The cost of road crashes in the Netherlands

An assessment of scenarios for making new cost estimates

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Content

Summary

The latest estimate of the costs of road crashes in the Netherlands was made for the year 2009. The Ministry of Infrastructure and Environment has the ambition to launch a study to make new cost estimates. It is recognised that the methodology used in that study needs to be revised, but also that a trade-off needs to be made between on the one hand the cost of developing a new methodology and on the other hand the resulting quality of the cost estimates based on this new methodology. This study presents the information needed to make this trade-off, based on a thorough assessment of various research scenarios to update the current methodology.

Coverage of cost items

A review of the international state-of-the-art of estimating road crash costs shows that the Dutch methodology is generally in line with international guidelines and practices. Almost all main cost items that are recommended by international guidelines are included. The main omission is the human cost of slight injuries, which was missing in the previous Dutch studies on road crash costs. As the expected impact of this omission on total costs of road crashes in the Netherlands is substantial, it is recommended to add this cost item in a new study.

Human costs of slight injuries need to be added.

Other relevant cost items that could be added to the current methodology include costs of non-market production (e.g. household work), damage to road infrastructure, administrative costs of health insurances and costs of vehicle unavailability.

Quality of methodology and data

Although the methodology used in the Dutch studies on road crash cost are to a large extent in line with international guidelines and practices, there are still several needs to improve the methodology uses. Particularly the quality of data that were used is a severe weakness of the current methodology. Estimating road crash costs requires many input data on both unit costs and casualty information, and for several cost items outdated data were used. This concerns relatively large cost items, such as human cost of fatalities, production loss and vehicle damage. An update of these data is recommended to substantially improve the accuracy of the estimate of the costs of road crashes.

Data quality is a severe weakness of the current methodology.

For some cost items, the quality of the methodology could be improved as well. This particularly concerns the human costs of serious injuries, which are currently based on a simple value transfer of estimates found in international literature instead of a country-specific study for the Netherlands.

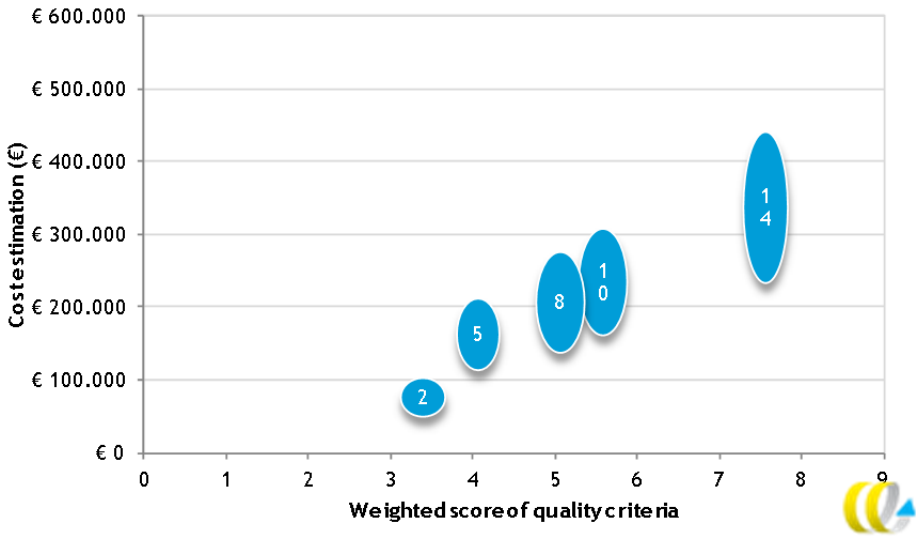
Trade-off between quality and costs

In this study we analysed several scenarios for a new cost study in the Netherlands, ranging from very simple approaches (cost are updated by using inflation correction and new road safety statistics only) to extensive methodological improvements. The assessment shows that there is no superior approach, that is clearly preferred to all other approaches. More simple approaches have the advantage of having low cost, but they provide less improvements with respect to the quality of the cost estimates and the resulting quality of the cost estimates is poor. On the other hand, more sophisticated approaches do provide much better quality estimates, but their

The quality and costs of improving the road crash costs estimates are linearly related. Therefore, the highest quality of cost estimates should be looked for within a given budget.

costs are significantly higher. The relationship between the costs of improving the cost estimates and the quality improvement is found to be quite linear. This is illustrated in Figure 1. The implication is that the available budget determines the quality that can be achieved and that within a given budget the highest quality of cost estimates should be looked for. Available resources should, therefore, be spent on cost items that have the most significant impact on total costs and which can be improved in the most efficient way. Next to a large-scale update of the data used, this concerns methodological improvements for cost items such as human costs of injuries, market production loss, unreported vehicle damage and human costs of fatalities.

Figure 1 **Comparison of quality improvements and costs for several scenarios to update road crash cost estimates**



Brief description of scenarios shown above (for more detailed description, see Section 5.2).

Scenario 2: Simple approach in which most cost items are only corrected for inflation.

Scenario 5: Data for most cost items are updated based on same sources as in previous study. No methodological improvements are made.

Scenario 8: Data for all cost items is updated; sometimes based on the same sources as in previous study, but often based on more recent/sophisticated sources.

Scenario 10: Same as Scenario 8, but human costs of fatalities and injuries are based on DALYs and values per DALY instead of common WTP values for road casualties.

Scenario 14: Sophisticated approach to update all cost items, including large scale methodological improvement. International cooperation is sought for several cost items.

International cooperation

Collaborating with other countries could increase the possibilities to improve the methodology, particularly since the costs of methodology development can be shared in such a scenario. Better comparability of costs estimates across countries is an additional advantage. The main option to realise international cooperation is an international project initiated and funded by (possibly multiple) national governments. A broad inventory under representatives of international organizations shows that information on costs is considered as very important for road safety research and policy making, and that there may be support for such an initiative. However, such a project would require substantial efforts and can probably

Opportunities for international cooperation on the longer term.

only be launched on a longer term. Therefore, a phased approach may be attractive: in a first step a new study could focus on cost items that require relatively limited resources or are less suitable for international cooperation (e.g. medical costs, administrative costs), while in a second step more sophisticated methodologies may be developed in an international project to update the other cost items (e.g. human costs of casualties and injuries).

1 Introduction

1.1 Background

Road crashes are responsible for significant social costs: in 2009 these costs were about € 12.5 billion in the Netherlands (Wit & Methorst, 2012). Wijnen and Stipdonk (2016) estimate, based on an comparison of road crash costs in several countries, that the share of these costs in national GDPs ranges from 1.5 to 6%. Because of the significant contribution of the costs of crashes in total social costs of road traffic, accurate and up-to-data information on their size and composition is desirable. This information provides an indication of the social-economic impact of road crashes and the level of traffic safety in a country. Furthermore, it provides the opportunity to compare the impact of crashes with other negative impacts of road transport (like congestion and emissions) or with the costs of road crashes in other countries. Finally, costs per victim and/or accident are useful indicators in social cost benefit analyses of traffic safety measures or road infrastructure projects.

The costs of road crashes are regularly assessed in the Netherlands. The most recent study is from Wit and Methorst (2012), which presents estimates of these costs for the years 2003, 2006 and 2009. In this study, it was recognised that for some cost items recent and reliable input data was missing and/or that methodologies were (at least partly) outdated. This was, for example, the case for the human costs of (particularly) injuries, production losses and non-claimed vehicle damage. As these cost items significantly contribute to the overall costs of road crashes, the lack of data and/or methodologies to accurately calculate their size seriously affects the estimate of the total costs of road crashes.

According to Directive 2008/96/EC, (EC, 2008) all EU Member States are obliged to report their costs of road crashes every five year. In this light, Rijkswaterstaat is planning an update of the 2012 study on the costs of road crashes. This new study should consider the years 2009, 2012 and 2015. To what extent it is desirable and possible to update the current input data and methodology is an issue for discussion, particularly because such an update may require significant research efforts and hence investments. These costs should be carefully considered against the additional quality and accuracy of improved estimates. European cooperation is important as well, as it may offer the opportunity to develop new methodologies in an efficient way and to achieve greater European harmonisation of estimates of the costs of road crashes.

Because of these developments, Rijkswaterstaat has commissioned CE Delft and W2Economics to study the various options that are available to update the estimations of the costs of road crashes. The results of this study are discussed in this report.

1.2 Objective and scope

The objective of this study is to identify and study relevant options to update the estimations of the social costs of road crashes in the Netherlands.
More specific, the project aims to:

- discuss the scope, methodologies and data currently used in estimations of the costs of road crashes in the Netherlands and abroad;
- give a broad overview of possible scenarios to update the estimation of the costs of road crashes;
- from this broad range of scenarios select the most promising scenarios using a multi-criteria framework;
- carry out an in-depth analysis of the quality, costs and international dimension of these selected scenarios.

In this study we will only consider road traffic crashes; other traffic related accidents are out of the scope of the study. Furthermore, this study does not provide new road crash cost estimates themselves, but is limited to assessing the most promising options to estimate these costs.

1.3 Overview of the study

In this study, we first discuss the international practice with respect to (the estimation of) the costs of road crashes (Chapter 2). The results of this analysis are compared to the most recent study on road crash costs in the Netherlands, as input for the development of scenarios to update the road crash cost estimates. A longlist of these scenarios is developed and described in Chapter 3. In Chapter 4 the scenarios on the longlist are assessed using a Multi Criteria Analysis and based on the results of this analysis the most promising scenarios are selected for an in-depth analysis. This in-depth analysis and its results are described in Chapter 5. Finally, the main conclusions and recommendations of the study are presented in Chapter 6.

2 Road crash cost assessment in an international perspective

2.1 Introduction

Road crash costs have been studied in many countries, particularly high income countries, including several European countries, but also in low/middle income countries. This chapter discusses the costs of road crashes and methodologies to estimate these costs in an international perspective.
We provide an overview of:

- the costs components that are included in costs studies according to international guidelines and international good practices;
- the (potential) size of each cost component relative to the total costs;
- the methods used to estimate each cost component.

Finally, we compare the international practices with the latest study into road crash costs in the Netherlands, as an input for developing scenarios for a new road crash study.

The overview of is based on a recent analysis of costs studies in 17 countries, including 10 high income countries and 7 Asian low/middle income countries (Wijnen & Stipdonk, 2016)[1] and guidelines for estimating road crash costs that are developed within the European projects SafetyCube (Martensen, forthcoming) ; (SafetyCube, forthcoming) and InDeV (Kasnatscheew, et al., forthcoming). We concentrate on the high income countries, and consider the analysis of the costs in low/middle income countries much less relevant for the European situation (e.g. regarding the road safety situation and data availability).

2.2 Cost components

Overviews of road crash cost studies (Wijnen & Stipdonk, 2016; Trawén et al., 2002; Elvik, 1995, 2000) as well as international guidelines for estimating these costs (SafetyCube, forthcoming; Kasnatscheew et al., forthcoming; Alfaro et al., 1994) show that in general six main cost components are distinguished:

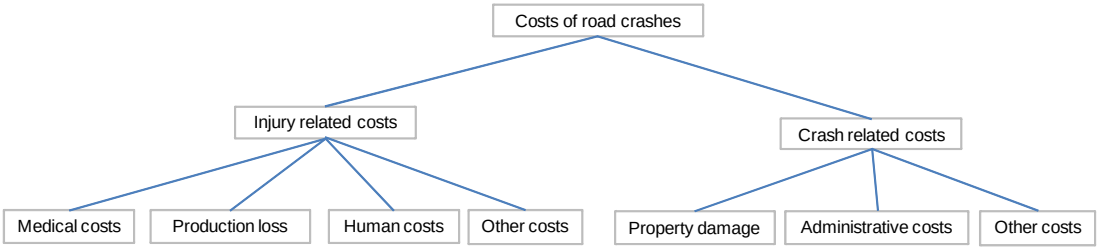
- Medical costs: costs of medical treatment provided by hospitals, rehabilitation centers, general practitioners, nursing homes, etc. as well as costs of appliances and medicines.
- Production loss: the loss of production or productive capacities resulting from casualty's permanent or temporary inability to work for an employer or to carry out non-market work such as household work and voluntary work.
- Human costs: immaterial cost lost life years (fatalities) and pain, grief and lost quality of life (injuries, relatives and friends).

[1] This is an updated and extended analysis of a previous review (Wijnen, 2014). Other international reviews of cost studies (the most recent one published in 2002, see Wijnen & Stipdonk, 2016)) are quite outdated and for that reason they will not be included here.

- Property damage: damage to vehicles, infrastructure, freight and personal property.
- Administrative costs: this includes costs of police[2], fire service and other emergency services (other than medical services) that assist on the crash location. In addition, there are administrative costs related to insurances (vehicle, health and other insurances) as well as legal costs, such as costs prosecution of offenders who caused a road crash and costs of lawsuits.
- Other costs, such as costs of congestion resulting from road crashes, vehicle unavailability and funeral costs.

These costs can either be casualty related (medical costs, production loss, human costs and some other costs) or crash related (property damage, administrative costs[3] and some other costs), see Figure 2.

Figure 2 Classification of road crash costs



Source: SafetyCube, 2016.

Wijnen & Stipdonk (2016) show that it is common practice to include these five main costs components: they are included in all cost studies included in their review (high income as well as low/middle income countries). However, within these main components there are several differences between countries regarding the more specific cost items that are included, as illustrated by Table 1.

2 Excluding costs related to prevention of crashes, such as costs of enforcement. Prevention costs are not in included in cost studies because they are not a (direct) consequence of road crashes, but are intended to decrease the number of crashes (see for example SafetyCube (forthcoming)).

3 Administrative costs related to health insurances are an exception, since these costs are casualty related.

Table 1 **Cost items included in national road crash costs studies in nine countries**

Country	Medical costs				Production loss			Human costs			Property damage		Administrative costs				Other		
	Emergency transport	Hospital	Follow -on treatment	Medicines, appliances	Paid	Unpaid	Friction	Fatalities	Serious injuries	Minor injuries	Vehicles	Other	Police	Legal	Fire department	Insurance	Congestion	Vehicle unavailability	Funerals
Australia	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Austria	x	x	x		x			x	x	x	x	x	x	x	x	x	x	x	
Belgium	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		x
Germany	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x
Netherlands	x	x	x	x	x			x	x		x		x	x	x	x	x		x
New Zealand	x	x	x		x			x	x	x	x		x	x					
Switzerland		x	x	x	x		x	x	x	x	x		x	x		x			x
UK	x	x	x	x	x	x		x	x	x	x	x	x			x		x	x
US	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Source: Wijnen & Stipdonk (2016)

Within the SafetyCube and InDeV projects, preliminary guidelines for estimating road crash costs have been developed, including an overview of all relevant cost items. This overview is based on previous guidelines developed by the European Commission (Alfaro, et al., 1994) and recent developments in cost studies, for example as identified by Wijnen & Stipdonk (2016). SafetyCube (2016) classifies cost items using two dimensions: the size of the costs and the extent to which cost items are commonly included in previous guidelines and in cost studies (relevance). The latter dimension can be seen as a an indicator for the relevance of a cost item: more relevant costs items, in particular costs that are a direct consequence of a crash such as medical costs, are commonly included in guidelines and cost studies, while less relevant costs items (e.g. indirect costs such as vehicle unavailability) are less commonly included.

A distinction is made between (see Figure 3):

- Main cost items: costs that have a large share in total costs, but also relevant smaller costs (that are commonly included in guidelines and cost studies).
- Minor cost items: costs that are most probably relatively small and are less relevant.
- Other cost items: costs that are not always included in previous guidelines and costs studies and whose size is not exactly known but may be substantial.

Figure 3 Classification of costs items, based on SafetyCube (2016)

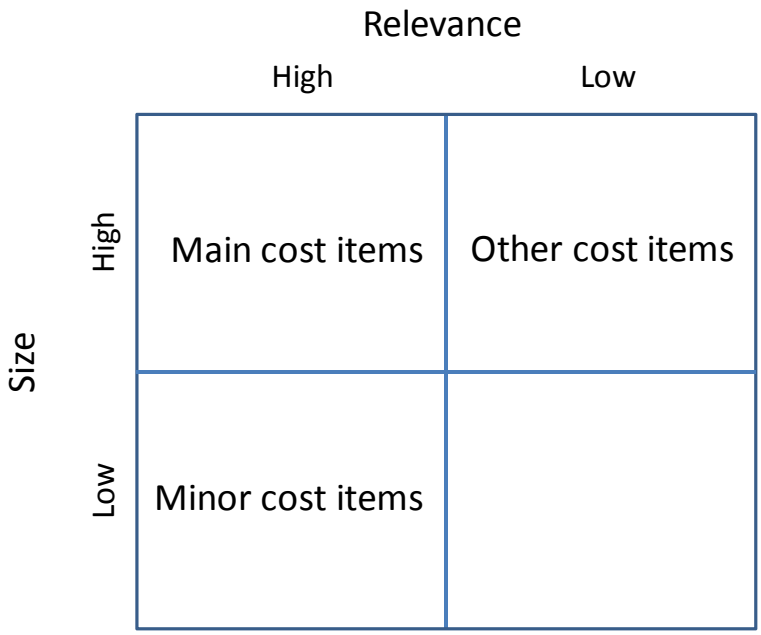


Table 2 gives an overview of all cost items as well as the state of the art methods that were identified in the SafetyCube project.

In addition to these costs, avoidance costs are discussed in the literature (Wijnen & Stipdonk, 2016; Wee, et al., 2014). These are the costs of adapting travel behaviour because of perceived safety levels, such as changing travel mode, route, destinations or the decision whether or not to travel at all. For example, some people that may prefer to stay at home (e.g. during snowy weather) because they think travelling is too risky, or parents choose to bring their children to school by car instead of by bicycle. Avoidance costs related to road safety have not been studied (yet), and so they are not included in any study on costs of road crashes. However, they have been included in studies into the costs of congestion in the Netherlands (KiM, 2012), showing that avoidance costs have a share of 30 to 40% in total congestion costs. The importance of avoidance costs regarding road safety is not known, as no studies have been carried into these costs

The next section discusses the methods in more detail.

Table 2 Overview of costs items and methods in the SafetyCube guideline (Martensen, forthcoming); (SafetyCube, forthcoming)

Cost component	Cost item	Description
Main	a) First aid at crash location and transportation	First aid at the crash location provided by medical emergency services and transportation of casualties to hospital by ambulance and helicopter.
	b) Treatment at the accident and emergency department of hospitals	Medical treatment at the accident and emergency department (AED) of hospitals. This concerns fatalities who have firstly been treated at the AED, seriously injured who were brought AED before hospital admittance as well as slightly injured only treated at the AED without hospital admittance.
	c) In-patient hospital treatment	Treatment of casualties who are admitted to hospital (with overnight stay).
	d) Out-patient hospital treatment	Policlinical hospital treatment (without overnight stay and excluding AED treatment).
	e) Non-hospital treatment	Medical treatment by: - General practitioners - Rehabilitation centres - Physiotherapists - Home care providers - Nursing homes
Minor	f) Aids and appliances	Aids and appliances that casualties need to cope with their limitations or handicap, such as wheelchairs and crutches.
	g) Medicines	Medicines that casualties need related to injuries resulting from a road crash.
Main	a) Lost market production	Loss of human capacities of casualties to participate in market production due to death (fatalities), disability or sick leave (injuries).
Other	b) Lost non-market production (household work, taking care of children, voluntary work, etc.)	Loss of future non-market production, such as household work, taking care of children and voluntary work.
Minor	c) Friction costs	Costs for employers for recruiting and training new employees to replace road casualties and costs of vocational rehabilitation of casualties, such as cost of finding a new job and training.
Main	a) Fatalities	Immaterial losses resulting from loss of life years.
	b) Serious and slight injuries	Pain, grief, sorrow and loss of quality of life resulting from injuries.
Other	c) Human costs for relatives and friends	Pain, grief, sorrow and loss of quality of life for relatives and friend of the injured.
Main	a) Vehicles	Damage to, or total loss of, vehicles.
Minor	b) Infrastructure, fixed roadside objects and buildings	Damage to infrastructure, fixed roadside objects and buildings.
	c) Freight carried by lorries	Damage to, or loss of, freight carried by lorries.
	d) Personal property	Damage to personal properties (e.g. in damaged vehicles, clothes, etc.).

Cost component	Cost item	Description
Main	a) Police costs	Costs of time police officers spend on road crashes (excluding prevention of road crashes) as well as material costs, such as vehicle costs, and overhead costs.
	b) Fire service costs	Cost of fires services for assistance on the crash location.
	c) insurance costs	Administrative costs of insurers related to vehicle insurances.
	d) Legal costs	Costs of prosecution of offenders who caused a road crash, costs of lawsuits resulting from road crashes and costs of imprisonment.
Other	e) Other insurance costs	Administrative costs of insurers resulting from road crashes that are related to other insurances. This concerns in particular health insurances, but also legal assistance, accident and disability insurances.
	f) Administrative costs for persons involved in an accident	Time spent on insurance forms, time for bringing/pick up of vehicle for repair, etc.
Main	a) Funeral costs	Costs of funerals for fatalities.
	b) Congestion costs	Direct and indirect costs resulting from delay (f.i. traffic jams) resulting from crashes: loss of time, costs of unreliability of travel times, costs of adapting travel behavior to traffic jams, extra fuel costs and environmental damage (pollution) and public transport costs.
Minor	c) Vehicle unavailability	Costs of vehicle unavailability if it is damage in a crash, such as costs of hiring a replacing vehicle, costs of time loss.
	d) Visiting people in hospital	Costs for relatives and friends who visit casualties such as time and travel costs.
	e) Moving and house adaption cost	Costs of house adaptations for handicapped (e.g. inside elevator) and costs of moving to another house if the casualty's house is not suitable for handicapped.

2.3 Methods

According to international guidelines for estimating costs of road crashes (SafetyCube, forthcoming; Alfaro et al., 1994), there are in general three types of methods that can be used to estimate costs of road crashes.

1. Restitution costs (RC) approach: this approach focuses on the costs of resources that are needed to restore road casualties and their relatives and friends to the situation which would exist if they would not have involved in a road crash. These costs can be interpreted as the direct costs resulting from a crash (ERSO, 2006), such as the costs of medical treatment and vehicle repair. According to the international guidelines, the RC approach is the appropriate method to estimate medical costs, property damage and administrative costs.
2. Human capital (HC) approach: in this approach the value for society of the loss of productive capacities of road casualties is measured, for example based on the added value that a person produces. This approach is the appropriate method for estimating production loss.
3. Willingness to pay (WTP) approach: in this approach costs are estimated on the basis of the amount individuals are willing to pay for a risk reduction. The WTP approach is the appropriate method to estimate human costs, since there is no market price for such immaterial impacts. On the basis of WTP studies the value of a statistical life (VOSL) can be estimated, which is used to calculate human costs of fatalities.

We discuss the methods for each cost item, as summarized in Table 2, in more detail below.[4]

2.3.1 Medical costs

Using the RC approach, medical costs are estimated on the basis of the actual costs of medical treatment, such as the costs of ambulance trips, overnight hospital stay and non-hospital treatment. It is common international practice to use a bottom-up approach to estimate these costs, that means using costs per 'unit' (per ambulance trip, per hospital/rehabilitation centre day, per treatment in hospital or by general practitioner, etc.) and the number of 'units', such as number of ambulance trips, average duration of hospital stay (per injury category), frequency of non-hospital treatment, etc.

Although the principles of the calculation method are relatively simple, estimating medical costs is quite demanding in terms of data availability. Data are needed on the number of ambulance and helicopter trips, the length of stay in hospital, number of policlinical visits, visits to a general practitioners, physiotherapist), number of casualties admitted to a rehabilitation centre/nursing home, number of casualties receiving home care, etc. Moreover, preferably this information should be available by injury severity category. In addition costs estimates of costs per day in hospital, rehabilitation centre and nursing home and costs per visit to a general practitioner, physiotherapist, etc. should be known. In the Netherlands a model has been developed to calculate medical costs of injuries, including road injuries, that includes most of these data ((Polinder, et al., 2016).

[4] This section partly draws on SafetyCube (forthcoming).

2.3.2 Production loss

Production loss (market) of a casualty is calculated by multiplying the period of time he/she is not able to work due to a crash by a valuation of production per person per unit of time. Regarding fatalities, the period of time is the remaining number of productive years until retirement. For injured casualties the relevant period of time ranges from a few days absence from work, to all remaining working years until retirement if someone is permanently disabled.

Note that there is also a loss of consumption: people who are killed in a road crash cannot consume anymore and injured people may temporarily consume less as a result of their injuries. In that respect a distinction should be made between gross and net production loss. Gross production loss includes consumption loss, while net consumption loss is defined as gross production loss minus consumption loss. Gross production loss is measured by the (lost) value added that an employed person produces. Part of this value added is used for the payment of wages, which in turn are used for consumption expenditures. Gross production loss is the most common measure for production loss (Wijnen & Stipdonk, 2016). If gross production loss is calculated, consumption loss should be deducted from the VOSL to avoid double counting of consumption loss (see human costs below).

Loss of non-market production can be estimated using information on time spending on household work, child care, etc. and a shadow price that reflects the values of time (e.g. based on wages). However, it should be noted that it is common international practice to calculate the 'potential production loss' (Wijnen & Stipdonk, 2016; SafetyCube, forthcoming). This means that the capacity to produce is valued, regardless of what someone is actually producing. Consequently, there is a risk of double counting production loss to some extent, because unemployed people (whose capacity to produce is included in loss of potential market production) may be more involved in non-market production.

