include road safety impacts in CBAs for infrastructure investments).
  - ⇒ There is no regular guidance on the analysis of safety effects.
- o Barriers to implementation arise basically from category D mentioned above. Additionally, problems resulting from the methodology of the EAT (referring to the technical barriers mentioned above) may constitute barriers to implementation.

Absolute barriers are mainly in category D (implementation barriers) and category B (institutional barriers) mentioned above. The barriers presented in these categories cannot be removed easily or avoided in the short term. Processes have to be

<sup>21</sup> See also Rosebud WP 2 report, p. 13 ff., Rosebud WP 1 report

rearranged and organizational settings have to be restructured. This requires – in addition to expenditure of time and money – the willingness of politicians, experts etc. to change the decision-making process. In addition to implementation or institutional barriers, fundamental barriers (category A) also belong in part to the category of absolute obstructions which cannot be influenced, at least, if such objections are not based on misunderstandings or lack of information about EAT.

Relative barriers can be influenced or even removed by proposals or improvements to the use of EAT for decision-making. The provision of knowledge and guidance about impact assessment for decision-makers and users of EAT can certainly help to eliminate this kind of barrier. Compared to the earlier classification of barriers, this category will mainly contain technical barriers (category C), also some institutional barriers (especially those that are linked to technical barriers).

It was mentioned when presenting the different classifications of barriers that these classifications are linked. The relations and connections between the different clusters of barriers (absolute/relative, use/implementation, fundamental/institutional/technical/implementation) are illustrated in Figure 2.

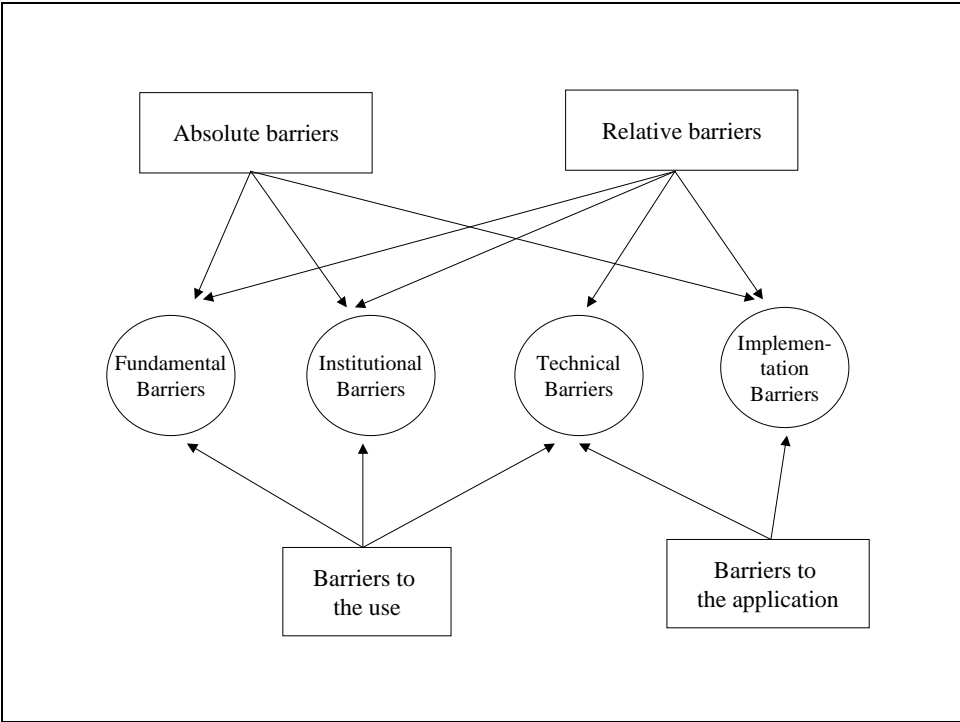


Figure 2: Relations between different classifications of barriers to the use of EAT (Source: Rosebud, WP 2 report., p. 35)

The various classifications that have been developed in the ROSEBUD project actually represent different points of view about the problems that decision-makers and users of EAT face when making decisions about implementing road safety measures; however, they mainly deal with the same problems. The following section deals with ideas for overcoming barriers to the use of efficiency assessment tools, and it will be important here to classify barriers as absolute or relative, since the

section concentrates on the possibility of finding solutions and bypasses the objections to using EAT.

## 5.2 Overcoming barriers to the use of efficiency assessment tools

Overcoming the existing barriers will be a long term process during which various types of steps need to be taken. Road safety experts with relevant knowledge about CBA and its benefits should play a vital role in this process. Their role lies mainly with collecting and disseminating information and hence persuading responsible decision-makers and politicians at all levels of the necessity of using CBA of road safety measures when reaching decisions.

An international methodology and better data about road accidents should create a good background for implementing CBA, especially at the national level. The whole system of overcoming of the barriers and obstacles should also be supported by the necessary funds, for otherwise the efficiency and scope of the whole process would be very limited. Last but not least, national conditions (e.g. Administrative structures, various bodies involved, system of financing etc.) should be taken into account when trying to overcome obstacles.

Economic assessment is successfully applied in many countries. This indicates that barriers were successfully removed in these countries. Aiming to reduce or remove barriers to the use of EAT in road safety policy does not imply a technocratic position which insists that CBA and CEA dictate public policy – with the politicians as somewhat superfluous masters of ceremonies who rubber stamp the irrefutable truths from the economic analyses. It should be recognised that politicians in democratic countries are elected to represent the will of society, and their role is to take account of the results of the EAT.

There are several basic ways to overcome existing barriers to implementing EAT.

- o Create a standardised economic methodology for road safety assessment. Public authorities at the national and EU level can improve the quality and uniformity (comparability) of efficiency assessment studies, e.g. by establishing good practice guidelines for the methods and techniques.
- o Establish a system for exchanging information about ways of operating CBA and the impact of various road safety measures, to serve as the background for decision makers. To stimulate the more uniform and reliable evaluation of safety effects in the EU, it would be useful for example. to establish a database with typical values of the effects, based on international experience. The quality of efficiency assessments can be improved by introducing impartial quality control.
- o There should be more scope for CBA at the European level, executed both by the DG TREN and especially by expert support of the EU bodies<sup>22</sup>. The use of EAT can be stimulated, for example, by legally embedding EAT in the decision-making process for large road investments.

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<sup>22</sup> This would not only lead to more efficient EU road safety policy but but also provide inspiration for decision makers and politicians at the national level to take CBA seriously.

Road safety experts should make greater efforts to disseminate information and knowledge about the operation and impact of CBA within their countries, drawing upon international experience. Such information should be disseminated with great expertise, using very clear and understandable arguments. Presentation of the benefits of CBA using non-technical language should help to widen understanding of CBA, especially among politicians at all levels.

The dissemination of information is limited by the available financial resources. More money for disseminating information and better explanations of the CBA of road safety measures could play a very important role in gaining greater acceptance.

Special attention should be paid to politicians at all levels. Involvement of NGOs in disseminating information about the benefits of CBA could play an important role in overcoming political opposition.

It is vitally important to overcome institutional . National road safety administrations (ministries) and national road safety institutes should play a key role in achieving this, and international co-operation both at the EU level and bilaterally should make an important contribution.

One of the most fashionable ideas currently influencing governmental reform in many states is to delegate as many tasks as possible to the lowest level of government. The arguments made for such reforms are that local problems are best solved at the local level, and that local government can be reinvigorated if it is given more tasks and more freedom to choose how to solve these tasks. The problem at the local level is very often lack of resources. If the delegation of responsibilities is not accompanied by extra funding, an extra barrier can be created and the effect of keeping decision making as close as possible to citizens can be lost. This barrier should thus be overcome by providing sufficient funding at the local level.

Creating one very detailed road accident database or, as a preliminary, co-operation between existing databases should help to encourage the wider use of CBA. Good information, possibly comparing international road accident trends and the impact of road safety measures, should create a favourable environment for introducing CBA with the benefit of international experiences. An important step for achieving this is to create a common methodology for collecting road accident and traffic data at national level among member states. At the international level, closer co-operation between the various international organisations charged with improving road safety and road transport should be encouraged,

The importance of CBA should be emphasised by incorporating CBA in EU, national, regional and local road safety plans and strategies.

## 6 Professional code for analysts

The following guidelines give an overview about the minimum conditions which should be fulfilled by a professional road safety related assessment. These guidelines should give decision makers support when they have to decide about the conduct of a road safety related assessment. It could also be useful for consultants and analysts to consider these guidelines when drafting a proposal.

The professional guidelines can be summarised by the following short rules:

<b>The competence of the consortium has to be adequate for the assessment task.</b>
<b>Several items have to be fixed before the assessment starts.</b>
<b>A quality control board could be established for large assessment projects.</b>
<b>Important interim results during the assessment process should be defined as milestones.</b>
<b>The whole assessment process has to be distinct and transparent (no “black box”).</b>
<b>Assessment of a road safety measure requires the application of the current state of scientific knowledge to a specific assessment task</b>
<b>The choice of the assessment method depends on the variety and characteristics of the considered effects.</b>
<b>All effects, which could be caused by the implementation of the measure, have to be considered in the assessment.</b>
<b>Data has to be attributed correctly to its sources and it has to be documented where and how estimations were made to fill data gaps.</b>
<b>The most important step of any road safety related assessment is the estimation of the accident reduction potential, therefore it would be highly undesirable for this estimate to be hidden somewhere within the text.</b>
<b>Analysts should avoid to create own figures where official monetary values exist.</b>
<b>It has to be explained under which conditions results are valid and which developments could influence the result.</b>
<b>Decision makers should not be flooded with irrelevant information.</b>
<b>The whole assessment process has to be documented in a report, starting with a summary and highlighting the main results.</b>

*Table 5: Professional guidelines for analysts*

## **6.1 Networking**

The consortium or team which carries out the assessment should possess all the skills and experience which are necessary to solve the assessment problem. While an experienced knowledge in road safety related analysis is always necessary additional knowledge is required when, for example, economic or environmental effects are also to be assessed. A good knowledge in one field cannot outweigh missing qualities in other fields. The whole quality of the assessment would suffer if one aspect is addressed in an inadequate manner.

