TRANSPORT ACCIDENT COSTS
AND THE VALUE OF SAFETY

January 1997

European Transport Safety Council
Rue du Cornet 34
B - 1040 Brussels

Tel.: + 32 2 230 4106 / 4004

Fax: + 32 2 230 4215

ISBN: 90-801936-9-0

Acknowledgements

ETSC gratefully acknowledges the contributions of members of ETSC's Transport Accident Statistics Working Party to this review:

Mr Matthijs KOORNSTRA (Chairman)
Dr Jeremy BROUGHTON
Mr Jean-Pierre CAUZARD
Ir. Ruddy DIELEMAN
Prof. Andrew EVANS
Ir. Cees GLANSDORP
Prof. Niels JØRGENSEN
Mr Lasse HANTULA
Mrs Ingrid VAN SCHAGEN (WP Secretary)

ETSC is grateful for the financial support provided by DGVII of the European Commission and for the contribution towards the printing and dissemination costs of this review provided by 3M Europe, Ford Europe, BP, KeyMed and KLM Royal Dutch Airlines. The contents of this review are the sole responsibility of ETSC and do not necessarily reflect the view of sponsors nor organisations to which research staff participating in the Working Party belong.

The European Transport Safety Council

The European Transport Safety Council (ETSC) is an international non-governmental organisation which was formed in 1993 in response to the persistent and unacceptably high European road casualty toll and public concern about individual transport tragedies. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

The Council brings together experts of international reputation on its Working Parties, and representatives of a wide range of national and international organisations with transport safety interests and Parliamentarians of all parties on its Main Council to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

Mr Pieter van Vollenhoven

Mrs Jeanne Breen

Contents Page

Executive Summary

Why is there a need to put monetary values on transport accidents ?

The mobility of persons and goods is an essential element of modern society. At the same time, travel, whether by road, rail, air or ship, carries one of the highest risks of accidental death and injury of any everyday activity. Safety is, therefore, a very important aspect of transport planning.

However, although safety is important, other aspects play an important role as well, notably the efficiency and environmental impact of transport. Achieving an appropriate balance between all three is a fundamental aim of transport policy. Attaching monetary values to time savings, accident savings and environmental effects allows policy makers to assess objectively the costs and benefits of investment options and to make the maximum use of generally limited resources.

The current review aims to estimate the socio-economic costs of accidents in road transport and in the non-road transport modes for the European Union as a whole. For road transport, the COST 313 inventory of socio-economic costs of road accidents, which took place in the early nineties in 14 EU and non-EU European countries is updated and extended to cover all EU Member States. Whereas in the COST 313 study the national methods of valuing casualties were used, for the current estimate one method is applied, including economic costs and a value of human life, based on the willingness-to-pay approach. For each of the three non-road transport modes the same principles of calculating costs are applied. The results, however, are less certain than those for road, because empirical data are scarce and many tentative estimates have had to be made.

How to value transport safety ?

Socio-economic costs of injury accidents comprise both pure economic costs as well as a value for a lost human life or serious injury.

To put a monetary value to human life, there are two main methods in use in the EU Member States: the human capital method and the willingness-to-pay method. In the human capital approach, the major component of the cost of a fatality or injury is the lost economic output of the victim. The principle objection to this approach, is that most people do *not* value their life for its contribution to economic output, but rather because it has intrinsic value to them and to their relatives. In that case, the value of safety, or of reductions in risk to life, should be taken to be the amount that people are willing to pay for it, i.e. the willingness-to-pay approach.

Currently, in the European Union, United Kingdom, Sweden, Finland and, to some extent, Denmark use the willingness-to-pay method for valuing fatalities. Switzerland also uses willingness-to-pay. The other countries use the human capital method, though with a large number of variants. In the UK the willingness-to-pay approach is also used for valuing non-fatal serious injuries. Both the COST 313 study and the recent European Commission's Green Paper *Towards Fair and Efficient Pricing in Transport* use the willingness-to-pay method for valuing fatalities and injuries in transport accidents. ETSC follows this line of reasoning in estimating the transport accident costs.

Socio-economic costs of road accidents in the EU

For those countries that already use the willingness-to-pay method in practice, generally the same costs and valuations have been used as in the COST 313 study. This implies that the official willingness-to-pay valuations as used in the countries concerned, are applied, together with additions for pure economic costs. For those countries that do *not* at present use the willingness-to-pay method in practice, estimates have been made based on those who do. The economic cost elements are taken from the COST 313 study for those countries where they are available, corrected, if new data were available, and updated to 1995 price levels. Again, estimates have been made for those countries where data on economic costs are not available. Based on a limited amount of studies, the willingness-to-pay value for a serious injury is taken to be 10 per cent of the value for a fatality. For slight injuries only economic costs are considered.

The next table shows that in 1995 in the 15 Member States of the European Union the socio-economic costs of road accidents amounted to 162 billion ECU, 100 billion of which is attributed to economic costs and 62 billion to the value of human life. Of the total cost of 162 billion ECU, 58 billion is attributed to unreported accidents.

	Economic costs	Value of human life	Total socio-economic costs
Fatalities	21	29	50
Serious injuries	23	33	56
- reported	16	23	39
- non-reported	7	10	17
Slight injuries	7		7
- reported	3		
- non-reported	4		
Damage-only acc.	49		49
- reported	12		
- non-reported	37		
Total reported	52	52	104
Total unreported	48	10	58

TOTAL	**100**	**62**	**162**

The total socio-economic costs of 162 billion ECU in 1995 with 45,000 fatalities means that nowadays it is cost-beneficial to invest 3.6 million ECU per fatality for a road safety measure which will prevent one fatality, the concurrent 8 serious injuries, 26 slight injuries and 211 damage-only accidents as well as all unreported injury and damage-only accidents which may be expected to happen per fatality. If the costs of damage-only accidents are disregarded, an investment of 2.5 million ECU in a safety measure which would prevent one fatality and the associated reported and non-reported injuries is cost-beneficial, given the total socio-economic costs of fatalities and injuries of 113 billion ECU.

Socio-economic costs of non-road transport accidents

The number of studies published on accident costs and valuation of life and injury in non-road transport is very limited. The amount of accessible information on numbers of accidents and fatalities in these modes is limited as well, and reliable data on non-fatal injuries are virtually non-existent. The estimates of accident costs in railway, aviation and waterborne transport are necessarily crude and based on many assumptions.

As far as possible, the same cost elements are applied as in road transport, i.e. economic costs for fatal, serious and slight injury accidents and for damage-only accidents, together with a value for lost human life and serious injury, based on the willingness-to-pay method.

There is no reason in principle why the value for a lost human life used for evaluating public transport safety measures should necessarily be the same as those used for road safety measures. Indeed, there is a little evidence, obtained from a study of willingness to pay for safety on the London Underground, that public transport passengers may be willing to pay about 50 per cent more for risk reduction measures on public transport than they would be willing to pay for risk reductions in road transport. This is mainly because they are willing to pay more for safety in situations where they perceive that they have no control over the risks. Obviously, there is a need for further study on the willingness to pay for safety on public transport but for the purpose of the current study, the value of life in non-road transport is based on this 50 per cent higher willingness-to-pay value.

The following table shows, that the annual socio-economic costs of accidents in the three non-road transport modes within the EU amount to around 5 billion ECU at 1995 price levels. Of this amount railway accident costs are the largest, followed by waterborne transport. Although the estimate is crude it is clear that non-road transport accounts for around 3.5 per cent of the overall transport accident costs in the EU.

	Total socio-economic costs (billion ECU)
Railway accidents	2.7
Aviation accidents	0.5
Waterborne accidents	1.8
TOTAL	5.0

Conclusions and recommendations

The estimates in this review for the total socio-economic costs (including economic costs and a value for human life) in the 15 EU Member States for transport accidents across the modes represent the best estimates that can currently be applied rather than scientifically indisputable facts. This is mainly due to the limited amount of empirical data on valuing life and number of casualties, in particular for non-road transport. Nevertheless, it is expected that with different assumptions and different data sets similar outcomes would have been obtained.

The next table provides a summary of the socio-economic costs per fatality in each of the four transport modes and the total socio-economic costs of the expected or estimated number of fatalities and casualties in 1995. The costs per fatality include the costs of personal injuries, property damage in injury accidents as well as property damage in non-injury accidents. Only for rail were data on damage-only accidents not available. The amounts are expressed in ECU at 1995 price levels.

Mode	Total socio-economic costs per fatality x million ECU	Estimated number of fatalities in 1995	Total socio-economic costs x billion ECU
Road	3.6	45,000	162.00
Rail	2.1	1,300	2.74
Air	2.7	186	0.50
Water	9.8	180	1.78

As can be seen, the socio-economic costs per fatality is three to four times higher in waterborne transport than in the other modes. This is solely due to the very high material and environmental costs which result from water freight transport accidents on the one hand and the relatively small number of personal injuries in these accidents on the other.

Compared to rail and aviation, the socio-economic costs per fatality in road transport are somewhat higher, although the willingness-to-pay value (included in the total socio-economic costs of fatalities and serious injuries) for non-road transport modes was assumed to be 50 per cent higher than for road transport. Since the costs per fatality include the costs for corresponding injuries and property damage, the difference is mainly due to the fact that the ratios of these to fatalities are much higher in road transport than in non-road transport. This is not surprising when it is recognised that injury accidents in aviation and rail generally result in much more severe personal outcomes, due to generally higher collision speeds and the number of people involved.

The last column of the table shows that around 97 per cent of all socio-economic costs for transport accidents within the EU are made in road transport. This is mainly due to the large share of road transport compared to other modes and the much higher risk levels in road transport. In the EU, approximately 70 per cent of freight transport and 88 per cent of passenger transport are carried out by road.