Friction cost can be calculated on the basis of the actual cost of resources (mainly labour) spent on recruiting and training new personnel and costs of vocational rehabilitation. Note that time spent on vocational rehabilitation should not be included. If vocational rehabilitation is regarded as an element of sick leave, the value of this time is included yet in production loss of the injured.

Several more detailed methodological issues concerning estimating production loss are discussed in the literature (for example Trawén, et al., 2002). These including the questions whether the actual or potential production loss should be estimated, which production indicator should be used, whether future loss should be discounted and whether a production growth rate for future production should be used. SafetyCube (forthcoming) recommends using the concept of potential production loss, that is the value that casualties could potentially produce, instead what casualties actually produce (taking into account unemployment for example).Potential production loss is regarded as a better measure, because in this approach the loss of productive capacities as a consequence of road crashes is the basis for the valuation. Regarding indicators for production, gross national/domestic product per capita or income (total income or available income) can be used as these are appropriate measures for the social value of the individual's production. Finally, SafetyCube recommends applying a discount rate for future production loss (e.g. the discount rate that is recommended in national guidelines for economic analysis) but not a growth rate for future production. A growth rate

is difficult to determine, because it should cover a very long time period (up to about 80 years) implying that there are (too) many uncertainties.

Estimating non-market production loss requires data on time spending on non-market activities and values of time, and estimating friction costs requires data on costs of recruiting and training new personnel and costs of vocational rehabilitation (e.g. training).

2.3.3 Human costs

The willingness to pay (WTP) approach is generally acknowledged as the most appropriate and theoretically sound method to estimate human costs. This method is recommended in guidelines for road crash cost studies (SafetyCube, forthcoming; Alfaro et al., 1994), and it is good practice to apply this approach in national road crash cost studies (Wijnen & Stipdonk, 2016) as well as in European studies such as HEATCO (HEATCO, 2006). In WTP studies an estimate is made of the amount of money people are willing to pay for a reduction of the risk of getting killed in a road crash.

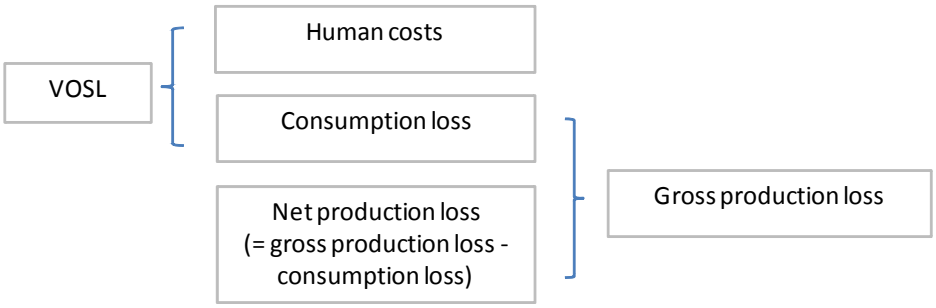
There are in general two approaches to determine the willingness pay, either using a 'stated preference' (SP) method or a 'revealed preference' method (RP) method. RP methods value risk reductions on the basis of actual behavior, for example purchasing behavior regarding safety provisions (e.g. airbags), while SP methods use questionnaires in which people, directly or indirectly, are asked how much they are willing to pay for more safety. The results of a SP or RP study are used to derive the value of a statistical life (VOSL). This is the value that is attached to a (prevented) fatality. SafetyCube (forthcoming) discusses both approaches and concludes that 'with the current state of knowledge the SP approach is considered, at least in Europe, as the most suitable and scientifically sound method to estimate the VOSL in the context of road safety'. A main advantage of SP methods is the broader possibilities to apply the method, as it is not dependent on information on actual consumer behavior. Furthermore, consumers usually are not (fully) aware of the risk reduction resulting from safety devices, and stated preference methods allow to provide this information to help respondents understand (small) risk reductions correctly. For these reasons, SP methods are more commonly used in the context of road safety in Europe. However, SP-methods also have several limitations, which are mainly related to biases that occur when questionnaires are used. For example, results are found to be dependent on the size of the risk change for which a valuation is asked. On the other hand, SP methods have been discussed extensively in economic literature and methods have been developed to cope with these limitations. For a further discussion on the pro's and con's of these methods, see for example De Blaeij (Blaeij, et al., 2003).

While in European countries SP-method are more commonly used, in the US RP methods are more often applied (Lindhjem, et al., 2010). In the US the VOSL for road safety is based on the RP studies in the field of occupational safety, which is significantly higher than European values (Wijnen & Stipdonk, 2016).

In most cost studies relatively old VOSL estimates are used, because VOSL studies are not carried out regularly. A VOSL dating from 10 to even 20 years ago is not exceptional (Wijnen & Stipdonk, 2016). This means that the VOSL needs be updated for application in a cost study. There is no standard method for updating the VOSL, but at least a correction for inflation is applied and some countries apply a correction for income growth in addition. Of course, this introduces a certain level of inaccuracy in the estimates of human costs.

It should be noted that the VOSL includes both human costs and consumption loss. Therefore, consumption loss should be deducted from the VOSL, resulting in human costs. This presumes that the concept of gross production loss, that also includes consumption loss, is used for the calculation of market production loss, see Figure 4. Consumption loss of fatalities is calculated on the basis of number of lost life years and yearly (market) consumption.

Figure 4 Relation between VOSL, human cost, consumption loss and net and gross production loss



The WTP approach is also applicable to injuries. In several WTP studies for (serious and slight) injuries the value of an injury is estimated relatively to the VOSL. For example, in a stated preference study in the UK (O'Reilly et al., 1994) respondents were asked to imagine that they were a casualty in a road crash, and to make a choice between two (hypothetical) treatment options. The treatments resulted in different health outcomes. They were given a description of their health prognosis if they were medically treated in a normal way. Then they were asked to imagine that an alternative treatment is available that would return them to their normal health state, but if unsuccessful would worsen their health state or even result in death. From these questions the value of human costs of injuries was derived, relative to the VOSL. Studies into the human costs of injuries are much more complicated than, because the severity and consequences of injuries are very diverse. For that reason, just of a few of studies have carried out in the field of road safety (in Belgium, Sweden and the UK; (Wijnen & Stipdonk, 2016)). These studies show that the human cost of serious injuries are about 10-16% of the VOSL and the human costs slight injuries of 0.9-1.6% of the VOSL.

An alternative approach to estimate human costs of injuries is based on Disability Adjusted Life Years (DALYs). DALYs are a measure for impact of injuries on quality of life that combines impact on mortality (fatalities) and morbidity (injuries). The impact on mortality is expressed in the number of years of life lost (YLL) and the impact on morbidity is expressed in years lived with disability (YLD). A main advantage of this approach is the possibility to express impacts on fatalities and injuries in one single measure. DALYs are primarily used to provide information on the burden of injury resulting from road crashes (by transport mode, age, crash type, etc.), as has been done for example in a recent Dutch study (Weijermars, et al., 2014). However, DALYs can be used additionally to express loss of life years and loss of quality of life in monetary terms. This requires an estimate of the monetary value of a DALY. Such values can be retrieved from studies into the willingness to pay for quality of life (see for example Bobinac, et al., 2013), or alternatively they can be deducted from the VOSL (see for example Hirth, et al., 2000). Several publications in the field of public health have proposed values that could be used in the Dutch context, ranging from € 60,000-80,000 (RIVM, 2014); (RVZ, 2006) to 'more than € 100,000' (RIVM, 2006). The DALY approach has only

been used in the US so far to estimate human costs of injuries (Blincoe, et al., 2014). In the US DALYs have been estimated for each MAIS category (1-5) and multiplied by the value per DALY that was derived from the VOSL. As an illustration Table 3 shows the results. The DALY approach is also applied on other policy fields, for example health care and in studies into the costs of crime. In the Netherlands, guidelines for cost-benefit analysis of health care interventions (RIVM, 2014) include valuation of benefits in terms of QALYs gained.[5] In studies into the costs of crime in the Netherlands (e.g. SEO, 2007), costs of loss of quality of life of victims of crime is estimated on the basis of DALYs and the value per DALY.

Table 3 **Human costs in the US, 2010**

Injury category	Number of casualties	Human costs per casualty	Total human costs
MAIS 1	3,459,200	23,241	80,395
MAIS 2	338,730	340,872	115,464
MAIS 3	100,740	805,697	81,166
MAIS 4	17,086	2,037,483	34,812
MAIS 5	5,749	4,578,525	26,322
Fatal	32,999	7,747,082	255,646
Total			593,805

Source: Blincoe et al., 2014.

The DALY approach has the advantage of taking into account detailed information on injuries and the impact of injuries on quality of life, whereas the WTP approach, in which valuations of injuries are directly elicited from a survey, use a very limited number of broad injury categories. On the other hand, the DALY approach includes some debatable aspects, in particular the fact that the value per casualty depends on the age of casualty.
The implication that road casualties are valued differently may raise ethical concerns. Moreover, a value which is decreasing with age may not be consistent with the literature on the relation between the VOSL and age: some studies show that the VOSL increases with age until a certain age and then start to decrease, while in other studies no significant relation between VOSL and age is found (in some case up to a certain age), see for example Lindhjem et al. (2010).

Several other approaches are available to calculate human costs (see for example World Bank, 2005). These approaches are based on financial compensations that are awarded to road casualties or their relatives in courts or by law (statutory values), premiums people pay for life insurances or public expenditures on improving (road) safety. Although these approaches are in some countries to estimate human costs, they have severe (theoretical) limitations.[6] For that reason the WTP method is recommended in international guidelines (SafetyCube, forthcoming; Alfaro et al., 1994) and this approach is used in the majority of high income countries (Wijnen & Stipdonk, 2016) as well as in European studies into costs of transport, including costs of road

5 QALYs (Quality Adjusted Life Years) is the opposite measure of DALYs: a QALY gained is equal to a DALY lost.

6 A main limitation is the fact that these methods are not based on valuations of individuals (the road users themselves). This conflicts with economic welfare theory on which cost-benefit analysis, and thus costs of road crashes as an input for cost-benefit analysis, are based.

crashes, such as HEATCO (Bickel et al., 2006), and the Handbook on estimation of external costs in the transport sector ((CE Delft ; INFRAS; Fraunhofer-ISI; University of Gdansk, 2008); (Ricardo-AEA ; DIW econ ; CAU, 2014). In the report we follow the international standard to use the WTP approach to estimate human costs.

2.3.4 Property damage

In general there are two approaches for calculating vehicle damage (which is the main cost item of property damage): bottom-up or top-down. In the bottom-up approach the (average) car damage is multiplied by the number of vehicles involved in a crash, while in the top-down approach total damage is directly estimated (e.g. on the basis of insurance data on total payments) and the costs per vehicle or per crash can be derived from the total costs (top-down).

A limitation of the top-down approach (that has been applied in the Netherlands) is the fact that insurance statistics on total damage do not include damage that is not reported to an insurance company or which is not paid for by the insurance company. Therefore, information about the completeness of insurance statistics is required to be able to estimate total vehicle damage. Examples in three countries show that damage that is unreported or unpaid vehicle damage makes up about 20 to 50% (50% in the Netherlands) of total vehicle damage (Wijnen & Stipdonk, 2016).
The bottom-up approach also has limitations, because usually there is no precise information about number of crashes, particularly low severity crashes.

Usually damage to cars, motorcycles and trucks/vans is included in road crash cost studies. Other vehicles may be added, such as buses, mopeds and bicycles.

Infrastructure damage, which is included in cost studies in several countries, is mostly based on damage registrations by road authorities.

Damage to freight and personal property, which is expected to be relatively very small and is not commonly included in cost studies, can be based on information of transportation companies and road users about the average value of freight and personal property respectively.

2.3.5 Administrative costs

- Police cost and fire service costs can be calculated either bottom-up or top-down. In a bottom-up approach costs per unit, such as time police/fire service costs per hour or per crash, is multiplied by the time spent on a road crash or the number of crashes. In a top-down approach the share of costs related to road crashes in total police/fire service costs is estimated using information on police/fire service time spending on road crashes. Both approaches are appropriate, so usually data availability determines which method is used.
- Insurance costs relate to the cost of personnel handling claims, including overhead costs. It is good international practice to include all administrative costs related to vehicle insurances. The underlying idea is that these costs can be attributed to road crashes, because insurance would not be needed if there were no crashes. These costs are usually available from insurance branch statistics. An alternative approach estimates the costs that are specifically related to handling insurance claims resulting from road crashes, based on number of claims and costs per claim.

- Legal costs can be estimated using a bottom-up or a top-down approach. In a bottom-up approach cost per 'unit' (cost for prosecution per offender, per lawsuit, per prisoner) are multiplied by the number of units (prosecuted offenders, lawsuits, prisoners). In a top-down approach the proportion of total legal costs (costs of prosecution, lawsuits, and imprisonment) is determined on the basis of certain variables (e.g. prosecuted people due to a road crash as a proportion of total number of prosecuted people).
- Other insurance costs, particularly health insurances, can be based on insurance statistics on the average administrative costs (personnel costs, overhead costs) per claim and the number of claims related to road crashes.

2.3.6 Other costs

- Funeral costs are calculated as the difference between the actual costs of a funeral and the future costs of the funeral if the person was not killed in a road crash. The future costs are calculated as the present value of the costs of a funeral in the future, using a discount rate.
- Congestion costs are calculated on the basis of time loss due to traffic delays resulting from crashes and the value of time. Congestion costs can be calculated on the basis of time losses and the (WTP based) value of time (bottom-up). Alternatively congestion costs can be calculated on the basis of total congestion costs and the proportion of time loss related to road crashes in total time loss due to (all) traffic jams (top-down). These total costs may include WTP values of unreliability of travel times, costs of adapting travel behaviour to traffic jams, extra fuel costs and environmental damage (pollution).
- Costs of vehicle unavailability can be estimated on the basis of the actual costs of replacing the vehicle (e.g. renting car and time costs; restitution costs approach).
- Cost of visiting casualties can be calculated on the basis of the actual costs of visits, in particular travel costs and time costs (restitution costs approach).
- The costs of adapting houses and moving are calculated as the actual costs of the adaptations and moving, such as costs of an inside elevator, labour costs and hiring a removal firm.

2.3.7 Summary

Table 4 summarizes the costs items and the appropriate method for estimating each cost item as identified in the SafetyCube project.

Table 4 Overview of costs items and methods in the SafetyCube guideline (Martensen et al., 2016; SafetyCube, forthcoming)

Cost component	Cost item	Method
Medical costs		
Main	a) First aid at crash location and transportation	- RC: Actual costs of medical resources (labour, equipment, etc.), - Calculation: costs per 'unit' (per ambulance trip, per day, per treatment, etc.) times the number of 'units' (number of ambulance trips, average duration of hospital stay, frequency of non-hospital treatment, etc.)
	b) Treatment at the accident and emergency department of hospitals	
	c) In-patient hospital treatment	
	d) Out-patient hospital treatment	
	e) Non-hospital treatment	
Minor	f) Aids and appliances	
	g) Medicines	

Cost component	Cost item	Method
Production loss		
Main	a) Lost market production	- HC: production per person per year (e.g. GDP/capita or income) times lost productive years - Gross production loss: including consumption loss - Potential production loss
Other	b) Lost non-market production (household work, taking care of children, voluntary work, etc.)	- HC: time spent on non-market production times value of time (e.g. wage as indicator)
Minor	c) Friction costs	- RC: actual costs of recruiting and training new employees and actual costs of vocational rehabilitation
Human costs		
Main	a) Fatalities	- WTP, based on stated or revealed preference - Calculation: (VOSL-consumption loss) * number of fatalities
	b) Serious and slight injuries	- WTP injury relative to VOSL, stated preference - Calculation: %VOSL *number of injuries - %VOSL may be taken from other countries (value transfer)
Other	c) Human costs for relatives and friends	- Not calculated separately: assumed to be included in WTP fatalities/injuries
Property damage		
Main	a) Vehicles	- RC: actual costs to repair damage or replace vehicles - Preferably cars, motorcycles and trucks/vans; optionally buses, mopeds an bicycles - Two calculation approaches: 1. Bottom-up: average damage per vehicle * number of damaged vehicles (including non-reported crashes) 2. Top-down: total vehicle damage (including estimate of unreported and unpaid damage)
Minor	b) Infrastructure, fixed roadside objects and buildings	RC: actual costs to repair damage or replace property
	c) Freight carried by lorries	
	d) Personal property	
Administrative costs		
Main	a) Police costs	- RC: actual costs of resources of police assistance (labour, equipment) - Two calculation approaches: 1. Bottom-up: time spent on road crashes * costs per unit of time 2. Top-down: total police costs * time share road crashes
	b) Fire service costs	- RC: Actual costs of resources of fire service assistance (labour, equipment) - Bottom-up or top-down calculation (similar to police cost)
	c) insurance costs	RC: all administrative costs (personnel, overhead) related to vehicle insurances
	d) Legal costs	- RC: actual costs of prosecution, lawsuits and imprisonment - Bottom-up or top-down calculation

Cost component	Cost item	Method
Other	e) Other insurance costs	RC: all administrative costs (personnel, overhead) related to other insurances (e.g. health)
	f) Administrative costs for persons involved in an accident	
Other costs		
Main	a) Funeral costs	Difference between the actual funeral costs and (discounted) future costs of the funeral if the person was not killed in a crash
	b) Congestion costs	- Calculation: time loss *value of time (WTP), or total congestion costs * share road crashes - Cost of travel time unreliability of travel times, adapting travel behaviour, extra fuel costs and pollution may be included
Minor	c) Vehicle unavailability	- RC: actual costs of replacing the vehicle (e.g. renting car and time costs)
	d) Visiting people in hospital	RC: actual costs of visits, in particular travel costs and time costs
	e) Moving and house adaption cost	RC: actual cost for moving and for adaptations (equipment, labour)

2.3.8 European methods

Several European studies into the costs of transport have been published the last decades. One of the first studies was carried out by ECMT (1998). This study included European estimates of the costs of road crashes, besides estimates of several other costs such as congestion and environmental costs. The ECMT report presented a European standard figure for the VOSL (€ 1.5 million in 1998), based on a review of VOSL estimates in several countries. Costs of serious injuries were added as a percentage of the VOSL, based on a WTP study in the UK (O'Reilly, et al., 1994). Also other costs (medical costs and administrative costs only) were estimated as a percentage of the VOSL on the basis of the ratio of VOSL and is some countries. All figures were differentiated by country based on income and purchasing power differences. Subsequent European projects include UNITE (Nellthorp, et al., 2001), HEATCO (HEATCO, 2006) and the Handbook on estimation of external costs in the transport sector (CE Delft ; INFRAS; Fraunhofer-ISI; University of Gdansk, 2008); updated in 2014: (Ricardo-AEA ; DIW econ ; CAU, 2014). These studies adopted the same approach as ECMT (1998) by determining a standard VOSL and using percentages for other costs as well as for costs of serious and slight injuries. Each of these studies draws on previous reports, in particular ECMT (1998): they all use the same methodology and propose the same values per casualty. Particularly the HEATCO values got attention in the field of road safety. For example, the European Road Safety Observatory refers to HEATCO figures (ERSO, 2006) and some countries use (some of the) HEATCO values in road crash costs estimates (for example Austria, Belgium and Switzerland). However, it should be noted that these studies only include external costs of road crashes, defined as costs that are not covered by insurances (and thus not paid for by the individual involved in a road crash through insurance premiums). This means for example that medical costs and damage to vehicles are not (fully) taken into account in these studies.

In addition, ETSC (2012) has developed a standard European VOSL per fatality (€ 1.7 million in 2009), based on a review of VOSLs in eight countries. This value has been used in ETSC reports to estimate the costs of road fatalities in Europe, but has not been applied (yet) in other cost studies.

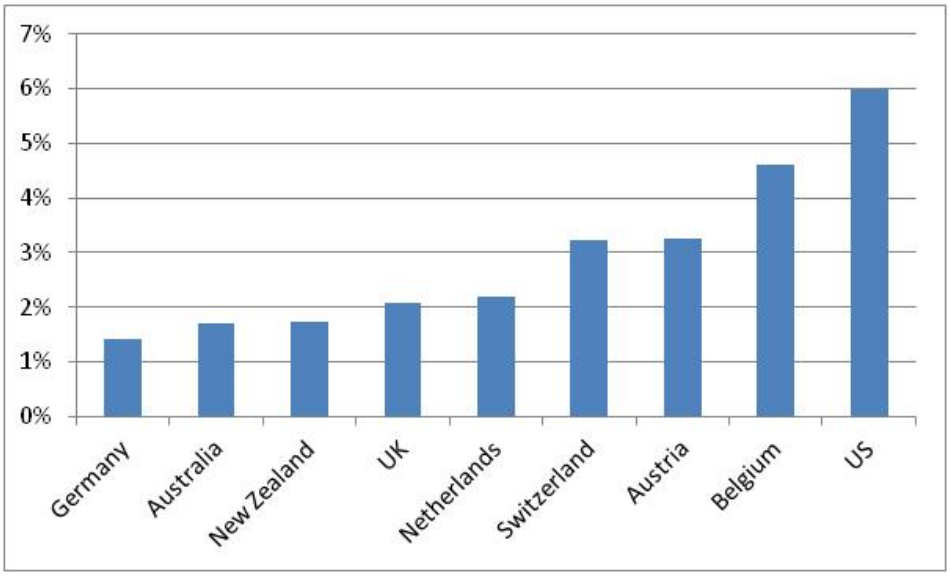
2.3.9 Updating costs

In most countries a study in to the costs of road crashes is carried every 5 to 10 years without making yearly updates (e.g. Austria, Netherlands, Switzerland, US). Some other countries (e.g. Germany, New Zealand, UK) make yearly calculations based on the latest cost study. Updates are made on the basis of the number of road casualties in a new base year and updated estimates of the costs per casualty. In New Zealand costs per casualty are updated using inflation indicators for specific costs components. Some of them include income growth in addition to price developments. The details of the updating approach have not been reported for other countries.

2.4 Size of the costs

The costs of road crashes in the high income countries included in Wijnen & Stipdonk (2016) range from 1.4% of GDP in Germany to 6.0% of GDP in the US (Figure 5). A main explanation for differences between countries relates to methodological differences, particularly regarding human costs. For example, Germany and Australia do not apply a WTP approach, but values based on financial compensations that are awarded to road casualties or their relatives in courts or by law (statutory values). This results in much lower values for human costs in these two countries. In the US a relatively high VOSL has been used, based revealed preference studies (see Section 2.3). The costs in the Netherlands are at the lower end of costs in countries that apply a WTP method. There are methodological explanations for this, in particular the fact that in the Netherlands human losses of slightly injured casualties are not included and that production loss is (probably) underestimated (see Section 2.3). In addition, the relatively small number of casualties may be an explanation of the lower costs in the Netherlands (Wijnen, 2014).

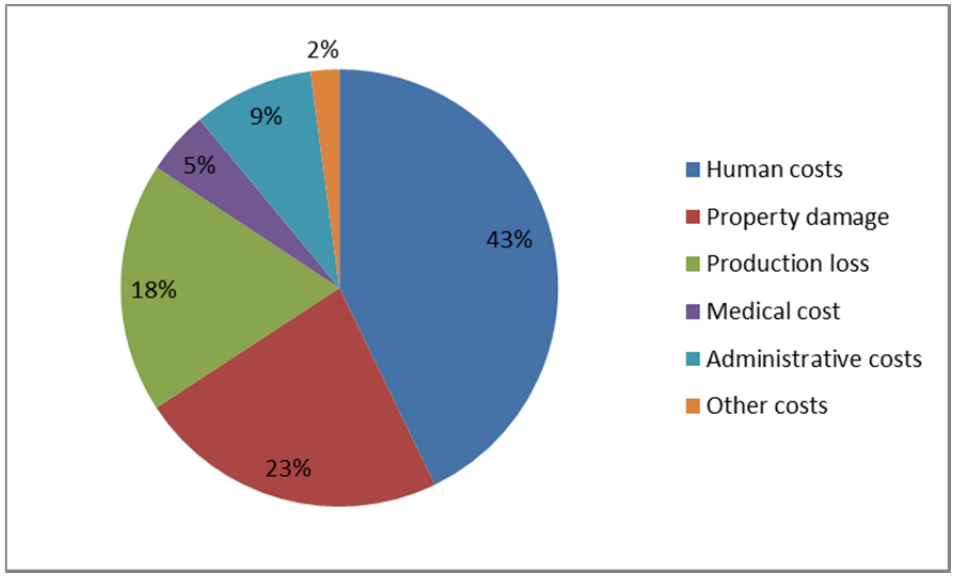
Figure 5 Costs of road crashes as a percentage of GDP in nine high income countries



Source: Wijnen & Stipdonk, 2016.

Wijnen & Stipdonk (2016) give an overview of the relative size of each main cost component in several countries. Figure 6 shows the average share of each costs component in eight countries. Human costs have a major share in total costs (43%), followed by property damage and production loss. Administrative costs, medical costs and other costs are relatively small.

