TRANSPORT SAFETY PERFORMANCE INDICATORS

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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.

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EXECUTIVE SUMMARY

Transport accidents and injuries present a cost to the European Union estimated at around 2% of GDP - around twice its entire annual budget for all activity.

Transport safety is a key priority in the Common Transport Policy and a high level of protection for EU citizens in all harmonisation activity is required by the Treaty.

Policymakers and managers aiming for a higher level of safety need to take an interest in as many of the factors influencing safety as possible and, at least, those factors they are able to affect or control.

Safety performance indicators provide a means by which policymakers can ensure that their actions are as effective as possible and represent the best use of public resource.

What are safety performance indicators?

These are defined as any measurement that is causally related to crashes or injuries, used in addition to a count of crashes or injuries, in order to indicate safety performance or understand the process that leads to accidents.

A large number of potential safety performance indicators exist. Not all of them are equally important. In general, the importance of a safety performance indicator can be assessed in terms of the strength of its relationship with accident or injury occurrence, if it makes a major contribution to accidents and if it can be influenced by road safety measures or programmes.

Why do we need them?

Transport safety can be assessed in terms of the social cost of accidents and injuries. Yet, it is clear that simply counting crashes or injuries is often an imperfect indicator of the level of transport safety. There are several reasons for this:

- **The number of transport crashes or injuries is subject to random fluctuations, meaning that a short-term change in the recorded number does not necessarily reflect a change in the underlying, long-term expected number.**

- **Reporting of crashes and injuries in official road accident statistics is incomplete. This means that an observed change in the number of crashes could merely be a change in the propensity to report crashes to the police.**

- **A count of crashes says nothing about the processes that produce crashes. It is, to some extent, a matter of chance whether a hazardous situation or a near miss results in a crash or not. It is, therefore, entirely possible that conditions are very risky, but that, luckily, no accidents have occurred.**

- **In order to develop effective measures to reduce the number of accidents or the number of killed or injured people, it is necessary to understand the process that leads to accidents. Safety performance indicators can serve this end.**

Such indicators can give a more complete picture of the level of transport safety and can point to the emergence of new problems at an early stage, before these problems show up in the form of accidents. A regular monitoring of safety performance indicators improves the understanding of road accident trends. Since these monitoring results can become available far more quickly than registered accidents, they are particularly useful for policymakers.

Do all modes need to use the same safety performance indicators?

There are fundamental differences between road transport and other modes of transport with respect to the regulatory and operational regimes to which individual operators in the system are subjected. While there is a longer tradition of use of performance indicators in the non-road transport modes, and particularly in aviation, it is not so easy to correlate them with crash data as is the case in road transport. Therefore, no attempt has been made in this report to make a case for the standardisation of safety performance indicators across transport modes. The appropriate set of safety performance indicators will vary from one mode of transport to the next.

Road transport represents by far the greatest transport safety problem in all European countries with around 90% of all transport accident fatalities occurring in road transport. The main emphasis in this report has, therefore, been put on road transport, although reference has also been made to the other transport modes.

This report considers best practice in the use of road safety performance indicators in transport and presents recommendations for the use of such indicators as an integral part of safety programmes both at EU and national level.

Safety performance indicators in safety programmes

This model illustrates the role of safety performance indicators in a wider context and serves as a device for identifying important safety performance indicators.

(Targeted) safety programmes
↓
Safety measures implemented
↓
Operational conditions of transport production (performance indicators)
↓
Consequences of operational conditions (accidents) ↔ social costs
↑
Safety targets (policy intentions)

Targeted safety programmes produce a set of safety measures to be implemented. These measures result in certain operational conditions of transport production, which in addition to the safety measures, are also influenced by a broad set of environmental and societal factors. The term 'operational conditions' comprises measures of operator behaviour and the technical condition and quality of the infrastructure and the vehicles used. The operational conditions of transport production result in a certain accident rate and number of casualties, usually taking into account the differing severity of accidents. These numbers are compared to safety targets, in order to monitor progress in achieving them.

Road safety performance indicators

Among the road safety performance indicators most commonly used are those that relate to behavioural characteristics such as speed levels, the rate of drink driving and the use of seat belts. In addition, a number of infrastructure, vehicle or trauma-related indicators are relevant. These provide a more straightforward means of monitoring the impact of a measure or programme and enable early, target-oriented adjustments of specific interventions. In addition, they allow for a more detailed understanding of the reasons for safety problems than is possible by looking at crash frequency alone.

Some EU Member States – usually those that have performed best in reducing casualties – have shown how safety performance indicators can be used efficiently in targeted safety programmes. In fact, some countries have specified certain behavioural characteristics as concrete targets in their national safety programmes in addition to pure casualty reduction targets. Working with performance indicators results in an increase of the understanding of policymaking authorities in the effects of their policies. Experience in some EU Member States show that the authorities using performance indicators are more engaged with their policies if performance indicator data are reported to them regularly.

Performance indicators for maritime, rail and aviation safety

Safety in the maritime, rail and aviation sectors has a long history and strong tradition based on regulation (initially only national, now increasingly pan European and international) and inspection to assess compliance with regulations. The underlying idea being that the greater the compliance the better the safety performance. Safety is an important design criterion for these transport modes. However, these sectors are organised in such a way that the interaction of many independent actors, both public and private sector, play important roles in achieving high levels of safety.

Inspection and investigation reports by government appointed agencies could be considered as the backbone of safety in these transport modes. In such reports, accidents and incidents play a dominant role. A growing interest is observed in all these transport modes to enrich the existing procedures to improve safety. Safety performance indicators are a promising development in this respect. In the maritime, aviation and rail sectors, examples are evident of initial steps to develop safety performance indicators, although these attempts cover only parts of the whole sector. Working with safety performance indicators allows for comparisons both within and between sectors. This is a useful aid to achieving a higher level of safety through a better understanding of the causes of accidents and by more transparent and rational decision-making.

Recommendations

For decades, the concept of utilising indicators for the continuous monitoring and analysis of processes has been standard practice in industrial quality management. The safety community should exploit this simple and robust concept. Once introduced and established for all the transport modes, the application of safety performance indicators will further stimulate safety work and thus reduce crash rates across Europe.

The European Commission should encourage Member States to agree upon and regularly collect a scientifically established set of safety indicators for all transport modes. At the same time, recommendations on harmonised sampling and application methodologies should be given. It is recommended that this implementation of safety performance indicators be built systematically over time and reviewed regularly.

In road transport, a natural starting point would be the main behavioural indicators – speed levels, drink driving rates and seat belt and helmet use – the comparability of which over time and between countries is of utmost importance. Thereafter, quality indicators such as road networks, vehicle fleets and emergency services should be added. There will be considerable benefit from the harmonisation of collection methods and the extension of the list of regular indicators. Initially, this will be easiest to accomplish among those Member States that currently do not collect safety indicators, and within the applicant countries.