In view of the above summarised facts and figures ETSC recommends:

- to give higher priority to the safety in road transport in EU Member States' transport investments as well as in other relevant policies of the EU, such as the R&D programme for transport;
- to attach monetary values to transport accident savings which include not only economic costs, but also values for lost human life and serious injury based on the analysis of the willingness to pay for improved safety;
- to carry out, as part of the decision making process, cost-effectiveness analyses, wherever possible, of transport safety measures by valuing life based on the willingness-to-pay approach, at European, national or regional level;
- to include in cost-effectiveness estimates and policy documents not only the costs for reported accidents, but also the costs for non-reported accidents, in particular for road passenger transport where underreporting of accidents is very high;
- to promote and fund studies to collect data on the value of human life and the willingness to pay for safety measures for the road transport mode in countries where these data not yet exist, as well as for the non-road transport modes. This will allow more precise estimates for the costs of fatalities and serious injuries in transport accidents;
- to establish without delay an EU accident database for each of the non-road transport modes which gives a complete and reliable picture of the safety situation and the number of casualties in passenger transport on EU territory and of EU transport companies;

- to update the transport accident cost estimates on a regular basis to take account of changes in accident frequencies, changes in ratios of injury accidents to fatal accidents, changes in costs and prices, and to incorporate the latest findings on valuing human life.

1. Introduction

The mobility of persons and goods is an essential element of modern society. At the same time, travel, whether by road, rail, air or ship, carries one of the highest risks of accidental death and injury of any everyday activity. Safety is, therefore, a very important aspect of transport planning.

However, although safety is important, other aspects play an important role as well, notably the efficiency and environmental impact of transport. Achieving an appropriate balance between all three is a fundamental aim of transport policy. Attaching monetary values to time savings, accident savings and environmental effects allows policy makers to assess objectively the costs and benefits of investment options and to make the maximum use of generally limited resources.

Putting a monetary value of human life and limb often provokes strong reactions on ethical grounds. However, if this is not done, casualty reduction measures cannot be weighted properly in relation to resource allocation for other transport measures.

The present review has three aims. Firstly, it aims to provide an explanation of the different approaches to valuing safety and transport casualties, their usefulness and the philosophy behind them (Section 2). It is concluded that a method which takes account of both the direct economic costs such as lost productivity as well as the intrinsic value that people attach to their life - based on the willingness-to-pay approach, is the most appropriate way of calculating transport accident costs.

Secondly, the review aims to update and extend the inventory of road accident costs in 14 European countries, which was carried out in the early nineties as one of the COST-Transport actions[*] (COST 313: Alfaro, Chapuis and Fabre, 1994). This COST study provides an overview of the methods that were used for calculating costs of road transport casualties and the actual costs per country according to the national method at that time. The present review provides an estimate of the average cost per fatality, serious injury, slight injury and damage-only accidents in the 15 Member States of the European Union as well as the total cost for road accidents in the European Union based on the willingness-to-pay method, updated for the 1995 price level (Section 3).

The third aim of the present review is to extend the method for valuing road accident costs to estimate the costs of accidents in other transport modes, notably air, rail and waterways (Section 4). Although valuing life and injury is not yet frequently practised in these modes of transport, and the number of studies in this area is limited, there is some evidence that valuations of statistical life are higher than for road

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[*] COST stands for European Co-operation in the field of Scientific and Technical Research. The COST framework as a whole covers pre-competitive research in fifteen areas, one of which is transport. COST is not part of the European Community but gets substantial Community support for its work.

transport. Based on a limited amount of empirical data on valuation of life and the limited amount of accessible accident statistics, the present review provides a tentative estimate of the total transport accident costs in each of the three non-road transport modes.

2. Need for and methods for valuing transport safety

2.1 Why there is a need to value risk reduction

Safety, or freedom from risk, is highly valued by people, but there is a cost to its provision, and absolute safety is unattainable. Therefore, organisations and governments are continually faced with the problem of deciding how much resource in money, effort, or time should be devoted to reducing risk. They may wish to reduce risk as much as possible, but risk reduction competes with other resource needs, and balances have to be struck between the reduction of risk and other objectives.

These balances are often struck informally on the basis of judgement and experience. Thus, for example, many organisations develop rules or standards specifying what decisions should be made in what circumstances. These are usually sensible, but they have the disadvantages that, first, they are not open to scrutiny and review, and, secondly, the rules adopted by different organisations, or different parts of the same organisation, may be inconsistent. For example, one organisation may devote far more resources to avoiding an accident fatality than another with the result that resources are then not used as efficiently as they might be.

In order to overcome these disadvantages, some organisations place explicit monetary values on the risks of unwanted events, notably on the risk of fatalities and injuries in accidents. This makes it possible to compare the value of the benefits of measures to reduce risk with the cost of those measures, and to adopt only those for which the benefits exceed the costs. If resources for safety measures are constrained, as they usually are, it is possible also to choose those measures that give best value for money.

It should be noted that when the saving of a life is valued in this way, it is not the value of a particular person's life, but the small reduction in risk for a large number of people that can be expected on average to save one person's life. The valuation placed on the saving of one such life is sometimes called the *value of statistical life,* to emphasise that no specific person is involved, but it is also often somewhat misleadingly shortened to the *value of life.* The arguments are different if one specific person's life is at stake, as for example when search-and-rescue operations are mounted.

2.2 Methods for the valuation of life and limb

There are two methods for valuing life and limb, though there are many variants of each. These are the human capital method and the willingness-to-pay method. Both these methods are in use. The COST 313 report mentioned in Section 1 (Alfaro et al., 1994) discusses the methods and results of 14 European Countries. At the time of the study, Denmark, Great Britain, Sweden, Finland and Switzerland used the willingness-to-pay method for valuing fatalities, and the remaining countries used the human capital method, though with a large number of variants. Since then, there has been a tendency to move towards the willingness-to-pay method. In 1993, the British Department of Transport also switched from the human capital approach to the willingness-to-pay approach for valuing non-fatal serious injuries. The European Commission's Green Paper *Towards Fair and Efficient Pricing in Transport* (CEC, 1995), also applied the willingness-to-pay method for valuing fatalities and injuries in transport accidents.

Human Capital

There are two variants of the human capital approach: the 'gross output' approach and the 'net output' approach, but the latter is now discredited, so it is not considered here. Under the gross output approach, the major component of the cost of a fatality or injury is the discounted present value of the victim's future output or income which is lost as a result of premature death or injury. In the case of individuals whose services are not marketed, such as house persons, imputations may be made for the value of their services. An allowance is then added for other effects such as damage, police and medical costs, etc. In some countries a more or less arbitrary amount is then added for the 'pain, grief, and suffering' of the victim's relatives and friends.

In the human capital approach, life is valued as the economic output of the victim, including non-marketed output, plus an allowance for the pain, grief, and suffering of relatives and friends. The major objection to this approach, advanced by Professor Michael Jones-Lee (1990) among others, is that most people do *not* value their life for its contribution to output, but rather because it has intrinsic value to them and to their relatives. In that case, the value of safety, or of reductions in risk to life, should be taken to be the amount that people are willing to pay for it. This is the willingness-to-pay approach, which is discussed next.

The accident costs which emerge from the human capital approach are typically much less than the willingness-to-pay approach.

Willingness-to-pay

The willingness-to-pay approach is based on the idea that although people do not trade off their life against money or other commodities, they do trade off small changes in *risk* against other commodities. For example, they make decisions about whether or not to have particular safety features in their cars, and they make decisions between modes of transport, one of which may be cheaper but less safe than the other. These decisions reveal preferences about the value of safety relative to the value of other things, in the same way as trade-offs between money and time reveal information about the value of time. However, evidence about the value of safety is more difficult to come by than evidence about the value of time.

As mentioned above, reductions in risk to life can be aggregated across groups of people into changes in the expected number of lives saved, often called *statistical lives*, as distinct from the lives of identifiable people. Similarly, willingness-to-pay can be aggregated across groups, to give a willingness-to-pay to avoid one statistical death, which is what is usually called the value of life.

It is hard to obtain evidence on the trade-offs people make regarding risk and money, but there have been a number of studies in various contexts. In transport, the most common method has been by questionnaire, pioneered in Britain by Jones-Lee, and also used in other countries. These questionnaires essentially elicit how much the respondents say they would be willing to pay for safety measures that reduce their risks by various specified amounts. Outside transport, there have been studies examining the wage differential for risky occupations as compared with similar, but less risky ones.

The results from transport studies show a very wide range of individual values of willingness-to-pay for safety measures, and a very skew distribution, with most values below the mean, but some very high ones. Even the average values from different studies have a range of a factor of about 3. Therefore, a fairly wide range of different willingness-to-pay valuations can be defended, and different countries using the willingness-to-pay method have chosen different valuations from within the defensible range. However, the valuations of the countries that use this method are higher than any of the countries that use the human capital approach.

The COST 313 European study mentioned above assumed that valuations based on evidence of willingness-to-pay would cover only those components of the losses due to injury or death that are borne by the individuals at risk and their relatives, and not losses borne more widely by society. The study therefore added these wider losses to arrive at an estimate of the total socio-economic costs of casualties. The added losses comprise first medical and similar public costs, and secondly *net* productive losses, that is the difference between the average value of lost production, as estimated by the human capital method, and the average value of lost consumption by the individuals at risk. These net productive losses accrue to society generally, and not to individuals at risk, and this is why they are presumed to be outside what individuals are willing to pay for. The added components are only a small proportion of the total socio-economic costs of casualties.

In Section 3 of this report, an estimate is made of the total socio-economic costs of road accidents in the European Union, using the willingness-to-pay method for the valuation of casualties. For those countries that already use the willingness-to-pay method in practice, generally the same costs and valuations is used as in the COST 313 study. This implies that the official willingness-to-pay valuations as used in the countries concerned, are applied together with the additions for public costs and net productive losses mentioned above. For those countries that do *not* at present use the willingness-to-pay method in practice, estimates have been made of their willingness-to-pay valuations, which are discussed in Section 3. As far as possible, the same classification of costs as in the COST 313 study is used.