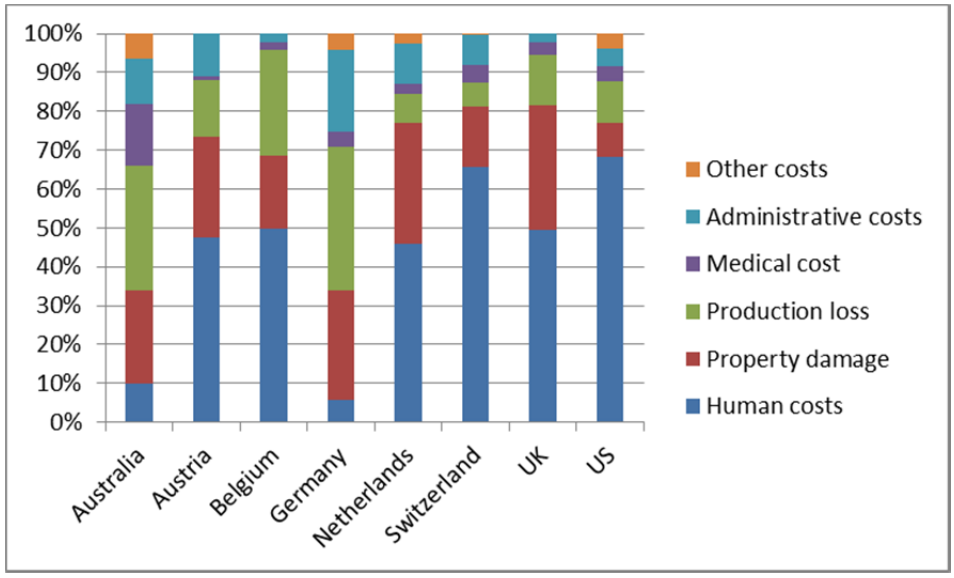
Figure 6 **Share of costs components in total costs, average eight countries**



Source: Wijnen & Stipdonk, 2016.

There are variations between countries, as shown by Figure 7. One of the main explanations of these variations relates to the method for estimating human costs. Australia and Germany do not use the WTP approach, resulting in much lower values for human costs.

Figure 7 **Share of cost components in total costs in eight countries**



Source: Wijnen & Stipdonk, 2016.

We discuss the (potential) size of cost items within the main cost components here in more detail.

Human costs

As shown by Table 1, it is common international practice to estimate human costs of fatalities, serious injuries and slight injuries and international guidelines (e.g. SafetyCube, forthcoming) recommend including human costs for these three casualty categories. Estimates for six countries (Australia, Austria, Germany, Switzerland, UK and US) show that injuries have a major share in total human costs: serious account on average for 43% of total human costs and slight injuries for 32%. Fatalities have an average share of 25%.

Property damage

Property damage mainly consist of vehicle damage: estimates in a few countries show that other property damage than vehicle damage, mainly damage to infrastructure, accounts for about 1% (Australia) to 10% (Austria and Germany) of total property damage.

Production loss

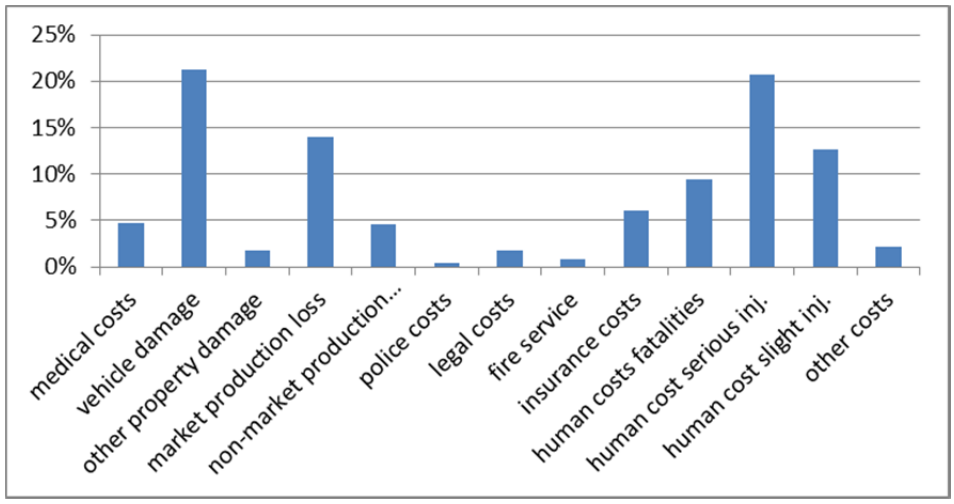
Estimates of non-market production loss are available, to our knowledge, only made in Germany and the US, where these costs have a share of 45% and 25% in total production loss. However, the German estimate includes black market activities which is not in line with common practice and international guidelines (SafetyCube, forthcoming). Based on the US estimate, we can conclude that market production loss is the main element of production loss, although non-market production loss is likely to be a substantial cost item too. Estimates of friction costs in four countries (Australia, Germany, Switzerland and US) show that these cost are at most 5% of total production loss. Vocational rehabilitation is not included in these figures however.

Administrative costs

Cost studies in four countries that have included all four types of administrative costs (Australia, Austria, Belgium and the Netherlands) show that insurance costs have a major share in total administrative costs (67% on average), followed by legal costs (19%). Costs of fire service and police are relatively small (9% and 5% respectively).

Based on the information on the relative size of each cost component discussed above, we have estimated the share of each cost item in case all of these cost items would be included in a study into the costs of road crashes. Figure 8 shows the results, indicating human costs of serious and slight injuries are major cost items, as well as vehicle damage and market production loss. Medical costs and other costs have not been specified into cost items since these cost component are already relatively small. Note that some of these estimates are based on studies is just a few countries, so these figures are only rough indication that serve as a guidance for developing scenario's in the next phase of this study.

Figure 8 Indication of the relative size of each cost item



2.5 Comparison of the Dutch methodology and international state-of-the-art

In the latest study into the costs of road crashes in the Netherlands (De Wit & Methorst, 2012), costs have been estimated for the years 2009, 2006 and 2003. Table 5 provides an overview of the methodology that has been used in this study and its strengths and weaknesses. In this table we have copied the classification for costs components and costs items that has been developed in the SafetyCube and InDeV projects (SafetyCube, forthcoming; Kasnatscheew et al., forthcoming; see Table 5). The table shows:

- Which cost items were included (green: included, orange: not included).
- The methods that were used for each cost item and whether or not the method is consistent with the international state of the art and international guidelines as discussed above (green: consistent, orange: not consistent).
- The data that were used to estimate each cost item. Green cells indicate that accurate and recent data have been used, while data in the orange cells were less accurate and/or outdated. In case recent data (that is for 2009) were not available, the table lists the year for which data were used.

In the Dutch study, the six main costs components in the SafetyCube (and previous guidelines') classification have been distinguished. A slight difference is the fact that the category 'other costs' only includes congestion costs, while the other items of 'other costs' were included in medical costs.

Regarding the cost items the table shows that:

- One cost item that SafetyCube considers as a 'main' costs item is missing: human costs of slight injuries. As discussed above, it is common practice to include these costs and they have a very substantial share in total human costs, and thus in total costs.
- Three 'other' cost items are not (explicitly) included: loss of non-market production, human costs of relatives and friends and administrative costs of insurances other than vehicle insurances (health insurances for example). These may be substantial cost items, although it is not common international practice to include these costs items. Human costs of relatives and friends are usually assumed to be included in human costs of casualties. However, there is no strong evidence for this assumption.

- Three minor cost items are not taken into account: friction costs, property damage other than vehicle damage (in particular infrastructure damage) and costs of vehicle unavailability.

The third column shows that methods that are used in the Netherlands are all consistent with the international state of the art and international guidelines.

The fourth column shows that there were several data limitations in the latest study:

- Medical costs: estimates of the costs of transportation of casualties to hospital (ambulance, helicopter) are outdated (based on an estimate in 1997). However, this is a relatively small cost item.
- Production loss: the estimate of market production loss is based on unemployment benefits data (WAO and WIA laws), but not all road casualties receive such benefits. Consequently, the WAO/WIA data do not correctly reflect the number of road casualties who are unemployed due to a road crash. This is illustrated by the fact that production loss was estimated to be decreasing between 2003 and 2009, while the number of (serious) injuries was not decreasing. Probably this reflects a decrease in the share of road casualties receiving these benefits. Moreover, data on sick leave are outdated (based on 1990 data).
- Human costs fatalities: these costs have been estimated in a PhD study on the VOSL in the Netherlands (Blaeij, et al., 2003), using a well-designed WTP method ('stated choice' approach). The WTP survey was carried in 2001, so the data is getting outdated (and will be even more outdated when it is applied in future cost studies). Although a correction for inflation is applied, it is highly questionable whether the current VOSL still correctly reflects the valuations of the Dutch population.
- Human costs serious injuries: these costs are based on a WTP study in the UK carried out in 1991 ('value transfer'). Obviously, the UK data are outdated and moreover, it is questionable to what extent results from UK are applicable to the Dutch situation.
- Property damage: a major share of vehicle damage concerns damage that was not reported to an insurance company. This damage was estimated to be more than 50% of total vehicle damage on the basis of a SWOV study using data from 1991. Obviously, the results of this study are outdated.
- Police costs: these costs were based on studies on time spending of police officers, although time spending on road crashes was not separately included in these studies. Assumptions were made to make a (rough) estimate of this time spending.
- Other costs: costs of visiting people in hospital and costs of house adaptations are partly based on outdated estimates. However, these are minor costs components.

Table 5 Comparison latest Dutch cost study with international guidelines (green: consistent, orange: not consistent) and accuracy of data used in the Dutch study (green: accurate, orange: not accurate or outdated)

Cost component	Cost item	Method	Data
Medical costs			
Main	a) First aid at crash location and transportation	Restitution costs approach, bottom-up, using the burden of injury model (LLM)	- Studies ambulance and trauma helicopter costs, 1997
	b) Treatment at the accident and emergency department of hospitals		- Hospital data (included in LLM) - OBiN survey - Social security data (AWBZ), 2004-2005 - Assumptions (medicines)
	c) In-patient hospital treatment		
	d) Out-patient hospital treatment		
	e) Non-hospital treatment		
Minor	f) Aids and appliances		
	g) Medicines		
Production loss			
Main	a) Lost market production	Human capital approach	Fatalities: recent data age and life expectancy fatalities, Statistics Netherlands (CBS)
			Injuries: - Sick leave data, Statistics Netherlands (CBS), 1990 - Recent social security data unemployment (WAO, WIA)
Other	b) Lost non-market production (household work, taking care of children, voluntary work, etc.)		
Minor	c) Friction costs		
Human costs			
Main	a) Fatalities	Willingness to pay (WTP) approach	WTP survey, 2001
	b) Injuries	Seriousinjuries: WTP (value transfer	Value from WTP study in UK, 1991
		Slight injuries: not included	
Other	c) Human costs for relatives and friends		
Property damage			
Main	a) Vehicles	Restitution costs approach (top-down)	Insured damage: recent insurance data, Dutch Association of Insurers
			Unclaimed damage: analysis of data provided by an insurance company, 1991
Minor	b) Infrastructure, fixed roadside objects and buildings		
	c) Freight carried by lorries		
	d) Personal property		
Administrative costs			
Main	a) Police costs	Restitution costs approach	Police budget, estimate time spending police based on times spending studies, 2004 and 2006, assumptions
	b) Fire service costs and other emergency service		Fire service budget, number of incidents (Statistics Netherlands, CBS)

Cost component	Cost item	Method	Data
	c) Vehicle insurance costs		Insurance branch statistics, Statistics Netherlands (CBS)
	d) Legal costs		Statistics Ministry of Security and Justice (WODC)
Other	a) Other insurance costs		
Other costs			
Main	a) Funeral costs	Difference actual cost funeral and discounted future costs	- Survey costs of a funeral - Data age and life expectancy fatalities, Statistics Netherlands (CBS)
	b) Congestion costs	Willingness to pay approach	- WTP study value of time and reliability of travel time - Data on congestions due to crashes, Rijkswaterstaat
Minor	a) Vehicle unavailability		
	b) Visiting people in hospital	Restitution costs approach	- Assumption costs per visit, 1997
			- Hospital data
	c) Moving and house adaption cost	Restitution costs approach	- Social security data (law assistance disabled, WVG)
			- Percentage on disabled due to road crashes, 1993

2.6 Conclusions

This chapter provided an overview of the international state-of-the-art of road crash cost studies and an assessment of the methodology that has been used in the latest study in the Netherlands for the years 2009, 2006 and 2003.
The Dutch methodology has several strengths, in particular the fact that the classification of the six main cost components and the methodological approaches for each cost component are in line with international good practices and guidelines.

The main weaknesses of the Dutch methodology are twofold. Firstly, human costs of slight injuries are not included, which is considered as a main cost item in international guidelines. Moreover, all other countries in this overview have included these costs. In addition some other relevant cost items are missing, such as loss of non-market production (e.g. household work), infrastructure damage, administrative of health insurances. However, these are internationally not considered as main cost items. The second weakness relates to data limitations that have been identified: for several (major) costs items, such as production loss of injuries, vehicle damage and human costs of serious injuries, inaccurate or outdated data have been used. These are relatively large cost items (particularly human costs of serious injuries and vehicle damage), implying that data limitations may have substantial impact on the estimate of total cost

We conclude that some methodological improvements as well as several major revisions of input data would be needed to be able to make accurate calculations of the costs of road crashes in the Netherlands. Obviously, there is a trade-off between the quality of new estimates and the efforts that are needed to make these estimates. In the next chapters several scenarios for making new calculations will be developed and assessed.

3 Research scenarios

3.1 Introduction

In this chapter we present a longlist of scenarios for the update of the assessment on road crash costs in the Netherlands. We assume that in every scenario an update of road safety statistics (number of casualties, number of crashes, etc.) will be available. Therefore, the scenarios will be focussed on the assessment of the data and methodologies used to estimate the costs related to these crashes/victims.

The definition of the scenarios on the longlist does exclude the frequency of the update of the assessment on road crash costs in the Netherlands (e.g. whether the update approaches described are applied every year, once every 5 years, etc.). In that respect, hybrid scenarios (e.g. a detailed update every 5 years and a light update every year) are not considered in this chapter as well. The frequency of the update and its implications for the various possible update scenarios are discussed in detail in Chapter 5, as the preferred research scenarios are assessed.

In Section 3.2, we first briefly discuss the methodology used to define the scenarios. As input for the development of the scenarios, the various individual cost components are assessed in Section 3.3. Based on the results of this assessment, a longlist of scenarios is composed in Section 3.4.

3.2 Methodology

In order to develop a longlist of scenarios for the update of the assessment on road crashes in the Netherlands, a four step approach is applied:

1. **Identify all relevant cost components**; based on the review of the latest road crash cost study for the Netherlands and the international literature on this topic (as discussed in Chapter 2), all relevant cost components are identified.
2. **Assessment of the individual cost components**; the various cost components are assessed on the following criteria:
   - *Relevance*; the cost components differ with respect to their relevance, i.e. their contribution to the total crash costs and the extent by which they have a direct relationship with road crashes. We distinguished three classes of components: very relevant (large contribution and direct relationship), relevant (direct relationship) and not very relevant (small contribution, no direct relationship). The allocation of the cost components to these three classes have been based on the results of the latest study and the review of international literature (see Chapter 2).
   - *Need for data update*; the extent by which data (from the same sources as used in the latest cost study) should be updated. For example, new hospital (LIS) data on the number of injured people treated at hospitals is available to be used in the cost estimated.
   - *Need for data renewal*; the extent by which better and more recent sources should be used to estimate the road crash costs. For example, in the latest cost study the cost of emergency helicopters have been

based on a study from 1998 and hence this source may need to be updated.

- *Need for methodology update*; the extent by which new methodologies can be developed to improve the estimation of a cost component (e.g. new WTP study to estimate the VOSL) or to include components in the cost calculations that are currently lacking (e.g. human costs for slight injuries).
- *Opportunity for, and relevance of, international cooperation*; the extent by which the data update/renewal of methodology cooperation can be done in cooperation with other European countries and the extent to which such cooperation makes sense. For example, developing methodologies for estimating human costs would be sensible, because of the complexity of the methods and comparability of values. On the other, medical costs may vary substantially between countries, so international cooperation on this issue is considered as less relevant.

3. **Definition of research scenarios**; based on the results of the previous step, a long list of research scenarios has been developed. These scenarios differ with respect to the cost components that are included, the extent by which data and methodologies are updated/renewed, and the extent by which international cooperation will be applied. The list of scenarios is non-exhaustive, but intends to show a broad spectrum of scenarios that can be applied to update the road crash cost estimates in the Netherlands.
4. **Describing research scenarios**; in the final step, the various scenarios are briefly described.

3.3 Assessment cost components

Based on the results of the assessments carried out in Chapter 2, the individual cost components have been assessed on the five criteria mentioned in Section 3.2. The results of this assessment are shown in Table 6.

Table 6 **Assessment of individual cost components**

Cost category	Cost item	Relevance	Need for data update	Need for data renewal	Need for methodology update	Opportunity for international cooperation
Medical costs	First aid, transportation					
	Hospital: – AED treatment – In-patient hospital treatment – Out-patient hospital treatment					
	Medicines, appliances – Aids and appliances					

	– Medicines					
Production loss	Market production loss					
	Non-market production loss					
	Friction costs					
Human costs	Fatalities					
	Serious injuries					
	Slight injuries					
Property damages	Vehicles					
	Other					
Administrative costs	Police					
	Legal					
	Fire department					
	Insurance					
Other costs	Congestion					
	Vehicle unavailability					
	Funerals					
	Hospital visits					
	House adaptions, moving					

Not very relevant / no specific need / no opportunity
Relevant / minor need / some opportunity
Very relevant / significant need / good opportunity
Not applicable

As already mentioned in the previous chapter, human costs, material damages, (market) production loss and insurance costs are the most relevant cost components. Other cost components that significantly (may) contribute to the total road crash costs are non-market production losses, material damages other than damages to vehicles, legal costs and congestion costs due to crashes. The remaining cost components have a minor impact on the total costs.

For all cost components, an update of the data would be desirable. For several components, such as medical costs and most administrative costs, the same sources as used in the previous study can probably be used for this update. However, for some components new data sources are desirable, because currently relatively old or rough data is used or because the previously used data sources are not available anymore. This is, for example, the case for the cost of ambulances, which is based on figures from 1998. Also for property damages, mainly on the non-claimed part of these costs, and production loss additional data would significantly improve the cost estimates.

New methodologies are particularly needed for cost items that are currently missing in the total road crash cost figures: human cost of slight injuries, non-market production losses, friction costs and costs of vehicle unavailability. However, also for the human cost components (fatalities and in particular serious injuries) methodological improvements are interesting to consider. For example, new estimates of the Value of Statistical Life or the monetization of human costs by estimating disability adjusted life years (DALYs) may be interesting options to improve the quality of the cost estimates.

Finally, international cooperation seems most promising for estimating human costs. These costs do not depend on national regulation or institutions and hence can be relatively easily transferred by applying a value transfer approach. Furthermore, the assessment of these cost components require relatively large resources, which makes an international approach even more interesting. For some other cost components, international cooperation may be relevant as well, particularly in the development of surveys or methodologies. Possibly methodologies can be developed internationally and applied on national data to provide specific national figures. For example, for non-market production losses a harmonised international methodology can be developed, which can be applied in several countries to estimate country specific figures. Also regarding human costs surveys may be carried out in individual countries using an internationally developed method. Countries that are not able to participate may transfer the results to their national context.

3.4 Longlist of scenarios

Based on the assessment of the individual cost components, a longlist of 15 scenarios has been developed (see also Table 7). These scenarios are described hereafter. As mentioned above, we have assumed that in every scenario an update of road safety statistics (number of casualties, number of crashes, etc.) is available.

1. **Minimal scenario**
   In this scenario, all cost components in the last cost study are corrected for inflation. The most simple approach is to use one Consumer Price Index (CPI) or GDP deflator value to correct all cost components. However, using specific values per good/service category may result in (slightly) better updated figures.

2. **EU guidelines scenario**
   In this scenario the approach to estimate the road crash costs in the Netherlands will be brought in line with the EU guidelines that are developed in the current SafetyCube project (Martensen, forthcoming). One cost item that is considered as a 'main' cost item is missing in the last cost study: human cost of slight injuries. The addition of this cost item in this scenario may be based on a value transfer of figures found by a literature review (Scenario 2) or on a specific Dutch WTP study (Scenario 2b). All other cost items are updated by correcting them for inflation (as in Scenario 1).

3. **EU guidelines + scenario**
   In addition to the EU guidelines scenario, this scenario also covers the inclusion of other potentially important cost components that were missing in the last cost study: non-market production loss and property damage other than vehicle damage (in particular damage to infrastructure). This requires the development of a methodology and (particularly) the collection of all necessary data.

4. **Data update scenario**
   Compared to Scenario 1, this scenario describes a more sophisticated general approach to update the various cost components: for all cost components new data is collected from the same (or comparable) sources as in the previous study (if possible). In other words, all data from Statistics Netherlands, VeiligheidNL (using the burden of injury model, LLM), etc. are updated. Data based on specific studies for which no new

values are easily available (e.g. the cost of the emergency helicopter, human costs of fatalities and serious injuries) are only corrected for inflation in this scenario.

5. **Data update scenario + WTP slight injuries**
   In addition to the 'Data update scenario', this scenario also covers the inclusion of a potentially important cost component that is missing in the last cost study: the human costs of slight injuries. As in Scenario 2, two options to include this cost item can be considered: value transfer of figures found by a literature review (Scenario 5a) or executing a specific Dutch WTP study (Scenario 5b).

6. **Data renewal scenario light**
   In addition to the 'Data update scenario' (Scenario 4), the data approach used for some cost items will be renewed. This will be done for the cost items for which data renewal is most needed: emergency transport, market production loss, human costs of serious injuries (based on new foreign studies), costs of visiting people in hospital and costs of house adaptations and moving. Costs of unreported vehicle damage and police costs will not be renewed, because we anticipate that no new data are available and that a development of a new methodology will be needed. In this scenario, no new cost items will be covered.

7. **Data renewal scenario extensive**
   In addition to the 'Data renewal scenario light' (Scenario 6), the data used for human costs of fatalities will be renewed. This means that a new WTP survey will be carried out using the methodology developed by Blaeij, et al., (2003). As in Scenario 6, no new cost items will be covered.

8. **Data renewal scenario + WTP slight injuries**
   In addition to the 'Data renewal scenario extensive' (Scenario 7), specific values for the human costs of slight injuries will be estimated by applying a value transfer approach based on figures found by a literature review (8a). An alternative option would be to estimate these costs by a specific Dutch WTP study (8b).

9. **Data renewal scenario + valuation injuries based on DALYs**
   In addition to the 'Data renewal scenario extensive' (Scenario 7), the human costs of (serious and slight) injuries are estimated based on 'burden of injury' method. In this method, the disability-adjusted life years (DALYs) due to crashes are estimated, using the methodology developed by SWOV (Weijermars, et al., 2014). These DALYs are monetized by using a Value of Life Year lost (VOLY), for which a specific value for the Netherlands will be determined in this scenario. This value will be based on existing literature on the value of a VOLY in the Netherlands or will be derived from the VOSL.

10. **Data renewal scenario + valuation all casualties based on DALYs**
    In addition to the previous scenario, this scenario applies the 'burden of disease' approach for fatalities as well (instead of the Value of Statistical Life).

11. **Data renewal scenario + methodological improvements**
    In addition to the 'Data renewal scenario light' (Scenario 6) methodological improvements will be made for cost items that require these improvements and whose size is considerable: non-market production loss, human costs of serious and slight injuries, unreported

vehicle damage, property damage other than vehicle damage and non-vehicle insurance costs. For human costs of injuries a relatively simple approach will be applied, using results from other countries (value transfer).

12. **Maximum scenario national**
    This scenario describes the most sophisticated approach to update the road crash costs in the Netherlands. This implies:
    - Medical costs: update of data using the LLM model and renewal of data used to estimate these costs if needed.
    - Production loss: market production loss will estimated based on new, most recent data. For non-market production loss and friction costs, methodologies will be developed and required data will be collected.
    - Human costs: new, Dutch specific, estimates for the Value of Statistical Life will be estimated in order to monetize the human costs of fatalities. Additionally, a Dutch WTP study will be carried out to estimate the human costs of serious and slight injuries.
    - Property damages: new, more recent data sources will be used to estimate the material damage to vehicles (particularly relevant for the unreported part). Furthermore, the costs of other material damages will be added based on state-of-the-art methodologies and data.
    - Administrative costs: for the cost of police (particularly time spent by the policy on crashes) a new methodology will be developed, while for insurances (particularly relevant non-vehicle insurances) better data sources will be looked for to estimate them or surveys will be carried out. For the other cost components the same data sources as in the previous study can be used to update the cost estimates.
    - Other costs: for congestion and funerals, the estimates are updated based on comparable sources as in the previous study. The cost of the unavailability of vehicles will be added to the calculations. Finally, the costs of visiting people in hospital and costs of house adaptations and moving will be updated based on new data sources.

    In this scenario, all analyses will be carried out without any cooperation with foreign partners.

13. **Maximum scenario international – light**
    This scenario is in line with the 'maximum scenario national' (Scenario 11), except for the human costs. To provide state-of-the-art estimates of the human costs of (serious and slight) injuries, an international WTP study (in cooperation with some international partners) will be carried out. In this study, a survey will be designed that can be applied in the various countries concerned, such that specific figures for the Netherlands may be obtained against lower costs than in the 'maximum scenario national' (Scenario 11). No new study to the human costs of fatalities will be carried out; these costs will be based on the estimates already used in the latest crash cost study.

14. **Maximum scenario international – extensive**
    In this scenario, maximum international cooperation is sought, in order to provide a very sophisticated estimate of the costs of road crashes in the Netherlands. This implies that next to international cooperation to estimate the human costs of injuries, also an international study to the Value of a Statistical Life will be conducted (in line with the approach applied for the WTP study for the human costs of injuries). Furthermore, international cooperation will be sought to estimate other cost items that need methodological updates: non-market production loss, unreported vehicle damage, other material damages, friction costs, administrative

costs of police and cost of vehicle unavailability (e.g. by developing surveys together with foreign partners, which may be applied in each country concerned). For all other cost components, the same approach as in 'maximum scenario national' (Scenario 11) will be applied.