In view of the above, ETSC recommends to the EU:

- **To set up and specify a set of relevant safety performance indicators (SPI) to be used at European and national level as a means of assessing the trends in safety levels and the success of casualty reduction programmes;**
- **To convene, for this purpose, a working group of the High Level Group on Road Safety, comprising road safety experts and representatives of the Member States to consider the list of 'best practice SPI' as suggested in section 5 of this report, i.e. behavioural indicators on speed, alcohol, restraint systems and safety devices as well as SPI in the areas of quality management of road networks, vehicle fleets and emergency services;**
- **To support feasibility and pilot studies on SPI collection and application at Member State level;**
- **To require, on the basis of the above studies, the Member States to collect SPI in a regular and harmonised way and to encourage them to make continuous safety monitoring an integral part of their national safety strategies;**
- **To give guidance to the Member States as regards data collection and observation methodologies (such as sampling frequencies, sample size and time, measuring protocols) as well as on data administration and fusion, in order to produce harmonised sets of SPI that are comparable over time and between countries at a European scale; to recommend that independent bodies collect data on SPI;**
- **To help disseminate current best practice in collection and use of safety performance indicators across the Member States and make annual results and trends available in statistical publications as well as through the electronic media such as the Internet and the Commission's future Road Safety Information System;**
- **To require the Member States to deliver regularly an agreed set of national SPI data to the Commission for international communication, taking the Commission's "Road Safety Quick Indicator" and the CARE database as an example;**
- **To negotiate, during the consultations on the coming action programme, a common set of relevant SPI with the Member States and to implement quantified targets for SPI into the programme;**
- **To include a task in the 6th R&D framework programme of carrying out further research into running and benchmarking integrated safety management**

programmes, with a view to the causal relationships between safety performance indicators and crashes or injuries; and

- **For the other transport modes, there is a need to develop a comprehensive set of performance indicators covering the whole sector and to use that information to improve safety and for more transparent and rational decision making. This requires a general accepted model of why accidents occur and how to prevent them effectively and efficiently. It is recommended to develop such a model and to derive from that model performance indicators.**

The added value for the European Union lies in a harmonised and comprehensive system of transport safety performance indicators allowing the EU to use these data for its own policies and to provide a facility for Member States to reflect on their own performance.

1. INTRODUCTION

1.1 Terms of reference

This ETSC review provides an overview of transport safety performance indicators at the European level.

Traditionally transport safety work has been based on crash data. However, transport crashes are relatively rare events. There is a need to establish and specify safety performance indicators, which are causally related to crash frequency and severity. Increasingly, behavioural measures such as percentage usage of seat belts, crash helmets, proportion of drivers being drunk, exceeding the speed limits or running red light cameras are used. Such measures can give direction to policy instruments, make it possible to assess limited areas of transport safety and within very specified problem areas. Because of the high information density they allow quicker and more local analyses and monitoring than crashes. They are also easier and more effective for public information work.

This report considers best practice in the use of safety performance indicators in road safety and in other modes and gives recommendations for the use of such indicators as an integral part of safety programmes both at the EU and national levels.

1.2 Study objectives

The main objectives of the study are:

- **To explain how and why transport safety performance indicators can be used as one element of a rational safety management system, and give examples of the use of such indicators as part of a safety programme;**
- **To give an overview of transport safety performance indicators that can be used in addition to crash records to monitor safety trends and assess safety problems in all modes of transport;**
- **To describe in general terms the causal relationship between each of the transport safety performance indicators and safety outcomes such as the number of crashes or crash severity;**
- **To survey the current use of road safety performance indicators in Europe; and**

- **To outline best practice in the use of transport safety performance indicators, by identifying the most important indicators and briefly outlining how to collect and present data referring to these indicators.**

At the outset, some definitions will be given to clarify some of the key concepts and terms used in this report.

1.3 Definitions

Definitions of some key concepts are given in Table 1 and are briefly discussed below. The terms "crashes" and "accidents" are used interchangeably in the report.

Table 1: Definitions of key concepts

Safety performance   **Changes over time in the level of transport safety, with a reduction in the number of accidents or the number of killed or injured people defined as an improvement in safety performance**
Safety performance indicator   **Any measurement that is causally related to crashes or injuries, used in addition to a count of crashes or injuries in order to indicate safety performance or understand the process that leads to accidents**
Importance of a safety performance indicator   **The strength of the relationship between an indicator and the number of crashes or severity of injuries, expressed in terms of, for example, the risk attributable to changes in the value of the indicator (see example in section 2.3)**

Transport safety can be assessed in terms of the frequency and socio-economic cost of accidents and injuries. Yet, it is clear that simply counting crashes or injuries is often an imperfect indicator of the level of transport safety. There are several reasons for this.

- **The number of crashes or injuries is subject to random fluctuations, meaning that a short-term change in the recorded number does not necessarily reflect a change in the underlying, long-term expected number.**
- **Reporting of crashes and injuries in official accident statistics is incomplete. This means that an observed change in the number of crashes could merely be a change in the propensity to report crashes to the police.**
- **A count of crashes says nothing about the processes that produce crashes (even if a longer period of time is considered). It is, to some extent, a matter of chance whether a hazardous situation or a near miss results in a crash or not. It is therefore entirely possible that conditions are very risky, but that, luckily, no accidents have occurred.**
- **In order to develop effective measures to reduce the number of accidents or the number of killed or injured people, it is necessary to understand the process that leads to accidents. Safety performance indicators can serve this end.**

For these reasons, counts of crashes or injuries need to be supplemented by other transport safety indicators. These indicators can give a more complete picture of the level of transport safety, and point to the emergence of new problems at an early stage, before these problems show up in the form of accidents. Regular monitoring of safety performance indicators improves the understanding of the process that leads to accidents. Policymakers and managers aiming for a higher level of safety need to take an interest in as many of the factors influencing safety as possible, at least those factors they are able to affect or control.

Safety performance denotes the trend over time in the number of crashes or killed or injured people. Performance is improved whenever these numbers decline - it deteriorates whenever they increase. It is important to note that trends refer to systematic changes over time, not to random fluctuations. Any indicator of safety performance should, therefore, be able to distinguish systematic changes from random fluctuations.

A safety performance indicator is any variable that is used in addition to accidents or injuries to measure changes in safety performance. Examples of such indicators will be given in a subsequent section. A safety performance indicator should be amenable to reliable measurement and should have a causal relationship to accidents or injuries. It should also be easy to understand.

This report covers all transport modes. It is, however, not meant to provide a basis for comparing safety in different transport modes. Such a comparison can be found in a previous ETSC report (ETSC, 1999a). The transport safety performance indicators that are regarded as useful will vary depending on transport mode. The place of transport safety performance indicators in a safety management system is shown in Figure 1 (LTSA, 2000).

The essential elements of a safety management system are safety measures or programmes (specific to each transport mode), safety performance indicators, measures of final outcomes, and measures of the social costs of accidents and injuries. The relevant set of safety performance indicators will vary from one mode of transport to the other. In this report, it is assumed that each mode of transport has instituted a safety management system that enables a sensible choice of safety performance indicators to be made. It is important to understand the fundamental differences between performance indicators and the deliverables of programmes and measures: these deliverables (e.g. police hours) have to result in changes of performance indicators (e.g. seat belt wearing rates).