## **6.2 Agreement on the term of reference**

Several items should be fixed between the decision makers and the analysts before the assessment starts:

- Objective of the study
- Number of case studies to be assessed (and relevant alternatives)
- Assessment method (see below)
- Degree of completeness of analysis
- Lifetime and sustainability of the measure (i.e. how many years could effects be attributed to the measure)
- Agreement on evaluation criteria and on degree of thoroughness
- Milestones (see below)
- All relevant circumstances, including already detected barriers
- Reports (see below)
- Installation of a quality control group (see below)

## **6.3 Quality control**

The quality of the efficiency assessment could be improved by introducing a quality control procedure. To this end, it is advisable to consider introducing a permanent or ad-hoc evaluation board to accompany large assessment projects. General assessment experts and specialists for the specific item under assessment should form such a group.

## **6.4 Milestones**

Important interim results during the assessment process should be defined as milestones (e.g. completion of the data sets, estimation of the reduction potential etc). When a milestone is reached it should be possible to end the assessment project if the expected result documented by the milestone is not reached and adequate alternative strategies are missing.

## **6.5 Transparency**

The whole assessment process has to be distinct and transparent. Decision makers have no use for “black boxes” where only the analyst knows how input leads to output. Data sources, calculation methods, costs and benefits have to be documented. It is necessary to document the assumptions which are made and the influence of these assumptions on the results of the assessment.

## **6.6 Application of the state of knowledge**

To assess a road safety measure means to apply the actual scientific knowledge to a specific assessment task. Such an assessment task is not the playground for theoretical discussions and controversies. Where official or superior approaches are missing and competing approaches exist, it is the task of the analyst to decide which approach should be applied and to explain succinctly the reasons for this decision.

## **6.7 Assessment method**

The choice of the assessment method depends on the variety and characteristics of the considered effects, the intentions of the client and the kind of decision which is to be supported by the assessment. In principle, analysts should try to carry out a cost-benefit-analysis due to the advantages of this method. A cost-effectiveness-analysis could be carried out if only one-dimensional safety effects (usually the reduction of fatalities) have to be considered, e.g. for ranking different measures.

## 6.8 Coverage

All effects of the measure which influence the allocation of resources have to be considered in the assessment.

Always to be included are the values of:

- o safety effects
- o implementation and maintenance costs

Such an assessment has been called a “mini-CBA” in ROSEBUD.

When basic traffic parameters like speed distributions or traffic volumes are influenced by introducing a measure, additional effects should be taken into account:

- o travel time changes
- o changes in fuel consumption
- o pollution
- o global warming

To consider environmental effects (pollution) it is necessary for at least the emission changes of NO<sub>x</sub>, HC and CO to be considered. To consider the effects on global warming, CO<sub>2</sub>-emissions should be considered. Depending on the assessment task, the inclusion of further effects, such as noise, could be recommended .

## 6.9 Data bases

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.

## **6.10 Estimation of the accident reduction potential**

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.

What has been mentioned before regarding the transparency of the whole assessment process is especially true for the estimation of the accident reduction potential. Above all, the estimation of the reduction potential should not be simply hidden somewhere in the report.

## **6.11 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 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.

## **6.12 Discussion of the results**

After an assessment result has been derived it is the duty of the analysts to explain the stability of the result, i.e. to explain under which conditions the result is valid and which developments could influence the result. Above all, analysts have to be honest about the weak points of their assessment, e.g. where judgements were necessary to close data gaps or where small changes of specific parameters could influence the whole assessment result.

The discussion of the results should not be done in difficult, technical terms, but by translating the assumptions and uncertainties in different outcomes of the efficiency assessment (sensitivity analysis). If this is not done, decision makers may become suspicious because they could not understand the outcomes.

Effects which cannot be addressed by means of CBA or CEA should be mentioned, e.g. distributional effects.

Finally, unresolved questions should be presented clearly.

### **6.13 Brevity**

Road safety related assessment is carried out to enable decision makers to make an adequate decision although they are usually facing a very complex situation. The complexity of the situation is condensed into one figure like the cost-benefit-ratio. This advantage of the assessment shouldn't be weakened by flooding the decision makers with all other information which has been collected during the assessment process. Thick reports, unclear tables and incomprehensible language are undesirable and counter-productive.

Nevertheless, decisionmaker often demand something more than one figure. To this end a summary e.g. in tables can be used.

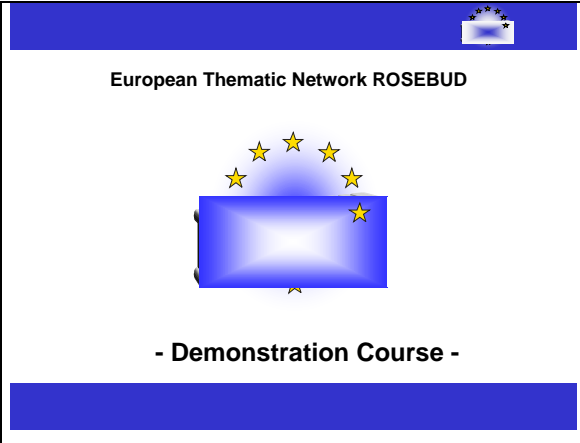
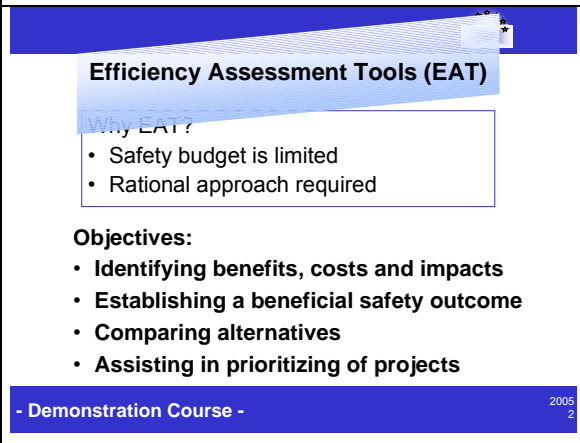
### **6.14 Documentation**

The whole assessment process has to be documented in a report, fulfilling all the requirements as described above regarding transparency and brevity. At the beginning of every report a summary should inform about the key results. The main results should be highlighted and not hidden in the report. Complementary to the report, a personal presentation can be given by the analyst. It would be recommended that together with the report a clear and simple presentation of the results is provided. The presentation has to ensure that the subject is understandable and accessible.

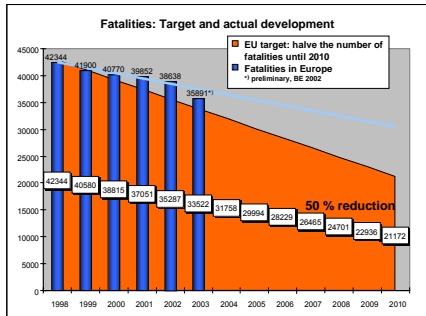
## 7 Demonstration course

The following PowerPoint presentation is available on the ROSEBUD homepage [www.rosebud-eu.org](http://www.rosebud-eu.org) and can be downloaded and used free of charge. The main purpose is to prepare the presentation of efficiency assessment results, to support the recipients with the necessary knowledge. Everyone using this presentation may - and is strongly encouraged to - adopt it for his own purpose, specifically considering the professional experience and educational background of the audience. However, this presentation was designed to suit for most of the possible recipients. This contains the possibility to adopt the depth of knowledge transported by adopting the comments given presenting each single slide.

Further, the example used is a quite critical one which contains a lot of problems which may be addressed in the presentation. In the Appendix the reader will find the full description of the measure and the economic evaluation of it. The presenter may also use other examples, but only results from state-of-the-art efficiency assessment studies should be selected for this purpose.