15. Scenario for EU-consistent cost estimate

In this scenario the methodology of the HEATCO study is used to estimate (EU consistent) accident costs. This scenario foresees a detailed update of the results of the HEATCO study, consisting of:

- an EU-average VOSL (which can be transferred to national values by applying a relevant value transfer approach);
- specific EU-average indicators to estimate the human cost of serious and slight injuries, i.e. % of the VOSL that can be used to estimate the human costs of these injuries.
- specific EU-average indicator (i.e. % of VOSL) to estimate the other cost components, including costs that were not included in HEATCO.

The EU-averages are based on meta-analyses of existing costs studies, so no new studies will be carried out.

Table 7 Overview of scenarios

	Medical costs				Production loss			Human costs			Property damages		Administrative costs				Other costs				
	Emergency transport	Hospital	Follow-on treatment	Medicines, applicances	Market production loss	Non-market production loss	Friction costs	Fatalities	Serious injuries	Slight injuries	Vehicles	Other	Police	Legal	Fire department	Insurance	Congestion	Vehicle unavailabitly	Funerals	Hospital visits	House adaptations
1. Minimum scenario																					
2. EU guidelines scenario																					
3. EU guidelines + scenario																					
4. Data update scenario																					
5. Data update scenario + WTP slight injuries																					
6. Data renewal scenario light																					
7. Data renewal scenario extensive																					
8. Data renewal scenario extensive + WTP slight injuries																					
9. Data renewal scenario + valuation injuries based on DALYs																					
10. Data renewal scenario + valuation all casualties based on DALYs																					
11. Data renewal scenario + methodological improvements																					
12. Maximum scenario national																					
13. Maximum scenario international – light																					
14. Maximum scenario international - extensive																					
15. Scenario EU-consistent cost estimate - extensive																					

Only correction for inflation
Data update
Data renewal
Methodology development + data renewal
International cooperation

4 Broad assessment of scenarios

4.1 Introduction

In this chapter the longlist of scenarios developed in Chapter 3 will be assessed and prioritized, in order to select the most promising scenarios for estimating the costs of road crashes in the Netherlands. Firstly, we describe the methodology that is used for the assessment and in particular the assessment criteria (Section 4.2). In Section 4.3 the 15 scenarios are assessed by assigning scores on each of these criteria. Section 4.4 presents an overall assessment of the scenarios.

4.2 Methodology

To assess the 15 scenarios, a set of criteria will be used that reflect the issues that are relevant for prioritizing the scenarios, such as the methodological quality and the (research, data) costs of a scenario. Next, for each scenario scores will be given to each criterion on a 1 (lowest score) to 7 (highest) scale. The score should be interpreted as indications for the differences between the scenarios, but not as absolute judgements. For example: the quality of the current Dutch is rated at 3, but this does not necessarily mean that the quality is not sufficient. This score is given because the other scenarios include several methodological improvements, that should be rated higher.

The criteria are related to the (scientific) quality of the methodology in each scenario, availability and quality of data, costs of carrying out the study according to each scenario, comparability with previous estimates in the Netherlands and with practices in other countries, complexity of applying the method for future updates, opportunities for international cooperation and for applying the approach in other countries. Table 8 gives an overview of these broad criteria and the subcriteria that are used for the assessment of the scenarios.

Table 8 Overview of assessment criteria

Criteria	Sub-criteria
Quality of the methodology	– Scientific quality – Consistency with international state-of-the-art – Importance of cost items for which methodology will be improved for total cost
Availability and quality of input data	– Completeness of data – Extent to which recent data are used – Reliability of data – Continuity of data
Costs	– Costs of providing an one-time update of the costs of road crashes
Comparability with the previous study	– Extent to which the outcomes are comparable with the previous estimates in the Netherlands – Extent to which differences with the previous study can be explained – Possibilities to apply a (simple) correction on the

Criteria	Sub-criteria
	previous estimates to make them comparable with the new estimates
International cooperation and harmonization	– Opportunities for international cooperation on developing new methodologies – Opportunities to apply the methodology in other EU countries (that are not involved in developing the methodology)

Hereafter we briefly explain the interpretation of the criteria:

Quality of the methodology for each cost item

- *Consistency with international state-of-the art*: to what extent is the methodology consistent with the international guidelines and literature, or does a scenario go beyond the state-of-the art? The assessment of the scenarios on this criterion will be based on the state of art as summarized by Table 2 and the discussion of other methodologies in Chapter 2.
- *Scientific quality:* to what extent is the methodology in line with recent scientific literature on costs of road crashes and economic valuation methods?
- *Size of cost items for which methodology will be improved for total cost*: this criterion reflects to what extent methodological improvements in a scenario are (at least) focussed on the largest cost items. The more large costs are methodologically improved, the higher the score. The indication of the relative size of cost components as shown by Figure 8 will be used for the assessment of this criterion.

Availability and quality of data

This criterion specifies four subcriteria: completeness, recentness, reliability and continuity. The assessment is aimed mainly at the input data as used in the methodology from the latest road crash cost study. New cost components that are added in scenarios affect the results when 1) they are expected to have a significant share in total road crash costs, and 2) when the score for the new cost component is significantly different from the other data sources. For example, in case the reliability of the data used for the estimation of the human costs of slight injuries is significantly better than for the other, current cost items, the overall score of the scenario will be increased. On the other hand, in case very reliable data is used to estimate friction costs, this is expected not to affect the overall data reliability, as this item only has a minor share in the total costs.

A more specific interpretation of the four subcriteria with respect to availability and quality of the data is:

- *Completeness of data*: the extent to which accurate data is available. A scenario scores high on this subcriterion if actual data, which is highly representative for the population studied, is available (e.g. annual accounts of insurance companies provide rather complete data on the insurance costs made with respect to road crashes). On the other hand, scenarios for which the required data is not available (and have to be estimated by using assumptions) or is based on data from samples of the study population score lower with respect to the completeness of the data.
- *Recentness: extent to which recent data are used.* This criterion evaluates the most recent year for which actual data is used in the scenario's (i.e. year of the original data, not data corrected for inflation). The newer the data, the higher the score.

- *Reliability of data*: Represents the extent to which data can be retrieved from high quality sources, i.e. databases, surveys and publications. The quality of the source is considered with respect to the specific Dutch situation. For example, for human costs the value transfer approach is considered to deliver relatively unreliable data (as the original data is coming from a foreign source which doesn't provide high level reliable data for the Dutch situation), whereas a Dutch WTP study results in highly reliable data. This subcriterion overlaps slightly with completeness and recentness, as more complete and recent data is often considered more reliable as well. However, in this study we tried to distinguish between this different aspects of data reliability as much as possible.
- *Continuity of data*: the extent to which consistent time series are expected to be available, also in the future. Continuity of data guarantees that the methodology applied in the scenario can also be applied in the future, without risks on (large) trend breaks.

Costs

- *Costs of providing a one-time update of the costs of road crashes.* These costs include both direct financial costs that have to be made to update the cost of road crashes (e.g. purchase of data) as well as the (indirect financial) costs of the man days that are needed to carry out all necessary analyses. The costs of regularly updating the estimates (e.g. yearly update for inflation or yearly update of input data) are not considered, as explained below.

Comparability with the previous study

- *Extent to which the outcomes are comparable with the previous estimates in the Netherlands*: the latest road crash study has been carried out for the years 2009, 2006 and 2003. The extent to which outcomes of a scenario are comparable with the results of that study depends on the differences in methodology and data.
- *Extent to which differences with the previous study can be explained:* several types of explanations might be applicable. Firstly, methodological changes may explain the differences. Adding cost items explain differences relatively easy, while applying a new method for a cost items make the explanation more complicated (for example: why does the a DALY approach to estimate human costs result in different values?). Secondly, explanations are found in changes in data sources. The implications of new data might be difficult to explain if the type of data is different from previously used data. Also differences in completeness of the data may explain different results.
- *Possibilities to apply a (simple) correction on the previous estimates to make them comparable with the new estimates*: in order to establish time series for costs of road crashes, a correction to the previous estimates should be made if the methodology or input data have been changed. If costs components are added, a correction might be relatively simple, for example by assuming constant share of these new cost items in total costs. In other cases, new cost estimates per casualty may be applied to previous years for costs items with improved methods. Note that in some cases new results reflect developments in the general cost level, technology or welfare. These developments influence the real cost level and should not be corrected for.

International cooperation and harmonization

- *Opportunities for international cooperation on developing new methodologies*: to what extent are there opportunities to develop new methodologies for some or more cost items in cooperation with several other countries? We give a first indication of these opportunities in each scenario and they will be explored in more detail for the preferred scenarios in Chapter 5.
- *Opportunities to apply the methodology in other EU countries (that are not involved in developing the methodology)*: if a methodology is developed in international cooperation, probably a limited number of countries will be involved (at least not all EU countries). To achieve more international harmonization of costs estimates, it is important that the methodology can also be applied in countries which are not involved in developing the methods. This criterion concerns the extent to which the methodology can also be applied in these countries. Note that this depends on the extent to which the methodology is developed in international cooperation. For example, if new method for estimating the VOSL is developed and applied in several countries, applying the results in other countries may be more appropriate than applying Dutch results only. Therefore, when assigning scores on this criterion we assume that there is no international cooperation. This avoids overlapping scores with the previous criterion.

Other relevant criteria are the complexity/user friendliness of making regular (e.g. yearly) and more thorough updates (e.g. once every five year) updates and the costs of making these updates. However, the scenarios as described in Chapter 3 do not have a time dimension (yet). For each scenario several subscenarios can be distinguished in terms of the frequency and comprehensiveness of updates. This would make the scenarios and their assessment much more complex but will probably not result in a substantially different ranking of the scenarios. Therefore, this time dimension will be added in the assessment of the preferred scenarios in Chapter 5.

4.3 Assessment of scenarios per criterion

4.3.1 Quality of the methodology

Consistency with international guidelines

In general the methodology that has been applied in the latest road crash cost study in the Netherlands is consistent with international guidelines, as shown by Table 5 (third column). The only inconsistency concerns the omission of human costs of slight injuries. Also other costs items are missing, but these are not considered as main cost items in international guidelines. Consequently, a score of 3 is assigned to all scenarios that apply the current method but do not include a methodological improvement (Scenarios 1, 4, 6 and 7).

In Scenarios 2, 5, 8, 9 and 10 an estimate of human costs of slight injuries is added to the current Dutch method. This implies that these scenarios are more in line with international guidelines, resulting in score 4. In Scenario 3 also other cost components that are recommended by international guidelines are added, resulting in score 5. Note that international guidelines recommend using a WTP-method for estimating human costs and consider the DALY approach as a promising new approach. Because the DALY approach includes a willingness to pay element (the willingness to pay for a DALY), we do not assign a different rate to scenarios that include the DALY approach (9 and 10).

In Scenario 3 several cost items are added, resulting in a methodology that is more in line with international guidelines, resulting in scores 5. Scenario 11 is rated at 6 because further methodological improvements are made (adding non-vehicle insurance costs). In Scenario 12 all cost items that are included in guidelines are taken into account, resulting in the highest score (7). The same score applies for Scenarios 13 and 14 because they include the same cost items and the methodology is basically the same.

Scenario 15 applies the HEATCO approach instead of the Dutch methodology. Assuming that relevant cost items that are missing in the current HEATCO approach will be added, this approach generally will be in line with international guidelines (score 4). This also assumes that the studies that are used to derive the European average values have applied state-of-the-art methods.

Scientific quality

As noted above, in general the Dutch methodology is in line with international guidelines (except for human costs of slight injuries). As international guidelines are based on state-of-the-art scientific knowledge, also the scientific quality of the latest Dutch study is sufficient to good in general. However, using inflation correction only would strongly worsen the quality, because data are not updated or renewed, resulting in score 1 for Scenario 1. Scenarios 2 and 3 have a higher score because missing cost items are added to the current method. The score depends on the method that is used for human costs of slight injuries: value transfer (score 2 and 3 respectively) or a WTP study (score 3 and 4 respectively). Scenario 4 is rated the same as Scenario 3 (3), because data are updated but no new cost items are added. In Scenario 5 human cost of slight injuries are added, resulting *in a score 4 to 5 (depending on the method).*

Data renewal will improve the quality of the method, as more accurate data will be used. This results in rate 4 for Scenarios 6 and 7 and rate 4 to 5 for Scenario 8 (depending on the method for human costs of slight injuries).

In Scenario 9 human costs of slight and serious are calculated using the DALY approach and in Scenario 10 also human costs of fatalities are based on DALYs. The DALY approach has methodological pros as well as cons compared to a willingness to pay approach without using DALY and therefore we consider the scientific quality of these two approaches to be equal. However, applying DALYs to estimate human costs of serious injuries is a clear improvement compared to the value transfer method that is currently applied for serious injuries, resulting in score 6 for Scenarios 9 and 10.

In Scenario 11 several relatively large cost items are added, resulting in a substantially better methodology. This includes new estimates of human costs of serious and slight injuries, but this is based on a relatively simple method (value transfer). Moreover, the estimate of human costs is only corrected for inflation. This results in the same rate (6) as Scenarios 9 and 10.

Scenario 12 obtains the highest score (7), as in this scenario all relevant cost items will be included and estimated using the most sophisticated methods. The same score applies for Scenarios 14: the methodology in these scenarios is basically the same as in Scenario 12 but will be developed with international cooperation. The score for Scenario 13 is slightly lower (6) because human cost of fatalities will only be corrected for inflation.

Scenario 15 applies the HEATCO approach instead of the Dutch methodology. The quality of this approach strongly depends on the scientific quality of the national values that are used to derive European standard figures and the applicability of these figures to the Netherlands. Due to both of these aspects we anticipate that the quality of this approach is poor (1) compared to the Dutch methodology.

Importance cost items for which methodology will be improved

In Scenarios 1, 4, 6, 7 and 15 there are no methodological improvements of the current methodology in the Netherlands, so the score on this criterion is 1 for these scenarios.

In Scenarios 2, 5 and 8 the only methodological improvement concerns adding human costs of slight injuries. Since only one (although relatively large, see Figure 8) cost item is improved, these scenarios are rated at 2. In Scenario 3 a medium (non-market production loss) and a small (other property damage) cost item are added, resulting in a slightly higher score (3).

In addition to slight injuries, Scenario 9 includes an improvement of the methodology of human costs of serious injuries, which is a very large cost item, resulting in score 4. In Scenario 10 improvement of the estimate of human costs of fatalities, which is also a relatively large cost item, is added, resulting in score 5.

A score of 6 is assigned to Scenarios 11 because they include, in addition to human costs of serious and slight injuries, improvements to other cost items that are relatively large, in particular unreported vehicle damage and insurance costs.

In Scenario 12 the methodology is improved for all cost items that need these improvements. This scenario is rated at 7, mainly because an improvement of the estimate of human costs is added (compared to Scenario 11). The other additional methodological improvements concern relatively small costs items such as friction costs, police costs and costs of vehicle unavailability. The same score applies for Scenarios 14, as these include the same methodological improvements. Scenario 13 is rated at 6 because the estimate of human costs of fatalities is not improved in this scenario.

4.3.2 Availability and quality of input data

As a starting point for the assessment of the availability and quality of the input data, a review of the input data used in the latest road crash study has been made (De Wit & Methorst, 2012). For all cost items, the data sources were checked and the type of source(s), reliability and year were assessed. The result is available in Table 9.

The information gathered on the input data used in the latest road crash study is used as starting point for the assessment of the four subcriteria with respect to availability and quality of the input data. In the next step, it has been analysed to what extent this data basis changes in the scenarios compared to the current situation and what the consequences of these changes are for the availability and quality of the input data. For example, to estimate the costs of emergency transport, the current study uses assumptions on the share of trips of emergency services that are related to road crashes. In case one of the scenarios replaces this assumption by actual data, the completeness of the data increases.

The following information on the input data used in the latest road crash study has been used to assess the four subcriteria with respect to availability and quality of the input data:

- Completeness: the type of sources used has been used as one of the indicators (e.g. using CBS statistics results in more complete input data than using assumptions).
- Recentness: frequency by which the input data is updated provides insight in the recentness of the data. In case data is yearly updated, recent data will be available, while infrequent updates may result in outdated data.
- Reliability: the reliability of the data is assessed directly, mainly based on the quality of the data source used.
- Continuity: frequency by which the data is updated provides insight in the future continuity of the data as well.

Table 9 Summary and assessment of data sources used in the latest road crash study

		Latest road crash study			Data update	
Cost component	**Cost item**	**Type of source**	**Reliability**	**Year**	**Frequency**	**Availability**
Medical costs	Emergency transport	Report, assumption	-	1998	One time	No
	Hospital	Cost model	+	2009	Yearly	Upon request
	Follow-on treatment	Cost model	+	2009	Yearly	Upon request
	Medicines, applicances	Assumption	-	2009	One time	No
Production loss	Market production loss	Statistics CBS, CPB, UWV	++	2009	Yearly	Public
	Non-market production loss	*N/a*	*N/a*	*N/a*	*N/a*	*N/a*
	Friction costs	*N/a*	*N/a*	*N/a*	*N/a*	*N/a*
Human costs	Fatalities	Survey	+	2001	One time	No
	Serious injuries	Foreign survey study (value transfer)	-	1991	One time	No
	Slight injuries	*N/a*	*N/a*	*N/a*	*N/a*	*N/a*
Property damages	Vehicles reported	Statistics	++	2009	Yearly	Public
	Vehicles unreported	Report	--	1995	One time	No
	Other	*N/a*	*N/a*	*N/a*	*N/a*	*N/a*
Administrative costs	Police	Annual account, report	+/-	2006	One time	Partly public
	Legal	Internal data	+	2009	Yearly	Upon request
	Fire department	Statistics CBS	++	2009	Yearly	Public
	Insurance	Statistics CBS	++	2009	Yearly	Public
Other costs	Congestion	Model calculation	+	2009	Yearly	Upon request
	Vehicle unavailabitly	*N/a*	*N/a*	*N/a*	*N/a*	*N/a*
	Funerals	Survey	+/-	2003	One time	No
	Hospital visits	Assumption, report	-	1997	One time	No
	House adaptations moving	Statistics CBS, report	-	1995	One time	Upon request

Completeness

The assessment of input data sources of the latest road crash study provided that there are some significant gaps in the completeness of the data sources used (e.g. market production loss. Therefore the minimum scenario scores a 2.

The completeness of the data in Scenario 4 is comparable with Scenario 1, as the same data sources are used (2). Scenario 2, 3 and 5 add some additional cost items (mainly the costs of slight injuries) and hence the completeness of the data is considered to be slightly higher (3). The implicit assumption used is that the average completeness of the data used to estimate the new cost items is higher than the data used for calculating the existing cost items.

For Scenarios 6 and 7 the data is renewed for which it is most needed: emergency transport, market production loss, visiting people in hospital, house adaptations and moving. Therefore, the data will probably be more complete than in Scenario 5 (4). Particularly for market production loss the completeness of the data needs a significant improvement, as the current estimates only partly covers this cost item. The scenarios only vary in the extent and way in which human costs are assessed, but the input data will not be more complete. Scenarios 8, 9, 10 are the same but also add human costs of slight injuries, which results in a slightly higher score (5). In Scenario 11, more new cost items are added, which results in higher level of completeness (6).

In the maximum scenario (12) national new cost components are added, which results in the highest score on completeness (7). The international scenarios (13 and 14) score the same. For Scenario 15, the collection of complete data will be difficult and the EU average road crash costs will probably not be very representative for the Netherlands. For these reasons, Scenario 15 is rated a 1.

Recentness

In Scenario 1 the input data for cost items will not be updated, but only corrected for inflation. This means that the most recent year of input data is the same as for the latest road crash study, and hence this scenario is rated 1. Because human costs of slightly injuries are added for a recent year, the score is slightly better for Scenario 2 and 3 (2).

The Scenarios 4 and 5 which include a data update have a higher score (4), as for many cost items more recent data than in the latest study will be gathered. However, not all data can be easily be updated based on the sources used in the latest cost study. For example, the costs of ambulances per trip has been based on specific studies which are not updated regularly.
More recent data on these aspects require the use of alternative sources (data renewal), which will be done in Scenario 6 to 10. Therefore, all these scenarios are rated a 6, except for Scenario 6 (5). In Scenario 11, the human costs of fatalities isn't updated as well, but two new cost items (non-market production loss and non-vehicle property damage) are added. As we assume that recent data is used to estimate these items, we assess the recentness of this scenario to be equal to Scenario 10 (6).

Finally the maximum scenario national and international add relevant and recent data sources and score therefore best (7). The EU-consistent cost estimate (Scenario 15) will be based on existing studies available for various countries. As a consequence, the recentness of the data will probably be poor and hence is assigned a score of 1.

Reliability

Reliability of the scenarios was assessed according to Table 10. It explains the reliability that is realised for the various cost categories by applying the various approaches to update them. For example, updating the data for medical costs increases its reliability, but renewing the data would increase the reliability even more. More specifically per cost category:

- For medical costs, a data update is acceptable. Data renewal would include improved data sources for emergency transport.
- Data for production loss can be updated, but it would be better to renew the data source for incapacitated people due to road crashes.
  New methodologies would include non-market production loss and friction costs with recent and complete data.
- Human costs can be updated either with new WTP studies (as previously performed for fatalities), new methodologies concerning DALY measures or by applying values from other countries (value transfer). Obviously, values transfer is considered to be less reliable than WTP and DALY approaches.
- Property damages data are not very reliable at the moment as they depend heavily on the assumption of unreported or non-awarded claims which contribute about 50% to the total property damages (vehicles). New methodology would be needed to include property damage other than vehicle damage.
- Other costs such as funerals, hospital visits and house adaptations would need a data renewal to achieve reliable data. Congestion costs are reliable when updated with the same data source. Costs of vehicle unavailability are only available when new methodology is developed.

Table 10 **Assessment of reliability**

	Correction for inflation	Data update	Data renewal	New methodology
Medical costs	-	+	++	N/a
Production costs	--	-	+	++
Human costs	-	N/a	+	++
Property damages	--	-	N/a	+
Administrative costs	-	+	+	+
Other costs	-	+/-	+	++

Based on the considerations mentioned above, the data reliability of Scenario 1 is rated low (2). As several figures are based on rather rough assumptions or outdated studies, the reliability of these figures are relatively low and this will worsen if these figures are only corrected for inflation. When human costs of slight injuries are added, reliability slightly improves in Scenario 2 en 3 (3).

For Scenario 4, the same data sources as in Scenario 1 are used and hence the score on reliability is equal (2). Adding the cost of slight injuries in Scenario 5 increases the score slightly (3).
For the Scenarios 6, 7, 8, 9 and 10 the data is renewed for which it is most needed: emergency transport, market production loss, visiting people in hospital, house adaptations and moving. Additionally, new estimates for (parts of) the human costs are provided. In Scenario 6, only the data used to estimate the human costs of serious injuries is improved (based on value transfer) and therefore a score of 4 is assigned to this scenario. In Scenario 7, also the data for the human costs of fatalities is improved by using a new WTP

study for the Netherlands (5), while in Scenario 8-10 the data for all components of the human costs (fatalities, serious injuries, slight injuries) is improved (6).

In Scenario 11, new methodologies are developed for non-market production loss, human costs of serious and slight injuries, unreported vehicle damage, property damage other than vehicle damage and non-vehicle insurance costs. However, for human costs of fatalities only a correction for inflation is made and human costs of injuries are estimated using value transfer. Compared to the other data renewal scenarios (Scenario 7-10), reliability is slightly lower (5).

The maximum national scenario and international scenarios score highest on reliability (7). Data for all important cost components is updated or renewed where needed and for some cost components new methodology is developed. Scenario 13 scores slightly lower than Scenario 12 and 14, as the human costs of fatalities is only corrected for inflation (6).

Finally, the reliability of data input in the EU-consistent cost estimate is the lowest (1). This approach estimate the non-human costs of road crashes as a share of the human costs, which provides a lot of uncertainty.

Continuity

Data used in Scenario 1 is expected to be available in the future, as only a correction for inflation is needed (7). In Scenario 2 and 3 new cost components are added which might be more difficult to update in the future (5). Scenario 4 scores lower than Scenario 1, as there is a risk that the data sources used to update the data will change in the future (6). However, as no new cost items are added, this scenario scores better than Scenario 2 and 3. Therefore we rate this Scenario 6. Scenario 5 scores slightly less compared to Scenario 4, as new cost items are included (5).

The data renewal scenarios have a lower score for continuity (4 for Scenario 6 and 3 for 7-10). In these scenarios data sources are renewed, mainly based on studies that are not regularly updated. This increases the risk that future data is not completely comparable with the data that is used in the upcoming update of the road crash cost study. Results for human costs might be less continuous when different methods are used (DALY and WTP both).

In the maximum scenario national continuity is worst (1) as many new data sources have to be implemented. This holds for Scenario 12 and 14. Scenario 13 scores slightly better (2), as the human costs of fatalities is only corrected for inflation.

Finally, the rather simple approach applied in the EU-consistent cost estimate scenario result in low risks on changes in input data in future updates of the estimates of costs of road crashes. Therefore, a score of 6 is assigned to this scenario.

4.3.3 Costs

The costs of a one-time update of the estimates of costs of road crashes heavily depend on the number of person days needed to carry out the required assessments. The direct financial costs (e.g. purchase of data) are expected to be limited.