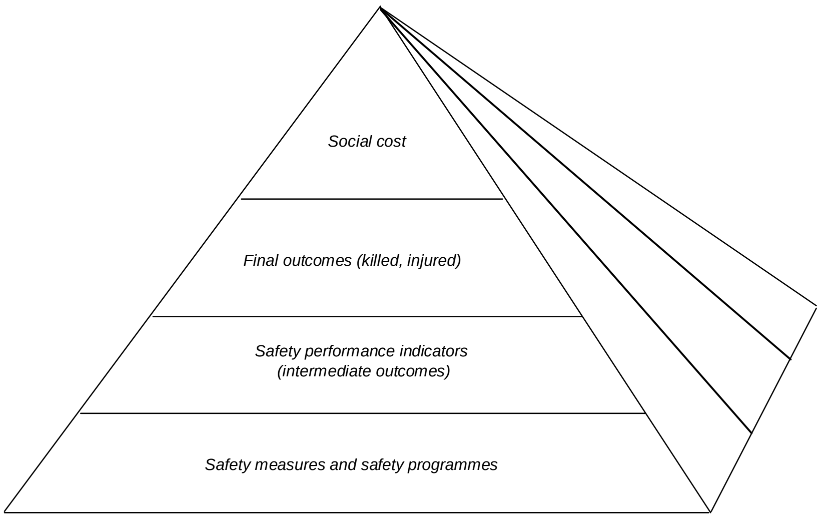


Figure 1: Essential elements of a safety management system*

* **It is not unusual for 'final outcomes' and 'social cost' to be considered together within a safety management programme as, say, accident cost rate or accident cost density.**

A large number of potential safety performance indicators exist. Not all of them are equally important. In general, the importance of a safety performance indicator can be assessed in terms of the strength of its relationship with accident occurrence and the strength of that relationship can be measured in many ways.

A useful way to show the importance of a safety performance indicator is to measure the change in accident or injury risk attributable to a certain change in the value of the indicator. The concept of attributable risk is frequently employed in epidemiological research. It denotes the size of the change in the number of accidents or injuries expected to occur if a risk factor is removed. A numerical example showing how to measure the importance of a safety performance indicator is given in section 2.3 of the report.

1.4 Framework for safety performance indicators

The role of safety performance indicators as monitors of changes in safety can be explained by reference to a conceptual model of transport safety policymaking shown in Figure 2.

(Targeted) safety programmes

↓

Safety measures implemented

↓

Operational conditions of transport production (performance indicators)

↓

Consequences of operational conditions (accidents) ↔ social costs

↑

Safety targets (policy intentions)

Figure 2: The role of transport safety performance indicators in transport safety policy making

Starting with targeted safety programmes, which are programmes aimed at achieving a specified improvement in safety performance, a set of safety measures are implemented. The measures that are implemented result in certain operational conditions of transport production. These operational conditions are influenced by a broad set of environmental and societal factors, not just the safety measures. The term 'operational conditions' comprises measures of operator behaviour, but is also intended to include indicators of the technical condition and quality of the infrastructure and the vehicles used. Safety performance indicators will often refer to aspects of operator behaviour within a certain transport system, but need not be limited to this. Safety performance indicators are always needed in a targeted safety programme, but are useful even if no such targeted programme has been adopted. An example of the use of safety performance indicators in a targeted road safety programme is given in section 2.7.

The operational conditions of transport production result in a certain accident rate and number of casualties. These numbers are compared to safety targets, in order to monitor progress in achieving them. There is, at least ideally speaking, a close interplay between safety targets and targeted safety programmes (OECD, 1994). These two components of transport safety policy ought to be mutually adjusted to each other, in the sense that targeted safety programmes contain the measures that

are needed to realise safety targets, while the targets have been set with a view to what it costs to realise them.

The description of safety performance indicators in this report refers to the conceptual model in Figure 2. It will, however, not discuss all the other elements of this model in detail. The model is intended only to show the role of safety performance indicators in a wider context and serve as a framework device for identifying important safety performance indicators.

1.5 Treatment of different transport modes

Road transport represents by far the greatest transport safety problem in all European countries with around 90% of all transport accident fatalities occurring in road transport (ETSC, 1997). The main emphasis in this report has therefore been put on road transport, although reference has been made to all transport modes.

There is a long tradition for using safety performance indicators in other transport modes, particularly aviation. Most airlines keep a detailed record of "events", or irregularities of various kinds, that are used to monitor performance and set targets for improving it. These records are normally not made public, but are often used in internal safety audits and in education of new staff. The comparatively few serious accidents that do occur in aviation are often investigated in depth by public inspectorate bodies or national accident investigation boards. These bodies try to determine the causes of each accident, and normally propose a number of measures that can be taken to improve safety. The use of in depth accident investigations in aviation, rail transport and maritime transport differs from road transport, in which very few accidents are investigated in depth (ETSC, 2001).

Moreover, the level of professionalism of transport operators differs greatly between road transport, on the one hand, and all other modes of transport, on the other. Not everybody can become an airline pilot, but everybody is allowed to use public roads as a pedestrian or cyclist, and the majority of the adult population in Europe holds a driving licence. Road users can decide freely where they want to go, when to travel, and which means of transport to use. Pilots flying commercial aircraft, on the other hand, are normally operating in controlled air space and have to follow the orders given by a traffic control centre that monitors all air traffic in a certain area.

In short, there are fundamental differences between road transport and other modes of transport with respect to the regulatory regimes to which individual operators in the system are subjected. Hence, no attempt has been made in this report to standardise safety performance indicators across transport modes. The selection of safety performance indicators has to be made within each transport mode.

2. ROAD SAFETY PERFORMANCE INDICATORS

2.1 Principal road safety problems in the European Union

The international best practice reviews which ETSC has carried out since 1993 indicate that despite some differences in levels of motorisation, the road safety problems in most Member States have many similarities. The key problems are as follows:

- **Excess and inappropriate speed is widespread**

One of the most important challenges is how to reduce excess and inappropriate speeds. Speed is a key element in determining injury outcomes for road users in crashes. For example, in pedestrian impacts with cars:

-at 60 km/h, most pedestrians do not survive the impact;
-at 45 km/h, many pedestrians are seriously injured and almost half are killed;
-but at 30 km/h very few pedestrians are killed and most injuries are minor.

The lack of compliance with speed limits (excess speed) is widespread across the EU. Surveys in various Member States show that around two thirds of drivers exceed the speed limit on urban 50 km/h roads and half exceed the limit on single carriageway rural roads. Better speed management across the EU which reduces average speeds by 5 km/h has the potential to prevent over 11,000 deaths and 180,000 injury accidents annually.

- **Many accidents result from excess alcohol**

Despite the significant reductions experienced by different countries over the last 15 years, many accidents still result from drinking and driving. While a small percentage of drivers drive with excess alcohol, they are responsible for at least 20 per cent of the serious and fatal traffic injuries in the EU - some 9,000 fatalities per year. A minor reduction in drinking and driving above the legal limit would make a large contribution to the improvement of road safety. Epidemiological research does not support a legal limit for a blood alcohol level above 0.50 promille.