 <p>European Thematic Network ROSEBUD</p> <p>- Demonstration Course -</p>	<p>Page 1: Front page</p> <p>Efficiency assessment (EA) and efficiency assessment tools (EAT) shall support the decision making process in political decisions on road safety measures. They should serve as an objective means of setting priorities. This incorporates both to support the introduction of useful (i.e. efficient) measures and to prevent the introduction of measures which are not useful from the road safety point of view.</p>
 <p>Efficiency Assessment Tools (EAT)</p> <p>Why EAT?</p> <ul style="list-style-type: none"> <li>• Safety budget is limited</li> <li>• Rational approach required</li> </ul> <p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>• Identifying benefits, costs and impacts</li> <li>• Establishing a beneficial safety outcome</li> <li>• Comparing alternatives</li> <li>• Assisting in prioritizing of projects</li> </ul> <p>- Demonstration Course -</p> <p>2005 2</p>	<p>Page 2: Efficiency Assessment Tools (EAT)</p> <p>The core topic of EA is to get the best value for the money spent. It may also be the other way round, that means that a certain safety target is set and EA is used to support finding the cheapest solution. This means, comparing different road safety measures by means of public economic costs (keeping in mind the questions, who pays and who benefits).</p>

## Road safety in Europe



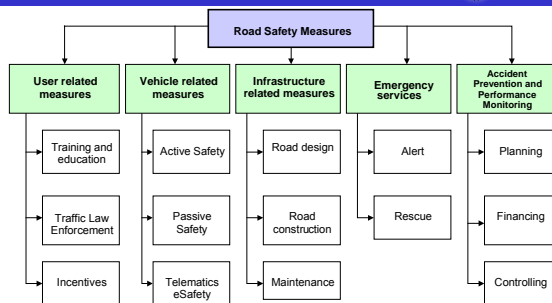
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### Page 3: Road Safety in Europe (EU15).

This sheet shall support to point out the importance of road safety measures at the European level referring to the Europeans road safety target of reducing the number of fatalities by 50% until 2010.

## Road safety measures



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### Page 4: Road Safety Measures

This sheet systematically lists all fields of road safety work. It may support decisions, if measures shall be taken in one of the fields, where only little has been done in the past. It may also support measures which address more than one of the fields.

At least, it is a good overview of all the approaches to reduce road deaths and injuries.

## Efficiency assessment

- The aim of the assessment is to identify the most efficient measures.
- This will enable the society to allocate the resources to the most beneficial use.




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### Page 5: Efficiency assessment

Decisions should be taken aiming at efficient strategies. The decisionmaker should commit to aim at the best value for the money to prevent as many accidents, deaths and injuries as possible. EA supports him with the information he need for such decisions.

<p><b>EAT in the decision making process</b></p> <p>Possible scheme of a systematic evaluation of road safety activities</p> <p>- Demonstration Course - <span style="float: right;">2005 6</span></p>	<p><b>Page 6: EAT in the decision making process</b></p> <p>All of the following steps provide decision-makers with information to steer the road safety activities.</p> <p>Controlling I: Implementation plan and reality should be compared at successive milestones. (Identifying problems to implementation.)</p> <p>Controlling II: Target variables and indicators should be defined and the expected effects should be compared with the results reached in reality. At this step, measures with unsatisfactory results or (unintended) side-effects should be identified.</p> <p>Controlling III: Comparison of ex-ante and ex-post CBAs and CEAs should be made. This step should identify the efficiency or inefficiency of road safety activities.</p>
<p><b>Efficiency assessment can help</b></p> <ul style="list-style-type: none"> <li>• Efficiency assessment = a systematic assessment of the improvement in road safety that can be realised by means of various road safety measures</li> <li>• Two main forms of efficiency assessment: <ul style="list-style-type: none"> <li>– Cost-effectiveness analysis (CEA)</li> <li>– Cost-benefit analysis (CBA)</li> </ul> </li> </ul> <p>- Demonstration Course - <span style="float: right;">2005 7</span></p>	<p><b>Page 7: EA can help...</b></p> <p>In many cases, there are many different ways to solve a specific road safety problem. EA shall support to make the best choice.</p> <p>There are also other methods (e.g. multi criteria analysis), but CEA and CBA are most commonly used, since they have the best relation between necessary efforts and usability of results.</p>
<p><b>Main elements of efficiency assessment</b></p> <ul style="list-style-type: none"> <li>• A list of road safety measures</li> <li>• An estimate of the effects of these measures on accidents or injuries</li> <li>• An estimate of the costs of the measures</li> <li>• For cost-benefit analysis, monetary valuation of impacts is needed</li> </ul> <p>- Demonstration Course - <span style="float: right;">2005 8</span></p>	<p><b>Page 8: Main elements of efficiency assessment</b></p> <p>For CEA an efficiency threshold may be defined (maximum cost per life saved), by CBA a single measure may also be judged whether it is effective or not. Establishing reliable estimates for safety effect is the most difficult task. There may be information given, how such estimates may be established, e.g. by using results from similar measures, from equal measures at other locations, using accident prediction models or other methods. The main parts of the costs are investment and maintenance.</p>

<div style="text-align: right;"></div> <h3 style="text-align: center;">Cost Effectiveness Analysis</h3> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <math display="block">\text{Cost Effectiveness} = \frac{\text{Number of accidents prevented}}{\text{Costs of implementation}}</math> </div> <p><b>Necessary data</b></p> <ul style="list-style-type: none"> <li>• <b>Implementation costs</b></li> <li>• <b>Estimate of the number of accidents prevented</b></li> </ul> <div style="text-align: right;"><small>2005 9</small></div>	<p><b>Page 9: Cost Effectiveness Analysis</b></p> <p>The typical results are figures like a ranking of measures by costs per accident prevented or costs per life saved. Start implementing measures bottom down in this list until the available financial resources are completely spent or until the safety target is supposed to be reached.</p>
<div style="text-align: right;"></div> <h3>Cost-effectiveness analysis</h3> <ul style="list-style-type: none"> <li>• Pros: <ul style="list-style-type: none"> <li>– A simple technique which focuses on safety effects</li> <li>– Does not require monetary valuation of safety</li> </ul> </li> <li>• Cons: <ul style="list-style-type: none"> <li>– Can only be used for ranking measures</li> <li>– Does not consider tradeoffs against other policy objectives</li> <li>– It is not possible to consider different accidents consequences (severe and slight injuries, property damages)</li> </ul> </li> </ul> <div style="text-align: right;"><small>2005 10</small></div>	<p><b>Page 10: Cost Effectiveness Analysis</b></p> <p>Ranking are mainly based on simply the number of accidents prevented. Hence, CEA is one bit step forward towards efficient use of resources in road safety policies. This is specifically important, if such valuations face serious objections. CEA also does not require monetary valuation of all other effects, results can be found much quicker.</p> <p>Ranking of measures is most common purpose, but defining a threshold for maximum cost per life saved, it may also be used to assess single measures. Environmental issues, time consumption, and mobility costs are neglected. In some cases safety measures would be rejected by a CEA ranking, but be very efficient when assessed by CBA (e.g. railroad crossings have a high impact on travel time for rail and road as well, so they are frequently cost-beneficial, but not cost-effective.</p> <p>The "casualty mix" (fatalities, injuries, property damage) is different for different measures. Even if the number of accidents is selected as the safety parameter, CEA will hardly mirror the complete range of impacts.</p>
<div style="text-align: right;"></div> <h3 style="text-align: center;">Cost Benefit Analysis</h3> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <math display="block">\text{Cost benefit ratio} = \frac{\text{present value of all benefits}}{\text{present value of implementation costs}}</math> </div> <p>Particularly useful if</p> <ul style="list-style-type: none"> <li>• multiple policy objectives exist</li> <li>• policy objectives are conflicting</li> <li>• objectives refer to goods without market prices (safety, environment, mobility)</li> </ul> <div style="text-align: right;"><small>2005 11</small></div>	<p><b>Page 11: Cost Benefit Analysis</b></p> <p>Such policy objective could be e.g. environmental interests or influencing modal split. Most of the measures, where there are no conflicting policy objectives, are put into truth already.</p> <p>Experts could give an overview, how the monetary valuation of goods without market prices is done.</p>

 <p style="text-align: center;"><b>CBA: Necessary data</b></p> <ul style="list-style-type: none"> <li>• Costs of implementation</li> <li>• Estimate of the number of accidents prevented</li> <li>• Other quantified effects (environmental, traveltime, vehicle operation etc.)</li> </ul> <p style="text-align: right;">2005 12</p> <p style="text-align: left;">- Demonstration Course -</p>	<p><b>Page 12: Necessary data</b></p> <p>It is crucial to determine, which effects occur when implementing a measure. Some effects might not be considered in a CBA due to certain reasons, but a state-of-the-art CBA should include all the relevant parameters.</p>
 <p style="text-align: center;"><b>CBA: Necessary data</b></p> <p style="text-align: center;">monetary values (benefits)</p> <div style="border: 1px solid black; padding: 5px; margin: 10px auto; width: 80%;"> <p>Changes of</p> <ul style="list-style-type: none"> <li>– accident costs</li> <li>– environmental costs (noise, air pollution)</li> <li>– mobility costs (time consumption)</li> <li>– travel costs (vehicle operating)</li> </ul> </div> <p style="text-align: right;">2005 13</p> <p style="text-align: left;">- Demonstration Course -</p>	<p><b>Page 13: Necessary data</b></p> <p>All the quantified impacts have to be transferred to economic values in a CBA. For this purpose, costs per unit (e.g. Euro per ton CO<sub>2</sub>, average cost per one severe injury) need to be determined for all the relevant parameters. These valuations should be prepared as exact as possible considering the time and location of the measure. If they are not available, values from other countries or European figures may be used.</p>
 <p><b>Cost-benefit analysis</b></p> <ul style="list-style-type: none"> <li>• Pros: <ul style="list-style-type: none"> <li>– Considers all relevant policy impacts</li> <li>– Enables a direct comparison of costs and benefits</li> </ul> </li> <li>• Cons: <ul style="list-style-type: none"> <li>– Monetary valuation e.g. of human life and quality is controversial and difficult, but inevitable</li> <li>– Not all effects can be assessed (e.g. distributional effects)</li> </ul> </li> </ul> <p style="text-align: right;">2005 14</p> <p style="text-align: left;">- Demonstration Course -</p>	<p><b>Page 14: Cost-benefit analysis</b></p> <p>The most important advantage of a CBA is that it shows the total impact on public economy and therefore able to determine whether a road safety measure in term of public economy is worth the money or not.</p> <p>Monetary valuations of human life and injuries are on the one hand difficult to calculate and on the other hand controversially discussed and sometimes not accepted easily.</p> <p>Mainly distributional effects are addressed here, which cannot be assessed in a CBA.</p>




**CBA: basic rules of the game**

- Consumer sovereignty is respected
- Maximum efficiency (Pareto-optimality) in resource allocation is sought
- The existing distribution of income is taken as given

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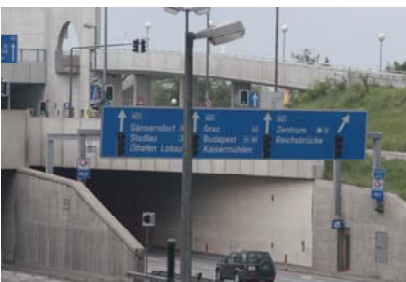
**Page 15: Basic rules of the game**

The application of CBA is based on economic principles: consumer sovereignty and pareto-optimality. The distributional effects of the implementation of the measure is not part of the assessment.