Valuation of non-fatal injuries

Most countries value non-fatal injuries on the basis of lost output, that is the human capital approach, together with allowances for the medical, police, damage and administrative costs. Britain did so until 1993, but the Department of Transport then switched to the willingness-to-pay approach for serious non-fatal injuries, and to the more serious kind of 'slight' casualties, though slight casualties are still valued mainly on the basis of lost output and other costs. It is difficult to design questionnaires to elicit reliable estimates of willingness-to-pay for the avoidance of injury, especially as the category of 'serious injury' covers a wide range of injury from conditions almost 'worse than death' to conditions from which recovery is quick and certain.

After experimenting with various approaches, the British Department of Transport adopted a method in collaboration with Jones-Lee and others, which values injury not in absolute terms, but relative to death, called the 'Standard Gamble' approach. The essence of the approach is the following. Respondents are asked to suppose that they have suffered a given road accident injury, which, if treated in the normal way, would have a given prognosis. They are then asked to suppose that an alternative medical treatment is available, which, if successful, would return them to their normal state of health, but, if unsuccessful, would kill them. Respondents are then essentially asked to state what level of probability of success of the alternative treatment they would require for them to accept it. From the answers, it is possible to deduce the valuation of the injury under consideration relative to the valuation of a fatality. The value, averaged over all the different types of serious injury, turned out to be about 10 per cent of a fatality, which is again much higher than was obtained by the human capital approach.

2.3 Use of casualty valuations in practice

Road transport

Road transport organisations were among the leaders in the field in valuing the benefits of reducing risk. This is because they were also leaders in adopting social cost-benefit analysis for the appraisal of road investment projects, and reductions in accidents are often one of the most important aims of road projects, both in urban and rural areas. Therefore, cost-benefit analyses of road projects would be seriously incomplete if they omitted to include their effects on road accidents. It is remarkable how well-established is the idea of valuing road fatalities and injuries, considering how difficult it is in other fields, such as industrial safety or health care. Almost all developed countries, including most EU countries, place values on the reduction of death and injuries in road accidents as a matter of routine, though, as mentioned above, not all adopt the same methods of valuation, and there is a wide range of values used.

Non-road transport

Although valuations of life and injury are well established for road transport, including road public transport, they are *not* well established for the other transport modes. The traditional ethos on these modes has been somewhat different, and safety measures have been based much more on engineering standards and operational performance standards. The result is that safety standards on the non-road modes are generally higher than on the roads, but some adopted safety measures are very expensive in relation to the number of lives and injuries that they can be expected to save. However, the approach to safety assessment on the non-road modes is beginning to change, and some railways, for example Britain's Railtrack, are beginning to adopt explicit values for the avoidance of fatalities and injuries.

There is no reason in principle why the valuations of statistical life used for evaluating public transport safety measures should necessarily be the same as those used for road safety measures. There is a little evidence (Jones-Lee and Loomes, 1995), obtained from a study of willingness-to-pay for safety on the London Underground, that public transport passengers may be willing to pay about 50 per cent more for risk reduction measures on public transport than they would be willing to pay for road risk reductions, mainly because they are willing to pay more for safety in situations where they perceive that they have no control of the risks. There is a need for further study on the willingness-to-pay for safety on public transport.

It is sometimes suggested that fatalities in multi-fatality accidents should be valued proportionately more highly than the same number of fatalities in smaller accidents. The work for the London Underground mentioned above did not find any support for that proposition. However, if high-profile multi-fatality accidents cause potential passengers to over-estimate public transport risks, then it would be worthwhile for operators to allocate disproportionate resources to avoiding such accidents.

If the human capital method is adopted for valuing life and limb, the value of life for public transport passengers would differ from that for road users only if the expected value of the lost output differed between the groups. This might be the case if, for example, the age distribution of victims were different, but this seems unlikely to lead to large differences, and the road value would probably be higher, since road casualties are on average relatively young.

2.4 Conclusions

The use of casualty valuations is well established for evaluating road safety measures in most developed countries. Such valuations are useful in ensuring that resources are effectively applied, and they demonstrate that road safety measures are often good value for money. ETSC supports their use.

The use of casualty valuations on the non-road public transport modes is much less well-established. ETSC believes that it would be desirable if there were more extensive use of such valuations in public transport. The valuations themselves need not be the same as in road safety, though any differences should be justified. There is a need for more study concerning willingness to pay for public transport safety measures.

ETSC generally supports the willingness-to-pay method for valuing life and limb, even though it is recognised that the resulting valuations are not precise. This is because it seems reasonable to presume that people value their life and limb not primarily for its contribution to economic output, but for its intrinsic value to themselves and their families. This conclusion is in line with the COST 313 report and the European Commission's Green Paper *Towards Fair and Efficient Pricing in Transport.*

The distinction between *statistical* lives and *identifiable* lives is important. The values for fatalities and injuries used in the analysis of both road and public transport safety represent the aggregation of relatively small risks run by a large number of people, all of which together amount to an unacceptably high level of casualties. It must also be emphasised that the values of statistical lives cannot be a basis for insurance claims. The arguments are different in situations where a small number of identifiable people are at high risk, but those situations do not generally arise in transport.

3. Socio-economic costs of road accidents in the EU

3.1 Introduction

As mentioned earlier, in 1994 the results of a major COST-transport action (COST 313) were published in a report entitled 'Socio-economic cost of road accidents' (Alfaro et al., 1994). This COST 313 report provides an overview of methods for valuing road accidents which were at that time in use in 14 European (both EU and non-EU) countries, as well as the costs per road fatality, per seriously injured and per slightly injured person in each of the countries according to the national valuation method in ECU for 1990. Several follow-up analyses were published in scientific journals (e.g. Persson and Ödegaard, 1995; Elvik, 1995). In the COST 313 report and in the paper by Elvik (1995) the differences between countries in road accident economic cost estimates are largely explained by national GNPs, discount and growth rates, age structure and other variables.

The COST 313 report does not provide an estimate of the overall road accident costs in the EU. Such an overall estimate, albeit crude, was made in the Report of the High Level Expert Group on a European road safety policy, the Gerondeau-report (Gerondeau, 1991). In this report the economic loss of road accidents is estimated to be 70 billion ECU (range 45 - 90 without further justification) for the then 12 countries (without eastern Germany) of the European Community which had 50,256 fatalities in 1990.

This Section deals with the estimation of the total socio-economic costs of road accidents in 1995 for the 15 Member States of the EU with actual values transformed to the 1995 ECU rate. The problems for a well-based estimate of a total EU value for road accidents are manifold. First of all, different Member States use different methods to value road accidents. Secondly, some countries do not have data for some specific cost elements and other countries, notably Ireland, Italy and Greece, do not have any cost estimates at all. A third serious problem concerns the differences between EU countries in definition of injury severity and in degree of accident reporting. This is particularly the case for serious injury, slight injury and damage-only accidents, but to some degree even for fatal accidents (see also ETSC, 1994).

Despite these problems, in the remainder of this Section an attempt is made to arrive stepwise at an estimation of the total socio-economic costs of road accidents in the 15 EU Member States. It will be clear that this type of estimate requires certain assumptions and restrictions and that the validity largely depends on the soundness of these assumptions and restrictions. It is not claimed that the estimate is scientifically indisputable, but it is claimed that it would be difficult to find a better based estimate.

3.2 Method and approach

The estimate is made by relating the total road accident cost estimates of a country to its number of road fatalities. This method is based on a ratio between the number of fatalities and the number of accidents of other severity in a particular year. The reason for estimating costs in this way is that fatalities are almost completely reported in every EU-country, and differences in definitions can be easily corrected. Another reason for this choice is that it is simple to use, since it allows for updating the estimate of the total costs of a country or the EU as a whole by knowing the annual number of fatalities. However, it must be borne in mind that the costs of a fatality, if defined like this, comprise not only the costs of one single fatality, but also the costs of the number of non-fatal accidents that generally correspond to a fatal injury. Since the ratios between fatalities and accidents with various other levels of severity change over time as do prices, it is recommended that the total costs per fatality should be updated at least every ten years.

The ratio between injuries and fatalities, i.e. the numbers of injured persons (slight and serious) per fatality, differs between countries. This is partly explained by differences in definition of injury and degree of reporting between countries. However, differences in risk level are another important explaining factor. There is a general tendency that the severity of accidents decreases with increasing motorisation or mileage. It has been found that with increasing motorisation, the risk of a fatality per kilometre decreases more steeply than the risk of a serious injury and even more so than the risk of a slight injury (Koornstra, 1992). It is likely that the numbers of damage-only accidents (including the non-reported ones) hardly decrease at all with traffic growth. This means that for countries where ratios between fatal accidents and accidents of other severity are not available, estimates must be based on the data of countries with similar levels of motorisation.

In order to deal with the various problems of estimating the overall EU socio-economic costs of road accidents in 1995, four successive steps are taken. First the relevant 1990 data in the 15 Member States on reported road fatalities are taken, together with the ratios of serious injury and slight injury to fatalities in these countries; then the costs per fatality, serious injury and slight injury are calculated (or partially estimated) in 1990 ECU. Secondly, a correction for the estimated level of underreporting of the different injury severity categories is applied for the EU as a whole. Thirdly, the costs of damage-only accidents is estimated. The fourth step comprises the calculation of the effect of proportional changes in number of fatal, injury and damage-only accidents from 1990 to 1995 and the price increases from 1990 to 1995 in the EU in order to arrive at 1995 estimates.

3.3 Socio-economic costs of fatalities and reported injuries in 1990

As explained, the first step in the estimate only looks at nationally reported fatalities, serious and slight injuries and their costs, leaving out the unreported and damage-only accidents for the moment. In other words, this first phase takes the national costs of those fatalities and casualties reported in each EU country and totals these to arrive at a total EU cost. Data are obtained from the OECD-IRTAD database (for fatalities uniformly defined as death within 30 days after the accident) and from the EU-CARE database and IRF statistics (for ratios of registered injuries to fatalities). For countries which do not distinguish between serious and slight injury (4 countries), it is assumed that the ratio is similar to that of an EU country with comparable fatality rate per motor vehicle, because of the previously mentioned relationship between severity of accidents and fatality risk. For Sweden the ratio of The Netherlands is used, for Finland that of Germany, for Austria that of Belgium, and for Italy the mean ratio of France and Germany is taken.