- **The accident risk of young novice drivers is too high**

Road accidents are the main cause of death of young people. Research demonstrates that the combination of youth and inexperience in driving are two significant factors in determining accident risk. Most of the 15-24 year olds killed in EU traffic (over 10,000 in 1998) die in the first year after obtaining a driving licence. Young and inexperienced drivers also have a higher risk of accident involvement after drinking alcohol.

- **The accident risks of pedestrians, cyclists, moped riders and motorcyclists are too high**

For EU countries, pedestrians have a nine times, and cyclists an eight times, higher death risk than car occupants. The death risk for motorcyclists is 20 times that of car users.

- **Non-use of protective equipment such as seat belts and crash helmets**

The use of seat belts in motor vehicles and crash helmets by motorcyclists reduces the risk of serious and fatal injury by almost half. Despite EU legislation on seat belt use, usage rates vary considerably between Member States, with low rates in the front seats in some countries and low rear restraint wearing rates in general. ETSC has estimated that if the lower seat belt wearing rates were brought up to the best rate which has been achieved internationally at any one time, then around 7,000 lives could be saved annually in EU countries. Eighty per cent of the 7,000 motorcyclists and moped riders killed annually in the EU sustain fatal head injuries. Crash helmets have the potential to reduce the incidence of fatal head injuries by 50 per cent.

- **Unforgiving vehicles and infrastructure**

Recent research suggests that vehicles gaining a higher ranking during EuroNCAP tests produce approximately 30 per cent less fatal and serious injuries than low-ranked vehicles (Lie and Tingvall, 2000). Roadside design and the design and siting of street furniture also have a key role to play in reducing injury in the event of a roadside collision. In many Member States, a high proportion of severe accidents involves vehicles leaving the road and collisions with roadside obstacles, especially with trees.

2.2. Road safety problems and potentially relevant safety performance indicators

A large number of factors contribute to road accidents and injuries. Road user behaviour and their physical vulnerabilities figure prominently among these factors.

There are many aspects of road user behaviour that influence the number of accidents. Consequently, a large number of safety performance indicators are available for road transport. Some aspects of road user behaviour that could function as safety performance indicators include:

- **Speeding, with respect both to (a) mean speed, (b) speed variance, and (c) percentage of speed limit violations;**
- **Percentage use of seat belts and child restraints;**
- **Percentage use of crash helmets;**
- **Incidence of drinking and driving;**
- **Failure to stop or yield at junctions or at pedestrian crossings;**
- **Inadequate headways – close following;**
- **Use of daytime running lights;**
- **Use of reflective devices, especially for cyclists and pedestrians; and**
- **Use of pedestrian crossing facilities (by pedestrians).**

At the same time, road and vehicle engineering can have a large influence on accident and injury reduction, by influencing behaviour and by offering crash protection. In addition to behavioural safety performance indicators there are engineering indicators:

- **Pavement friction, especially in winter and on wet road surfaces;**
- **Percentage of new cars with the top star rating in the European New Car Assessment Programme (Euro-NCAP);**
- **Percentage of technically defective vehicles; and**
- **Percentage of road network not fulfilling safety design standards**

Indicators of the quality of emergency medical services can be added to this list.

The most commonly used safety performance indicators for road transport in Europe are speed measurements, surveys of the use of seat belts and crash helmets, and surveys of the incidence of drinking and driving.

However, the degree of detail of these performance indicators varies considerably. In some countries, only a few general indicators are used and in some others, more systematic approaches are followed. In addition, the different methodologies used for the estimation of these performance indicators limit considerably the comparison between the European countries. Table 2 lists road safety performance indicators used in some European countries as of December 2000. It is evident that there are great differences between countries.

In view of the large number of potentially relevant safety performance indicators for road transport, a selection of a small number of important indicators has to be made. The next section proposes a basis for assessing the importance of a road safety performance indicator.

Table 2: Road safety performance indicators used in selected European countries (as at Dec 2000).

	A	F	FIN	GR	NL	N	S
Mean speed of traffic at selected points							
Speed variance							
Incidence of exceeding speed limits							
Percentage use of seat belts							
Percentage use of crash helmets							
Incidence of drinking and driving							
Incidence of red light running							
Failure to stop or yield in junctions or at pedestrian crossings							
Inadequate headways – close following							
Use of daytime running lights							
Use of reflective devices, especially for cyclists and pedestrians							
Use of pedestrian crossing facilities (by pedestrians)							
Detection distances, for example to traffic signs							
Pavement friction, especially in winter and on wet road surfaces							
Percentage of new cars with four stars in the Euro-NCAP							
Percentage of technically defective vehicles							

2.3 Assessing the importance of a road safety performance indicator – the notion of attributable risk

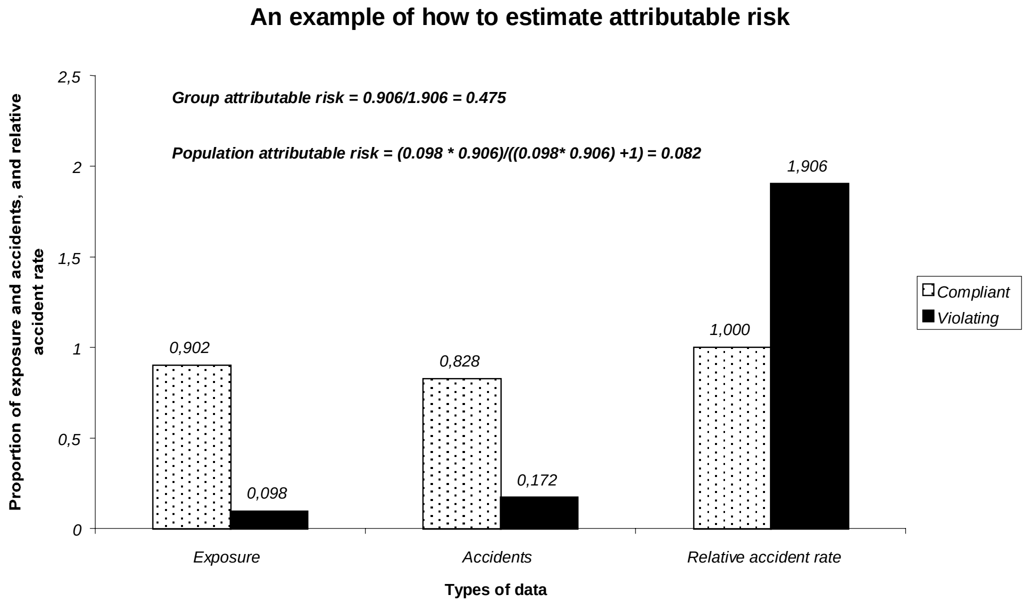
Any list of road safety problems is likely to contain problems that partly overlap one another, and that differ in their importance in contributing to accidents. Briefly stated, a road safety problem is important if it makes a major contribution to accidents, less important if it makes a minor contribution.