**Site overview**


Section Control  
Kaisermühlen Tunnel



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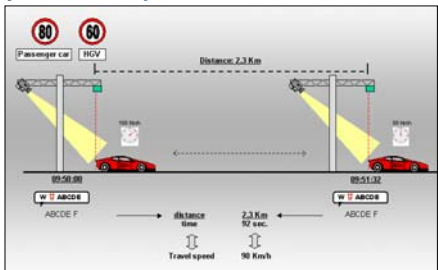
**Page 16: Example Kaisermühlen Tunnel**

"Section Control" (SC) is an automatic device for speed enforcement, not based on measuring at a certain spot, like the "conventional" measures like radar and laser guns do. This device is installed in a highway tunnel in the city of Vienna, three lanes in each direction, speed limit 60 km/h for trucks over 7,5 t and 80 km/h for all others.



**System description**

Section Control  
Kaisermühlen Tunnel



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**Page 17: System description**

The vehicle runs through a radar curtain, which shall detect its size (i.e. the relevant speed limit) and a photo is taken from behind. The licence plate is detected automatically. After 2,5 km an equal device is installed. The licence plates are compared, and if they are equal, using passage time and distance, the average speed is calculated. If the speed is over the limit, photos and data are transferred to the relevant authorities, else the data is deleted immediately.

**Section Control**  
Kaisermühlen Tunnel

**Costs/Benefits**

**Costs of the measure**

- ☞ Investment costs
- ☞ Annual costs of operation and maintenance

**Economic benefits**

- ☞ Reduction of accident costs (numbers, severity of injury)
- ☞ Reduction of road traffic emissions

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**Page 18: Costs and Benefits of the measure**

The costs of one such device are at 1,5 Mio. Euro approximately. Due to technical reasons, the life-span is 10 years. The average speed of the vehicle decreased by about 5 to 10 km/h depending on the time gap to the introduction of SC. The reduction of fuel consumption and exhaust gases was assessed using this speed difference. It was decided not to consider increased time use for passing the tunnel, because advantages collected illegally (by driving over the speed limit) shall not be considered. Also, the fines were not considered as benefits. Noise impacts of reduces speed may be disregarded due to the fact that the whole range affected is in a tunnel.

**Section Control**  
Kaisermühlen Tunnel

**Effects on accidents**

From	To	Period	Injury accidents	Fatalities	Seriously injured	Slightly injured
12.08.1999	12.08.2000	IV <sub>a</sub>	7	1	0	10
12.08.2000	12.08.2001	III <sub>b</sub>	7	0	1	9
12.08.2001	12.08.2002	II <sub>b</sub>	7	1	1	11
12.08.2002	12.08.2003	I <sub>b</sub>	7	0	0	9
Mean (IV <sub>a</sub> - I <sub>b</sub> )			7.0	0.5	0.5	9.8
12.08.2003	12.08.2004	I <sub>a</sub>	5	0	0	7

- ☞ Reduction in total numbers of casualty accidents and severity of injury
- ☞ since August 2002: no fatal accident or serious injury recorded

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**Page 19: Effects on accidents**

The total numbers of injuries and fatalities were quite low, which is not a very good basis for a stable assessment. The local accident rates need to be considered if Section Control is implemented somewhere else.

**Section Control**  
Kaisermühlen Tunnel

**Costs and Benefits**

Components of the CBA	Benefits	Costs
Road traffic emissions	79,108	
Saving of accident costs	1,025,903	
Installation and maintenance costs		204,272
<b>Total</b>	<b>1,105,011</b>	<b>204,272</b>


  




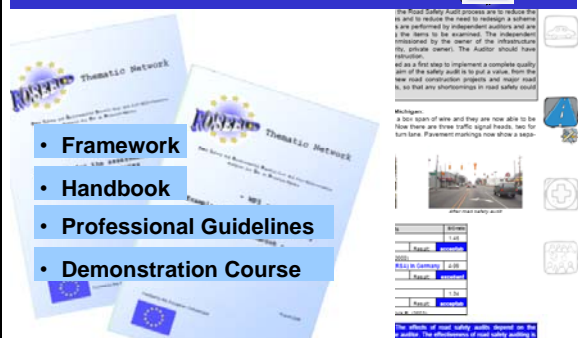
Category	Amount of savings	€ per unit (2002-price)	Cumulated value
Fatalities	1	949,897	949,897
Seriously injured	1	51,439	51,439
Slightly injured	3	4,359	13,077
Property damage	2	5,745	11,490

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**Page 20: Costs and Benefits**

The values for injuries and fatalities in Austria were calculated in 1997 based on data from 1993 and transferred to 2002 prices. The Austrian values are based on a non-behavioural model and therefor quite low in the international comparison.

<p style="text-align: center;"><b>Cost-Benefit Ratio (CBR)</b></p>  <p style="writing-mode: vertical-rl; transform: rotate(180deg);">Section Control Kaisermühlen Tunnel</p> $CBR = \frac{\sum \text{Benefits}}{\sum \text{Costs}} = \frac{1,105,011}{204,272} = 5.4$ <p style="text-align: center;">⇒ ROSEBUD (WP1): <b>CBR &gt; 3</b> are ranked „excellent“</p> <p style="text-align: right;">- Demonstration Course - <span style="float: right;">2005 21</span></p>	<p><b>Page 21: Cost-benefit ratio</b></p> <p>On an annual basis, the costs and benefits are calculated to a cost benefit ratio.</p> <p>A detailed description of the assessment of this measure you will find in the annex of this handbook.</p>
<p style="text-align: center;"><b>Recent analyses of road safety policy</b></p> <ul style="list-style-type: none"> <li>• There is a large potential for improving road safety</li> <li>• Only a part of this potential will be realised if current policies are continued</li> <li>• If priorities for road safety measures were based on cost-benefit analyses, large gains in safety could be realised</li> </ul> <p style="text-align: right;">- Demonstration Course - <span style="float: right;">2005 22</span></p>	<p><b>Page 22: Analysis of road safety policy</b></p> <p>Studies in Sweden and Norway have shown that only a small share of road casualties will be avoided if current road safety policies are maintained. A cost-effective prioritising in road safety policy could at least triple the number of accident and casualties prevented at the same cost.</p>
<p style="text-align: center;"><b>Efficiency analysis in context</b></p> <ul style="list-style-type: none"> <li>• Not all inefficient policy priorities can be eliminated by doing efficiency analysis</li> <li>• A systematic use of efficiency analysis can, however, help achieving targets more efficiently</li> </ul> <p style="text-align: right;">- Demonstration Course - <span style="float: right;">2005 23</span></p>	<p><b>Page 23: EA in context</b></p> <p>Frequently, decisions on road safety measures incorporate issues like employment. Constraints deriving from environmental considerations are frequently difficult to overcome by using EA.</p>