The number of person days needed are expected to be very limited in case a correction for inflation is applied. Data update requires some more efforts, and data renewal even more. However, the most significant costs are probably due to new (in-depth) studies that are needed to develop new methodologies. Therefore, the number and extent of new studies per scenario mainly determine the score for costs in this assessment. An overview of these types of studies in the various scenarios is given in Table 11.

Table 11 Overview of new methodology studies needed per cost component

Cost component	Methodology, studies needed
Medical costs	– No methodology update
Production loss	– Non-market production loss: methodologies will be developed and required data will be collected – Friction costs: methodologies will be developed and required data will be collected
Human costs	– Fatalities: new, Dutch specific, estimates for the Value of Statistical Life, DALY study or WTP-international – Serious injuries: Value Transfer of international values found in literature, Dutch WTP study, international WTP study or DALY study – Slight injuries: Value Transfer of international values found in literature, Dutch WTP study, international WTP study or DALY study
Property damages	– Unreported property damages: new methodology development to estimate the unreported property damages – Other material damages will be added based on state-of-the-art methodologies and data
Administrative costs	– Administrative costs: for the cost of police (particularly time spent by the policy on crashes) a new methodology will be developed – For insurances (particularly relevant non-vehicle insurances) better data sources will be looked for to estimate them or surveys will be carried out
Other costs	– The cost of the unavailability of vehicles will be added to the calculations. Methodology could also be developed internationally (e.g. by developing surveys together with foreign partners, which may be applied in each country concerned)

Concerning the development of new methodology, the scenarios vary mostly in the way human costs are determined (and hence these differences are important to explain the cost differences between scenarios). They are calculated either through a Dutch WTP study, international WTP study, value transfer of international values found in literature or a DALY study based on the 'burden of injury' method. Table 12 shows the methodologies that are foreseen to be used or developed per scenario. For some Scenarios (e.g. 3, 11, 12, 13 and 14) also studies to implement other methodological improvements contribute significantly to the costs.

Table 12 Methodologies used for human costs per scenario

Scenario	Fatalities	Serious injuries	Slight injuries
1. Minimum scenario	-	-	-
2/3. EU guidelines (+) scenario	-	-	Value Transfer (2a/3a) or Dutch WTP (2b/3b)
4. Data update scenario	-	-	-
5. Data update scenario + WTP slight injuries	-	-	Value Transfer (5a) or Dutch WTP (5b)
6. Data renewal scenario light	-	Value Transfer	-
7. Data renewal scenario extensive	Dutch WTP	-	-
8. Data renewal scenario extensive + WTP slight injuries	Dutch WTP		Value Transfer (8b) or Dutch WTP (8a)
9. Data renewal scenario + valuation injuries based on DALYs	Dutch WTP	DALY	DALY
10. Data renewal scenario + valuation all casualties based on DALYs	DALY	DALY	DALY
11. Data renewal scenario + methodological improvements	-	Value Transfer	Value Transfer
12. Maximum scenario national	Dutch WTP	Dutch WTP	Dutch WTP
13. Maximum scenario international – light	-	International WTP	International WTP
14. Maximum scenario international - extensive	International WTP	International WTP	International WTP
15. Scenario EU-consistent cost estimate - extensive	EU average value	EU average value	EU average value

Based on the consideration above, the costs of Scenario 1 are assessed to be the lowest and hence a score of 7 is assigned to this scenario. In Scenario 4, more efforts are needed to update the data from all current sources, but as no new studies have to be executed, the costs are relatively limited. Therefore a score of 6 is assigned.

In Scenario 2, a study to provide estimates of the human costs of slight injuries have to be carried out. In case this is done by studying international literature and apply a value transfer approach Scenario 2a), these costs are relatively low. Therefore, this scenario is rated a 6. However, as a new Dutch WTP study is applied, the costs will be higher (5). In Scenario 3, new studies on some more cost items (i.e. non-market production loss and non-vehicle property damages) are applied, resulting in higher costs than in Scenario 2 (5 for Scenario 3a and 4 for Scenario 3b).

Compared to Scenario 4, Scenario 5 applies a new study (based on value transfer in Scenario 5a and a new WTP study in Scenario 5b) on the human costs of slight injuries. Therefore, this scenario is rated slightly higher than Scenario 4 (5 for Scenario 5a and 4 for Scenario 5b). A score of 5 is assigned to Scenario 6. Although no new methodological studies are needed in this scenario, several assessments to renew some data sources require quite some efforts.

Compared to Scenario 6, in Scenario 7 a new WTP study on the human costs of fatalities is applied, which results in higher costs (4). These costs are higher in Scenario 8a, because there also a WTP study on the human costs of slight injuries is carried out (3). In Scenario 8b, this cost item is valuated based on a literature review, resulting in lower costs (4). In Scenario 9, the number of new methodological studies required is increased even more, as a new WTP study for fatalities is carried out, while for the human costs of injuries a study based on DALYs is applied. Therefore, this scenario is rated 2. The costs of Scenario 10 are expected to be slightly lower (3), as no new WTP study on fatalities is carried out (these costs are based on a study on DALYs).

In Scenario 11, a lot of new methodological studies have to be done, resulting in relatively high costs (2). These costs are even higher in Scenario 12 (1), as in this scenario all possible methodological improvements are applied, resulting in many in-depth methodological studies. These studies are also done in Scenario 13 and 14, but the costs of them are shared with other countries.
In Scenario 13, only the WTP studies on the human costs of injuries are done together with foreign partners, resulting in a slightly lower score (2).
In Scenario 14, almost all methodological studies are done in cooperation with other countries and hence the costs are expected to be significantly lower (3).

Finally, Scenario 15 is mainly based on a meta-analysis of existing studies. The costs of these analyses are relatively limited and hence this scenario is rated a 3.

4.3.4 Comparability with the previous study

In Scenario 1 the results are highly comparable (score 7) with the previous Dutch study for 2009, 2006 and 2003, because the same results are used and these are only corrected for inflation. Differences with the previous study are very easily explained (7), and a correction is not needed (7) because there are no changes in methodology or data.

Also in Scenario 2 and 3 the comparability is very good (6). The only difference with Scenario 1 is the addition of one or a few cost items, and these differences with the previous study can be easily explained (6). Correcting the results of the previous study is relatively simple (6). For example, the additional cost items may be added to the previous results as a percentage of other costs items (e.g. non-market production loss as a percentage of market production loss).

In Scenario 4 data will be updated using the same or comparable sources as those that were used in the previous study. If comparable data are not (readily) available, inflation correction will be applied. Furthermore, there are no methodological changes and although there might be trendbreaks in the data, comparability is expected to be good (5) and differences can be explained quite easily (5). A correction to make the results comparable with the previous study is only need in case of trendbreaks in the data. Nevertheless a correction can be made easily (6), because the same or similar data sources will be used without any changes in the method.

Scenario 5 is the same as Scenario 4 except for the addition of human costs of slight injuries. This results in worse comparability (5) and easiness of explaining the difference with the previous study (5). A correction can be applied very easily (6), as in Scenario 2.

In Scenario 6 and 7 data from other sources are used for several cost items than those used in the previous study. This results in a weaker comparability (5) because the data from other data sources, in particular regarding market production loss, are expected to be quite different from the data used in the previous study. Explaining the differences is more complicated than in the previous scenarios (4). Some differences may be explained by pointed at the incompleteness of the data that were previously used (e.g. market production loss), while other differences can be explained by general developments in cost level and technology (e.g. trauma helicopter) and welfare and risk perception (human costs fatalities in Scenario 7). Correcting the results of the previous study is not applicable in case the differences reflect developments in the general cost level, technology or welfare. These developments influence the real cost level and should not be corrected for. However, a correction does make sense if the quality of the new data is better than the previously used data. This mainly concerns market production loss. In this case the new data (e.g. production loss per severely injured) may be applied to the number of casualties in previous years. However, also other developments may influence the costs, such as employer policies regarding sick leave, which complicates such a correction. Consequently, the score for correction possibilities is lower (4) than in the previous scenarios.

Scenario 8 is the same as Scenario 7, except for the addition of human costs of slight injuries, resulting in worse comparability (4). The scores for the complexity of explaining the difference with the previous study and for possibilities to apply a correction are the same as in Scenario 7 (both 4), as this complexity mainly depends on the new data that will be used for other cost components.

Applying the DALY approach for human costs of injuries (Scenario 9) and fatalities (Scenario 10), will substantially worsen the comparability of the results with the previous study (3), as this approach is quite different from the common willingness to pay approach. Differences may not be easily explained (3), since the basis of the calculation is fundamentally different (valuing injuries/lives versus valuing DALYs/life years in combination with duration of quality of life loss). However, the complexity of correcting the costs in previous years is more or less the same as in Scenario 7 (4), as the results of the DALY approach can be applied to the number of casualties in previous years.

In Scenario 11 several costs items are added to the current method and new methods are developed for some costs items, implying that a considerable part of the results will not be comparable with the results for previous years. On the other hand, the methodological changes regarding human costs have less influence on the comparability than in Scenario 10 (no DALY approach, no different method for fatalities). Therefore, comparability and the extent to which differences can be explained is expected to be about the same as in Scenario 11 (3). Applying a correction is more complicated than in previous scenarios (3), because there are more methodological changes.

Comparability with previous results is low in Scenario 12, because for most costs items the methodology will be revised or data will be renewed. Explaining differences is expected to be complicated, if not problematic. Correction factors may be developed for each cost item (as in other scenarios), but this is much more complex as many costs items are involved. Therefore score of 2 is assigned to each criterion. The same scores apply to Scenarios 13 and 14, although international cooperation might even worsen the

comparability though if this cooperation is not limited to developing methodologies but also includes data collection on the international level.

The results of Scenario 15 will be very difficult to compare with the results of the previous Dutch study (1), as this international approach is different in many respects. Almost all cost components are based on different data sources and partly on different methods. Only human costs of fatalities and serious injuries may be comparable to some extent, as the approach is basically the same (VOSL for fatalities and a percentage of VOSL for serious injuries). Consequently, differences with the Dutch methodology in general are very difficult to explain (1) and applying a correction would not be feasible (1).

4.3.5 International cooperation and harmonisation

Opportunities for international cooperation on developing new methodologies

In Scenario 1 international cooperation is not very relevant (score 1), because in this scenario existing national cost estimates are updated using inflation figures only. At most, international standards for such an inflation correction (e.g. which inflation indicator to be used) could be developed.

In Scenarios 2, 5 and 8 there might be some opportunities (3) for international cooperation to estimate human costs of slight injuries that are added to the Dutch methodology. Although other countries include human costs of slight injuries, there is no solid foundation for these costs estimates (usually a standard EU-figure: 1% of VOSL). So other countries might be interested in better estimates of these costs on the basis of value transfer (Scenario 2a) or a WTP-study (2b).

In Scenario 3 also non-market production loss and other property damage than vehicle damage are added. Not many countries have estimates of these costs, so countries might be interested to add these costs. On the other hand, these costs are not regarded as main cost items in international guidelines. Consequently, opportunities for international cooperation are expected to be limited (2).

In Scenarios 4, 6 and 7 there are no methodological improvements of the current Dutch methodology. Only data are updated or renewed. This implies that there is no opportunity for international cooperation (1).

The DALY approach that is applied in Scenarios 9 and 10 is, as discussed in Chapter 2, a promising method for estimating human costs, that might be attractive for several countries. This approach not only enables countries to improve their estimates of human costs, but also provides detailed information on the health consequences of road injuries and. In the European SafetyCube project special attention is paid to this approach, which illustrates the international interest in this approach. Therefore, these scenarios are expected to have good opportunities for international cooperation (6).

The methodological improvements in Scenario 11 all concern cost items that are relevant for other countries (non-market production loss, human costs of serious and slight injuries, unreported vehicle damage, property damage other than vehicle damage and non-vehicle insurance costs). Most other countries have outdated estimates of these costs or have not included these costs at all, implying that opportunities for international cooperation may be expected (5).

In Scenario 12 there will be further methodological improvements in addition to the ones in Scenario 11. Opportunities for international cooperation are expected to be more limited (4), because this scenario also includes improvement of less relevant or smaller cost items such as friction costs and costs of vehicle unavailability which may be less interesting for other countries. However, there might be good opportunities to cooperate on some of the methodological improvements, like in Scenario 11.

Scenarios 13 en 14 are specifically focussed on international cooperation. In these scenarios it is beforehand assumed that there are opportunities for this cooperation. For that reason, these scenarios cannot be assessed on this criterion.

The best opportunities for international cooperation (7) are expected in Scenario 15. The HEATCO approach is a relatively simple but internationally well known method, which is (sometimes partly) applied in road crash cost studies in some countries. Moreover, the HEATCO approach is (probably more intensively) used outside the field of road safety, such as cost-benefit analysis of transport projects. Therefore it is expected that updating and extending the HEATCO approach will be attractive for several countries.

Opportunities to apply the methodology in other EU countries (that are not involved in developing the methodology)

There are three scenarios that have good opportunities to be applied in other EU countries: Scenarios 1, 2 and 15. Scenario 1 is a very simple approach (inflation correction only) and inflation data are available for all EU countries, so each country can easily apply this approach (score 7). Of course, this assumes that other countries have their own cost estimates yet. Also Scenario 2 can be easily applied in other countries (5), especially if the human costs of slight injuries are based on value transfer (2a) as this value can be used in other countries too. Scenario 15 offers a method that can be applied relatively easily in other EU countries (6), because in this scenario European average values are developed which can be used to calculate cost using their own statistics on number of casualties and crashes.

In all other scenarios the opportunities to apply the methodology in other EU countries is very limited, because these scenarios are focussed on improving the Dutch method by updating or renewing (Dutch) data, adding missing cost items or improving the methodology for specific cost items on the basis of new research in the Netherlands.[7] It is expected that other countries cannot easily benefit from this because of differences in data availability: data in other countries may be different or not be available at all. At most, countries might copy some elements of the Dutch methodology that are not included in their own methodology yet and collect data in their own country or transfer values from the Netherlands (and/or other countries). Consequently, a score of 2 is assigned to all other scenarios, except for the international scenarios (13 and 14) which will probably provide outcomes that are more applicable to other countries (score 3).

[7] Note that we have not taken into account that opportunities to apply a methodology in other EU countries increase if methods are developed and applied in international cooperation, to avoid overlap with the previous criterion as explained in Section 4.2.

Table 13 Overview of scores per scenario

	Quality of methodology			Data availability and quality				Costs	Comparability previous study			International cooperation and harmonization	
	Consistency guidelines	Scientific quality	Methodology improvement	Completeness	Recent	Reliability	Continuity	Developing methodology	Comparability outcomes	Explanation differences	Possibilities correction	Developing methodology	Application in other countries
1. Minimum scenario	3	1	1	2	1	2	7	7	7	7	7	1	7
2a. EU guidelines scenario	4	2	2	3	2	3	5	6	6	6	6	3	5
2b. EU guidelines scenario		3						5					
3a. EU guidelines + scenario	5	3	3	3	2	3	5	5	6	6	6	2	2
3b. EU guidelines + scenario		4						4					
4. Data update scenario	3	3	1	2	4	2	6	6	5	5	6	1	2
5a. Data update scenario + WTP slight injuries	4	4	2	3	4	3	5	5	5	5	6	3	2
5b. Data update scenario + WTP slight injuries		5						4					
6. Data renewal scenario light	3	4	1	4	5	4	4	5	5	4	4	1	2
7. Data renewal scenario extensive	3	4	1	4	6	5	3	4	5	4	4	1	2
8a. Data renewal scenario extensive + WTP slight injuries	4	4	2	5	6	6	3	4	4	4	4	3	2
8b. Data renewal scenario extensive + WTP slight injuries		5						3					
9. Data renewal scenario + valuation injuries based on DALYs	4	6	4	5	6	6	3	2	3	3	4	6	2
10. Data renewal scenario + valuation all casualties based on DALYs	4	6	5	5	6	6	3	3	3	3	4	6	2
11. Data renewal scenario + methodological improvements	6	6	6	6	6	5	4	2	3	3	3	5	2
12. Maximum scenario national	7	7	7	7	7	7	1	1	2	2	2	4	2
13. Maximum scenario international – light	6	6	6	7	7	6	2	2	2	2	2	n.a.	3
14. Maximum scenario - extensive	7	7	7	7	7	7	1	3	2	2	2	n.a.	3
15. Scenario EU-consistent cost estimate - extensive	4	1	1	1	1	1	6	6	1	1	1	7	6

4.4 Overall assessment of scenarios

A multi-criteria analysis was used to compare the scenarios and choose five preferred scenarios for in-depth assessment. The multi-criteria analysis was performed in a session with the steering group in two steps. Per main criterion the subcriteria were appointed weight factors which add up to 100 per main criterion. Subsequently the five main criteria were appointed weigth factors which add up to 100.

The subcriteria were given weight factors as follows:

1. Quality of methodology: A high weight factor was given particularly to scientific quality (50%). Consistency with international guidelines (30%) and methodological improvements (20%) weigh less heavily but are also relevant.
2. Under data availability and quality, the sub-criterion continuity has a lower weight (10%) because of the trade-off with other three sub-criteria (30% each).
3. Costs: Developing methodology 100%.
4. Comparability previous study: The weighting is determined by comparable outcomes (40%), explanation of the differences (40%), possibility of correction (20%). In a new study the year 2009 will be included, so that the comparison between methods in previous studies is easier. There is great emphasis on firm underpinning when there is a trend break.
5. International cooperation/harmonization: The benefits of international cooperation are mainly found in joint development of methodology (70%). Whether the results can also used in other countries (30%) will be particularly dependent on the perceived added value for other countries and is considered as less relevant for the Netherlands.

The five main criteria were weighed to retrieve one total score, according to another distribution of 100%. The emphasis is on quality criteria and costs. The quality of the methodology (25%) and quality and availability of data (25%) are together appointed 50%. Costs represent 40%. The remaining 10% is distributed between comparability with the previous study and international cooperation and harmonization.

The weight factors appointed to all criteria and subcriteria are displayed in Table 14.

Table 14 Weights appointed to all criteria and subcriteria

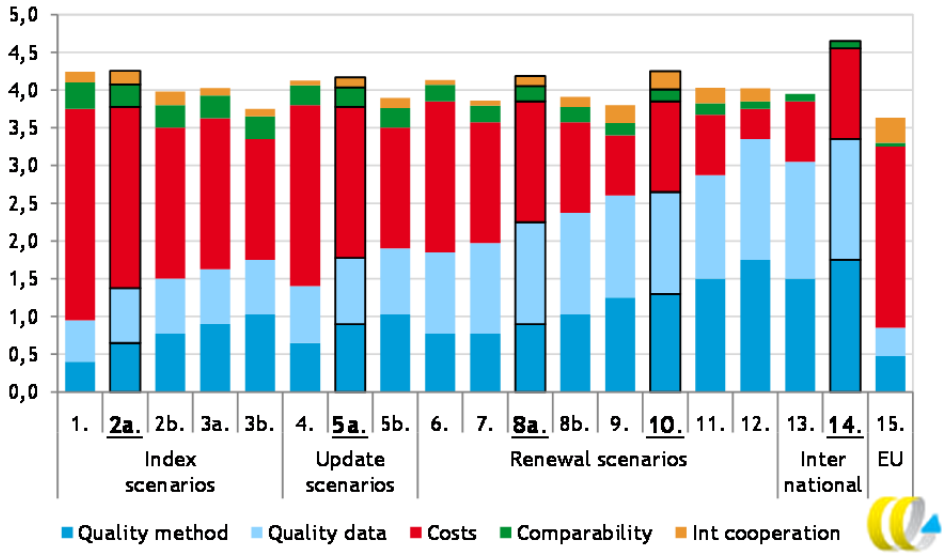
Main criterion	Sub criterion	Weight factor	Sum
Quality of methodology	Consistency int. guidelines	**30**	**25**
	Scientific quality	**50**	
	Methodology improvement	**20**	
Data availability and quality	Completeness	**30**	**25**
	Recent	**30**	
	Reliability	**30**	
	Continuity	**10**	
Costs	Developing methodology	**100**	**40**
Comparability previous study	Comparability outcomes	**40**	**5**
	*Explanation differences	**40**	
	Possibilities correction	**20**	
International cooperation and harmonization	Developing methodology	**70**	**5**
	Application in other countries	**30**	

Figure 9 shows the weighed cumulative scores for each scenario. The scores have been used to determine a top 5 of preferred scenarios. These are:

- 2a: EU guidelines scenario (minimum + Value Transfer slight injuries);
- 5a: Data update scenario + Value Transfer slight injuries;
- 8a: Data renewal scenario extensive + Value Transfer slight injuries;
- 10: Data renewal scenario + valuation all casualties based on DALYs;
- 14: Maximum scenario extensive.

The chosen scenarios are displayed on the horizontal axis as bold.

Figure 9 Weighed scores



The figure shows that at least one scenario from each category of scenarios was chosen for in-depth assessment. However, the scenarios have high cumulative scores for different reasons:

- The index scenarios have low quality for methodology and data, but have a good score for costs. Of these, Scenario 2a has the best overall score.
- The update scenarios (Scenarios 4-5) are balanced between costs and quality. Of these Scenario 5a has the best balance.
- The renewal scenarios score much better on quality of data and methodology, increasingly when additional options are added. However, higher costs are also the consequence of additional research (and thus, lower scores). Scenario 8a and Scenario 10 find the best balance between data and quality.
- Scenario 14 scores best overall, with very high scores on quality of methodology and data, but also an average score on costs because efficiency gains are expected with international cooperation.

In Chapter 5, these scenarios are subjected to an in-depth assessment.

5 In-depth assessment of preferred scenarios

5.1 Introduction

In this chapter the five scenarios that have been selected in Chapter 4 are assessed in more detail. In Section 5.2 the scenarios are described in more detail, including the way the costs are updated and the update frequency. In Section 5.3 the scenarios are assessed according to the same criteria that were used for the broad assessment in Chapter 4. The scenarios will in particular be assessed in more detail on the criteria that were considered as most important (quality of the methodology, data availability and quality, costs). Section 5.4 presents the overall assessment of the scenarios

For Scenarios 2, 5 and 8 the a-variant is assessed in this chapter (which indicates the use of the value transfer method for human costs of slight injuries). So in this chapter Scenario 2, 5 and 8 refer to 2a, 5a and 8a.

5.2 Description of the scenarios

Table 15 gives an overview of the five preferred scenarios, which is extracted from Table 7. Each scenario will be described in more detail below.

Table 15 Summary of preferred scenarios

Cost category	Cost item	2. Index	5. Data update	8. Data renewal WTP	10. Data renewal DALY	14. International
Medical costs	Emergency transport					
	Hospital					
	Follow-on treatment					
	Medicines, appliances					
Production loss	Market production loss					
	Non-market production loss					
	Friction costs					
Human costs	Fatalities					
	Serious injuries					
	Minor injuries					
Property damages	Vehicles					
	Other					
Administrative costs	Police					
	Legal					
	Fire department					
	Insurance					
Other costs	Congestion					

Cost category	Cost item	2. Index	5. Data update	8. Data renewal WTP	10. Data renewal DALY	14. International
	Vehicle unavailability					
	Funerals					
	Hospital visits					
	House adaptations moving					

5.2.1 Number of casualties and crashes

In all scenarios data on number of casualties are needed to be able to estimate the costs of road crashes. We assume that accurate data on the number of fatalities and serious injuries are available in each scenario. These data are published yearly by the Ministry of Infrastructure and Environment.

Regarding slight injuries, the current Dutch methodology on costs of road crashes distinguishes between casualties who are admitted to hospital with injury severity lower than MAIS2 or who are treated (only) at the emergency department of a hospital ('slight injuries') and casualties who are not treated in hospital at all but only by a general practitioner for example ('other injuries'). In addition, the current methodology uses information on the number of property damage only (PDO) crashes. Data on the category 'slight injuries' are available through the Injury Surveillance System which is maintained by VeiligheidNL, and we assume that these data are also yearly available in each scenario. Data on 'other injuries' and PDO crashes will not be readily available.[8]

In Scenarios 2, 5 and 8 no efforts will be spent on collecting data on other injuries and PDO crashes. Assumptions regarding the number of other injuries will be made instead, as was done in the latest cost study. In these scenarios the number of PDO crashes will not be used, implying that the costs per PDO crash will not be calculated in these scenarios. However, total property damage will be calculated in these scenarios, because these costs are not based on the number of crashes but on insurance statistics on total property damage. In Scenario 10 the number of other injuries will be estimated once every five years, as part of the assessment of DALYs of slight and other injuries. In Scenario 14 both the number of other injuries and PDO crashes will be estimated.

Note that for several cost items, in particular medical costs and production loss, more detailed information on road casualties is required. For example, to estimate medical costs data are needed on the number of casualties (by severity level) who are admitted to hospital, who visit hospitals for policlinical treatment, who are admitted to a rehabilitation centre or nursing home, who visit general practitioners, etc. For production loss information is needed, among others, on the number of fatalities by age and the number of casualties who are permanently or temporarily unable to work. Collecting such information is part of the research activities in each scenario.

[8] In the latest cost study these numbers were not available and it was assumed that the numbers were not changed since the previous costs study (that means constant since 2003).

5.2.2 2: Minimum scenario + human costs slight injuries

Inflation correction

In this scenario the current Dutch cost estimates for 2009 are updated by using a correction for inflation only. The inflation correction will be applied to the cost per fatality, per serious injury and per slight injury. Separate inflation indicators for each cost component will be used as much as possible.
For example price developments regarding medical cost are best reflected by inflation indicators for the health care sector and production can be corrected for inflation by using GDP deflators. To calculate total costs, the updated costs per casualty (fatality, serious and slight injury) are multiplied by the number of casualties in a new base year. However, the yearly numbers of 'other injuries' and PDO crashes are not available (as discussed above). In this scenario, a simple rule of thumb is applied to update the costs of these costs, for example by assuming a fixed proportion of these costs in total costs or by correcting the total costs for these categories by inflation only (as has been applied by SWOV and KiM in previous updates).