It is possible to measure the importance of a certain road safety problem in contributing to road accidents and this measurement can serve as the basis for selecting important road safety performance indicators. One of the basic notions of epidemiology is that of *attributable risk*, also known as etiologic fraction (Kleinbaum, Kupper and Morgenstern 1982). Attributable risk is simply the proportion of accidents or injuries that is attributable to a certain risk factor, or – to put it differently – the size of the reduction in the number of accidents or injuries that would be achieved by removing the risk factor.

Attributable risk is generally expressed as a fraction and can take on values in the range from 0 to 1. A risk factor is any factor that, all else being equal, increases the probability of sustaining an accident or worsens the severity of injuries. Road user behaviour is generally recognised as an important risk factor. To illustrate the

concept, consider the case of traffic law violations. One possible safety performance indicator is the incidence of traffic law violations. Spolander (1997) compared the accident rate of drivers convicted for traffic law violations to the accident rate of drivers who had not been convicted of traffic law violations. Figure 3 shows one of the results of his study.

Figure 3: The risk attributable to traffic law violations committed by male car drivers in Sweden. (Source: Spolander 1997).



Starting with exposure, traffic violators made up 9.8% of all kilometres driven (as a car driver). They were, however, involved in 17.2% of injury accidents. If the accident rate for drivers complying with the law is set equal to 1.0, the relative accident rate for the violators becomes 1.906. If this excessive risk were eliminated, the accident rate of the violators would drop by 0.906/1.906 = 47.5% (0.475 as a proportion). This is the group attributable risk for the group of traffic violators. Traffic violators make up 9.8% of all drivers. Hence, their contribution to the total number of accidents, referred to as population attributable risk, is:

$$(0.098 \cdot 0.906)/((0.098 \cdot 0.906) + 1) = 0.082$$

This can be interpreted as the size of the reduction of the number of accidents that could be accomplished if traffic violations were eliminated, but traffic violators continued to drive the same number of kilometres as before, while complying with the law. It comes to an accident reduction of just over 8%.

The larger the potential reduction of the number of accidents, or the number of killed or injured road users that can be accomplished by eliminating a certain type of unsafe road user behaviour, or by correcting a certain deficiency in the design of the road traffic system, the more important is this aspect of road user behaviour or system design as a safety performance indicator. An example of an analysis of the importance of a number of factors contributing to road accidents is given in a recent report by Elvik and Amundsen (2000).

2.4. Functional requirements for road safety performance indicators

This report defines a transport safety performance indicator as a 'measurement that is causally related to crashes or injuries, used in addition to a count of crashes or injuries in order to indicate safety performance'. The interest is in the relationship between performance indicators and types of crashes, and not in relationships at the level of individual crashes. Furthermore, that a performance indicator can be influenced by interventions and, more importantly, that in a road safety policy a proposal is made to reduce the risks of a certain types of crashes (see also 1.4).

Another possibility is to use performance indicators to characterise the safety quality of (components of) a road transport system: the compliance of a present situation with a standard (manual) or a law, for example how a certain section of the road complies with a design standard or guideline. Audit techniques can be used to compare actual performances with a 'norm' and to assess differences between these.

As indicated before, the process of establishing a performance indicator starts with determining a causal relationship and expressing this relationship in a quantitative sense. This needs to be based upon well-documented and well-known research results. It is, consequently, not necessary that in each country similar causal relationships are laid down if the possibilities for generalisation to national conditions are ascertained. The European Commission is considering launching a Road Safety Information System and this type of research result should be incorporated in this information system (CEC, 2000).

As a next step, a road transport safety problem has to be transformed into an indicator. All principal safety problems should result in a comprehensive system of safety indicators. To illustrate this: in most countries there is interest in driving speed in relation to road safety. Here two indicators are of importance: driving faster than the legal limit (excessive speed), and secondly, driving too fast for the conditions (inappropriate speed) (ETSC, 1995). The first indicator is not very complicated to measure: standard methodologies related to sampling have to be applied. The second indicator requires interpretation of 'inappropriate', which requires expert judgement.

Obviously, a measuring protocol must be designed with an indication as to how measurement should be carried out, and thereafter, the time intervals for that measurement.

The formulation of 'targeted road safety programmes' and, in particular, the formulation of quantitative targets, are not only based on a future aspiration to eliminate a certain type of crash or at least to reduce its risk, but also on the efforts foreseen to reach such a target. Consequently, these will also be based on a 'baseline measurement'. For example, to reach seat belt wearing rates of 95% will require a different approach with a baseline of 40% to that of 75%. In other words, target setting, targeted safety programmes, using safety performance indicators and feedback mechanisms are an essential part of rational decision-making in transport safety.

In summary, the following steps are identified for defining and measuring performance indicators in the framework of transport safety policy:

1. Establish a causal relationship between crashes and a potential performance indicator;
2. Assess the policy relevance of a potential performance indicator;
3. Define a potential road transport safety problem as an indicator or set of indicators;
4. Define the results of step 3 in a measuring protocol per performance indicator;
5. Define a performance indicator measuring programme;
6. Carry out the measurements;
7. Compare results of 6 with 'targeted road safety programmes', if appropriate;
8. If possible, verify/validate the assumptions formulated in step 1;
9. Based on the outcome of step 6, modify a 'targeted road safety programme'; and
10. Report on the results of this whole process, e.g. annually.

2.5. Measuring protocols for road safety performance indicators

A measuring protocol shows in detail which data and the frequency with which they will need to be collected. The frequency (for example: once a month, once a year, etc.) is on the one hand based on content and in accordance with policy requirements and on the other hand on the practical (financial) possibilities for data compilation. In this framework, data are needed to make longitudinal or time-series analyses possible. A performance indicator must, in the first instance, be observed over a certain period of time to determine changes in performance. Thereafter, the causes of the established changes in performance should be explained, preferably, by using monitoring information on implemented safety interventions.

A good and well-known example of this sort of protocol is the data compilation in the Australian State of Victoria that showed casualty reductions following large scale police enforcement and information campaigns on drinking and driving and speeding. (Cameron et al, 1995). The data compilation (in this case monthly measurements!) was an essential element of the policy and agreements made beforehand. It enabled valid and reliable statements on programme effectiveness and facilitated early feedback to the public.

It is recommended that actors who are responsible for road transport safety policy carry no responsibility for the interpretation of performance indicator measuring, but that this is carried out independently. A kind of 'masterplan' for a whole jurisdiction (EU, country, region) can be helpful and leads to more efficient use of resources. Furthermore, it is recommended for efficiency reasons that existing data collections are incorporated as much as possible.

2.6. Reporting and communication

Working with performance indicators increases the understanding of policymaking authorities of the effects of their policies. Experiences in some EU Member States show that policymakers using performance indicators are more engaged with their policies if performance indicator-data are reported to them regularly.