<div style="text-align: right; border-bottom: 1px solid black; padding-bottom: 5px;">  </div> <p><b>Do policy makers value efficiency analysis?</b></p> <ul style="list-style-type: none"> <li>• Yes, cost-effectiveness analysis is regarded as useful</li> <li>• Opinions differ more with respect to cost-benefit analysis</li> <li>• The techniques are continuously being improved – making them more relevant for policy makers</li> </ul> <div style="border-top: 1px solid black; padding-top: 5px;"> <span style="float: left;">- Demonstration Course -</span> <span style="float: right;">2005 24</span> </div>	<p><b>Page 24: Value of EA</b></p> <p>These are the results from a broad survey among decision makers carried out in ROSEBUD WP2</p>
<div style="text-align: right; border-bottom: 1px solid black; padding-bottom: 5px;">  </div> <p><b>Final remarks</b></p> <ul style="list-style-type: none"> <li>• Efficiency analysis should be part of any road safety programme</li> <li>• In many countries efficiency analyses are not used to their full potential</li> <li>• More efficient policy priorities will improve road safety</li> <li>• Having the European reduction target in mind, the benefits of reducing road accident fatalities by at least 50% exceed the costs</li> <li>• Efficiency assessment can help bringing better results in road safety policy</li> </ul> <div style="border-top: 1px solid black; padding-top: 5px;"> <span style="float: left;">- Demonstration Course -</span> <span style="float: right;">2005 25</span> </div>	<p><b>Page 25: Final remarks</b></p> <p>The assessment of road safety measures should not only be a single process at a certain stage in the process (normally at the beginning) or only to create a single programme. The application of CBAs and CEAs allows the results of systematic monitoring of road safety activities to be assessed (an example of application is described in page 6 of this Demonstration Course)</p>
<div style="text-align: right; border-bottom: 1px solid black; padding-bottom: 5px;">  </div> <p><b>Final ROSEBUD - products</b></p> <div style="display: flex; align-items: flex-start;"> <div style="flex: 1;"> <ul style="list-style-type: none"> <li>• Framework</li> <li>• Handbook</li> <li>• Professional Guidelines</li> <li>• Demonstration Course</li> </ul> </div> <div style="flex: 2;">  </div> </div> <div style="border-top: 1px solid black; padding-top: 5px;"> <span style="float: left;">- Demonstration Course -</span> <span style="float: right;">2005 26</span> </div>	<p><b>Page 26: Final products</b></p> <p>All of the mentioned ROSEBUD products are available on the ROSEBUD homepage:  <a href="http://www.rosebud-eu.org">www.rosebud-eu.org</a>.</p>

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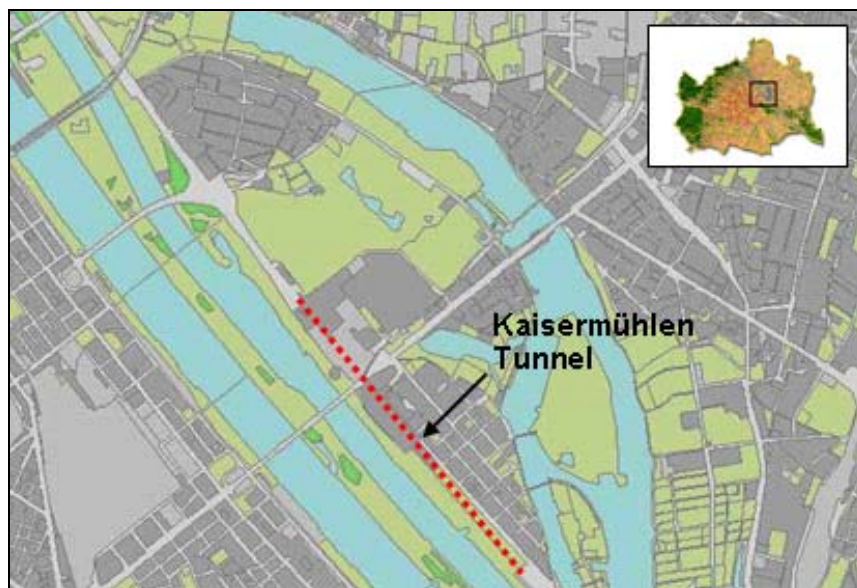
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**Annex I : Description of the assessed measure “Section Control”  
Automatic Speed Enforcement in the Kaisermühlen Tunnel (Vienna,  
A22 motorway); by Christian Stefan; Austrian Road Safety Board  
(KfV), Austria; WP4 Report (2005)**

The Kaisermühlen Tunnel is an urban tunnel with separate tubes for each direction of traffic. More than 90,000 vehicles use this part of the A22 motorway everyday; about 10% are Heavy Goods Vehicles (HGV). Due to a nearby tank lot, the proportion of HGVs carrying flammable liquids (e.g. motor spirits, diesel oil) is extremely high. The tunnel offers 3-4 lanes per direction with entrance and exit ramps within the tunnel.



*Figure 3: Site overview of the Section Control in the Kaisermühlen Tunnel*

The Austrian highway operator (ASFINAG) introduced a new instrument of traffic surveillance to reduce accidents and traffic delays in the Kaisermühlen Tunnel on one of Vienna’s most frequented motorways (A22) in August 2003. This so-called Section Control does not measure speed at a certain point in space and time, but calculates the average speed by means of passage time in a defined area (see Figure). The aim is to force drivers not only to slow down at certain points of stationary speed control (e.g. automatic speed cameras), but also adhere to the speed limit over the entire distance. It also provides live monitoring of traffic flow behaviour and thus contributes to harmonizing traffic flow.

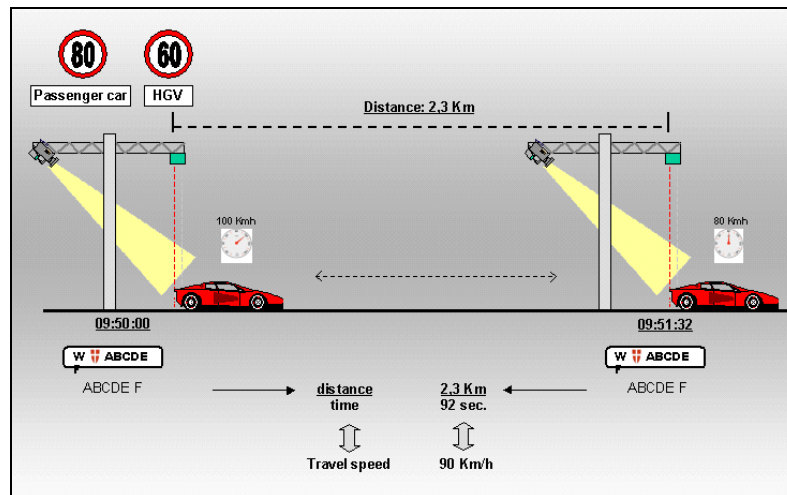
<b>KAISERMÜHLEN TUNNEL</b>	
Road classification	Urban motorway (A22)
Type of road	Tunnel with two tubes
Number of lanes per direction	3-4
Width per lane	3.5 m
Length	2.3 km
Speed limit	Passenger cars, buses, motorcycles: 80 km/h; Heavy Goods Vehicles (>7,5 t): 60 km/h
Daily traffic (2003 <sup>23</sup> )	91,915 vehicles/24 hours
Amount of Heavy Goods Vehicles (HGV)	10.0%

*Table6: Road characteristics of the Kaisermühlen Tunnel (Source: Vienna Municipal Department 34, calculations of KuSS)*

The system consists of two facilities, one for each driving direction. Vehicle detection is carried out optically. A video system placed above the road on gantries (one camera above each of the three lanes) takes two pictures of each passing vehicle, one at the beginning of the tunnel and one at the end. These photographs provide details of the event (passage time, use of lane) and the license plate number. Furthermore a laser scanner installed adjacent to the video system is programmed to differentiate between passenger cars and lorries (HGVs), which is fundamental to keep different speed limits under surveillance.

At the entrance and exit of the Kaisermühlen Tunnel, laser scanners are installed to obtain the required data. The system continually looks for two matching licence plates - if a match is found, the average speed is calculated and if it exceeds a defined level, an image of the licence plate is transmitted to the traffic supervision department. This information is used to establish the owner of the vehicle via the national motor vehicle and driver's licence registration database. Data of vehicles not exceeding the pre-set speed limit (plus a certain tolerance) are deleted immediately afterward. Only aggregated data is kept for statistical reasons.

<sup>23</sup> Computed data by means of a linear regression model. Vehicle data related from the automatic counting station have been inadequate due to false HGV readings in one direction.



*Figure4: Scheme of Section Control in the Kaisermühlen Tunnel (Source: Vienna Municipal Department 34)*

The Section Control system is designed to operate with speeds up to 250 km/h and a maximum traffic flow of 2 vehicles per second and lane. Vehicle detection is independent of the position of a vehicle on or between lanes. There is no necessity for pavement installations (like inductive loops) or disruption of the traffic flow.

The target accident group of this measure consists of accidents occurring in the Kaisermühlen Tunnel. This survey concentrates on injury accidents because data for material damage accidents could not be collected without enormous strains on budget and working hours. Thus, the cost-benefit ratio computed in the following chapters underestimates the real impacts on accidents to a certain extent. This should be kept in mind whenever Section Control systems are considered for further use in traffic safety programmes.

The main task of Section Control is the measurement of average speed of motor vehicles for the purpose of speed control and traffic enforcement.

### Objectives

- Monitoring different speed limits that apply to different vehicle classes
- Harmonization of traffic flow (reduction of “Stop-and-Go” traffic or congestion during peak hours)
- Surveillance of closed lanes (in combination with route information and management systems)
- Detection of wrong-way drivers (“ghost cars”)
- Image triggering (including alarm release) for vehicles exceeding height limits
- Detection of stolen vehicles
- Traffic surveillance (for the tunnel operator)
- Statistical data (traffic speed, loads, headways)
- Impact of Section Control on average speed

In 2003 more than 35% of fatal accidents on roads in Austria occurred because of inappropriate speed. In its first year of operation, a reduction in average speed by more than 10 km/h was recorded (see Figure). Traditional mobile and stationary speed surveillance (in use before the Section Control started operating) showed the average speed of all vehicles to be 85 km/h, whereas this value decreased to about 70 km/h shortly after the introduction of the measure. Further speed measurements carried out after a 6-month period revealed that average speed on this road section has levelled off to 75 km/h due to the fact that drivers tend to follow regulations in a very strict manner right after their implementation, but less some time afterwards due to unintended behavioural adaptations ("kangaroo effect").