For reasons of reference and comparison to the COST 313 report the total fatality and casualty costs per fatality are expressed in 1990 ECU and related to the national road safety statistics of 1990. For some countries particular cost elements are missing or absent altogether. In order to arrive at a total EU cost estimate it is assumed that for those countries the relevant costs per fatality and per serious and slight injury are equal to those of a country with a similar level of motorisation. Motorisation seems to be the most relevant index here and is highly correlated to national GNP per inhabitant. For Ireland the costs of Denmark are taken, for Italy the mean costs of Germany and France, and for Greece the Spanish costs are substituted.

In Appendix 1 the relevant numbers of fatalities, ratios of serious and slight injuries to fatalities, and their respective (estimated or actually studied) costs are given for each of the 15 EU countries. As argued in Section 2, the inclusion of a value of human life based on the willingness-to-pay method is to be preferred to the pure economic costs, consisting of the gross lost productivity and additional non-personal costs. The value of willingness-to-pay must be interpreted as the difference between gross and net loss of productive capacity per fatality plus a value of human life. Therefore, the value of human life is defined as the willingness-to-pay value minus the difference between gross and net loss of productivity.

The Appendix gives the socio-economic costs per country of a fatality as the sum of gross loss of productivity and additional non-personal costs plus the value for a lost human life in a road accident. The latter value is derived from the observed or estimated value for the willingness-to-pay method minus the difference between gross and net loss of productivity per EU country.

The socio-economic costs of serious injuries are calculated in a similar way: the gross loss of productivity and additional costs (economic costs for a serious injury) plus an estimated human value for a serious injury (10 per cent of the human value of a lost life, see Section 2.2). For slight injuries only the economic costs are taken into account, since its price for the human loss involved in a slight injury is negligible. The exact figures per EU country are given in Appendix 1. Table 3.1 gives the mean costs in the EU per fatality, serious injury and slight injury in 1990.

Table 3.1 Mean economic costs, mean value of human life, and mean total costs

per fatality, serious injury and slight injury in the EU in 1990 in ECU

	Economic costs	Value of human life	Total socio-economic costs
Fatality	385,000	545,000	930,000
Serious injury	37,500	54,500	92,000
Slight injury	2,000	--	2,000

Appendix 1 (Table I-2) shows that the total socio-economic costs of fatalities and reported injuries per fatality in the EU is just over 1.6 million ECU in 1990, which includes about 0.7 million ECU for pure economic costs. The ***total socio-economic costs of road fatalities and reported injuries in EU for 1990 is about 91 billion ECU***, of which about 39 billion for pure economic costs and 52 billion ECU for the value of human life in fatalities and serious injuries.

3.4 Socio-economic costs of fatalities and reported and unreported injuries in 1990

Generally, in Europe serious injuries are underreported by about 30 per cent and slight injuries by about 60 per cent (OECD-IRTAD, 1994). As the second step in the estimation, the figures from the first step are corrected to include the costs of non-reported injuries.

Although there are large variations in the percentages of underreporting in EU Member States, a correction for the EU as a whole by 30 and 60 per cent respectively seems fairly reliable. It yields a total of about ***110 billion ECU for the socio-economic costs of fatalities and all (reported and unreported) casualties in the EU in 1990***, including 15 billion for non-reported serious injuries and 4 billion for non-reported slight injuries. This 110 billion ECU consists of about 61 billion for the value of human life (31 billion for the human value of lost lives and about 30 billion for the human value of seriously injured persons) and about 49 billion for pure economic costs (22 billion for fatalities and 17 billion for reported and 10 billion for non-reported serious and slight injuries).

3.5 Economic and socio-economic costs of reported and unreported damage-only accidents in 1990

Although the material damage involved in fatal and injury accidents are taken into account in the earlier calculations, the costs of damage-only accidents are not yet included. In the Nordic and north-west European countries where relevant data is collected, the economic costs of reported damage-only accidents are around 45 per cent of the economic costs of *all* reported road accidents.

Applying this percentage for the EU as a whole and assuming that this percentage also holds for the total costs of all damage-only accidents (including the many unreported, but less costly damage-only accidents), then the actual economic costs of damage-only accidents for the EU in 1990 is estimated to be 40 billion ECU (calculated by 49/(1-.45) - 49; human values are not relevant here).

The pure economic costs of all road accidents in the EU for 1990 are estimated to be about 89 billion ECU. In summary, this 89 billion ECU for pure economic costs contain: just less than 22 billion for fatalities, just less then 21 billion for reported and unreported serious injuries, just over 6 billion for reported and unreported slight injuries and about 40 billion for reported and unreported damage-only accidents. Since the three newer EU countries and the Eastern part of Germany represent about 17 per cent of the total EU road accidents costs, the figure of 89 billion ECU economic costs corresponds to about 74 billion ECU for the former European Community of the 12 countries. This figure is close to the 70 billion ECU mentioned in the Gerondeau report (Gerondeau, 1991) for the European Community of the 12 countries.

The pure economic costs of 89 billion ECU are in addition to the 61 billion ECU for the value of lost human lives and serious injured persons in accidents, which brings the total ***socio-economic cost of all road accidents in EU to about 150 billion ECU in 1990.***

3.6 Economic and socio-economic costs of reported and unreported accidents in 1995

In the last step of the estimation of the total socio-economic cost of road accidents, the 1990 figures are converted into the relevant figures for 1995. First of all, in the period between 1990 and 1995 prices have increased by 20 per cent on average in the EU, including devaluation in some countries with respect to the ECU-value.

Secondly, the number of fatalities in the EU of the 15 countries decreased from 56,375 in 1990 to 48,210 in 1993, and probably to about 45,000 in 1995, which is 80 per cent of the 1990 number. At the same time, however, the ratios of injury accidents and damage-only accidents to fatal accidents have increased. The injury rate tends to decrease at a rate which is about half that of fatalities, somewhat less for serious and somewhat more for slight injuries. Therefore, it is estimated that in 1995 the ratio of reported serious injuries to fatalities approaches 8, and the ratio of reported slight injuries to fatalities approaches 26 for the EU as a whole.

The ratio of reported fatalities and casualties to reported damage-only accidents in the EU ranges from 1 to nearly 6 with large variations between countries. However, the underreporting of damage-only accidents is even higher than for slight injuries. In the

EU, police reported damage-only accidents are estimated to be only about 25 per cent of the insurance claimed damage-only accidents.

Table 3.2 summarises the accident frequencies and mean costs per type as updated to 1995 figures, assuming the same underreporting percentages for injuries and damage-only accidents in 1995 as in 1990, and increasing the mean economic costs and mean human values by 20 per cent for increased prices and national devaluation to the ECU. Given these data, Table 3.3 provides the 1995 figures for the total economic costs, socio-economic costs as well as values for human life resulting from the lack of road safety in the EU.

Table 3.2 Frequencies and mean cost values per type in the EU in 1995

	Total number in EU (x 1000)	Mean economic cost (x 1000 ECU)	Mean value of human life (x 1000 ECU)	Mean socio-economic cost (x 1000 ECU)
Fatalities	45	462.7	654.0	1116.7
Serious injuries	505	45.0	65.4	110.4
- reported	355			
- non-reported	145			
Slight injuries	2,950	2.4	--	2.4
- reported	1,180			
- non-reported	1,770			
Damage-only accid.	46,000	1.0	--	1.0
- reported	11,500			
- non-reported	34,500			

Table 3.3 Economic costs, values of human life and total socio-economic costs in 1995 in billion ECU

	Economic costs	Value of human life	Total socio-economic costs
Fatalities	21	29	50
Serious injuries	23	33	56
- reported	16	23	39
- non-reported	7	10	17
Slight injuries	7		7
- reported	3		
- non-reported	4		
Damage-only acc.	49		49
- reported	12		
- non-reported	37		

Total reported	52	52	104
Total unreported	48	10	58
TOTAL	**100**	**62**	**162**

The total socio-economic costs of all accidents increased from 150 to 162 billion ECU between 1990 and 1995, that is by 8 per cent. The total socio-economic costs of fatalities and all (reported and unreported) casualties is 113 billion ECU in 1995, which compared to the 110 billion in 1990 is an increase of almost 3 per cent. Despite the price increase of 20 per cent, the total socio-economic costs of fatalities decreased from 53 billion ECU in 1990 to 50 billion ECU in 1995, which must be attributed to the decreased number of fatalities in the EU. The costs for injuries increased by about 10 per cent between 1990 and 1995 and this was to be expected given that the injury rate tends to decrease with half the decrease of the fatality rate, i.e. a reduction of injuries of about 10 per cent with costs that have increased by about 20 per cent in the period between 1990 and 1995. The costs of damage-only accidents increased by about 20 per cent which equals the price increase and this can be explained by the fact that the number of damage-only accidents (including the non-reported) hardly changed between 1990 and 1995, because of the opposite effects of traffic growth and increased road safety.

The total socio-economic costs of 162 billion ECU in 1995 with 45,000 fatalities means that ***nowadays it is cost-beneficial to invest 3.6 million ECU per fatality in a road safety measure*** that will prevent one fatality as well as the 8 serious injuries, 26 slight injuries and 211 damage-only accidents, which on average are reported per fatality in the EU, together with the costs of unreported injury and damage-only accidents which may be expected per fatality. If the costs of damage-only accidents are disregarded, an investment of 2.5 million ECU in a safety measure which would prevent one fatality and the corresponding reported and non-reported injuries is cost-beneficial, given the total socio-economic costs of fatalities and injuries of 113 billion ECU.

Over the years not only prices increase and currency exchange rates change, but also, and even more importantly, the number of injuries and damage-only accidents per fatality tend to increase. Consequently, the total socio-economic costs per fatality tend to increase over time (from 2.7 million in 1990 to 3.6 million in 1995, i.e. 33 per cent), even if the number of fatalities decrease. The longer the past period the more a correction by means of co-efficients becomes unreliable. Therefore, it is recommended that the estimation is updated at least every ten years, meanwhile collecting empirical data on costs and accident underreporting in all EU countries to allow continuous improvement of the estimates. Since the current estimates are based on 1990 data, the first update is due for the year 2000.