Human costs slight injuries

Human costs of slight injuries are added to the current cost estimates, on the basis of 'value transfer'. This means that a review of the international literature on human costs of slight injuries is carried out, and an estimate for the Netherlands is made on the basis of estimates that have been made in other countries. These estimates should be consistent with international guidelines on costs of road crashes, and therefore they should be based on a willingness to pay method. Such studies have been carried out in Belgium, Sweden and the UK for example (see Chapter 2). In these studies the WTP for reducing the risk of getting slightly injured is determined relative to the WTP for reducing fatal risks, resulting in a value per slight injury as a percentage of the value of a statistical life. The value transfer method implies that a percentage of the VOSL is taken from foreign literature and applied to the Dutch VOSL. Attention should be paid to the extent to which the percentage of VOSL is applicable to slight injuries in the Netherlands. Differences in definitions of slightly injured implies that the percentages found in foreign studies cannot simply be applied to slight injuries in the Netherlands and in that case a correction should be made. Another is issue that should be considered relates to the fact that the VOSL includes both human costs and consumption loss (see Section Figure 4). Consumption loss due to slight injuries is probably very limited, which would imply that it is more appropriate to use a percentage of human costs instead of a percentage of the VOSL. In that case, gross production loss should be calculated instead of net production loss to include consumption loss of injuries.

Update frequency

In this scenario the costs are updated yearly on the basis of new numbers of casualties (fatalities and serious and slight injuries) and inflation indicators. Specific inflation indicators per cost component are used as much as possible. Human costs of slight injuries are added in the next cost estimate and will be updated yearly using an inflation indicator (just as all other cost components).

5.2.3 5: Data update scenario + value transfer slight injuries

Data update

In this scenario the data for each cost item that was included in the previous study, except human costs (see below), will be updated by collecting data from the same or comparable sources as in the previous study. No other cost items are added to the current methodology. Below we describe the data update for each cost component in more detail.

Medical costs: in the previous study most medical cost items have been estimated using the Burden of Injury Model developed and owned by VeiligheidNL. We assume that this model is maintained and updated by VeiligheidNL and can be applied to update the medical costs. For costs which are not included in this model (costs of nursing homes, ambulance/trauma helicopter and medicines) data will be collected from the data sources that have been used in the previous study, in particular the National Medical Register (LMR; number of casualties admitted to nursing homes), Statistics Netherlands (costs of nursing homes), Injury Surveillance System (LIS; number of ambulance trips) and the Royal Dutch Touring Club (ANWB; number of trauma helicopter trips). In the previous study some medical costs data were based on single studies (e.g. costs per trauma helicopter trip) or assumptions (costs of medicines). The same data or assumptions will be applied again and updated for inflation only, unless new information is readily available.[9]

Market production loss: the calculation of production loss is based on data on productivity and number of lost working days/years. Productivity data come from Statistics Netherlands (CBS) and the Netherlands Bureau for Economic Policy Analysis (CPB) which are published yearly and can be updated easily. The number of lost working years per fatality and permanently injured is based on the age of fatalities, which can be updated on the basis of casualty statistics, and year of retirement. Future production loss will be discounted using a discount rate that is recommended in the latest official guidelines for cost-benefit analysis. Regarding the number of permanently and temporarily injured and the duration of absence from work, data on social security benefits (WAO/WIA) from Statistics Netherlands and assumptions were used in the previous study. The same data for new base years and the same assumptions will be used in this scenario. However, as noted in the previous study, these data probably underestimate the costs of production loss resulting from injuries, because not all injured might receive WAO-benefits.

Property damage: insurance data on vehicle damage will be updated using data from the Dutch Association of Insurers. Vehicle damage which is not included in insurance data will be based, just as in the latest cost study, on a SWOV-study from 1995 (Flury, 1995) on unreported vehicle damage and additional assumptions that were made in the latest study. Other types of property damage are not included in this scenario.

[9] However, no active search for new data (as will be done in data renewal Scenario 8) will be carried out in this scenario. Only if the researchers are aware of new information that is readily available and easily applicable, this information will be incorporated in the new cost estimates.

Administrative costs: Data needed to update administrative costs are retrieved from the sources that have been used in the previous cost study, in particular Statistics Netherlands (police and fire department budgets, number of incidents fire department are involved in, insurance costs) and the Ministry of Security and Justice (WODC; legal costs). Time spending of the police will be based on the same studies and assumptions as in the previous studies, because there are no (yearly) data on this time spending.

Other costs:

- Congestion costs are updated using the latest estimate of the total costs of congestion and the updated share of time loss (data from the Ministry of Infrastructure and Environment).
- For funeral costs updated data on the number of fatalities, life expectancy (data Statistics Netherlands) are used in combination with the costs per funeral that was used in the previous study (unless new information on these costs is readily available).
- In the previous study costs of house adaptions and moving were based on data on total expenditures on all handicapped from Statistics Netherlands and the (assumed) share of road casualties in these expenditures.
  To update these costs new data on total expenditures will be used in combination with the assumption on the share of the expenditures related to road casualties.
- Cost of visiting people in hospital are updated on the basis of new data on number of hospital admissions and length of hospital stay (Injury Surveillance System, LIS). Assumptions about number of visits per day and costs per visit are copied from the previous cost study.
- House adaptations and moving are updated using new data on total costs for handicapped and the share of road casualties in these costs (assumption from previous study).

Human costs

In this scenario human costs are treated exactly the same as in Scenario 2. This means that human costs of fatalities and serious injuries are only corrected for inflation. Human costs of slight injuries are added on the basis of value transfer, similar to the method applied in Scenario 2.

Cost ranges

In the previous cost study, no ranges were calculated for the costs of road crashes but only single estimates. However, as discussed in Chapter 2 there are several weaknesses in availability and quality of data and therefore providing ranges of costs may be useful (or even needed) to indicate the possible inaccuracy of the costs estimates. For some costs items confidence intervals are available, for example regarding the VOSL. In other cases, the input data may not be very precise, for example when data from other several other countries is used, or assumptions are made and in such cases ranges of costs can reflect this uncertainty. In this scenario, but also in Scenarios 8, 10 and 14, such ranges may be given on the basis of available information and data.

Update frequency

In this scenario data will be updated every five year. In case the data which were used in a previous update are not available anymore for a new update, we assume that data from comparable sources will be available. If not, assumptions will be made (as was done in the latest cost study for several parameters: some parameters were simply assumed to be constant).
In addition, yearly updates will be made on the basis of new numbers of

fatalities, serious and slight injuries and (cost component specific) inflation correction of costs per casualty, similar to Scenario 2.

5.2.4 8: Data renewal scenario extensive + value transfer slight injuries

Data renewal

This scenario includes the same costs items as Scenario 5. Data will be renewed for six costs items for which the data used in the previous study were not accurate or up-to-date. New data on these six costs items will be searched for and applied in the cost calculations. This concerns:

- Emergency transport: new data on the costs per ambulance trip and trauma helicopter will be searched for. Potential data sources are the Royal Dutch Touring Club (ANWB; trauma helicopter), hospitals and insurance companies (ambulance costs). A small-scale survey among several hospitals or insurance companies may be carried out to get information on costs per ambulance trip.
- Market production loss: as noted above, the data used in the previous study may accurately reflect the production loss related to injuries. In this scenario the Burden of Injury Model developed by VeiligheidNL, that also includes modules for production loss due to sick leave, will be applied for production loss of injuries. In addition, costs of longer term inability to work are estimated by linking hospital data to data on social security benefits (WIA law).
- Human costs fatalities: a new estimate of the VOSL is made using the methodology that was developed for the previous VOSL estimate in 2001 (Blaeij, et al., 2003). This means that an identical willingness to pay survey is carried out as well as identical analyses, resulting in an updated VOSL.
- Human costs serious injuries: the current estimate of human costs of serious injuries, a percentage of the VOSL, is based on a study from 1994 in the UK (value transfer). In this scenario the estimate will still be based on value transfer, but more recent studies from e.g. Belgium and Sweden will be included to update this estimate. Similar to slight injuries (see Section 5.2.2), attention should be paid to the question whether a percentage of the VOSL (human costs + consumption loss) or a percentage of human costs only should be used, since consumption loss may be relatively less important for serious injuries compared to fatalities.
- Hospital visits: new information on the number of visits per casualty per day and the costs per visit will be collected. Public information on these costs will be searched for (e.g. number of visitors per hospital per day, parking costs, etc.) and additional assumptions will be made if needed.
- Costs of house adaptations and moving: regulations regarding these costs have been changed since 2006. Since then municipalities are responsible for providing and financing house adaptations and moving, following the Law Social Assistance (Wmo). The estimate of these costs will be renewed on the basis of evaluations of this law. These sources have also been used in a study on costs of road crashes for municipalities (Wijnen, 2014).

Human costs slight injuries

Human costs of slight injuries are added on the basis of value transfer, similar to the method applied in Scenario 2.

Update frequency

In this scenario we assume that there is a one-time data renewal in the next cost study and that, like in Scenario 5, all data will be updated every five year. In addition, yearly updates will be made using new casualty numbers and (cost component specific) inflation, similar to Scenario 2.

5.2.5 10: Data renewal scenario + valuation all casualties based on DALYs

In this scenario human costs of fatalities and serious injuries are based on the DALY approach. As discussed in Section 2.3.3, this approach has the advantage of expressing quality of life loss of all injury severities in one single measure. Moreover, it allows using detailed information on injury severity and quality of life loss. On the other hand, this approach may raise (ethical) concerns, particularly concerning the relation between age and the value per casualty and the implication of using different values per casualty. Obviously, these considerations should be taken into account in decisions on the methodology in a new cost study.

Scenario 10 is equal to Scenario 8 regarding the other cost components.

DALYs

DALYs comprise two elements: the number of years of life lost (YLL; fatalities) and the number of years lived with disability (YLD; injuries). Lost life years are calculated on the basis of the number of fatalities by age and life expectancy by age. The calculation of YLD is more complicated, as it requires data on the number of injured people by injury severity, disability weights which represent quality of life loss resulting from injuries and the duration of this loss of quality of life. SWOV has estimated the YLD of serious injuries in the Netherlands for the years 2000-2011 (Weijermars, et al., 2014)based on an international standard methodology (Haagsma, et al., 2012). In this scenario the YLD is calculated for the years for which the costs are assessed, using the methodology applied by SWOV. YLD of slight injuries is not included in the SWOV methodology. However, it is estimated that slight injuries represent about a third of total YLD of road injuries (Polinder, et al., 2012). Therefore, the YLD of slight injuries is also calculated. An assessment of methodologies, for example the method applied by Polinder et al. (2012), will be carried out to determine the most appropriate method for estimating the YLD of slight injuries resulting from road crashes. The assessment should address the calculation method and data needs. Also determination of number of 'other injuries' (not treated in hospital, as discussed above) is an element of this approach. Potential data sources are Injury Surveillance System (LIS) and the General Practioner's Registry. Disability weights may be taken from international literature. When the methodology has been determined and data sources have been identified, the YLD of slight injuries will be calculated.

Value per DALY

To calculate human costs, DALYs should be converted into monetary values by applying a value per DALY. In this scenario there are two options to determine the value per DALY. Firstly, the value can be based on national and international literature. As discussed in Chapter 2, several publications, particularly in the field of public health, have proposed values that can be used in the Dutch context. The second option is to derive the value per DALY from the VOSL.[10] This means that the (average) number of lost life years of

[10] A third option is to carry out a WTP study into the value of a DALY. We consider this beyond the scope of this scenario because such a study a complicated and time consuming.

fatalities is determined. The VOSL represents the total value of these lost life years and so the value per year (which is equal to a DALY) can be deducted from the VOSL. In this scenario the pros and cons of the two options will be assessed, and on the basis of this assessment an approach will be chosen and applied.

Update frequency

In this scenario, the DALY approach will be developed in the next cost study and will be updated every five year. This means that the YLL and YLD will be calculated using the same method and data sources. We assume that the same value per DALY (corrected for inflation) will be used in every update.
In addition, every five years a data update will be made and every year an update will be made using new casualty numbers and (cost component specific) inflation, similar to Scenarios 5 and 8.

5.2.6 14: Maximum scenario extensive

In this scenario the current methodology will be improved dramatically. Firstly, several cost items are added to the current method: non-market production loss, friction costs, human costs of slight injuries, other property damage than vehicle damage, non-vehicle insurance costs and costs of vehicle unavailability. Secondly, new methods will be developed and new data will be collected for several other cost items: human costs of fatalities and serious injuries, vehicle damage and police costs. These methodological improvements will be developed in cooperation with several other countries. For the other cost components data will be renewed or updated, similar to Scenarios 8 and 10.

Developing methods

A first step in this scenario is a review of existing methods for each cost item for which the methodology will be improved. This implies that an overview is made of (pros and cons of) methods that are applied in road crash costs studies in other countries or in cost studies on other policy fields and of methods which are discussed in scientific literature. Also definitions and the scope of the new cost items will be assessed. For example, which costs should be included in the estimate of costs of vehicle unavailability (costs of time loss, costs of a replacing vehicle, etc.). On the basis of the review a method is selected or developed for application in the next cost study. For example, methods for estimating human costs of fatalities are reviewed (stated preference methods, revealed preference methods, DALY approach; see Section 2.3) and a method is selected or developed on the basis of this review.

Data collection

The next step is to collect the data that are needed to be able to apply the methods. We anticipate that in some cases data from public databases or publications are used, in particular regarding non-market production loss (data on time spending, values of time), friction costs (estimate time spent on recruiting and training new personnel, values of time), damage to freight (cargo statistics), non-vehicle insurance costs (insurance statistics) and costs of vehicle unavailability (costs of hiring a replacing vehicle). For relative small costs items (e.g. friction costs and costs of vehicle unavailability) additional assumptions may be made.

For other cost items, data will not be available and surveys will be carried out to collect the data. In this scenario we anticipate surveys on:

- Human cost of fatalities and injuries: a willingness to pay survey among the general population, which is needed to make a new VOSL estimate as well as estimates of the valuation of non-fatal road safety risks.
- Unreported vehicle damage: a survey on damage to vehicles resulting from road crashes and how people have treated this damage. This survey should reveal the size of the damage and the proportion of damages reported to an insurance company. In addition, questions are added about people's involvement in road crashes and the severity of these crashes, in order to collect information on the number of crashes including lower severity crashes. Also damage to personal property may be included. Such a survey has been carried out in the UK (Taylor, 1990).

These will be (web-based) surveys among the general public with a minimum sample size of 1,000 respondents.

In addition, two surveys targeted at specific stakeholders are anticipated:

- A survey among police representatives on police time spending on road crashes.
- A survey among road authorities on damage to infrastructure resulting from crashes. Additional analysis of road authorities' databases may be carried out if needed.

These are small scale face-to-face or telephone surveys with for example 10 police representatives and 20 road authorities (national, provinces and local).

Data analysis and cost calculations

Finally, all new data will be analysed and the results will be inserted in the cost calculations. The analyses and calculations will range from relatively simple to very complex. In general, most calculations of the costs items which are based on public databases and publication are not very complicated, for example costs of health insurances or costs of vehicle unavailability.
The calculation of costs items based on surveys among the general population require much more complicated analyses. In particular the research on human costs (methodology development, survey, analysis) is complex and this could be organized as a PhD study.

International cooperation

In this scenario it is anticipated that the methodological improvements are developed in international cooperation. This concerns the review of existing methods, selecting/developing methods for each cost component that will be improved and developing surveys. Data collection will be done individually by each participating country. Furthermore, we assume that data analysis will be a joint international activity, resulting in values per country that will be applied in the national costs calculations.

Update frequency

In this scenario we assume that there is a one-time improvement of the methodology that will be applied in the next cost study (possibly except for human costs which might be added a few years later if this is a PhD study). Like in Scenarios 5, 8 and 10, every five years a data update will be made and every year an update will be made using new casualty numbers and (cost component specific) inflation only.

5.3 Assessment of the scenarios per criterion

In this section the five preferred scenarios are assessed using the same criteria as the criteria which were used for the broad assessment of all scenarios in Chapter 4. Costs of making updates are added as an additional criterion. Table 16 gives an overview of the criteria.

Table 16 Overview of assessment criteria

Criteria	Sub-criteria
Quality of the methodology	– Scientific quality – Consistency with international state-of-the-art – Importance of cost items for which methodology will be improved for total cost
Availability and quality of input data	– Completeness of data – Extent to which recent data are used – Reliability of data – Continuity of data
Costs	– Costs of providing an one-time update of the costs of road crashes – Costs of updating the costs of road crashes
Comparability with the previous study	– Extent to which the outcomes are comparable with the previous estimates in the Netherlands – Extent to which differences with the previous study can be explained – Possibilities to apply a (simple) correction on the previous estimates to make them comparable with the new estimates
International cooperation and harmonization	– Opportunities for international cooperation on developing new methodologies – Opportunities to apply the methodology in other EU countries (that are not involved in developing the methodology)

5.3.1 Quality of the methodology

Consistency with international guidelines

All preferred scenarios are generally in line with international guidelines. In Scenarios 2, 5, 8 and 10 all main cost components are included and therefore consistency with international guidelines is the same in each of these scenarios. Note that there are of course differences in the methodologies that are used to estimate the costs. For example, in Scenarios 2, 5, 8 human costs of fatalities are based on the current value which is updated for inflation, while in Scenario 10 human costs are based on DALYs and a WTP value for a DALY. International guidelines recommend using a WTP method for human costs which is the case in each scenario. Of course, the quality of methods is different, which is reflected in the next criterion.

In Scenario 14 several cost items that are categorized as ‘minor’ or ‘other’ cost components are added compared to the other scenarios. In this scenario all costs items that are included in international guidelines are taken into account, implying that this scenario is very consistent with international guidelines.

Scientific quality

As a starting point for the in-depth assessment of the scenarios, we have assessed the quality of the methodology per costs item as applied in the latest costs study. A rate ranging from 1 to 9 is assigned to the quality of each cost item. The rate per cost item is weighted by a score (1-9) for the relevance of the cost item. This rate is based on relevance of cost items as shown in Table 6. The three categories have been converted into ranges of rate (not very relevant: 1-3, relevant: 4-6, very relevant: 7-9) and each cost item is given a rate within these ranges (smaller cost items a lower rate within the range, larger cost components a higher rate within the range).

We discuss firstly the quality of the current method and then the quality of each scenario with the quality of the current method as a reference.
The scores for scientific quality and relevance for each cost item is shown in Table 17.

Current method:

- Cost of emergency transport: these costs are based on a SWOV report that states the costs per ambulance and helicopter trip, but there is no underpinning of these costs. Because of this lack of a reliable scientific underpinning, the quality of this methodology is considered rather poor.
- Costs of hospital treatment and follow-on treatment are based on the Burden of Injury Model maintained by VeiligheidNL. The quality of this model is considered as high. Results have been published in peer-reviewed journals (e.g. Polinder et al., 2016).
- Costs of medicines are based on a simple assumption (costs are 1% of hospital admission costs). An underpinning of this assumption has not been reported and hence the methodological quality is considered very poor.
- Market production loss: these costs are based on the human capital method, which is the standard method for this cost items. It implies that the production loss is calculated on the basis of production per person, the number of people who cannot work temporarily or permanently due to a road crash, and the duration of absence from work. The number of casualties who are not able to work and the duration of absence from work are based on unemployment benefits data (WAO/WIA law). As noted in Chapter 2, these data may not accurately reflect the number of casualties who are not able to work as a result from a road crash. In addition, several assumptions are made regarding, for example regarding the duration of sickness leave and the number of injured who cannot work anymore permanently.
- Human costs fatalities: the method that has been applied to estimate the VOSL meets high standards for WTP-research. The stated choice approach which has been used is internationally regarded as one the most appropriate methods to estimate the VOSL (see for example Bahamonde-Birke et al., 2016). Results of the Dutch WTP study have been published in peer reviewed journals.
- Human costs serious injuries: the value of human costs per injury (percentage of VOSL) has been taken from a study in the UK. Although this UK study is outdated, the stated choice design of the study was very sophisticated and similar designs have been used in subsequent studies in other countries (Sweden and Belgium, see Chapter 2). Results have been published in a peer reviewed economic journal (O'Reilly, et al., 1994). However, the extent to which the results are applicable to the current Dutch situation is questionable and therefore the methodological quality for this cost item is scored relatively low (3).

- Reported vehicle damage: a top-down approach is used to estimate these costs, implying that total costs are estimated based on data on damage payments by insurance companies (from the Dutch Association of Insurers). This is regarded as a very appropriate approach using reliable data for all insurance companies. However, several assumptions were made, in particular to exclude payments for injuries and damage with is not related to road crashes (damage on private properties and related to parking).
- Unreported vehicle damage: this costs are based on an in depth analysis of insurance data by SWOV. This is regarded as an appropriate estimate, although it is based on data from just one insurance company. On the other hand, the database included more than 40,000 cases from which a sample was taken. Therefore, we scored the methodological quality for this cost item a 5.
- Police costs are based on two surveys on time spending by the police and additional assumptions. These surveys did not reveal the time spending on road crashes, but by combining the results of these surveys and making additional assumptions an estimate of this time spending was made. This can be regarded as an indication.
- Legal costs are based on a top down approach, in which share of road crashes in total legal costs (costs of prosecution, courts, imprisonment, etc.) is estimated on the basis of data on number of prosecutions, court cases, prisoners, etc. related to road crashes. This is generally regarded as an appropriate approach.
- Insurance costs are calculated on the basis of financial accounts of insurance companies. These accounts correctly reflect the actual costs.
- Congestion costs are calculated on the basis of total congestion costs, including costs direct time loss and costs of adapting travel behaviour due to congestions, and the share of road crashes in time loss due to crashes. This is considered as an appropriate approach that includes all relevant costs that result from congestion.
- Funerals cost are calculated as the difference between current funeral costs and the discounted future funeral costs if a casualty would not have died due to a road crash. This is the standard methodology, that is also applied in other countries.
- Hospital visits: these costs include the actual expenses of relatives and friends who visit casualties in hospital. These costs are mainly based on assumptions. Time costs are not included in the estimates. This implies that the method for this cost item is poor.
- Costs of house adaptations and moving: these costs are based on social security payments for handicapped and an (outdated) estimate of the share of road casualties in these payments. This method is considered as poor, because the social security payments not only include costs of adaptations and moving but also other costs related to handicapped people (which might be included in other costs items, for example medical costs). Moreover, the underpinning of the estimate of the share of road casualties in total costs is poor.

Table 17 shows the rate per cost item and the weighted average. The quality of the current method is rated at 5.

2: Minimum scenario + human costs slight injuries
In this scenario the results of the previous costs study are updated by using inflation and new numbers of casualties. This implies that the quality of estimates of all costs items is worsened, as this is a very rough method to update the figures. Therefore, a lower rate is given to each cost items compared to the quality of the latest estimate. On the other hand, human

costs of injuries are added to the current method, resulting in an improvement of the method. Still the quality of this scenario is considered as poor.
The resulting score for this scenario is 3.

5: Data update + human costs slight injuries
In this scenario data for most cost items are updated, using the same methods as in the previous study. For medical costs new model calculations are made, using the Burden of Injury Model, similar to the previous study. This means that the quality of the methodology is expected to be equal to the quality of the current method. Human costs and unreported vehicle damage are exceptions. Human costs of fatalities and serious injuries corrected for inflation only, resulting in a lower rate compared to the current method, while human costs of slight injuries are added to the methodology. Also unreported vehicle damage is only corrected for inflation because new data are not available. The resulting rate for this scenario is 5.

8: Data renewal + human costs slight injuries
For some costs items the data renewal in this scenario imply clear improvements in the quality of the methodology. This concerns in particular the application of the Burden of Injury Model to calculate production loss and a new value transfer study to estimate human costs of serious injuries.
The resulting score is 5.[11]

10: Data renewal +valuation all casualties based on DALYs
In this scenario the methodology for human costs is substantially improved by using the DALY approach. As explained in Chapter 2, a main advantage of this approach is the fact that detailed information on injury severity and the impact of injuries on quality of life is used. Values per DALY should be based on willingness to pay studies and existing values found in Dutch studies or a value deducted from the VOSL can be used to monetize DALYs. The resulting score for this scenario is 6.

14: Maximum scenario international extensive
Several methodological improvements are introduced in this scenario, resulting in major methodological improvements. For human costs WTP studies are carried. The quality of WTP methods is considered to be equal to the DALY approach (which uses WTP estimates for the value per DALY). The surveys that are carried out in this scenario will dramatically improve the quality of the estimates of unreported vehicle damage, police costs and infrastructure damage. Furthermore, several cost items are added to the current methodology, which also contributes to the quality of the methodology.
The score of this scenario is 8.

[11] The score is 0.8 point higher than the score for scenario 5, but the rounded scores are both 5.