Drivers started acting in accordance with the speed limit as soon as technical installations were established, and reports about this new system of speed control appeared in the media.

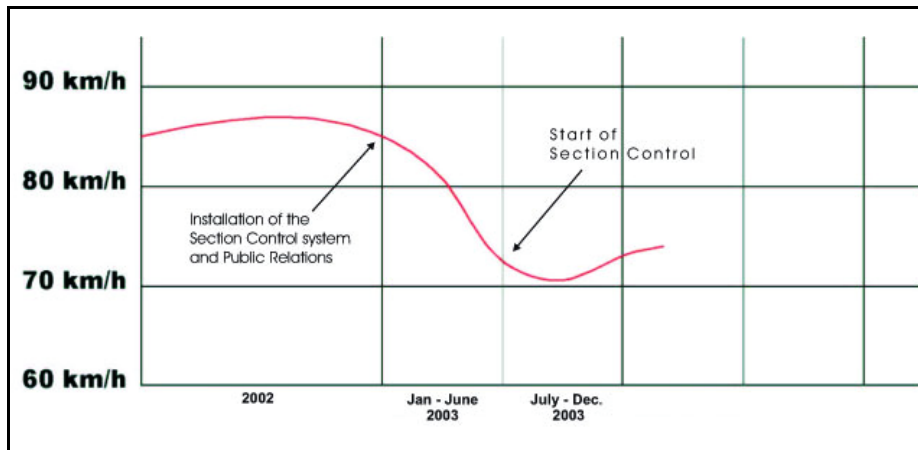


Figure5: Effect of Section Control on average vehicle speed (Source: Vienna Municipal Department 34)

	Passenger cars		HGV	
	Before	After	Before	After
Daytime	85 km/h	75 km/h	70 km/h	55 km/h
Night time	95 km/h	75 km/h	75 km/h	55 km/h

Table7: Average speed of passenger cars and lorries before and after implementation of Section Control (Source: estimations of KuSS in cooperation with local police services)

### Costs of the measure:

Investment costs for the Section Control in the Kaisermühlen Tunnel add up to € 1,200,000 (2003 price)<sup>24</sup>. Annual costs of operation and maintenance are about € 60,000.<sup>25</sup>

The Section Control system has a 10-year service life, beginning in 2003. After that period, software problems and missing spare parts for the hardware are expected to affect full operation of the system. Investment costs are incorporated in the form of an annual capital cost assuming a 4 percent interest rate in real terms (see Table). For the sake of comparability, all costs were converted to their 2002-price level. Total annual costs for operating the Section Control add up to € 204,272 per year.

	EURO (2003-price)	EURO (2002-price)		
Expense factors	Costs	Costs	Annual capital costs [n=10, 4% p.a.]	Total annual costs
Investment costs	1,200,000	1,178,782	<b>145,333</b>	204,272
Annual maintenance costs	60,000	<b>58,939</b>		

*Table 8: Total annual costs of Section Control in the Kaisermühlen Tunnel (Source: Vienna Municipal Department 34, own calculations)*

The “Handbook of Emission Factors for Road Transport” provides emission factors in g/km for all current vehicle types (e.g passenger cars, Light Duty Vehicles), each divided into different categories for a variety of traffic situations. The following parameters have been used:

- Type of emission: hot emissions, cold start emissions, evaporation
- Vehicle type: passenger car - Heavy Goods Vehicle (HGV)
- Estimated changes in composition of the vehicle fleet (2003-2013)
- Air pollutants (CO, NO<sub>x</sub>, SO<sub>2</sub>, PM<sub>10</sub>, VOC) and carbon dioxide (CO<sub>2</sub>)
- Type of road: urban motorway
- Time of day: daytime/night time

Table 9 gives values for both air pollutants and CO<sub>2</sub> as the most important greenhouse gas emitted by road traffic<sup>26</sup>.

<sup>24</sup> Construction work of gantries, cables and data lines to the Section Control server are included in this price.

<sup>25</sup> Covering a service contract of 4 service cycles per year plus additional repairs if the system starts malfunctioning.

<sup>26</sup> To arrive at 2002 prices, German Mark (DM) and Norwegian Krona (NOK) were first converted into Austrian Shillings (ATS) and then brought to a 2002 price level by using official inflation rates (see appendix). Values of traffic emissions were finally converted to € by multiplication with 0.07267.

Air pollution	Unit of valuation	Value per unit		
		DM (1995) <sup>27</sup>	NOK (1995) <sup>28</sup>	€ (2002)
CO	Tons of NO <sub>x</sub> -Equivalent <sup>29</sup>	1700		<b>974.64</b>
NO <sub>x</sub>	kg of NO <sub>x</sub>		115	<b>14.90</b>
SO <sub>2</sub>	kg of SO <sub>2</sub>		37	<b>4.79</b>
Particle (PM <sub>10</sub> )	kg of PM <sub>10</sub>		1800	<b>233.27</b>
VOC	kg of VOC		15	<b>1.94</b>
CO <sub>2</sub>	Tons of CO <sub>2</sub>		220	<b>28.51</b>

*Table 9: Valuation of environmental impacts for use in cost-benefit analyses (Source: own calculations)*

For the Kaisermühlen Tunnel, the boost in vehicle technology, along with a lower average speed due to Section Control, results in more than 12,000 tons of saved CO<sub>2</sub> emissions, having a discounted monetary value of more than € 280,000 (see Table).<sup>30</sup>

	Changes in road traffic emissions (t)	Discounted value of traffic emissions in €(2002-price)
CO	- 14.9	-137
NO <sub>x</sub>	- 39.0	-431,639
SO <sub>2</sub>	- 0.4	-1,552
Particle (PM10)	- 0.5	-87,029
VOC	+ 7.3	+11,247
CO <sub>2</sub>	- 12,879.6	-281,973
Accumulated value		-791.084
<b>Monetary value of saved emissions per year</b>		<b>-79,108</b>

*Table 10: Monetary value of saved emissions due to Section Control (accumulated value 2003-2013; Source: Austrian Umweltbundesamt, own calculations)*

Expected changes can be seen in Table, which states above all a constant decrease in saved nitrogen oxide emissions because of improvements in vehicle technology. In the year 2003 nearly 6 tons of NO<sub>x</sub> were saved through Section Control. This value decreases to one ton of NO<sub>x</sub> in 2013. Calculated over the economic lifetime of the

<sup>27</sup> EWS, 1997, page 41

<sup>28</sup> ELVIK, 1999, page 24

<sup>29</sup> Conversion factor: 1 ton of CO = 0.003 tons of NO<sub>x</sub>-Equivalent (EWS, 1997, page 41)

Section Control system, savings in NO<sub>x</sub> emissions amount to a value of more than € 430,000.

Volatile organic compounds (VOC), in combination with nitrogen oxides, are responsible for ground level ozone and smog. VOC are primarily produced when fuels are incompletely combusted. Looking at the VOC traffic emissions in the period under observation, an increase of one ton in 2003 and slightly less in the following years has been calculated. This is due to the fact that most vehicle engines have their lowest VOC output between 80 and 100 km/h. A decrease in average speed to 75 km/h (passenger cars) or 55 km/h (HGV) amounts to an increase of VOC emissions.

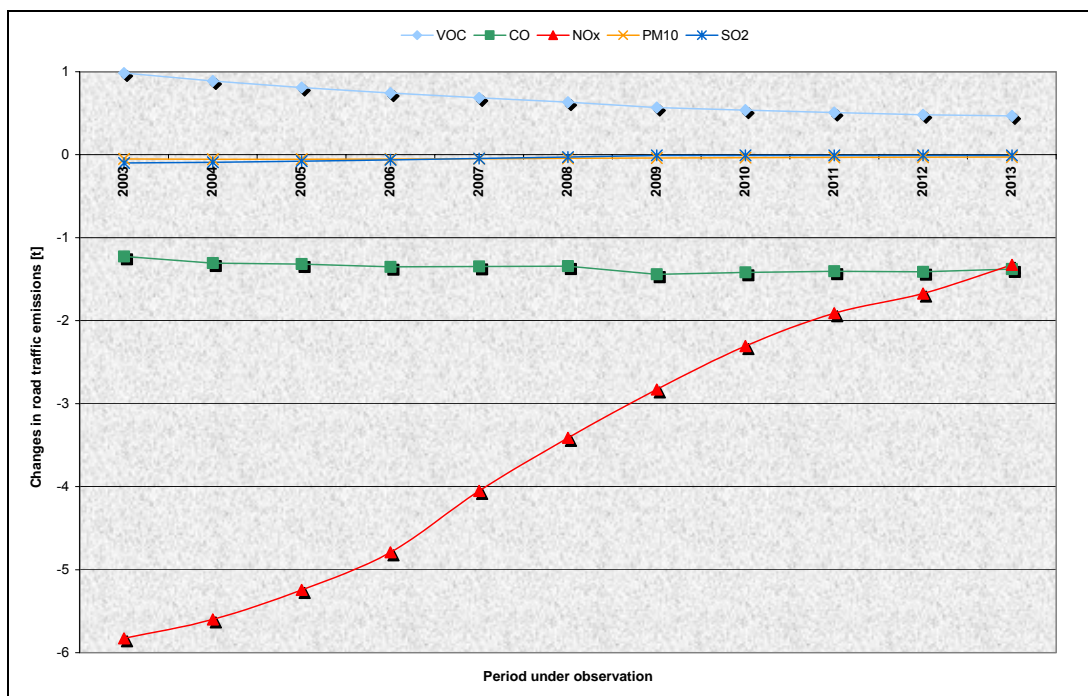


Figure 6: Changes in the emission of air pollutants due to Section Control

In its first year of operation, a positive impact of Section Control concerning accidents in the Kaisermühlen Tunnel was observed. Apart from the reduction in total numbers of casualty accidents, the severity of injury was also positively affected. In a four-year period prior to the start of the Section Control system (I<sub>b</sub>-IV<sub>b</sub>), one fatality, one person severely and 10 slightly injured have been recorded on average every year. Since August 2003 no fatal or severely injured road user was observed in the Kaisermühlen Tunnel, while the number of slightly injured drivers decreased to a total of 7 in the after-period (see Table).