A comprehensive set of performance indicators should give a full and accurate picture of road safety in a specific country or region, beside the results of the (official) registration of crashes. Should it be decided to formulate a quantitative target for road transport safety policies and, leading from this, to define targeted

road transport safety programmes, then performance indicators need to be measured and analysed periodically. In this regard, the preparation and public dissemination of annual reports is recommended. This could take place in parallel with the publication of the most recent crash figures. It is also possible that performance indicator reports are reported after the publication of recent crash figures has taken place, allowing understanding of certain developments in crashes using data on performance indicators. Another type of reporting on performance indicator data could be in the framework of evaluation studies on certain road safety programmes.

This approach seems to be appropriate for EU Member States as well as for the European Commission. The added value for the Commission lies in a harmonised and comprehensive system of road transport safety performance indicators allowing the Commission to use these data for their own policies and to offer Member States a valuable mirror for their own 'performance'.

2.7 An example of the use of safety performance indicators in a safety programme

The Swedish national road safety programme for the period 1995-2000 provides an example of how transport safety performance indicators can be used in a targeted safety programme. In this programme, eleven policy objective were defined:

1. **Higher valuation of road safety**
2. **Improving the urban traffic environment (road design and traffic control)**
3. **Improving the rural traffic environment (road design and traffic control)**
4. **Improving visibility (target was 60% use of pedestrian reflective devices by the year 2000)**
5. **Improving vehicles (better crashworthiness)**
6. **A higher use of seat belts, child restraints and airbags (target was 95% use by the year 2000)**
7. **A higher use of bicycle helmets (target was 80% use by the year 2000)**
8. **Fewer speed limit violations (target was 35% reduction by the year 2000)**
9. **Less drinking and driving (target was 27% reduction by the year 2000)**
10. **Fewer other violations of road traffic law (target was 50% reduction by the year 2000)**
11. **More effective rescue services and medical care**

For each policy objective a performance indicator was developed. Table 3 summarises the definitions given for the different indicators and the progress made by 1998 in realising them.

The indicators refer not only to road user behaviour, but also to the design of roads, vehicle crashworthiness and the quality of emergency medical services. Secondly, precise, and in most cases quantified, targets have been set for desired changes in the values of the safety indicators. Thirdly, a system for annual monitoring of progress has been set up for most of the indicators. Finally, the progress that has been made varies substantially from one indicator to another. As of 1998, the target set for a reduction in drinking and driving was the only one that had been fully realised.

Realising the target set for speeding (to reduce the proportion of driving at illegal speeds from 50% to 32.5%) has been estimated to reduce the number of road users killed by 28%. Increasing the wearing rate for cycle helmets from 15% to 80% is expected to reduce the number of fatalities by close to 3%. In other words, monitoring speeding is substantially more important for road safety than monitoring helmet wearing among cyclists.

Table 3: Road safety indicators in Sweden and progress in realising them by the end of 1998 (Vägverket 1999)

Policy reform	Indicator	Target for the year 2000 compared to the situation in 1994	Results achieved by 1998 compared to 1994
Valuation of road safety	Percentage of the population who regard road accidents as a public health problem	+30%	No measurements have been made
Drinking and driving	Percentage above the legal BAC limit in police checks	-27%	-40%
Speeding	Percentage of all vehicle kilometres of driving exceeding speed limits	-35%	No change
Other violations	Percentage of vehicles following too closely	-50%	No change
Safer urban traffic environment	Proportion of streets that do not satisfy safety standards	Reduction	No change
Safer rural traffic environment	Proportion of rural roads that do not satisfy safety standards	Reduction	No change
Use of protective devices in cars	Percentage of car occupants using safety devices	95%	No change
Safer cars	Index for crashworthiness	+12%	No measurements have been made
Visibility in traffic	Percentage of pedestrians and cyclists using reflective devices	60%	No measurements have been made
Use of cycle helmets	Percentage of cyclists wearing helmets	80%	18% wore helmets in 1998
Emergency medical services	Average response time from alarm to treatment; knowledge of first aid	Shorter response time; improved knowledge of first aid	No change

The safety benefits that may be achieved by realising all policy reforms shown in Table 3, in terms of a reduction of the number of road accident fatalities, can be summarised as follows:

- **Less drinking and driving: -3%**
- **Less speeding: -20%**
- **Fewer other violations: -14%**
- **Safer urban traffic environment: -3%**
- **Safer rural roads: -9%**
- **Increased use of protective devices in cars: -6%**
- **Improved visibility in traffic: -0.3%**
- **Increased use of cycle helmets: -2%**

- **Improved emergency medical services: -3%**

In estimating the contribution to improved safety from each of the policy reforms, it is acknowledged that the effects of these reforms overlap with respect to the types of accident or injury they influence, and hence cannot be added. Their combined effect is a 60% reduction of the number of road accident fatalities (Andersson et al 1998).

3. ROAD TRANSPORT - CURRENT PRACTICE

3.1 Road user behaviour

3.1.1 Traffic behaviour monitoring systems as safety performance indicators

Sweden is one of several countries in Europe to have recognised the importance and potential benefits of creating safety performance indicators and systematically monitoring driver behaviour. Such monitoring of traffic behaviour is also carried out in Finland, France, the Netherlands, the UK and USA amongst others. Repeated measurements on a regular basis enable the assessment of traffic behaviour trends within the surveyed area and the impacts of countermeasures applied. The data are usually collected and analysed under the supervision of a national research institute or a governmental statistical body.

There is evidence from several EU countries, e.g. Finland and the Netherlands, that time series of behaviour indicators, accompanied by relevant studies, serve as background for the evaluation and development of safety measures such as tackling drink driving or speeding.

3.1.2 Speed

Speed is an important influence factor in road safety; managing excessive and inappropriate speeds will increase safety. The higher the speed, the shorter the available time to prevent collisions, and the more severe are the results of a collision. Accidents seldom have just one cause; there is usually a conjunction of circumstances that cause an accident. Speed is very often a crucial factor.

3.1.2.1 The quantitative relationship between speed and accidents

Many studies give indications about the relationship between speed and accidents. One study summarised various projects in Europe to assess the effects of raising and lowering the mean speed on accidents. The changes were established in various ways and under various circumstances (Finch et al., 1994). From these results, it can be derived that, as a rule of thumb, an increase of 1 km/h in the average driving speed leads to a 3% increase in the number of accidents. On the other hand, a reduction of 1 km/h leads to a reduction of 3% in the number of accidents.

Greater effects were found for serious accidents. A change of 1 km/h in the average driving speed leads to a 5% change in the number of fatal accidents.

3.1.2.2 What is the most appropriate indicator for speed?

In several countries, the actual speeds driven by motor vehicles are measured. This can be monitored systematically and is known to be related to road safety. Examples of this are given in the following section.

Sometimes, speed limit offences as detected by the police (relative to the number of vehicles checked) are regarded as an alternative measurement. This, however, has clear restrictions regarding the comparability of results, because the results are strongly influenced by the enforcement strategies of the police.