Table 17 Scientific quality per cost item in each scenario and relevance of cost items

Cost component	Cost item	Relevance	Current method		2		5		8		10		14	
			Method	Quality	Method	Quality	Method	Quality	Method	Quality	Method	Quality	Method	Quality
Medical costs	Emergency transport	5	- Cost per trip: estimates SWOV, sources not reported - Number of ambulance trips: LIS - Number of helicopter trips: VU Medical Hospital Amsterdam	4	Inflation	2	See current method, data are updated	4	See 5, new data on costs per trip	7	See 5	7	See 5	7
	Hospital	6	Burden of Injury Model (LLM) calculation	8	Inflation	4	New LLM calculations	8	See 5	8	See 5	8	See 5	8
	Follow-on treatment	6	Burden of Injury Model (LLM) calculation	8	Inflation	4	New LLM calculations	8	See 5	8	See 5	8	See 5	8
	Medicines, applicances	4	Assumption (% hospital costs), source not reported	2	Inflation	1	See current method, data are updated	2	See 5	3	See 5	3	See 5	3
Production loss	Market production loss	9	- Production per person: statistics CBS, CPB - Number of casualties, duration of productivity loss: WAO/WIA data, assumptions	3	Inflation	2	See current method, data are updated	3	Burden of Injury Model calculation	8	See 5	8	See 5	8
	Non-market production loss	6	*N/a*										New method, consistent with state of the art	8
	Friction costs	2	*N/a*										New method, consistent with state of the art	8

Cost component	Cost item	Relevance	Current method		2		5		8		10		14	
Human costs	Fatalities	9	WTP survey (stated choice)	6	Inflation	4	See 2	4	See 5	4	DALY approach	9	WTP study	9
	Serious injuries	9	Value transfer WTP study UK	3	Inflation	2	See 2	2	New value transfer, including new studies	5	DALY approach	9	WTP study	9
	Slight injuries	9	Value transfer several foreign WTP studies	5	Value transfer	5	See 2	5	See 5	5	DALY approach	9	WTP study	9
Property damages	Vehicles reported	9	Total insurance payments assumptions	7	Inflation	4	See 2, data are updated	7	See 5	7	See 5	7	See 5	7
	Vehicles unreported	9	Analysis insurance statistics (SWOV report)	5	Inflation	3	See 2	3	See 5	3	See 5	3	Survey general population	9
	Other	**5**	*N/a*										Survey road authorities	8
Administrative costs	Police	**4**	- Time spending: genera surveys, assumptions - Police budget: CBS Statistics	4	Inflation	2	See current method, data are updated	4	See 5	4	See 5	4	Survey police administrations	8
	Legal	**5**	- Total legal costs: WODC study - Share of road crashes: WODC data	6	Inflation	3	See current method, data are updated	6	See 5	6	See 5	6	See 2	6
	Fire department	**4**	Share of road crashes in total incidents, fire department budget (Statistics CBS)	6	Inflation	3	See current method, data are updated	6	See 5	6	See 5	6	See 2	6
	Insurance	**9**	Actual costs from financial accounts insurance companies	8	Inflation	4	See current method, data are updated	8	See 5	8	See 5	8	See 2	8

Cost component	Cost item	Relevance	Current method		2		5		8		10		14	
Other costs	Congestion	**6**	Share of time loss in total congestions costs (direct time loss and adapting travel behaviour)	8	Inflation	4	New model calculation	8	See 5	8	See 5	8	See 2	8
	Vehicle unavailabitly	**1**	*N/a*										New method, consistent with state of the art	8
	Funerals	1	Difference actual funeral costs and discounted future funeral costs without crash	5	Inflation	3	See current method, data are updated	5	See 5	5	See 5	5	See 5	5
	Hospital visits	1	Calculation based on costs per visit (assumption) and number of visits per patient (assumption)	2	Inflation	1	See current method, data are updated	2	New data on costs per visit and number of visitors	6	See 8	6	See 8	6
	House adaptations moving	1	Share of road casualties (assumption based on outdated data) in total expenditures on handicapped (Statistics CBS)	2	Inflation	1	See current method, data are updated	2	New data from evaluations of Wmo law, assumptions	5	See 8	6	See 8	6
Weighted average				5		3		5		5		6		8

Importance cost items for which methodology will be improved

In Scenarios 2, 5 and 8 the only methodological improvement concerns adding human costs of slight injuries using values from other countries (value transfer). Although this is expected to be a large cost component, this implies that the methodology improvement is very limited (score 2).

In Scenario 10 human costs of fatalities and serious and slight injuries are estimated using the DALY approach. These costs have a large share in total costs (more than 50%) and so there a substantial improvement of the methodology (score 7)

In Scenario 14 methods are improved for several costs items. This concerns both large cost items (human costs, non-market production loss, unreported vehicle damage) and relatively smaller costs items (friction costs, other property damage, non-vehicle insurance costs, vehicle unavailability), resulting in the highest score (9).

5.3.2 Availability and quality of input data

The in-depth assessment of the availability and quality of input data builds on the assessment which was made in Chapter 4. An evaluation of the input data was made on the basis of Table 9 (see Section 4.3.2) which summarises the input data used in the latest road crash study (Wit & Methorst, 2012).
A complete and more detailed overview of all these data was made and is presented in Annex A.

With respect to availability and quality of the input data, the same four subcriteria as in Chapter 4 were used to assess the scenarios: completeness, recentness, reliability and continuity.

Completeness

The completeness of the data in Scenario 2 and 5 suffers from some significant gaps in the completeness of the data sources used in the latest road crash study, mainly market production loss, damages to vehicles, hospital visits and house adaptations. Although they add some additional cost items (mainly the costs of slight injuries), the completeness of the data is considered to be low. As the average completeness of updated data can be higher (e.g. Statistics Netherlands improve some of the statistics relevant to assess the costs of road crashes), Scenario 5 scores slightly higher (3) than Scenario 2 (2). For Scenarios 8 and 10 the data is renewed for the cost items for which it is most needed: emergency transport, market production loss, visiting people in hospital, house adaptations and moving. The data will be more complete than in Scenario 5. Particularly for market production loss the completeness of the data needs a significant improvement, as the current estimates only partly covers this cost item. However, there is a serious omission in the completeness of data in scenario 8 and 10, as the vehicle damage is only based on vehicle damage that is paid out by the insurance companies. Not paid out claims and non-reported damages are estimated though a rough assumption. Therefore a moderate score (6) is assigned to Scenarios 8 and 10. In the maximum international Scenario 14 more complete data on vehicle damages is added, as well as data on various new cost components, which results in the highest score on completeness (9).

Recentness

As was pointed out in Section 3.3, for seven out of the sixteen cost components that were included in the latest road crash cost study, data renewal would be preferred to data update. Two cost components (administration costs of police and insurances) can be either updated or renewed. For seven cost components a data update would suffice.

The input data for cost items will be corrected for inflation in Scenario 2, which means that the data itself will not be updated to a more recent year compared to the latest road crash study. This results in the lowest possible score (1).

In Scenario 5 more recent data is gathered for: emergency transport (LLM), hospital and follow-on treatment (LLM), market production loss (CBS, LLM), reported vehicle damages (insurance companies), administrative costs of police (annual accounts), legal (Justice department), fire department and insurances (CBS), congestion (Rijkswaterstaat and KiM Netherlands Institute for Transport Policy Analysis), Funerals (CBS), hospital visits (LIS) and house adaptations (CBS). However, not all data can easily be updated based on the same sources used in the latest cost study and data renewal would be preferable. For some data sources assumptions will be needed when data cannot be updated, such as the non-reported vehicle damages. Also, data on human costs are not updated, which means about half of the total cost of road crashes is still linked to older input data. Therefore Scenario 5 has a score of (4).

In Scenario 8 and 14 all data is either updated or renewed, where needed, including a new study on human costs. These scenarios rate a high score (8), but not the highest possible score. In Scenario 8 administration costs of police and insurances are not renewed, but they are less relevant (see Section 3.3). Scenario 14 adds new cost components, but some of them will be based on a literature review and as a result sometimes older data will be used for these cost components. Scenario 10 is similar to Scenario 8, but uses the DALY methodology for human costs. The value of a DALY will be based either on international literature, or on the VOSL that has been derived in the Netherlands in 2003. Therefore Scenario 10 scores lower on recentness (6).

Reliability

For the assessment of reliability of the scenarios the same approach as in Chapter 4 was used. For the in-depth assessment more emphasis was given to the cost components for which assumptions are made or limited calculations were made based on older literature (such as emergency transport, medicines, property damages, hospital visits, house adaptations/moving).

The data reliability of Scenario 2 is rated low (2). As several figures are based on rather rough assumptions or outdated studies, the reliability of these figures are relatively low and this will worsen if these figures are only corrected for inflation. The same data sources as in Scenario 1 are used for Scenario 5, but we assume that data which is updated over the years will be more reliable and hence the score on reliability is slightly higher (3).

For the Scenarios 8 and 10 the data is renewed for the cost items for which it is most needed: emergency transport, market production loss, visiting people in hospital, house adaptations and moving. Additionally, new estimates for (parts of) the human costs are provided. However, the rough assumptions for the not paid out vehicle damage claims and non-claimed damages are considered to be a major shortcoming of the Scenarios 2, 5, 8 and 10.

Therefore Scenario 8 and 10 score lower (6) than the maximum scenario (Scenario 14) in which a new study for vehicle damages is included. In Scenario 14 the data for all important cost components is updated or renewed where needed and new methodology is developed for a few cost components (9).

Continuity

For Scenario 2 the continuity of the data will be very good (8). No trend breaks in any of the data sources will appear, because the values are indexed. Only the addition of slight injuries will pose a difference to the previous cost crash study data.

Scenario 5 scores slightly lower to Scenario 2 on continuity (6). Due to the evolution of some of the data sources (such as the burden of injury model) some of de updated data will differ from historical data. It is also not entirely certain if the data sources will be available in the future, although it is expected that most of them will be (especially the data which is retrieved from Statistics Netherlands).

The data renewal Scenarios 8 (4) and 10 (4) have a much lower score for continuity, as the data sources are renewed, mainly based on studies that are not regularly updated. This increases the risk that future data is not completely comparable with the data that is used in the upcoming update of the road crash cost study. Results for human costs will be less continuous when different methods are used (DALY and WTP both), mainly compared to the historical data.

In the maximum Scenario 14 continuity is the lowest (2), as many new data sources have to be implemented. However, because of the inclusion of the year 2009 it is expected that if major trends breaks appear corrections can be made or at least they can be explained.

5.3.3 Costs

The in-depth assessment of the scenarios includes a detailed cost estimate for all cost components separately, based on estimates of the research group per study and activity and additional information from the TU Delft (on costs of a PhD position) and VeiligheidNL (on the costs of retrieving data from the Burden of Injury model).

Spreadsheet and reporting costs

There is a spreadsheet available which includes the detailed and total costs of road traffic accidents in the Netherlands from 2009, which can be used as a basis for the update. In Scenario 2 a simple spreadsheet is made, using output (costs per casualty) from the previous study to which new numbers of casualties and inflation figures are added. In Scenario 5 the spreadsheet from the previous study is used and delivered, while only correcting data or updating data sources. A limited report is delivered in Scenario 2 and 5 (~10 pages), in Scenarios 8 and 10 a more elaborate report will be written. In Scenario 14, project management and reporting will take much more effort, especially when more Member States are involved.

Burden of Injury Model

The Burden of Injury Model (in Dutch: LetselLastModel, LLM) is a valuable data source for cost data on medical costs and costs of production loss, and is maintained by the organisation VeiligheidNL. They are willing to contribute to the new cost study and help to deliver the needed data from their model. The LLM provides the required data for costs of production loss. It is also

possible to do an analysis of disability after traffic accidents by linking hospitalisation data to social security data via Statistics Netherlands. The medical costs can be analysed per period with the LLM if necessary and can be elaborated with an estimation of cost of mental health care.

The work required from VeiligheidNL in the new cost study is estimated at 40 hours for analyses with the LLM and 40 hours for an analysis of the number and categorisation of serious and slight injuries caused by road accidents. An analysis of disability with CBS data will take 30 hours. Additionally the use of the Remote Access (RA) servers of Statistics Netherlands is needed to link hospitalisation data to social security data (WIA). There are extra costs related to the use of these servers.

International cooperation

It was assumed that through international cooperation the costs can be significantly reduced. However, the cooperation will only be on the methodology development. All participating Member States have to carry out country specific data collection for their own data. Additionally, there will have to be some kind of cooperation in the form of meetings and teleconferences, and other project overhead costs.
Therefore, for the cost calculation it was assumed that 50% of the costs can be reduced when other countries also participate countries. For the study on WTP, all costs of the 2 PhD programmes are shared. Because the number of countries that will participate in an international study is uncertain, different options were assessed. The costs were assessed for 2 countries, including the Netherlands (1 PhD, high cost estimate) to 6 countries (2 PhDs, low cost estimate).

Costs of updates and annual indexation

Cost for making an annual correction from inflation is included in every scenario. The costs for making the update ranges from 1-4 days of work, depending on whether a general CPI is applied or a specific CPI per cost component. A short update report and explanation will be added. The annual costs will be € 2,000 to € 4,000. In Scenario 5, 8, 10 and 5 every 5 year a data update is performed. The costs of this data update is similar to the initial costs of the update in Scenario 5, and additionally for Scenario 10 the cost figures for DALY's are updated every five years (which will cost € 4,000 to € 8,000). The costs for updating the data every 5 years are somewhat higher for Scenario 14, as 4 cost components are added. Because of the new cost components, 16 cost components instead of 12 need to be updated, and therefore the updating costs are estimated 1/3 higher. The costs of updates and annual indexation are calculated annually, which means 1/5 data update (after every 5 years) per year.

Overview of all activities and costs

Several new studies are suggested in the various scenarios. The presumed costs per activity/study, scenarios in which they are carried out, and a description per activity are displayed in Table 18.

Table 18 Estimation of costs per sub component

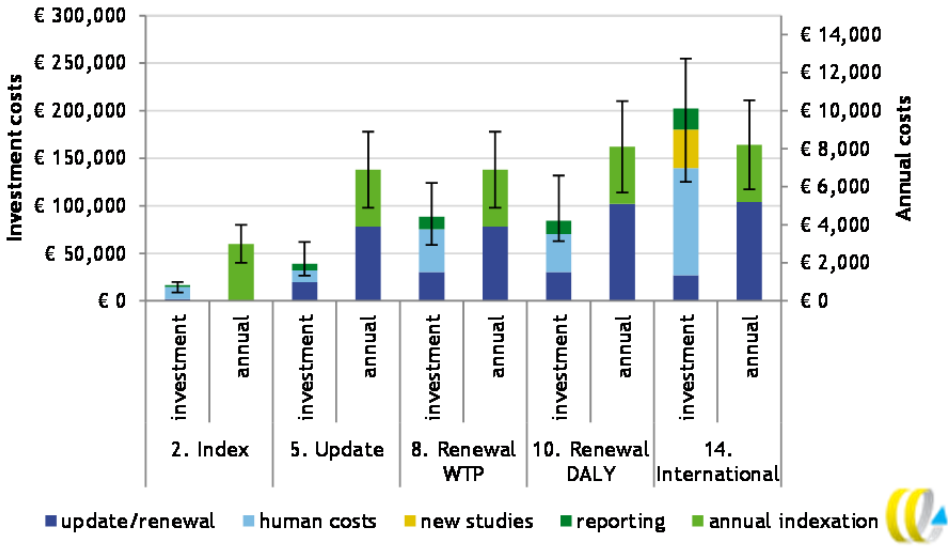
Category	Cost component	Costs	Scenario	Description
Indexation of costs	For all cost components	B	2	For every cost component, a specific or general CPI will be used to renew the cost figures of 2009. This will take approximately 1-3 days of work.
Data update	Emergency transport	A	5	Data from Royal Dutch Touring Club (ANWB; number of trauma helicopter trips). The ambulance costs are included in the LLM.
	Hospital,follow-on treatment	C	5; 8; 10; 14	From the burden of Injury model (VeiligheidNL) and LMR/CBS for the number of casualties admitted to nursing homes and costs.
	Medicines, appliances	A	5; 8; 10; 14	The same assumption will be used as in the previous road crash cost study.
	Market production loss	C	5	Update of data from Statistics Netherlands (CBS) and the Netherlands Bureau for Economic Policy Analysis (CPB) and information from Burden of Injury model.
	Vehicle property damage	B	5; 8; 10	Data from the Dutch Association of Insurers and same assumptions.
	Administrative costs police	A	5; 8; 10	Data from Statistics Netherlands, relatively simple calculations.
	Administrative costs legal	B	5; 8; 10; 14	Data from the Ministry of Security and Justice, more complex calculation.
	Administrative costs fire department	A	5; 8; 10; 14	Data from Statistics Netherlands, relatively simple calculations.
	Administrative costs insurance	A	5; 8; 10	Data mainly from Statistics Netherlands, relatively simple calculations.
	Congestion	A	5; 8; 10; 14	Data from the Ministry of Infrastructure and Environment and KiM Netherlands Institute for Transport Policy Analysis.
	Funerals	A	5; 8; 10; 14	Data from Statistics Netherlands.
	Hospital visits	A	5	Calculation based on Injury Surveillance System, LIS. The number of hospitalisations multiplied with the visiting costs per patient (assumption from the latest road crash study).
	House adaptations moving	A	5	House adaptations and moving are updated using new data on total costs for handicapped and the share of road casualties in these costs
Data renewal	Emergency transport	B	8; 10; 14	New data from: - Royal Dutch Touring Club (ANWB; traumahelicopter), - hospitals and insurance companies, - small-scale survey hospitals/insurance companies
	Market production loss	D	8; 10; 14	Additional analysis of disability after traffic accidents by linking LLM hospitalisation data to social security data via Statistics Netherlands.
	Hospital visits	B	8; 10; 14	New information on the number of visits per casualty per day and the costs per visit will be collected.
	House adaptations moving	B	8; 10; 14	New estimation of costs on the basis of the evaluations of the Law Social Assistance (Wmo).
New studies	Value Transfer study	D	2; 5; 8	A review of the literature on human costs of slight injuries is carried out, and an estimate for the Netherlands is made on the basis of estimates that have been made in other countries. On the basis of the review a percentage of the VOSL is taken from foreign literature and applied to the Dutch VOSL. Studies have been carried out in Belgium,

				Sweden and the UK.
	Willingness to Pay study	E	8	Fatalities: Identical Willingness To Pay study as well as identical analysis as in 2003.
		C	8	Value Transfer Study similarly to the latest study in 2003. More recent studies from e.g. Belgium and Sweden will be included. Lower cost compared to Slight injuries because the study is similar to the previous one.
	DALY study	E	10	Fatalities and serious injuries: YLD is calculated for the years for which the costs are assessed, using the methodology applied by SWOV. DALY based either on value transfer or VOSL.
		E	10	Slight injuries: First an assessment of methodologies, based on literature. Then calculation based on literature and data from the Injury Surveillance System (LIS) and the General Practioner's Registry. DALY based either on value transfer or VOSL.
	International WTP study	F + F	14	Depending on the scope and other Member States' participation, 1 or 2 PhD positions. The costs per PhD for a 4-year programme are estimated at €225.000. The costs are divided by the number of participating MS (in the cost estimate: 2-6 countries).
	Non-market production loss	C	14	Literature review and value transfer study; efficiency gains can be achieved when cooperating internationally. 50% of the costs can be shared, cost were assessed assuming the participation of 2-6 countries.
	Friction costs	C	14	Literature review and value transfer study; efficiency gains can be achieved when cooperating internationally. 50% of the costs can be shared, cost were assessed assuming the participation of 2-6 countries..
	Vehicle unavailability	C	14	Literature review and value transfer study; efficiency gains can be achieved when cooperating internationally. 50% of the costs can be shared, cost were assessed assuming the participation of 2-6 countries..
	Unreported vehicle damages	E	14	The non-reported/not granted vehicle damages are assessed through a (web-based) survey on damage to vehicles resulting from road crashes and how people have treated this damage. Minimum sample size: 1000 respondents. The methodology for the study can be developed internationally. 50% of the costs can be shared, cost were assessed assuming the participation of 2-6 countries..
	Administration costs police	C	14	Small telephone survey among police representatives on police time spending on road crashes. International experiences can be exchanged, but will not lead to significant cost reductions.
	Non-vehicle property damages	C	14	Small telephone survey among road authorities on damage to infrastructure resulting from crashes. Additionally, an analysis of road authorities' databases. International experiences can be exchanged, but will not lead to significant cost reductions.
	Non-vehicle insurance costs	B	14	Separate study into the costs of non-vehicle insurances that can be attributed to road traffic accidents (eg health insurance, legal insurances). This will be relatively easy using data from statistics Netherlands.

A: € 500-€ 2,000, B: € 2,000-€ 4,000, C: € 4,000-€ 8,000, D: € 8,000-€ 16,000,
E: € 16,000-€ 32,000, F: € 200,000-€ 250,000

All these costs per cost component are summed up to derive the total investment costs per scenario (displayed on the primary vertical axis) and the annual costs of indexation and 5-yearly updates (displayed on the secondary vertical axis). The result is displayed in Figure 10.

Figure 10 Total costs per scenario and type of study



The figure shows that the total investment costs range from around € 15,000 in Scenario 2 to € 150,000-€ 250,000 in Scenario 14, depending on the number of participating countries. When all the costs are added up, Scenario 2 is by far the least expensive scenario. The costs for Scenario 5 are around twice as high. Scenario 8 is slightly more expensive than Scenario 10, because the DALY study has lower costs. For Scenario 14 the costs will depend especially on the international WTP study. The total costs of a PhD position will be around € 225,000. If the costs of 2 PhD students can be shared with 6 countries, the costs for the Netherlands are € 75,000. However, when only 2 countries participate and share the costs of a PhD student, the costs will be over € 110,000.

The annual costs of annual indexation and 5-yearly updates are between € 3,000 and € 10,000. As explained before, the costs of the updates and indexation was based on the costs of Scenarios 2 (annual indexation) and 5 (updates), excluding the WTP study of slight injuries and reporting costs. From the calculation, it becomes clear that Scenario 10 is more expensive compared to Scenario 8 due to higher costs of updating the DALY figures.

The score per scenario is determined by the formula: 1+8*LP/P, where LP is the lowest price and P the price of the scenario. In other words, the scenario with the lowest costs has the maximum score and all other scenario gain their score relatively to the difference in costs.

5.3.4 Comparability with the previous study

In a new cost study, costs will be estimated for several years including the year of the previous study (Wit & Methorst, 2012). Consequently, in each scenario a comparison with the outcomes of the previous study can be made by comparing the results of the new study for 2009 with the results of the previous study. Nevertheless, the easiness of making this comparison differs between scenarios. In general, the more modifications are made to the current methodology, the more difficult it is to compare the new estimates with the previous results. This means that in Scenario 2 a comparison can be made most easily (score 8). The only differences with the previous estimates are new number of casualties, inflation and the addition of human costs of slight injuries, implying that the differences can be explained relatively easily (score 8). A correction of the previous estimates can be made by adding human costs of slight injuries. This can also be done relatively easily (score 8) on the basis of the (assumed) number of slight injuries in the years of the previous study (2003, 2006 and 2009) and the value per slight injury that is determined in the new study.

In Scenario 5 it is more difficult to make a comparison with the previous results, because for many cost items new data are used (in addition to new numbers of casualties, inflation for some cost items and adding human costs of slight injuries). These data may not be exactly comparable to the data that were used in the previous study, which implies that making a comparison and explaining the differences is more difficult than in Scenario 2 (score 6). Correcting the results of the previous study implies that the new data need to be applied on the number of casualties in 2003 and 2006, which is not very complicated (score 6).

In Scenario 8 data for several cost items are renewed (instead of updated in Scenario 5). This means that new data from other data sources are used, which implies that a comparison is more difficult to make (score 4). This concerns for example the calculation of production loss, which is based on the Burden of Injury model of VeiligheidNL. Most probably this will lead to results which are substantially different from the previous estimates. For most cost items differences can be explained on the basis of differences in data that are used, which is in general more difficult than in Scenario 5 (score 4).
Particularly regarding production loss new data on for example sick leave and consequences of injuries for inability to work are used, which may complicate making a comparison with previous estimates. Making a correction of the previous results is also more complicated (score 4), mainly because production loss for previous years should be estimated on the basis of the Burden of Injury. For other costs items, for example human costs, new values per casualty can be applied to the number of casualties in previous years.

Applying the DALY approach to human costs in Scenario 10 (in addition to data renewal) will result in completely new estimates of human costs of fatalities and serious and slight injuries. The results are difficult to compare with the previous estimates for human costs (score 3) and the differences are more difficult to explain than in the other scenarios (score 3), because new valuations are used: values per DALY instead of values per casualty.
This implies for example that the age of casualties influences the outcomes. Correcting the results of the previous study implies that DALY calculations need to be made for 2003 and 2006. This is possible by using data on injuries and injury severity for these years and assuming that other input data (such as disability weights for several injuries) are also applicable to these years. Obviously, this further complicates correcting the previous results compared to Scenario 8 (score 3).

In Scenario 14 several new cost items are added to the current methodology and new willingness to pay estimates are made for fatalities and serious and slight injuries, implying that comparability with previous estimates and explaining the differences is most problematic in this scenario (score 1). Correcting the results of the previous study implies that the new cost items have to be estimated for the years 2003 and 2006 (in addition to correcting the other cost items, similar to the Scenario 8). This requires collecting the input data that are need to calculate these cost items, which is expected to be quite time consuming. In addition, some data may not be available for these years. Consequently, correcting the results of the previous study is considered most difficult in this scenario (score 1).

5.3.5 International cooperation and harmonization

Developing methodology

To explore the possibilities for international cooperation regarding developing new methodologies, interviews have been carried out with representatives of the European Commission, ETSC and FERSI. Furthermore, this issue has been discussed at an IRTAD meeting and with the members of FERSI working group 'Road Safety Economics'. These latter discussions were also focused on developments and initiatives on road crash in individual countries, including usage of the cost estimates, quality of the estimates, upcoming studies, research needs and opportunities for international harmonization of costs estimates.