<sup>30</sup> Nitrogen oxide emissions are among the most harmful of all air pollutants. Thus, various nitrogen oxide catalytic converters have been developed which will help to reduce emissions of NO<sub>x</sub> significantly over the next 10 years.

From	To	Period	Injury accidents	Fatalities	Seriously injured	Slightly injured
12.08.1999	12.08.2000	IV <sub>b</sub>	7	1	0	10
12.08.2000	12.08.2001	III <sub>b</sub>	7	0	1	9
12.08.2001	12.08.2002	II <sub>b</sub>	7	1	1	11
12.08.2002	12.08.2003	I <sub>b</sub>	7	0	0	9
12.08.2003	12.08.2004	I <sub>a</sub>	5	0	0	7
Mean (IV <sub>b</sub> – I <sub>b</sub> )			7.0	0.5	0.5	9.8

*Table 11: Injury accidents before and after the implementation of Section Control*

To properly quantify the safety effect of Section Control, a simple before/after comparison of accidents is not suitable. It is necessary to compare the situation with Section Control (“after”) with the anticipated situation that would have occurred without Section Control.

Traffic performance in the before period (I<sub>b</sub>-IV<sub>b</sub>) increased in a linear manner, while in the after-period (I<sub>a</sub>) a slight drop in vehicle-km was observed. This phenomenon is due to the fact that traffic capacity on this road section has apparently reached its limit. Without further investments in additional lanes or route information and management systems, a further increase in daily traffic is unlikely. Because numbers of fatal and serious injuries are too low to produce meaningful results, these two categories were combined for further calculations. Furthermore, some effects of serious injuries on the quality of life (e.g. lifelong paraplegia) deem it necessary to ascribe these victims the same weight as fatalities.

Period	Traffic performance [million vehicle-km]	Accident rate	Rate of fatal and serious injuries	Rate of slight injuries
IV <sub>b</sub>	67.6	0.10	0.015	0.15
III <sub>b</sub>	70.3	0.10	0,014	0.13
II <sub>b</sub>	72.2	0.10	0,028	0.15
I <sub>b</sub>	74.8	0.09	0,000	0.12
I <sub>a</sub>	74.5	0.07	0,000	0.09
Mean (IV <sub>b</sub> - I <sub>b</sub> )		0.10	0.014	0.14
Standard deviation (IV <sub>b</sub> - I <sub>b</sub> )		0.004	0.011	0.015

*Table 12: Traffic performance and accident rates [per million vehicle-km] in the Kaisermühlen Tunnel*

The corrected “before” value (number of accidents, fatalities or injured people without treatment) results from multiplying the average number of accidents (per million

vehicle-km) in Table with the traffic performance in the “after” period ( $I_a$ ). The ratio of “after” and (corrected) “before” values constitutes the actual safety effect of the measure.

	Corrected before value	After value	Ratio <sup>31</sup>
Injury accidents	7	5	0.71
Fatal and serious injuries	1	0	0.00
Slightly injured	10	7	0.70

*Table 13: Corrected before and after values of accident severity due to Section Control*

The analysis also controls for general trends in the number of accidents by using the total number of accidents on motorways in the “before” and “after” period as a comparison group. The mean number of comparison group accidents in the before period was 2,485 and 2,540 in the “after” period. Thus, the number of comparison group accidents is sufficiently large to be only minimally influenced by random fluctuations. The effect of Section Control on the number of accidents (or fatalities or injured road users) was estimated as follows:

$$\text{Safety effect [\%]} = 1 - [X_a/E(m)_b] / [C_a/C_b]$$

whereas

$X_a$  = recorded number of accidents in the “after” period

$E(m)_b$  = expected number of accidents (correct before value) in the “before” period

$C_a$  = number of comparison group accidents in the “after” period

$C_b$  = number of comparison group accidents in the “before” period

From	To	Period	Injury accidents	Fatalities	Seriously injured	Slightly injured
12.08.1999	12.08.2000	IV <sub>b</sub>	2,535	134	1,218	2,847
12.08.2000	12.08.2001	III <sub>b</sub>	2,468	165	1,255	2,703
12.08.2001	12.08.2002	II <sub>b</sub>	2,402	121	1,173	2,663
12.08.2002	12.08.2003	I <sub>b</sub>	2,534	124	1,133	2,819
12.08.2003	12.08.2004	I <sub>a</sub>	2,440	108	1,165	2,642
Mean (IV <sub>b</sub> – I <sub>b</sub> )			2,485	136	1,195	2,758

*Table 14: Injury accidents and severity of casualties on Austrian motorways in the before/after period*

Statistical inference draws conclusions about a population based on sample data. It also provides a statement, expressed in the language of probability, of how much

<sup>31</sup> Slightly different numbers due to round off errors in the computation of the ratio

confidence we can place in the conclusions. The different values for the safety effect of Table acts as estimators of the (unknown) population parameter. The purpose of a confidence interval is to estimate this parameter with an indication of how accurate the estimate is and how confident we are that the result is correct. Any confidence interval consists of two parts: an interval computed from the data and a confidence level. The confidence level states the probability that the method will give a correct answer. That is, if you use a 95% confidence interval, the probability that the true value is out of this interval is only 0.05.

Table15 and Table 16 show estimates and 95% confidence intervals of the safety effects of Section Control on accidents. Computing the Odds Ratio, if any value out of 4 numbers involved in the evaluation is zero a correction must be applied, i.e. 0.5 should be added to each number.<sup>32</sup>

	Odds ratio	Safety effect [%]
Injury accidents	0.69	-30.5
Fatal and serious injuries	0.34	-66.4
Slightly injured	0.72	-28.4

*Table15: Safety effect of Section Control on accident severity*

Accident severity	Percentage change in the number of accidents	
	Best estimate	95% confidence interval
Injury accidents	-31	(-35; -26)
Fatal and serious injuries	-66	(-82; +143)
Slightly injured	-28	(-39; -13)

*Table 16: Best estimate and confidence interval of the safety effect of Section Control on accidents*

Table 17 gives an economic valuation of savings in the number of accidents and severity of injury due to Section Control. The original values were obtained from a study on economic costs of accidents<sup>33</sup>. Figures were then converted into EURO (€) and brought to a 2002 price level by using official inflation rates (see appendix). As can be seen from the bottom line of the table, the safety effect of the Section Control system amounts to annual savings of more than 1 million €.

<sup>32</sup> FLEISS, 1981, page 64

<sup>33</sup> BUNDESMINISTERIUM FÜR WISSENSCHAFT UND VERKEHR, 1997, page 136-141

Category	Amount of savings	of	€ per unit (2002-price)	Cumulated value
Fatalities	1		949,897	949,897
Seriously injured	1		51,439	51,439
Slightly injured	3		4,359	13,077
Property damage	2		5,745	11,490
<b>Total</b>				<b>1,025,903</b>

*Table 17: Valuation of savings in the number of accidents and severity of injury due to Section Control*

In the period under observation (13.09.2003 - 27.08.2004), more than 29 million vehicles passed through the Kaisermühlen Tunnel and about 40,000 drivers were charged because of excessive speeding (see Table). That is, only 0.14% or every seven hundredth driver, does not follow speed regulations on this road section and drives too fast. The top speed of a vehicle heading north was 175 km/h and 154 km/h heading south. About 5% (2,161) of all fines issued were acquired by HGVs. Keeping in mind that more than 10% of daily traffic is due to HGVs, a possible explanation for this phenomenon can be found in the high proportion of foreign vehicles among lorries. Due to the fact that mutual recognition of financial penalties has only been established with Germany and Switzerland, most of the foreign speed violators cannot be prosecuted.

	Vehicles passing the Section Control	Fines		
		Passenger cars	HGV	All vehicles
Heading south (A23)	13,450,345	19,162	951	20,113
Heading north (Stockerau)	15,973,473	19,558	1,210	20,768
Total	29,423,818	38,720	2,161	40,881

*Table 18: Speed violations and charges in the Kaisermühlen Tunnel (Source: Federal Ministry of the Interior, own calculations)*

At the Tampere European Council (15 and 16 October 1999), the Heads of State or Government of the EU-Member states and the President of the Commission agreed that mutual recognition of criminal and financial matters should be a cornerstone of judicial cooperation within the European Union. Thus, France, the United Kingdom and Sweden initiated the adoption of a Council Framework Decision that enables member states to execute criminal and financial offences against citizens of other

member states. Although this proposal is far from reaching legal status due to objections from several countries, it can be expected to pass legislation within the next 3-5 years. Obtaining fines from foreign speed violators should then be possible and benefits will be maximized.