Also considered, sometimes as a cheap alternative, are data on self-reported speeds. These are influenced by individual norms and values with respect to speeding. Additionally, it is not known to which situation the answer refers (e.g., ‘which speed do you normally drive inside urban area’ neglects differences in road types and traffic conditions). Self-reported behaviour is difficult to interpret and is not recommended as a performance indicator.

3.1.2.3 Speed: Selected examples from speed behaviour monitoring systems from Finland, France and the Netherlands

Finland. The speed monitoring system maintained by the Finnish Road Administration comprises about 250 sites throughout the country. The data provided by the system enable both the road authorities and the police on a national and a local level to direct their activities. The public also has access to real-time speed monitoring through the Internet, provided suitable PC software has been installed (http://www.tielaitos.fi/alk/index.html).

Vehicle speeds categorised by vehicle class (passenger car, van, bus, truck) may be described by means of various parameters such as:

- mean speed
- 15^{th}, 85^{th} percentile speeds (or some other percentile)
- variance or the standard deviation of speed
- proportion of speeding vehicles (e.g. all speeding vehicles, speeding > 10 km/h, > 20 km/h and > 30 km/h)

Parameters chosen for the description depend on the task at hand. The system also produces time-gaps of vehicles and, at some sites, the weight of a vehicle by means of the WIM-system (Weigh in Motion).

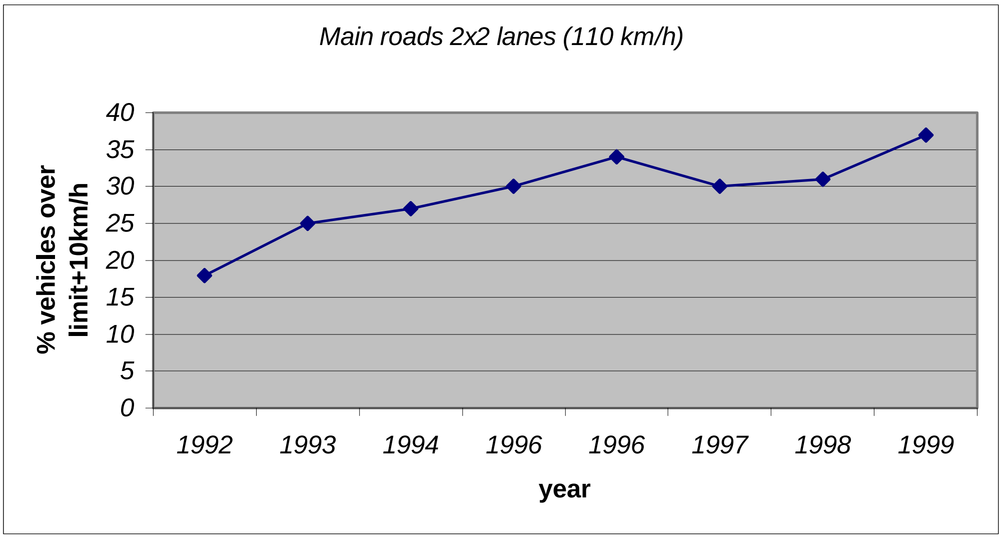
The data on speed are collected and analysed in several ways. For the set of traffic safety performance indicators created by the Central Organisation for Traffic Safety (Liikenneturva), 'speed' data are processed as monthly mean speeds in dry weather and at different times of day (with different traffic volumes).

France. A permanent monitoring board called the National Board of Behaviour Measurement (ONISR/ISL) has been operating nationally since 1972. At this time, police enforcement campaigns focused on speed limits on interurban roads and motorways, the wearing of seatbelts by front occupants and on compulsory helmet wearing for two wheelers. The system comprises a representative sample of sites classified by road category that are regularly used for observing and measuring traffic behaviour.

The current programme is based on quarterly roadside surveys. The aim of the programme is to monitor the speed behaviour of car drivers. Speed monitoring is the only measurement tool specifically built for estimating the development of mean speeds and speeding. Speed measurement data are processed as average speeds, standard deviations, and proportions of speeding. The grouping of data are, amongst others, by type of road, type of vehicle and weather / luminosity conditions.

The Institute of Survey (ISL) is responsible for the whole implementation of the project including the analysis of data and reporting the findings on a quarterly and annual basis. The implementation is monitored by the research institute, INRETS.

Figure 4. The percentage of vehicles exceeding the 110 km/h speed limit on dual carriageways by 10 km/h or more.



The Netherlands. The Dutch government recognises the need for uniform and comparable information on which to base their speed management policy. The implementation of traffic safety policy is now decentralised and there is an increasing need by regional agencies for systematically compiled information to formulate and amend policy.

In the mid-nineties a speed-monitoring system was set up in all 12 provinces in the Netherlands, organised by the Institute for Road Safety Research (SWOV) on behalf of the Ministry of Transport. The information collected is used for both national and regional policy on speed control. From the results, the provinces gain an insight into the seriousness of speeding on different types of road falling under their jurisdiction. Tracking changes in driving speed and traffic accidents over time is central to this and the monitoring network offers a worthwhile tool for assessing the effect of police surveillance on driving speed.

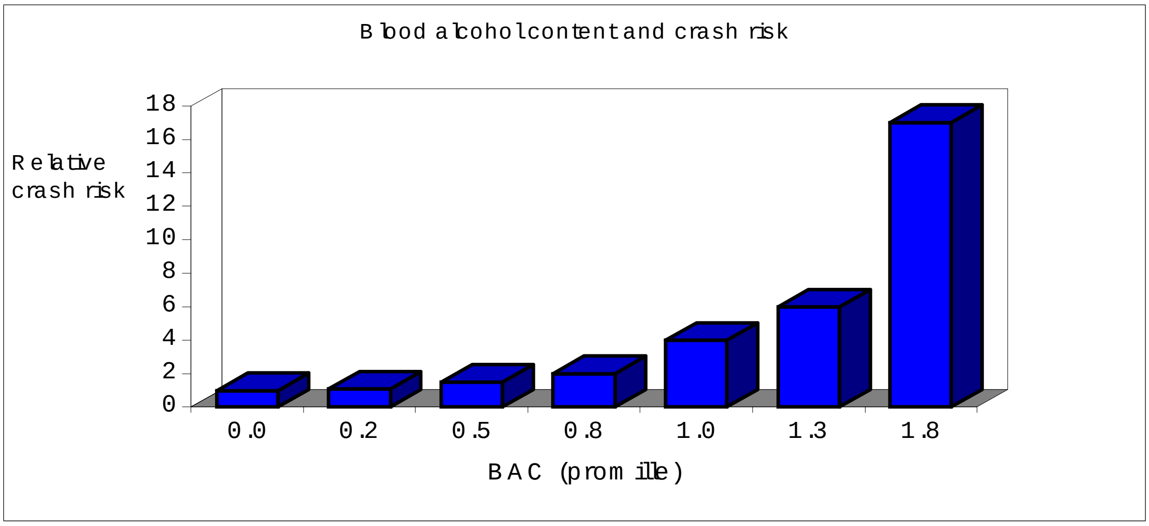
The Dutch speed monitoring system collects data at approximately 400 locations divided by road category. Monitoring locations from earlier years, where the road characteristics have remained the same, are included in the sample survey to further the comparability of data over the years. For motorways, such a system has been operational nationally since 1988. National data are published monthly.