In general, there are two options for setting up international cooperation on costs of road crashes:

1. An international project funded by an international organization.
2. An international project initiated and funded by national governments (known as 'matched funding'). Possibly an international organization(s), for example, ETCS could take part in such a project.

The feasibility of the first option is very limited at this moment, as the EC has no plans to launch a study and other international organizations do not have the financial resources to launch a study. The second option would be more feasible, as interviewees from several countries have indicated that there might be opportunities for national funding for such an initiative. Existing platforms for 'matched funding' might be used for this. Nevertheless, setting up such a project would most probably require substantial efforts and cannot easily be launched on the short term. Annex BAnnex B discusses the outcomes of the interviews in more detail.

In most countries research needs concern human costs, which means that opportunities for international cooperation are expected to be more or less the same in Scenarios 10 and 14. Improvements of methods for other costs in Scenario 14 probably will not provide additional opportunities. Both the 'common' WTP approach and the DALY approach may be interesting for international cooperation. Although most countries focus on the common WPT methods, the DALY method is a promising approach that attracts international interest, for example in the European project SafetyCube. The advantage of this approach is that it reveals information on the consequences of road crashes on quality of life, which is useful for road safety policy making in itself. Therefore, there might be opportunities for international cooperation on DALYs. In Scenarios 2, 5 and 8, the value transfer for human costs of slight injuries could be developed with other countries. However, this is not very plausible because most countries are more interested in serious injuries.

For other cost items in these scenarios international cooperation is not an issue, because this only concerns data updates or data renewal.

Opportunities to apply the method in other countries

In principle, Scenario 2 can be applied quite easily in other countries as this is a very simple approach requiring inflation data and number of casualties only. The number of slight injuries may not easily available in other countries, but in that case slight injuries may be treated the same way as 'other' injuries and property damage only crashes in this scenario, that means updating by using a simple rule of thumb (such as correcting total costs for inflation). In Scenarios 5, 8 and 10 opportunities to apply the methodology in other countries are very limited, because these scenarios concentrate on updating and renewing data within the current Dutch method. In Scenario 14, the results of applying new methods may be useful for other countries. For example, the results of research into human costs in a selection of countries using the same, internationally developed, may be used in other countries too using value transfer. Another example: estimates of unreported vehicle damage in several countries (relative to reported vehicle damage), may be used as an indicator for these costs in other countries.

5.4 Overall assessment of the preferred scenarios

All the scores of the in-depth assessment per criteria are combined and represented in the overview Table 19.

Table 19 Overview of scores per scenario

	Quality of methodology			Data availability and quality				Costs	Comparability previous study			International cooperation and harmonization	
	Consistency guidelines	Scientific quality	Methodology improvement	Completeness	Recent	Reliability	Continuity	Developing methodology	Comparability outcomes	Explanation differences	Possibilities correction	Developing methodology	Application in other countries
2. Minimum scenario + WTP slight injuries	5	3	2	2	1	2	8	9	8	8	8	3	6
5. Data update scenario + WTP slight injuries	5	5	2	3	4	3	6	5	6	6	6	3	2
8. Data renewal scenario extensive + WTP slight injuries	5	5	2	6	8	6	4	3	4	4	4	3	2
10. Data renewal scenario + valuation all casualties based on DALYs	5	6	7	6	6	6	3	3	3	3	3	7	2
14. Maximum scenario international-extensive	9	8	9	9	9	9	2	2	1	1	1	7	4

Using the same weight factors as in Chapter 4, the total scores are represented in Table 20.

Table 20 Final weighted scores of all criteria per scenario

Scenario	Quality of methodology	Data availability and quality	Costs	Comparability previous study	International cooperation and harmonization
2. EU guidelines scenario	3,4	2,3	9,0	8,0	3,9
5. Data update scenario + WTP slight injuries	4,4	3,6	5,0	6,0	2,7
8. Data renewal scenario extensive + WTP slight injuries	4,4	6,4	3,0	4,0	2,7
10. Data renewal scenario + valuation all casualties based on DALYs	5,9	5,7	3,0	3,0	5,5
14. Maximum scenario international - extensive	8,5	8,3	2,0	1,0	6,1

The table shows that Scenario 2 and 5 have low scores on quality of both methodology and data. Scenario 8 and 10 have higher scores and Scenario 14 scores best on the quality criteria. However, the costs for these scenarios are much higher. Scenario 8 and 10 have more or less the same costs. The studies 2 and 5 are best comparable with the latest road crash study, and Scenario 14 the least. However, as 2009 is to be included in the upcoming study, all differences should be explainable. Scenario 10 and 14 have high scores on international cooperation. Scenario 2 has an average score, however this is mainly because the method (indexation of all cost estimates) is easily applicable in other countries.

Given the in-depth assessment of the five main criteria, it makes sense to compare costs against the quality criteria for making a decision on how to move forward. The quality criteria were appointed to be the most important by the steering group, with costs as a constraint. Therefore, the quality criteria (weighed as 50/50) are displayed in Figure 11. The costs refer to the total costs over a period of 20 years (that is including updates).

Figure 11 Comparison of quality criteria scores and total cost estimations (over a 20 year period) from the in-depth assessment

* Note that the cost estimation in this figure is based on both the investment costs as the yearly and 5 yearly costs for some scenarios as described in Section 5.3.3 over a period of 20 years.

The bandwidth in the cost estimate is presented by upper and lower boundary of the ellipse shapes. From this figure, it becomes clear that there is a trade-off between costs and quality of methodology and data. The assessment can be used to decide, within the budget available, which quality level for the next update of the road crash cost study is possible.

6 Conclusions

Based on the assessments carried out in the previous chapters, several conclusions and recommendations can be formulated regarding the current methodology and data quality, as well as regarding the way forward to a new cost study. They are presented in this chapter.

Current methodology is generally in line with international state-of-the-art

The review of the international state-of-the art of estimating road crash costs, that was part of this pre-study, shows that the Dutch methodology is generally in line with international guidelines and good practices. This means that most main costs items that are recommend by international guidelines are included and that the methods that have been used to estimate these cost items are consistent with the international and scientific standards.

Human costs of slight injuries need to be added

The only missing in the Dutch methodology is the omission of human costs of slight injuries. These costs are recommended by international guidelines and commonly included in costs studies in other countries. Based on values used in other countries, the impact of this omission on total costs of road crashes in the Netherlands is expected to be substantial (approximately 10-15% of total costs). According to the multi-criteria analysis (see below), scenarios without human costs of slight injuries are clearly considered as inferior to the same scenarios with these costs: the added quality to the method outweighs the additional costs of adding this cost item. Human costs of slight injuries can be added with relatively limited resources if the value transfer method is used.

Other opportunities to further improve the methodology

The fact that the methodology is generally in line with the international state-of-the-art does not mean that there is no need to improve the methodology, as international guidelines are formulated quite broadly. For some cost items a relatively simple method is applied in the Netherlands while more sophisticated approaches are available. This concerns in particular human costs of serious injuries, which are based on a foreign willingness to pay study ('value transfer') instead of a country-specific study for the Netherlands. In addition, several relevant costs components could be added to the current methodology, such as costs of non-market production (household work, voluntary work, etc.), damage to infrastructure, administrative costs of health insurances and costs of vehicle unavailability.

Data quality is a severe weakness of the current methodology

This study shows that the main weakness of the current Dutch methodology concerns the quality of the data that were used, in particular the recentness of data. Estimating road crash costs requires many input data on both unit costs and casualty information, and for several cost items (sometimes very) outdated data were used. This concerns relatively large cost items, such as human costs of fatalities and serious injuries, production loss and vehicle damage. This results in substantial inaccuracy of the estimate of the costs of road crashes.

Trade-off between quality and costs

Several types of scenarios for a new cost study in the Netherlands have been developed and assessed in this study:

1. Very simple approaches where costs are updated using inflation indicators and new number of casualties only.
2. Scenario in which the data that were used in the previous study are updated, using the same or similar data sources.
3. Data renewal scenarios, in which new data are used for several cost items.
4. Scenarios that (also) include improvements of the methodology.

The multi-criteria analysis (MCA) that was used to assess these scenarios shows that there is not one type of scenario that is preferred above other types. On the contrary, each type of scenario was represented in the top-five of scenarios resulting from the MCA. The simple approaches have the advantage of being cheap, but the results are poor. The costs of the more sophisticated approaches, on the other hand, are many times higher, but the quality of the resulting cost estimating is also many times better.

Search for the highest possible quality within the available budget

The in-depth assessment of the five selected scenario did not reveal what is the most desirable scenario. The relation between the costs of improving method and the additional quality of these improvements are found to be quite linear. This confirms that there is a clear trade-off between costs and quality. The implication is that the available budget determines the quality that can be achieved and that within a given budget the highest possible quality of cost estimates should be looked for. This means that resources should be spent on costs items that have the most significant impact on total costs and which can be improved in the most efficient way (compared to other costs items). These cost items include:

- human cost of injuries, in particular slight injuries, based on value transfer;
- market production loss, using the Burden of Injury Model.

In addition, it is recommended to consider revising the following main costs items:

- unreported vehicle damage, based on a new survey;
- human costs of fatalities, using the existing methodology.

The costs of these improvements are more substantial, but the improvement of the quality of the estimates is expected to be large.
Finally, a data update for several costs items, including medical costs, administrative costs and other costs, is expected to be a cost-effective way of improving the methodology, as this will improve a larger number of cost items within a limited budget.

Opportunities for international cooperation: longer term perspective

Collaborating with other countries could increase the possibilities to improve the methodology since the costs of developing methodologies can be shared internationally in such a scenario. Furthermore, this would enhance the international comparability of cost estimates. In general, there are two options for international cooperation. Firstly, an international project funded by an international organization could be launched. However, no such initiatives have been identified. Currently, two European projects are focussed on costs of road crashes and results and recommendations of these projects will be awaited before launching a new project. The second option is an international project initiated and funded by national governments.

Representatives of research institutes in some countries have indicated that there might be opportunities for national funding for such an initiative. Other countries are particularly interested in developing methods for estimating human costs of fatalities and injuries. Existing platforms for 'matched funding' might be used for this. Nevertheless, setting up such a project would most probably require substantial efforts and cannot easily be launched on the short term.

A phased approach might be attractive: a new cost study could firstly concentrate on new estimates for cost items which require relatively limited resources (as discussed above) or which are less suitable for international cooperation. Other costs items may be updated, for the time being, on the basis of inflation. In the meantime, efforts can be spend on setting up an international project for developing new methods for these costs items, so these costs can be added in a later stage. In addition, it is important to (continue to) exchange information on cost estimates and methodologies and discuss opportunities for harmonization, e.g. in an international working group, as a first step towards to further international cooperation.

List of abbreviations

AWBZ	Algemene Wet Bijzondere Ziektekosten (Exceptional medical expenses act)
CBS	Centraal Bureau Statistiek (Statistics Netherlands)
CPB	Centraal Planbureau (Netherlands Bureau for Economic Policy Analysis)
DALY	Disability Adjusted Life Year
ECMT	European Conference of Ministers of Transport
ERSO	European Road Safety Observatory
ETSC	European Traffic Safety Council
EU	European Union
FERSI	Forum of European Road Safety Research Institutes
GDP	Gross Domestic Product
HC	Human Capital
IRTAD	International Road Traffic and Accident Database
KiM	Kennisinstituut voor Mobiliteitsbeleid (Netherlands institute for transport policy analysis)
LIS	Letselinformatiesysteem (Injury surveillance system)
LLM	Letsellastmodel (Burden of injury model)
LMR	Landelijk Medisch Register (National Medical Register)
MAIS	Maximum Abbreviated Injury Scale
OBiN	Ongevallen en Bewegen in Nederland (Injuries and physical activities in the Netherlands)
QALY	Quality Adjusted Life Year
PDO	Property Damage Only
RC	Restitution Costs
RP	Revealed Preferences
SP	Stated Preferences
SWOV	Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (Institute for road safety research)
VOSL	Value of a Statistical Life
WAO	Wet Arbeidsongeschiktheidsverzekering (Disablement benefits act)
WIA	Wet Werk en Inkomen naar Arbeidsvermogen (Work and income according to labour capacity act)
WODC	Wetenschappelijk Onderzoek- en Documentatiecentrum (Research and documentation centre)
WTP	Willingness to pay
WVG	Wet Voorzieningen Gehandicapten (Disablement assistance act for handicapped)
YLD	Years Lived with Disability
YLL	Years of Life Lost

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Annex A Overview of input data in the latest road crash cost study

Table 21 Detailed assessment of data sources used in the latest road crash study

Cost component	Cost item	Description	Source	Type of source	Availability	Most recently available year	Update frequency[12]
Medical costs	Emergency transport	Cost of ambulance per trip (fixed)	Charro & Oppe (1998)	Report	-	1998	Not updated
		Number of trips for road crashes	Assumption	Assumption	-	2009	
		Cost per emergency helicopter (12 hour deployment) (fixed)	Charro & Oppe (1998)	Report	-	1998	Not updated
		Number of emergency helicopters	www.traumahelicopter.nl	Statistic ANWB	Public	2016	Yearly
		Overhead of helicopters (fixed)	Charro & Oppe (1998)	Report	-	1998	Not updated
		% Helicopters deployed for road crashes(fixed)	www.azr.nl	Data from one hospital	Upon request	2009	Unknown
	Hospital	Hospital costs for casualties and injuries	Letsellastmodel VeiligheidNL	Cost model	Upon request	2015	Yearly
	Follow-on treatment	Follow-on treatment costs for injuries	Letsellastmodel VeiligheidNL	Cost model	Upon request	2015	Yearly
	Medicines, applicances	% Of cost inpatient accommodations hospital	Assumption	Assumption	-	2009	-
Production loss	Market production loss	Production value (LMR, OBIN, GAK)	CBS	Statistic CBS/CPB	Public	2015	Yearly
		Production value (LMR, OBIN, GAK)	CBS	Statistic CBS/CPB	Public	2015	Yearly
		Life years expectancy for remaining years per age	CBS	Statistic CBS	Public	2014	Every 4 years[13]

[12] For this study, the availability and update frequency has been checked. If the source was publicly available, the most recent available year and update frequency was recorded. For a non-publicly available source, the most recent available year and update frequency is noted as far as known to the researchers.

[13] Life expectancy for every age is determined for the previous 4 years.

Cost component	Cost item	Description	Source	Type of source	Availability	Most recently available year	Update frequency[12]
		Work force volume in 1,000 person-years, labour income, wages		Statistic CBS/CPB	Public	2015	Yearly
		Average number of days of absence per traffic injured person	CBS, BVG, Nationale Enquête Arbeidsomstandigheden (NEA)	Survey	Unable to find source	2009	Stopped
		National inflow figures WAO	CBS	Statistic CBS	Public	2015	Yearly
		Number of fully, partially disabled	CBS	Statistic CBS	Public	2015	Yearly
		Total number of WIA/WAO/Wajong/WAZ allowances	CBS	Statistic CBS	Public	2015	Yearly
		Inflow/outflow figures WAO	GAK (Now UWV)	Statistic	Upon request	2015	Yearly
	Non-market production loss	N/a					
	Friction costs	N/a					
Human costs	Fatalities	Fatalities VOSL	Blaeij, A. de et al. (2003)	Report	Stated-preference survey	2001	Not updated
	Serious injuries	Serious injuries, % of VOSL	WTP study	Report	preference survey (value transfer)	1991	"
	Slight injuries	N/a					
Property damages	Vehicles	Damage claims paid	CVS, Flury (1995)	Statistic CVS, report	Upon request	2009	Yearly
		Damage not reported and the damage not compensated	Flury (1995)	Report	-	1995	Not updated
		% Share of property damage in injury accidents	CVS, Flury (1995)	Statistic CVS, report		1992	Not updated
	Other	N/a					

Cost component	Cost item	Description	Source	Type of source	Availability	Most recently available year	Update frequency[12]
Administrative costs	Police	Total costs of police	Ministerie BZK	Annual accounts	Public	2015	Yearly
		% Police costs for road crashes	(AEF & BZK, 2005) (AEF & BZK, 2006) (Stol, et al., 2004)	Report	-	2006	Not updated
	Legal	Total legal costs	(Nauta, et al., 2011)	Report, also CBS	Public	2009	Yearly
		% Legal costs for road crashes (based on number of inflow number of criminal cases, number of summonses and length of detention)	WODC	Internal data source	Upon request	2009	Yearly
	Fire department	Number of fire alarms, emergency calls, false alarms, car rescue's	CBS	Statistic CBS	Public	2015	Yearly
		Total costs fire department	CBS	Statistic CBS	Public	2015	Yearly
	Insurance	Administrative expenses insurers	CBS	Statistic CBS	Public	2015	Yearly
Other costs	Congestion	Congestion costs caused by accidents; Mobiliteitsbeeld	KiM	Model calculation	Public	2014	Yearly
	Vehicle unavailabitly	N/a					
	Funerals	Average costs funeral/cremation	(Consumentenbond, 2003)	Survey	Subscription	2003	Not updated
		Share of cremated (fixed)	NNU		Source not found	2009	Not updated
		Avg age fatalities (men/women)	DVS	Registration	Restricted	2015	Yearly
	Hospital visits	Number of visits per day (fixed), average number of hospital days, costs per visit	assumption/DVS	Assumption	-	1997	Not updated
	House adaptations	Total costs WVG provisions	CBS	Statistic CBS	Public	2006	Stopped, WVG now part of

Cost component	Cost item	Description	Source	Type of source	Availability	Most recently available year	Update frequency[12]
	moving						WMO
		% of the Dutch disabled due to a road crash (fixed)	(Muizelaar, et al., 1995)	Report	-	1995	Not updated

Annex B Summary interviews on international cooperation

In this project an exploration of opportunities for international cooperation on developing methodologies for road crashes costs and harmonization of estimates was made. Interviews were carried out with representatives of the European Commission, ETSC and FERSI. Regarding FERSI, two interviews were held: one with board members and one with members of the FERSI working group 'Road Safety Economics'. The first interview concentrated on the views of FERSI as an international organization, while the second interview was focussed on developments regarding costs of road crashes in individual member countries. The interviewees are listed below. In addition, the project has been presented at an IRTAD meeting and opportunities for international cooperation and harmonization were discussed plenary as well as in a smaller group of IRTAD representatives. The views and role of IRTAD as an international organization was discussed as well the developments in some individual countries.

The interviews covered the following topics:
- usage of estimates of road crashes by international organizations and in individual countries;
- current and anticipated future activities on cost of road crashes;
- views on international harmonization of cost estimates and opportunities to achieve this harmonization;
- opportunities for international cooperation.

The results of the interviews have been used to assess the opportunities for international cooperation in Scenario 14, as this scenario explicitly takes into account international cooperation.

Usage of information on costs of road crashes

All interviewed international organizations stated that information on costs of road crashes are important or even 'top priority' (FERSI). The information is regarded, in particular by the EC, as an important input for economic assessment of road safety measures. Economic assessments in which road crash costs estimates are used, are carried out regularly on the European level, for example regarding vehicle legislation and an impact assessment of the Tunnel (> 500 m) Directive.

ETSC, FERSI and IRTAD also stress the importance of cost information in itself. For example, ETSC notes that information on costs helps to put road safety higher on the political agenda of European institutions. ETSC publishes an estimate of the costs of road crashes in the annual PIN report, using a single European value per fatality.[14] IRTAD published costs of road crashes in each member country in an annual report. Particularly ETSC, IRTAD and FERSI indicated that cost information is important for making international comparisons (see hereafter).

[14] ETSC uses the terminology 'value of prevention of a casualty' instead of 'costs of road crashes', because an important part in the costs does not reflect actual costs but the amount people are willing to pay to prevent casualties.

IRTAD and FERSI noted that the use of cost information for economic assessments is not restricted to the EU: information on costs in particularly important for emerging countries, as it may help to allocate more budget to road safety.

On the national level, cost information is mainly used for cost-benefit analysis of larger transport projects and national transport plans in most countries. In addition, cost information is used at the local level, by the police or insurance companies in some countries.

Current and anticipated future activities on cost of road crashes

Currently, there are two European projects which include a comprehensive analysis of costs of road crashes in member states as well as guidelines for estimating costs: SafetyCube and InDeV. These projects are funded by the EC (Horizon2020). Several FERSI and IRTAD member countries are involved in these projects. From the EC side, no other activities or projects on costs of road crashes have been planned at this moment. Directive 2008/96 on road infrastructure safety management requires that road safety is included in impact assessments and according to this Directive members state should estimate the cost of a fatal accident and a severe accident every five year. However, member states have a high degree of freedom on how to fulfill this requirement and they can choose the methodologies and figures themselves. At this moment, priority of the EC is that member states comply with this directive using their own methods and figures and according to the EC there is no direct need for developing (new) methodologies.

From the side of ETSC, FERSI and IRTAD, there are no activities or projects on costs of road crashes at this moment. The reason is that it these organizations prefer to await the results and recommendations of the current two EU projects. New activities regarding costs of road crashes, e.g. a survey among member states, have been on the agenda of IRTAD, particularly because an IRTAD report showed that cost data are hardly comparable across countries. IRTAD will decide about further initiatives after the results of the EU projects have been published. Also ETSC prefers to wait for the results of these projects and decide by then if there are any gaps that could be filled by ETSC (provided that funding is available). A potential topic for further investigation could be the costs of injuries, in particular developing an EU value of prevented serious injury (similar to the value of a prevented fatality that was developed by ETSC).

The members of the FERSI working group 'Road Safety Economics' indicated that costs estimates in individual countries are made (or updated) regularly. In general, there is no urgent need for revising the methodology, although in some countries the results of the current EU projects could be a reason to revise the methodology. In several countries there are research initiatives related to the methodology for specific cost items, in particular human costs and medical costs. In Germany a willingness to pay study will be launched soon and in France there are plans for developing new methodologies for (human) costs of injuries. In Belgium a PhD study on medical costs of injuries is carried out and in Germany a study on medical costs of vulnerable road users will be launched. In the Czech Republic attention is paid to congestion costs related to road crashes.

International harmonization

ETSC, FERSI and IRTAD (strongly) support improving the international comparability of cost estimates. In general, this will improve the quality of international road safety reports, in particular benchmark reports such as the ETSC's PIN flashes and IRTAD annual reports. Harmonized methods, supported by a majority of the member states, are imperative for benchmarks to be effective. For the EC, however, international comparability of costs estimates is not an important issue at this moment. For the EC it is more important that existing costs estimate are being used in economic assessments by member states.

ETSC recommends using one value for studies on the European level. Different values per country would imply that saving a fatality in one country is valued higher than saving a fatality in another country, which is considered undesirable for studies on the European level. This implies the ultimate level of harmonization: using common values for all countries (which may be differentiated on the basis of income and purchasing power differences). On the national level each country should be free to use its own value.

According to FERSI, it would be interesting to develop a method that could be applied by any country. This would be particularly useful for (low and middle income) countries which do not have a method yet to estimate costs of road crashes. This would automatically improve international comparability of cost estimates. The role of FERSI could be to authorize and endorse such a method. Such an approach might be less attractive however for countries which do have a well-developed national method. In that respect ETSC notes that harmonization should move towards best practices instead of towards values which are based on inferior methods.

According to IRTAD, international guidelines are important for achieving harmonization, for example as developed within SafetyCube. It is important that guidelines are authorized, preferably by leading economists (also outside the field of road safety). It would be an improvement to establish a working group aimed at authorization of guidelines or at a common methodology.

International cooperation

Two options for setting up international cooperation on costs of road crashes have been discussed in the interviews:

1. An international project funded by an international organization.
2. An international project initiated and funded by national governments (known as 'matched funding'). Possibly (an) international organization(s) could take part in such a project.

The feasibility of the first option is considered as very limited at this moment, as the EC has no plans to launch a study and other international organizations have indicated to have no financial resources to launch a study. However, the results and recommendations of the SafetyCube and InDev project might provide a stimulus for a new study.

The second option would be more feasible for the near future, as the interviewees from several countries have indicated that there might be opportunities for national funding for such an initiative. Such a project could focus on specific issues, in particular human costs and costs of injuries. Existing platforms for matched funding might be used for this. Nevertheless, setting up such a project would most probably require substantial efforts and cannot easily be launched on the short term. In the interview with the Road Safety Economics working group it was concluded that a first step could be to

start a working group on international cooperation on costs of road crashes. Such a working group might be helpful to exchange information, achieve more agreement on methodologies and to harmonise costs estimates internationally to some extent. Setting up a project might be a next step that might result from a working group.

FERSI noted that a project focused on the use of economic assessment tools in road safety policy making would be interesting. A previous European study on this issue (ROSEBUD, finished in 2004) was successful and it would be interesting to start a new project on this issue. The FERSI working group Road Safety Economics also selected this topic for further investigation, and this might be a first step towards such a project.

Interviewees:

- European Commission, Directorate General for Mobility and Transport (DG MOVE): Mr. A. Eordogh, Policy officer Road safety unit.
- European Traffic Safety Council (ETSC): Mrs. G. Jost (Projects director), Mr. R. Allsop (Board of directors) and Mr. H. Stipdonk (co-chair PIN steering group and PIN panel).
- FERSI: Mr. K. Machata (board member) and Mr. L. Persia (board member).
- FERSI working group 'Road Safety Economics': Mr. W. van den Berghe (BIVV, Belgium), Mr. D. Mignot (IFSTTAR, France), Mr. R. Alfonsi (Universita di Roma), Italy), Mrs. S. Schönebeck (BASt, Germany), Mr. J. Fric and Mr. O. Gogolín (CDV, Czech Republic) and Mr. R. Bauer (KfV, Austria).