According to Austrian law<sup>34</sup> 80% of the fines from speed violations belong to the operator of the infrastructure, which (in case of the Section Control) is the Austrian highway operator (ASFINAG). The remaining 20% are used to cover the maintenance costs of the system experienced by the Federal Ministry of the Interior.

Table 19 gives fines for different levels of speeding. Drivers exceeding the speed limit by more than 50 km/h have their driving licences revoked. During the observation period, this happened in 46 cases.

	<b>Fine</b>	<b>Violators</b>	<b>Revenues due to speed violation</b>
0 – 9 km/h	€ 21	16,176	339,696
10 – 19 km/h	€ 42	22,048	926,016
20 – 29 km/h	€ 56	2083	116,648
30 – 39 km/h	€ 70	409	28,630
40 – 50 km/h	€ 140	119	16,660
<b>Total</b>		<b>40,881</b>	<b>1,427,650</b>

*Table19: Revenues due to excessive speeding in the Kaisermühlen Tunnel (Source: Federal Ministry of the Interior, own calculations)*

The Cost-Benefit Analysis is based on the principle of economic efficiency, i.e. to estimate if a measure is worth being implemented, the benefits and costs of the treatment are computed and brought into relationship. The benefit term includes all positive (monetary) effects of the measure. In the case of Section Control, benefits consist of reductions in accidents and road traffic emissions. Revenues from speed violators were omitted in the calculation of the Cost-Benefit Ratio because of the fact that in an economic point of view, it is irrelevant if the money belongs to consumers buying goods and therefore increasing their personal benefits or the highway operator that uses the fines for additional safety campaigns. The Cost-Benefit Ratio will be the same at both events.

Different benefits are added to obtain a total benefit. The cost term on the other hand denotes implementation and maintenance costs.

Combining the benefits and costs calculated in the previous chapters, a net present value of all benefits (without fines from speeders) of € 1,105,011 and costs of € 204,272 is obtained.

<sup>34</sup> StVO, Article 100, Paragraph No.10

These values correspond to a Cost/Benefit-Ratio of 5.4. According to analyses of safety measures in Work Package 1 of ROSEBUD<sup>35</sup>, measures with a CBR larger than 3 are ranked “excellent”.

Components of the CBA	Benefits	Costs
Road traffic emissions	79,108	
Accident costs	1,025,903	
Installation and maintenance costs		204,272
<b>Total</b>	<b>1,105,011</b>	<b>204,272</b>

*Table 20: Present value of benefits and costs in € (2002-price) due to Section Control*

This survey concentrates on injury accidents because data for material damage accidents could not be collected without enormous strains on budget and working hours. Thus, the Cost-Benefit Ratio computed underestimates the real effects to a certain extent. This should be kept in mind whenever Section Control systems are considered for further use in traffic safety programs.

With the instrument of Cost/Benefit Analysis, it is possible to incorporate various effects of this safety measure into the evaluation process, i.e. not only reductions in casualty accidents and severity of injuries, but also impacts on the environment, such as road traffic emissions. A major problem of road traffic, which has been neglected due to the special situation of the Kaisermühlen Tunnel, is traffic noise. Regional governments in Austria have already expressed their intention to use Section Control as a means to reduce traffic noise in residential areas. Such an application of Section Control will raise the Cost-Benefit Ratio even more.

<sup>35</sup> **Road Safety and Environmental Benefit-Cost and Cost-Effectiveness Analysis for Use in Decision-making.** ROSEBUD is a thematic network funded by the European Commission to support users of efficiency assessment tools at all levels of government.

## Annex II: Valuation of safety impacts in CBA

Country	Fatality cost	Serious injury cost	Slight injury cost	Valuation method <sup>a</sup>
Czech Rep.	263	91	10	Non-behavioural
Hungary	276	25	3	Non-behavioural
Germany	1,257	86	4	Non-behavioural
France	1,500	150	22	N/A
Netherlands	1,741	256	38	Behavioural
Finland	1,934	261	50	Behavioural
Switzerland	1,912	169	18	Behavioural
Sweden	1,954	349	20	Behavioural
UK	2,107	237	18	Behavioural
Norway	3,016	474	41	Behavioural

Table 21: Official values of prevented fatalities/injuries (€ 1000); 2002-prices.

<sup>a</sup>Behavioural methods are founded on neo-classical theory, while non-behavioural are not [Sources: Blaeij et al. (2004), Koňárek (2004), Holló (2004), Höhnscheid (1998), DTT (2004), Metsäranta and Kallioinen (2004), Elvik (2004).]

Country	Working	Non-working		Valuation method <sup>b</sup>
	Business	Commuting	Others	
France	11.1	10.0	5.5	N/A
Netherlands	28.09	8.35	5.56	Behavioural
Finland	24.08	4.07	4.07	N/A
Switzerland	56.79	11.36	5.68	N/A
Sweden <sup>a</sup>	20.84	4.24	3.37	Behavioural
UK	32.39	6.95	6.95	Behavioural
Norway <sup>a</sup>	20.71	6.00	5.57	Behavioural
USA	22.59	10.20	10.20	Behavioural

Table 22: Official values of reduced time use (€). 2002-prices

<sup>a</sup> Swedish and Norwegian values are given for the case of shorter trips (less than 50 km) for car drivers.

<sup>b</sup> The opportunity cost approach using wage rates may be classified as a behavioural method – it is the behavioural assumption that is at stake, not the individual-based viewpoint. However, for non-working trips, the individuals' valuation of time is difficult to get hold of without applying stated preference methods involving specific comparisons, choices, and trade-offs where time is one of several travel attributes. Sources: Blaeij et al. (2004), DTT (2004), Metsäranta and Kallioinen (2004).

Country	NO <sub>x</sub>	VOC	PM <sub>10</sub>	SO <sub>2</sub>	CO <sub>2</sub> <sup>a</sup>
Germany <sup>b</sup>	0.405				181 – 227
France					100
Netherlands	6.71	6.71	21.4		64
Switzerland	5.11		15.3		96.5
Sweden <sup>c</sup>	6.92	3.46		2.34	89.3
Norway <sup>d</sup>	5.14 – 10.27	5.14 – 10.27	0 – 265	2.80 – 10.90	58
USA <sup>e</sup>	6.82 (15.0)	3.42 (14.1)	9.20 (5.20)	4.11 (10.1)	42

Table 23: Official and recommended values of reduced air pollution (€ per Kg). 2002-prices; Sources: Blaeij et al. (2004), DTT (2004).

<sup>a</sup> € per ton.

<sup>b</sup> Official value per NO<sub>x</sub> equivalent.

<sup>c</sup> Official values for regional air pollution effects.

<sup>d</sup> Interval from rural to urban; in the PM<sub>10</sub> case from 'other built-up' to city.

<sup>e</sup> Damage cost values, with social expenditures in brackets.

Country	Unit of valuation			
	Per person affected per year	Per dB(A) change per person affected per year	Per vehicle km	Per dB(A) change in house prices
Germany		50		
Netherlands		21		
France	156			0.4 – 1.1%
UK		15		0.08 – 2.30%
Finland	959			
Denmark <sup>a</sup>	3,316			
Sweden <sup>b</sup>	463	71		
Norway <sup>c</sup>	1,000 – 1,170		0.01 – 0.09	
Switzerland		22		

Table 24: Recommended values of reduced noise. € 2002-prices. Sources: Blaeij et al. (2004), Navrud (2002), Elvik (1999), DTT (2004), Metsäranta and Kallioinen (2004).

<sup>a</sup> Official values are given per dwelling/household highly annoyed (Navrud 2002). The numbers per person highly annoyed is obtained by dividing by average household size (2.1). It should be noted that values for highly annoyed are generally higher than for affected (comprising highly annoyed plus somewhat annoyed).

<sup>b</sup> A graded monetary scale based on dB(A) level is applied, whereby a reduction to 50 dB(A) from a starting point of 51 dB(A) has a value of €16, and a reduction from 75 dB(A) to 50 dB(A) has a value of €1,771. €463 is simply the average of the graded scale, and €71 is the average per dB(A) change.

<sup>c</sup> Interval for persons affected per year is due to different values for different noise sources (road, rail, air), while the interval per vehicle km goes from small cars to heavy cars.

<b>Main impact</b>	<b>Subcategories</b>	<b>Vehicle type, road user etc</b>	<b>Unit of valuation</b>
SAFETY	Road Crashes	All (estimated real cases of injury)	Fatality
			Serious injury
			Slight injury
			Property damage
MOBILITY	Travel time	Pedestrian	Person/hour
		Cyclist	Person/hour
		Car occupant	Person/hour
		Bus passenger	Person/hour
TRAVEL COST	Vehicle Operating Cost	Car	Km/travel
		Single truck	Km/travel
		Truck/trailer	Km/travel
		Bus	Km/travel
ENVIRONMENT	Traffic noise	Small cars	Km/travel
		Heavy cars	Km/travel
	Air pollution	CO	Kg of CO
		NO <sub>x</sub>	Kg of NO <sub>x</sub>
		VOC	Kg of VOC
		SO <sub>2</sub>	Kg of SO <sub>2</sub>
		PM <sub>10</sub>	Kg of PM <sub>10</sub>
	Global warming	CO <sub>2</sub>	1000 kg of CO <sub>2</sub>

*Table 25: Categorisation of impacts for use in cost-benefit analyses.*