4 Socio-economic costs of non-road transport accidents in the EU

4.1 General background

The number of studies published on accident costs in non-road transport is very limited. The amount of accessible information on numbers of accidents and fatalities in these modes is limited as well and reliable data on non-fatal injuries are virtually non-existent. The estimates of costs in railway, aviation and waterborne transport, presented in the following sections, are necessarily crude and are based on many assumptions.

Apart from making many assumptions about costs and numbers, a decision had to be reached as to which types of accident should be included in the calculations and which excluded in order to arrive at a more or less comparable estimate between the modes. The following decisions were made, often more for pragmatic reasons, based on availability of data, than out of principal:

1. to exclude costs of accidents that result from recreational and sporting activities in aviation and from recreational boating. Although it was realised that also in road transport some trips are made for the enjoyment of driving/riding only, this was considered to be a minor part of all road transport.
2. both freight and passenger transport accidents are included, with the exception of air freight transport, where data are hardly accessible. The number of casualties in aviation freight transport is assumed to be small.
3. to focus on costs of personal injury accidents, including the costs of property damage in these accidents, but to include where possible the costs of damage-only accidents, to allow for a comparison between road and non-road transport accident costs. Since basic data on number and costs of damage-only accidents are hardly accessible, only very crude estimations were possible for aviation and waterborne transport and not at all for rail.
4. to include accidents at EU territory, both of EU transport companies and non-EU companies, and to exclude accidents outside EU territory. This is similar to the situation in road transport, where accidents with non-EU vehicles at EU territory are included in the EU accident statistics and those of EU vehicles outside the EU are excluded.

4.2 Rail passenger transport

Data on cost elements

Only a few studies are available on the costs of railway accidents. One American study (Miller et al, 1995) provides data which are directly applicable in this context - apart from the fact that it is not a European study. In the UK, Railtrack (1996) mentions a value of life figure of £ 800,000 at 1995 prices, estimated through willingness-to-pay studies. This figure is, however, taken directly from UK studies of road transport costs. So it could not be considered an original estimate based on studies of railway accidents. Therefore, another approach has been chosen.

Willingness to pay for a reduction in risk and the level of accepted risk are supposedly interrelated. The level of accepted risk has been found in several studies to be dependent on the degree to which people believe that they themselves control events. In road traffic where car drivers are in control of the vehicle the risk acceptance seems to be higher than for cases without such control. Examples of lack of control are passengers in trains and aeroplanes. Another factor that has been found to be related to the level of accepted risk is the possibility of multiple fatality accidents, which again is higher in non-road transport than in road transport. This corresponds well with the results mentioned earlier from the study by Jones-Lee and Loomes (1995), who found that the willingness to pay for a statistical life was about 50 per cent higher for train passengers in the London Underground than for car drivers.

A willingness-to-pay value which is 50 per cent higher than for road transport, means that the total socio-economic cost of a road fatality goes up by 38 per cent. For this reason, the value of a statistical life in railway accidents is taken to be the 1990 total cost for a road fatality (0.93 million ECU, see Section 3.3) plus 38 per cent. To take account of the increased prices and changed currencies the 1990 figure needs to be increased by 20 per cent (see Section 3.5). This leads to an estimate of 0.93 x 1.38 x 1.20 = ***1.54 million ECU for a statistical life in rail at 1995 prices.***

Costs figures to be applied for railway injuries are developed in the following way. From the American railway accident study by Miller et al. (1995) estimates of the economic costs of both fatality and injury are available. The figure for an injury is approximately (1990) 23,000 ECU. The non-fatal road injury figures in Table 3.1 are split into serious and slight injuries with average economic cost estimates of about 37,500 ECU and 2,00 ECU (1990) respectively. The American figure of 23,000 ECU is, therefore, not in apparent conflict with the EU economic cost data on non-fatal road injuries. Therefore, the estimated EU data will be used in the further calculations. Railway accident data do not distinguish between serious and slight injuries. However, under the assumption that serious and slight injuries generate the same costs in road and railway accidents, it may be deduced from a comparison between the EU figures and the American figure that around 58 per cent of the railway casualties are serious casualties and around 42 per cent are slight injuries.

The total cost of a serious injury in road transport (Table 3.1) is estimated to be 92,000 ECU (1990). This amount plus 38 per cent to account for the higher willingness-to-pay values in non transport modes plus 20 per cent to account for price increases between 1990 and 1995 mounts to ***152,350 ECU for a serious railway injury at 1995 prices.***

Since slight injuries only involve economic cost as argued in Section 3.3, the cost of 2,000 ECU per slight injury (Table 3.1.) is simply updated to 1995 price levels by adding 20 per cent. This mounts to ***2,400 ECU for a slight railway injury at 1995 prices.***

In the American study figures are given for the property damage costs in terms of social costs in accidents involving passenger trains for various categories of accidents. For derailments the property damage per case is about 275,000 ECU, for rear end collisions about 125,000 ECU and for the relatively frequent highway - passenger train accidents about 15,000 ECU (1990 rates).

An estimation of the costs of railway accidents in EU might be obtained through an estimation of the fatality and the injury costs plus an estimate of the property damage cost per casualty. The American study gives an estimate of 40,000 ECU (1990) in property damage per casualty for passenger trains and 55,000 ECU per casualty for freight trains. Since there are many more injured in connection with passenger trains in Europe a total estimate of 45,000 plus the 20 per cent to update the figure to 1995 price levels could be assumed, i.e. ***54,000 ECU per casualty for the cost of property damage at 1995 prices.***

Data on fatalities and injuries

Based on data from EUROSTAT (1993) and some other sources it is possible to set up a crude estimate of the total number of fatalities and injuries in the EU. It should be noted that the differences between countries are very large. It seems likely that, in addition to some actual differences, an important part of the differences can be explained by differences in the application of casualty definitions and reporting rates.

The total number of fatalities in connection with rail traffic in the EU in the early 1990s is estimated to be about 1,300 and the number of injuries to be about 4,700 annually (see Appendix 2). Based on earlier mentioned assumptions around 58 per cent of the latter would be serious (2,700) and around 42 per cent slight (2,000). Suicides and attempted suicides are excluded from the EUROSTAT data. Rail passengers constitute about 15 per cent of the fatalities and about one third of other injuries. Major groups of the non-passenger victims are road users at highway crossings, trespassers and staff.

In this context it is reasonable to make a comment concerning the European Commission's Green Paper *Towards fair and efficient prizing in transport* (CEC, 1995). As distinct from this Green Paper, in the present study both accidents involving staff and accidents involving trespassers have been included. Accidents involving road-rail crossings are also included. Here, it could be considered equally reasonable to count only half of the accidents as was done in the Commission's Green Paper.

Costs of railway accidents in the EU

Table 4.1. gives an overview of the estimated costs per fatality, casualty and related property damage as well as the total costs of rail injury accidents in the EU in 1995, based on the foregoing data .

Table 4.1. Estimated annual costs of rail injury accidents in the EU

	Number per year	Unit cost in ECU	Total cost in MECU
Fatalities	1300	1,540,000	2,002
Serious injuries	2700	152,350	411
Slight injuries	2000	2,400	5
Property damage	6000	54,000	324
TOTAL			**2,742**

This crude estimate of the total cost of about 2.7 billion ECU per year in the EU is surprisingly small, the main component being the costs of fatalities, with injuries costs of around 20 per cent of the fatalities and property damage costs around 16 per cent of the costs for fatalities. Furthermore, the costs of a substantial part of the fatalities - road user fatalities at-grade crossings - are usually counted also under road accident costs. If only half of these accidents would be considered as railway fatalities, the cost estimate would decrease to below 2 billion ECU.

4.3 Air passenger transport

It has not been possible to locate studies of air transport accident costs - neither world-wide nor for Europe - which would be comparable to the figures for road accident costs for EU. However, in order to throw some light on the question a few data on aviation accidents are presented.

Available accident data on aviation accidents have different contents and definitions. In addition, some of the relevant data sources do not give the actual data but only statistical rates such as fatalities per passenger kilometre or per flight hour.

Data on accidents are usually given as the number of fatal accidents i.e. accidents with at least one fatality. Data on personal injury usually consist of only the number of fatalities. In some cases data are provided on the number of survivors without specification of degree of injury. In addition, the category of flight such as scheduled flights, general aviation etc., is also given.

The two main flight categories included in the calculations are airline passenger transport and general aviation personal transport flights. The remainder of this section will deal successively with an estimate of the number of casualties in airline passenger transport in the EU, an estimate of the number of casualties in general aviation in the EU, the costs of property damage, and the total costs in aviation accidents. Because of the lack of reliable data and also because of the relatively infrequency of the events, casualties and damage to third parties as a consequence of aviation (e.g. the 40 deaths resulting from the Boeing 747 EL AL accident in Amsterdam) are excluded in this estimate.

Casualties in airline passenger transport

World-wide it appears that the number of passengers killed in airline passenger transport has remained relatively constant over the last decades. In the period between 1982 and 1993, accident location within the EU (at that time 12 countries), with EU country operators the annual number of fatalities were:

Fatalities per year 1982 - 1993. 12 EU Member States

Passengers in scheduled flights:	60 per year
Other commercial passengers:	6 per year
Crew (+ other):	9 per year
Total:	75 per year

(Source: CAA: World Airlines Accident Summary.)

Note that the figures on aviation fatalities given in the European Commission's Green Paper *Towards fair and efficient prizing in transport* (CEC, 1995) are much lower. However, that figure is based on data of only one year, and because of the large variance over years as mentioned before may therefore be less reliable.

The average of 75 fatalities annually in the table above does not include fatalities in the three new Member States nor fatalities in non-EU airlines on EU territory such as for example the Lockerbie disaster.

A simple way to include aviation fatalities of the three new EU Member States, is to assume that the accident figures will be about 10 to 15 per cent higher than for the 12 Member States, i.e. about 85 fatalities instead of 75 fatalities per year. If accidents with non-EU aircraft at EU territory is included, the figure increases by another 10 to 20 per cent to about 100 fatalities per year in passenger traffic. There is no reason to assume a trend in the data.

General aviation

General aviation can be defined as all air operations other than public transport and includes commercial operations, aerial applications, police, ambulance, test flights, training and private flying. This flight category is generally excluded from official flight safety information because the accident rates such as accidents per flight km or flight hour are much higher than for scheduled flights. Inclusion would therefore be misleading with respect to passenger flight safety. Whereas many general aviation operations are for leisure and sporting purposes, it becomes increasingly important as a means of transport, in particular in larger companies. Therefore, an attempt is made to include accidents and casualties in those general aviation operations which, most likely, have a transport purpose.

It is only since 1994 that there is an official ICAO requirement to report occurrences in general aviation aircraft with a maximum certificated take-off mass between 2,250 kg and 5,700 kg. Previously, reporting of occurrences in this category had only been a recommended practice. Data on general aviation accidents in EU countries comprising the years 1970-1996 provided by ICAO leaves the impression that the recommended practice was not taken up equally well by all EU countries. For example, it is hardly credible that the UK and Germany together account for almost 80 per cent of the accidents, having less than 40 per cent of the population.

Fairly detailed and complete data have been provided by the UK Civil Aviation Authority (CAA) on fatal accidents and casualties in UK general aviation operations in the period 1985 - 1995. In the UK, general aviation generally refers to aircraft within the weight groups below 5,700 kg. In the UK, all accidents are reportable, irrespective of aircraft weight. The general aviation data, however, do not include gliders, hanggliders, microlights, balloon operations etc. On average, UK general aviation results in 27 fatalities, 14 serious injuries and 43 slight injuries per year. This data includes, however, accidents with very small and light aircraft, which will hardly ever be used for transport purposes. It is assumed that half of the general aviation casualties happen in flights with a transport purpose.

To estimate the annual number of general aviation fatalities and injuries in the 15 EU Member States, the UK data are extrapolated by multiplying 50 per cent of the UK casualties with the population ratio between EU and UK. Table 4.2. gives the results.

Table 4.2. Average number of fatalities and injuries per year in the period 1985-1995 in general aviation for transport, extrapolated from the UK CAA data

Type of injury	UK per year	ratio EU / UK	EU per year
Fatalities	13.5	6.4	86
Serious injuries	7	6.4	45
Slight injuries	21.5	6.4	138

In Canada the ratio between fatalities in commercial aviation and general aviation for transport is about 1 : 1 (Ministry of Supply and Services, 1992). The ratio for the EU, estimated on basis of the UK data, comes out very similar.

Material damage

From data published by the Swiss Reinsurance Company in its journal Swiss Re, Sigma (1996/1) it is possible to make a very cautious estimate of material damage (hull damage) in air transport. The data show that in Europe for the period 1975-1995 hull losses were about 90 per cent of the premiums paid. In 1994 world-wide $1,750 million premiums were paid. Premiums paid in Europe may be estimated as 0.22 * $ 1,750 million = $ 385 million. Hull damage costs for the whole of Europe would then be 90 per cent of this amount which equals $ 345 million or 275 million ECU. A correction to exclude non-EU countries in Europe would bring the figure down to about 200 million ECU.

Costs of aviation accidents

In order to arrive at some crude cost estimate of aviation accidents the following method has been applied.

Since the lack of control of events as experienced by the rail passengers is likely to be experienced by airline passengers as well, it seems reasonable to assume that the willingness to pay for saving a statistical life in aviation is similar to that in railway transport, i.e. 50 per cent higher than in road transport or 38 per cent higher than the total cost. It is also assumed that the pure economic costs for casualties are similar in the two modes, and therefore the same unit costs for fatalities and injuries as in rail are applied to calculate the costs of aviation casualties.

If it is assumed that the distribution between fatalities, serious and slight injuries is the same in airline passenger transport as in general aviation (i.e. 32, 17 and 51 per cent respectively), ***the direct costs of aviation accidents in the 15 EU Member States can be estimated to be 655 million ECU per year.***

Table 4.3. Estimated annual costs of aviation accidents in the EU

	Number per year	Unit cost in ECU	Total cost in MECU
Fatalities	186	1,540,000	286
Serious injuries	99	152,350	15
Slight injuries	296	2,400	1
Material damage			200
TOTAL			**502**

4.4 Waterborne transport

Data on numbers of accidents and human casualties

The number of ships lost world-wide has been slowly decreasing over time since about 1980. According to data of the Institute of London Underwriters, in the last decade, the average number of ships lost (> 500 GT) was about 180 with an average of about 800 lost lives per year word-wide. Studies of accident data in the framework of the COST 301 transport action indicate that the number of vessels lost (> 100 GT) in European waters is about 150 per year.

As for aviation accidents, there is a very high variance in the number of lost lives per year, due to some fairly rare but very significant disasters, such as for example the foundering of the Estonia, resulting in over 700 deaths. In general, however, in years without major passenger ship disasters, an important part of the fatal accidents on sea and inland waterways happen in non-passenger transport.

An analysis of the fatalities at sea related to the size of the world fleet indicates that per year on average 3 fatalities occur per 1 million GT (see Appendix 3, section 3). From the COST 301 study it can be derived that on average 31 million GT is plying European waters, whilst 13 million GT is in European ports. This leads to an average of 140 people losing their lives annually at sea in freight and passenger transport. This number does not include on-board working accidents. Fishing vessels are excluded as well. The average number of fatalities at inland waterways is estimated to be about 40 annually. The number of serious and slight injuries in sea and inland waterway transport are largely unknown.

Data on accident cost elements

The only indication of costs for fatalities at sea comes from records of insurance companies (see Motte, 1996). Obviously, in these records lost life is valued much lower since insurance companies do not apply the willingness-to-pay method. These data are, therefore, not applicable in the framework of the current study. In order to come to a crude estimate of the costs of a maritime transport fatality it is assumed that the socio-economic costs for maritime transport casualties are the same as those in the other non-road transport modes, i.e. 1.54 million ECU.

As mentioned before, data on number of personal injuries are not available. To enable some cross-modal comparisons of the total costs, the numbers of serious and slight injuries are estimated, based on averages of the ratios between injuries and fatalities in rail and aviation transport (1.30 for serious injuries and 1.56 for slight injuries).

More often than in the other non-transport modes, accidents at sea result in major damage with a few of them being very costly with losses of valuable cargoes or serious environmental damage. Based on claims to the British insurance company P & I club, the material property damage caused by accidents to vessels in European waters (including both injury and damage-only accidents) is estimated to be 770 million ECU annually, total losses amount to another 475 million ECU. The material property damage to inland waterway vessels is estimated to be 120 million ECU per year. A rough estimation of the environmental damage costs indicate an amount of 93 million ECU in Europe. These costs include oil beached and cleaned and the cost of oil swept at the sea surface as well as the value of the lost oil itself. This mounts to a total of

1,458 million ECU for damage costs. Appendix 3 provides more detailed information on these estimates.

Search and rescue (SAR) operations after accidents and incidents can also be considered as contributing to the total costs of accidents. Based on Dutch figures the amount of money spent to rescue one person is about 10,000 ECU. This leads to a crude estimation of 40 million ECU per year in European waters, of which approximately 50 per cent is spent on SAR operations following recreation and sport activities at water. Since this report does not include costs of recreational and sporting activities, the costs of SAR operations for waterborne transport is estimated to be 20 million ECU per year. However, these costs are assumed to be included as additional costs in the cost for fatalities and injuries.

Costs of waterborne accidents

Applying the figures above the total costs of sea transport accidents and inland waterway accidents in European waters is just less than 18 million ECU per year (see Table 4.4). Material damage costs account for 80 per cent of the total costs.

Table 4.4 Estimated annual costs for waterborne transport accidents in the EU

	Number per year	Unit cost in ECU	Total cost in MECU
Fatalities	180	1,540,000	277
Serious injuries	234	152,350	36
Slight injuries	281	2,400	1
Material damage			1,458
TOTAL			**1,772**

Contrary to the other transport modes, the main cost element in waterborne transport is related to property and environmental damage and not the costs of human casualties. This can be explained by the fact that for waterborne transport freight transport accidents are included as well, which often result in major damage without personal injury. If only personal injury accidents would have been taken into account, the proportions would be more like those in rail and aviation.

4.5 Discussion of results

The figures for the socio-economic costs of accidents which have been estimated for the three non-road transport modes are as follows :

Railway accidents	2,742 million ECU
Aviation accidents	502 million ECU
Accidents at sea	1,772 million ECU
Total	5,016 million ECU

The figures are quite uncertain for a number of reasons. In the first place accident and casualty data are probably incomplete and not reported in a uniform way. For air and sea transport, data on non-fatal injuries are usually not reported. There are differences in the interpretation of definitions between countries even where they are formally the same. Furthermore it was very difficult to find suitable studies of accident costs in non-road transport. Consequently, it was necessary to apply some crude assumptions on the cost elements and the costs of accidents. Lastly, there were decisions to be made in selecting accident categories and possibly relevant data had to be excluded because of their unavailability.

Based on the current study, taking into account the many uncertainties, it can be concluded that the annual costs of the accidents of the three non-road transport modes within the EU amount to around 5 billion ECU. Of this amount railway accident costs are the largest, followed by waterborne transport. Whereas for waterborne transport and for aviation the costs of damage-only accidents are included in the totals, this is not the case for railway transport.

Although the estimate is crude, it is clear, that non-road transport accounts for approximately 3 per cent and road transport for more than 97 per cent of the overall transport accident costs in the EU.

5. Conclusions and recommendations

Achieving an appropriate balance between safety, mobility and the environment is a fundamental task of transport policy both at a national level and a European level. In order to achieve this balance, to assess objectively the cost and benefits of investment options, and to make the maximum use of generally limited financial resources, attaching monetary values to time saving, accident savings and environmental impact are desirable. There are basically two methods to value transport casualties. One approach is the human capital approach which takes only account of the pure economic costs, such as lost productivity, medical costs etc. The other approach presumes that people value their life and limb not primarily for its contribution to economic output but for its intrinsic value to themselves and their friends and relatives. The latter values are generally determined by assessing the amount of money people are willing to pay for a reduction in risk. ETSC supports the principles of the willingness-to-pay method as a basis for the valuation of transport casualties, which is in line with the recommendation of the COST 313 study (Alfaro, et al., 1994) and the method used in the European Commission Green Paper *Towards Fair and Efficient Pricing in Transport* (CEC, 1995).

The use of casualty valuations, either by the human capital approach or by the willingness-to-pay approach, is well-established in road transport, but much less so in the other transport modes. Consequently, relevant data to come to a monetary value of fatal and non-fatal injuries in these other transport modes, and for some countries also in road transport are virtually non-existent. In addition, accident databases are incomplete, incompatible, and often difficult to access.

Therefore, the estimates in this review for the total socio-economic costs (i.e. including a value for lost human life) in the 15 EU Member States for transport accidents across the modes represent the best estimates that can currently be done rather than scientifically indisputable facts. Nevertheless, it is expected that with different assumptions and different data sets similar outcomes would have been obtained.

Table 5.1 provides a summary of the socio-economic costs per fatality in each of the four transport modes and the total socio-economic costs of the expected or estimated number of fatalities and casualties in 1995. The costs per fatality include the costs of personal injuries, property damage in injury accidents as well as property damage in non-injury accidents. Only for rail are the costs of damage-only accidents unknown and hence excluded. The amounts are expressed in ECU at 1995 price levels.

Table 5.1: Socio-economic costs per fatality and total socio-economic costs of accidents for different transport modes in 1995 in ECU

Mode	Total socio-economic costs per fatality x million ECU	Estimated number of fatalities in 1995	Total socio-economic costs x billion ECU
Road	3.6	45,000	162.00
Rail	2.1	1,300	2.74
Air	2.7	186	0.50
Water	9.8	180	1.78

As indicated in Table 5.1, the socio-economic costs per fatality is three to four times higher in waterborne transport than in the other modes. This is solely due to the very high material and environmental costs which result from freight transport accidents on the one hand and the relatively small number of personal injuries in these accidents on the other.

Compared to rail and aviation, the socio-economic costs per fatality in road transport are somewhat higher, although the willingness-to-pay (included in the total socio-economic costs of fatalities and serious injuries) for non-road transport modes was assumed to be 50 per cent higher than for road transport. Since the costs per fatality include the costs for corresponding injuries and property damage, the difference is mainly due to the fact that the ratios of these to fatalities are much higher in road transport than in non-road transport. This is not surprising if it is realised that injury accidents in aviation and rail generally result in much more severe personal outcomes, due to higher collision speeds and the number of people involved.

The last column of the Table shows that approximately 97 per cent of all socio-economic costs for casualties in transport within the EU are made in road transport. This is mainly due to the large share of road transport compared to other modes and the much higher risk levels in road transport. Approximately 70 per cent of freight transport and 88 per cent of passenger transport is carried out by road (Kinnock, 1996).

In view of the above summarised facts and figures ETSC recommends:

- to give higher priority to the safety in road transport in EU Member States' transport investments as well as in other relevant policies of the EU, such as the R&D programme for transport;

- to attach monetary values to transport accident savings which include not only economic costs, but also values for a lost human life and serious injury based on the analysis of the willingness to pay for improved safety;

- to carry out, as part of the decision making process, cost-effectiveness analyses, wherever possible, of transport safety measures by valuing life based on the willingness-to-pay approach, at European, national or regional level ;

- to include in cost-effectiveness estimates and policy documents not only the costs for reported accidents, but also the costs for non-reported accidents, in particular for road passenger transport where underreporting of accidents is very high;

- to promote and fund studies to collect data on the value of human life and the willingness to pay for safety measures for the road transport mode in countries where these data not yet exist, as well as for the non-road transport modes. This will allow more precise estimates for the costs of fatalities and serious injuries in transport accidents;

- to establish without delay an EU accident database for each of the non-road transport modes which gives a complete and reliable picture of the safety situation and the number of casualties in passenger transport on EU territory and of EU transport companies;

- to update the transport accident cost estimates on a regularly basis to take account of changes in accident frequencies, changes in ratios of injury accidents to fatal accidents, changes in costs and prices, and to incorporate the latest findings on valuing human life.

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Appendix 1: Cost calculations for road fatalities and casualties per EU Member State

The cost elements for the total costs per fatality and per reported injury are derived from national studies in EU Member States, as far as available. Most data can also be found in the COST 313 report, but for a number of countries an update or correction of the misprinted or misclassified data in the COST 313 report took place. These included:

1. For The Netherlands the data were updated by using the results of a recent national study (Muizelaar, Mathijssen and Wesemann, 1995). Table 2 p. 21 of the COST 313 report the 1983 figure for The Netherlands is net lost productive capacity instead of total cost;

2. For France the human costs are misprinted by a factor 10 and actually only contain some sort of judicial compensation cost;

3. For Belgium the same misclassification was made as for France;

4. For the UK the subdivision of costs differ from the correct one in figure 8 on p. 42 of the COSTS 313 report;

The value of willingness-to-pay must be defined as the value of human life plus the difference between gross and net loss of productivity per fatality. For this reason an estimation was made for the gross and net losses and for a value of a lost human life as is included implicitly by the willingness-to-pay method. However, the values of human life can only be derived from the willingness-to-pay value in countries where that value is available, i.e. for the UK, Sweden and Finland. The human costs which are available for Belgium and France are actually compensation costs from court decisions, which should be seen as part of the relative small 'other added cost' component. The reported Danish human values are politically determined and not derived from an empirical analysis.

For the three EU countries that independently have determined each value (S, SF, UK) the mean ratio of the value of human life and the gross loss per fatality is 1.54 (range 1.18 to 1.87). This ratio differs from the ratio of 1.35 used in Persson and Ödegaard (1995), since the Swiss study (not an EU country) and the incorrectly defined human costs of Belgium, France and Denmark are not used. Even this higher ratio of 1.54 is an underbound, since the Swiss ratio is 1.65 and, keeping the discount rate in consumption losses on 3 per cent, several known non-European ratios are all above 2. So an estimation per country by 1.54 times the gross loss per fatality gives a minimum value for a lost human life.

Several EU countries do not provide figures for the net lost productivity. For those countries an estimate was made, based on a ratio of the known gross lost productivity per fatality. This ratio is assumed to be .20, a value based on Persson and Ödegaard (1995). Based on (updated and corrected) figures for gross lost productivity per fatality in the COST 313 report with a few similarity substitutions (for I=>(F+G)/2, IRL=>DK, G=>E) and based on given or estimated figures for net lost productivity per fatality, data for all 15 EU Member States is obtained. By the ratio of 1.54 for the value of human life to the gross loss per fatality for EU countries with missing values, it is finally possible to obtain all types of costs per fatality for every EU country either from available data or by estimation.

These and the other additional costs per fatality are given in Table I-1, where figures of countries with (=x) are substituted and figures with * are estimated by the derived ratio's.

Table I-1: Costs per fatality (in 10^3 ECU) for fatalities in 1990

Country	gross lost product. (1)	net lost product. (2) *=(1)/5	other added costs (3)	human value costs (4) *=1.54x(1)	willing-ness to pay value =(1-2)+(4)	total socio-economic costs =(1)+(3)+(4)
Austria (A)	590	118*	3	911*	1382	1503
Belgium (B)	380	76*	19	587*	891	986
Denmark (DK)	205	41*	5	419	583	628
Finland (SF)	548	110*	2	864	1303	1414
France (F)	216	43*	19	334*	506	568
Germany (D)	670	134*	1	1035*	1571	1706
Greece (GR) =E	113	23*	58	174*	265	345
Italy (I) =½(D+F)	443	89*	10	684*	1039	1137
Ireland (IRL) =DK	205	41*	5	316*	480	526
Luxembourg (L) 3)	344	69*	0	532*	808	877
Netherlands (NL) 1)	433	59	0	669*	1044	1102
Portugal (P) 3)	225	45*	0	347*	526	571
Spain (E)	113	23*	58	174*	265	345
Sweden (S)	437	79	3	517	875	956
Un. Kingdom (UK) 2)	324	66	1	607	865	931

Data column (1) as in COST 313 table 2 p.21, apart from substitutions for GR, I and IRL
except for 1) source: Muizelaar, Mathijssen and Wesemann (1995)
2) same as COST 313 p. 42; source: UK. Department of Transport
3) the given costs are taken to be gross lost productivity

In Table I-2 the number of fatalities in the EU countries in 1990 and the ratios of nationally reported serious and slight injuries with respect to fatalities are presented as obtained from the OECD-IRTAD and some national statistics (fatalities corrected for the 30-day definition). Casualty data were taken from the EU-CARE or OECD-IRTAD database. If for a particular country these data were lacking, the ratio to fatalities was assumed to be the ratio of the EU country with the most similar fatality rate per motor vehicle.

The costs per serious and slight injury were based on the COST 313 report. Again, if missing, the costs of the EU country with the most similar level of motorisation were substituted. Except for Sweden and the UK the COSTS 313 data for costs of a serious injured person do not contain an element for human value of life. The ratio of the human value for a serious injured person to a fatality can be estimated to be 0.10, a value that is also used in the CEC Green Paper 'Towards fair and efficient pricing in transport' (1995). Therefore, for these other countries the value of human life, i.e. 10 per cent of the value in column 4 of Table I-1, is added to the costs for a seriously injured persons as provided in the COSTS 313 report. For slightly injured persons the costs are purely economic losses, since the loss in terms of human value is negligible. The sixth column in Table I-2 contains the total socio-economic cost per fatality (adding the last column of Table I-1 and products of columns 2 and 4 and of columns 3 and 5). Finally, the last column (product of column 1 and 7) gives the total socio-economic costs of road fatalities and reported injuries in each EU Member State and for the EU as a whole.

Table I-2: Fatalities, ratios of serious and slight injuries and their costs in 1990

Country	fatalities 1990 (1)	ratio serious/ fatal (2)	ratio slight/ fatal (3)	serious injured person costs (4) 10^3 ECU	slight injured person costs (5) 10^3 ECU	total costs per fatality 10^6 ECU	socio-economic costs fatalities & injuries 10^6 ECU
Austria (A)	1,558	7.9	31.9	116	2	2.48	3,864
Belgium (B)	1,976	7.4	31.1	106	1	1.80	3,557
Denmark (DK)	634	8.4	6.5	55	1	1.05	666
Finland (SF)	649	4.2	12.2	117	1	1.92	1,246
France (F)	11,215	3.9	13.0	65	2	0.85	9,532
Germany (D)	11,046	11.6	33.1	130	3	3.31	36,562
Greece (GR)	1,998	1.6	13.4	27=E	0.4=E	0.39	779
Italy (I)	7,151	7.8	23.2	97=½(D+F)	2 =½(D+F)	1.94	13,873
Ireland (IRL)	478	5.4	15.2	55=DK	1 =DK	0.84	402
Luxembourg (L)	70	7.3	14.2	123	2	1.80	126
Netherlands (NL)	1,376	8.4	26.3	86	2	1.88	2,587
Portugal (P)	3,017	3.9	18.2	42	0.1	0.74	2,233
Spain (E)	9,033	4.7	8.9	27	0.4	0.48	4,336
Sweden (S)	772	6.5	18.1	131	6	1.92	1,482
Un. Kingdom (UK)	5,402	8.7	49.3	97	8	2.17	11,071
EU	56,375	6.9	22.8	92	2	1.611	90,834

Appendix 2: Data on railway accidents

Railway fatalities and injuries in 1989. Data from EUROSTAT, UIC, and Nordic official publications.

Country	Persons killed				Persons injured				Fatalities/ fat.+injur.
	Passeng	Staff	Others	Total	Passeng	Staff	Others	Total	
Austria	16	15	43	74	26	36	37	99	0.43
Belgium	2	1	19	22	37	12	23	72	0.23
Denmark	3	2	5	10	9	16	15	40	0.20
Finland	4	0	17	21	94	26	41	161	0.12
France	44	16	155	215	54	12	66	132	0.62
Germany	28	25	129	182	304	373	216	893	0.17
Greece	0	4	24	28	26	52	61	139	0.17
Italy	23	10	46	79	141	11	21	173	0.31
Ireland	3	0	6	9	94	1	6	101	0.08
Luxemb.	0	1	1	2	0	0	0	0	1.00
Netherl.	7	2	32	41	21	23	35	70	0.34
Portugal	22	3	106	131	84	58	90	232	0.36
Spain	8	31	42	81	1	4	33	38	0.68
Sweden	3	0	35	38	37	23	90	150	0.20
UK	35	19	309	363	613	662	174	1449	0.20
TOTAL	198	129	969	1296	1541	1309	908	3758	0.26
TOTAL	exclud.	France/	Spain	1000				3588	0.22

Notes:

Data from Finland and Sweden come from Nordic data sources;

Data from Denmark are identical in both Nordic sources and EUROSTAT, i.e. definitions correspond;

The high values of fatalities/(fatal. + injur.) for France and Spain indicate that only fairly severe injuries are counted as injuries in these countries;

The year 1989 was exceptional for Ireland: unusual high number of injuries;

Disregarding France and Spain, there are on average about 3.6 injured per fatality;

Estimates for all EU countries on a uniform basis could be:

fatalities per year	1300
injuries per year	4700

Appendix 3: Damage cost waterborne transport

1. Material damage costs

The UK P & I club published 'Analysis of major claims 1992'. These claims were collected in the period 20/02/87 through 20/12/91. From this report the following Table has been derived:

design	number of claims	million $
cargo	590	240
pollution	70	110
collision	120	70
property	145	154
constructional losses	5	6
personal injury crew	320	106
personal injury non-crew	110	35
wreck removal	17	25
fines	17	5
unrecoverable	17	15
towage	10	8
other	23	10
total	1444	784
total without loss of vessels	1439	778

The following assumptions are being made:

- these claims relate to the UK fleet
- these claims do not include any claims for lives lost
- in this period 5 constructional total losses occurred

The average size of the UK fleet during the period was 7,557,619. If constructional total losses are excluded from the Table (they will be accounted for separately), the total amount of claims is 0.0584 $/day/GT.

From data of the COST 301 study the average amount of vessels present at any one time at sea has been calculated. Based on the number of arrivals in European ports and a mean staying time in each port, the average number of vessels is calculated that stays in port. Data on mean staying times are determined (Glansdorp, 1991). These data have been used to determine the number of vessels present at any one time in European ports. The following Table has been obtained for 6 GT classes:

number of ships	0.1-0.5k	0.5-1.6k	1.6-10k	10-60k	60-100k	100k+	total

present in European waters	553.0	857.1	1199.5	768.5	43.3	25.8	3447.2
present in European ports	238.1	369.0	516.4	330.8	18.6	11.1	1484.0
total	791.1	1226.1	1715.9	1099.3	61.9	36.9	4931.2

These data can be transformed to GT by multiplying the number of ships in each class by the average GT in each class. These mean values are determined by using Lloyds data on vessels' characteristics.

MGT	0.1-0.5k	0.5-1.6k	1.6-10k	10-60k	60-100k	100k+	total
GT/ship	410	1175	5232	22117	73847	136655	
present in European waters	227	1007	6276	16997	3198	3526	31230
present in European ports	98	434	2702	7317	1377	1518	13444
total	324	1441	8978	24314	4574	5044	44674

If the GT obtained in each class are multiplied by the value of 0.0584$/day/GT and the number of days in a year, the following Table is obtained. The assumption is that the damage pattern for the components being insured by the P & I club for British ships is identical with the damage pattern of the mix of ship plying in European waters.

damage costs	0.1-0.5k	0.5-1.6k	1.6-10k	10-60k	60-100k	100k+	total
total in million $	6.91	30.69	191.22	517.90	97.43	107.43	951.57
total in million ECU	5.56	24.70	153.91	416.84	78.42	86.47	765.90

2. Costs of constructional losses

From data of the Institute of London Underwriters on hull casualty statistics it was calculated that the average value of a constructional loss was $ 3.91 million or 3.15 million ECU. In the COST 301 study figures were published regarding the number of estimated accidents in European waters. The figures cover a 5 year period form 1978 to 1983. Accidents were taken at sea, in restricted waters as well as in ports. The lethal ratio indicates how often a particular accident leads to a total constructional loss (TC loss) of the vessels involved.

type of accident	number	lethal ratio	TC loss	MECU / ship	MECU
collisions	1309	0.14	183.26		
wrecks and stranding	1087	0.20	217.40		
contacts	404	0.05	20.20		
foundering	335	1.00	335.00		
total 5 years	3135		756		
per year	627		151	3.15	476.33

3. Loss of human life

The following Table, from the Institute of London Underwriters, shows the number of lives lost on a global scale. The Institute of London Underwriters also present data on the size of the floating world fleet and the percentage of ships laid-up. It is assumed that these laid-up vessels are not involved in accidents resulting in loss of life.

year	number of lives lost / year	total fleet		
		MGT floating	% laid-up	MGT sailing
1982	954			
1983	1300	422	12.44%	370
1984	1039	419	9.42%	380
1985	813	416	8.23%	382
1986	1517	395	5.07%	375
1987	4058	394	3.18%	381
1988	812	394	2.04%	386
1989	810	401	0.80%	398
1990	804	414	0.70%	411
1991	519	426	0.69%	423
1992	512			
total	13138	3681		3505
average	1194	409		389
# / MGT / year	3.067			

The final result is that about 3 people lose their lives per 1,000,000 GT per year. If this value is applied on the GT of vessels present at any one time in European waters, it can be estimated that annually 137 people lose their lives.

4. Environmental damage costs

In the Paper of the Commission of the European Communities 'A common policy of safe seas' (CEC, 1993) Tables were published which can be used for a rough calculation of the size of the oil spills in four European areas. The Tables provided data on oil present in tankers that sank and oil spill due to an oil tanker collision. The amount of oil beached and cleaned is estimated. The amount cleaned is based on average costs using Dutch figures. The costs of cleaning beached oil varies from 1000 to 100,000 ECU per ton, according to various sources. Damage to living species which affect the fishing industry is not taken into account nor is the damage to other sea animals and birds, since an agreed valuing mechanism is lacking.

oil spills	tons found	tons coll.	beached	cleaned	total
Baltic	4500	2000	250	500	750
North Sea	10000	13000	1625	3250	4875
Atlantic coast	11000	3000	375	750	1125
Mediterranean	30000	36000	4500	9000	13500
total	55500	54000	6750	13500	20250
$/ton	136.5	136.5	10000	2500	
loss in M$	7.58	7.37	67.50	3375	108.62
loss in MECU	6.10	5.93	54.33	2716	87.43

5. Inland navigation

An estimate of the total accident costs is made by using some Dutch statistic on inland navigation. The Dutch inland navigation register indicates that there are about 7,000 vessels. The level of accidents according to the Dutch accident database is about 2,000 per year. The mean value of the costs of these accidents is not known from these database. Experts' estimates suggest a cost of about 20,000 ECU per accident. On average 10 ships are lost or have become a total constructional loss in the Netherlands. The values of these vessels at the moment of the accident is about 200,000 ECU. The total European fleet is estimated to have the size of 20,000 units. The following Table provides the results.

Inland navigation / European fleet		
number of accidents	5714	
claim value per accident	20,000 ECU	114.28 MECU
no. total constructional loss	29	
value per ship	200,000	5.80 MECU
Total damage costs		120.08 MECU