3.1.3 Drinking and driving

3.1.3.1 The quantitative relationship between alcohol and road accidents

Alcohol use is one of the few single factors that have a strong and direct relationship with the incidence of road accidents resulting in death or severe injury. Alcohol risk increases with rising alcohol consumption, as is show in Figure 5, and is present even when small amounts of alcohol have been consumed.

Figure 5. Blood alcohol content and crash risk.



(adapted from: R. F. Borkenstein et al, 1974.)

3.1.3.2 What is the most appropriate indicator for alcohol in road traffic?

The rationale here is similar to that given previously on speed indicators.

In most countries the blood alcohol content levels of road users are measured and monitored on a systematic basis.

Sometimes the excess alcohol offences as detected by the police (relative to the number of drivers checked) are regarded as an alternative measurement. This, however, clearly limits comparability, as the results are strongly influenced by the enforcement strategies of the police.

Self-reported use of alcohol before driving is occasionally regarded as a cheap alternative. This is largely determined by individual norms and values with respect to drink driving and therefore self reported behaviour is difficult to interpret.

3.1.3.3 Selected examples of monitoring drinking and driving in Finland, France, the Netherlands and United Kingdom

***Finland.* The risk of being caught for drink driving has increased considerably since 1977, when the police were first empowered to carry out random breath testing and**

were equipped with pocket-size breath analysers. The number of breath tests increased in parallel with the number of testing devices. The number of tests exceeded 0.5 million in 1985, the figure doubled over the three following years and has now stabilised at about 1.4 million tests, about 40 per cent of drivers, annually. The number of those caught for drunken driving has more than halved during the past ten years. The overall positive trend is obvious when evaluating the figures and the results of roadside breath testing studies (Mäkinen and Veijalainen, 1997).

The police use regular and comparable data on the proportion of drink drivers in the traffic flow to monitor the progress of enforcement. Since 1979, the police, together with the National Health Institute (Kansanterveyslaitos), have carried out scientific monitoring tests, which produce:

- **the number of tests carried out by type of testing method;**
- **the proportion of drivers under the influence of alcohol in the traffic flow; and**
- **the proportion of drivers under the influence of alcohol involved in serious traffic accidents.**

France. **Annual figures of drink driving convictions by the courts have been systematically collected since 1992 by the Statistics Department of Justice and published in the annual traffic safety report of ONISR. Detailed annual series of statistics on penalty types and lengths allow the measurement of severity and trends in drinking-driving punishment through time (when associated with accidents or spotted by random breath testing). There is no annual project for systematically evaluating the effects on behaviour and rates of alcohol related accidents on the increasing number of drinking and driving convictions (25% of criminal courts sentences) and prison penalties. There is only a periodic monitoring carried out by INRETS. The monitoring shows no effects of the increased conviction numbers on alcohol related accidents (Jayet, 1994, 1995; Jayet and Biecheler 1997).**

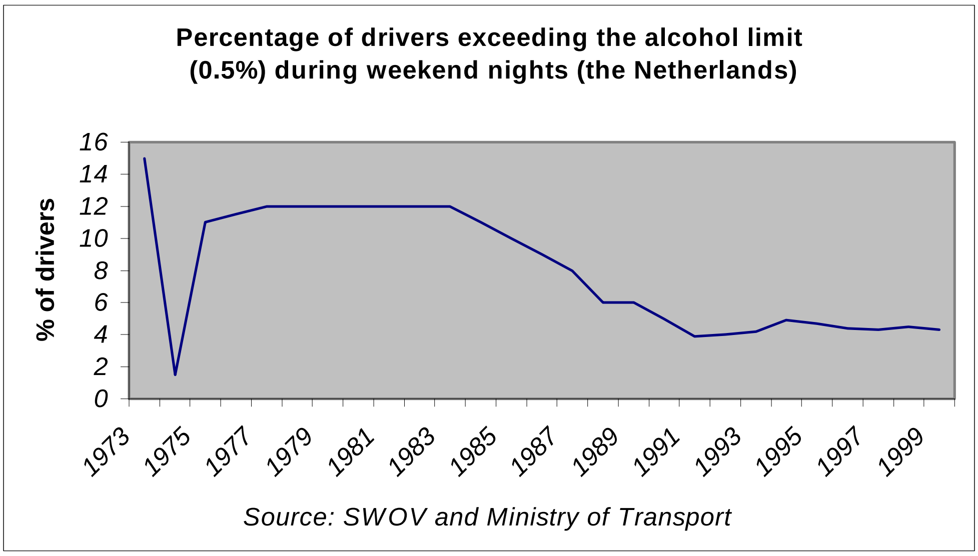
United Kingdom. **The techniques for carrying out roadside surveys of drink driving have been developed and were used in the early 1990s but not since. For example, in 1990, a roadside survey was conducted during the summer, on Thursday, Friday and Saturday nights, between 7 p.m. and 2 a.m., throughout England and Wales, on randomly selected drivers (Clayton & Everest, 1994). More than 13.5 thousand drivers were approached. Later, the Government firmly rejected proposals for random breath testing (RBT), despite the widespread support amongst MPs, road safety professionals and the wider public, arguing that the police resources would be put to better use if targeted at those whose behaviour gave reasonable grounds for suspicion of drink-driving.**

As breath tests are widely performed in the United Kingdom and their results are regularly reported (e.g. Wilkins & Addicott, 1999), these can be considered as a substitute for roadside surveys for monitoring drink-driving in the country. The police conduct the breath tests and their results, i.e. positive and negative numbers, are reported to the Government Statistical Office. The latter estimates annual figures of total number of tests, percentage of positive/refused tests and their distribution by month and by police force area; the outcomes are also presented per 100,000 area population.

The Netherlands. **Since 1970, the trend in alcohol consumption by drivers of private cars and delivery vans has been analysed by SWOV[1] using a standard research method to monitor drink-driving behaviour. Every year, almost 25,000 motorists are tested at random by the police in selected research areas and at chosen research sites. Since the tests are conducted by the police, an almost complete response from the test subjects has been achieved. The research is conducted on Friday and Saturday nights between 22.00 and 04.00 during the autumn. The subjects are, for the most part, drivers on main roads within urban areas.**

The main trend is represented in the following graph, which clearly shows the introduction of a legal alcohol limit in 1974 and the improvement of enforcement since the eighties:

Figure 6. Percentage of drivers exceeding the alcohol limit during weekend nights



By using a standard research method, not only are time comparisons possible, but also comparisons between geographical regions, areas with different degrees of urbanisation, Friday and Saturday nights, times of the night, the place they come from, and groups of drivers with different demographic variables such as age and gender.

Shortly after measurements are taken, the police in each province receive the results from their own area of jurisdiction. This has a motivating effect. The annual research is a unique example of excellent co-operation between a research institute and the police, as recommended in many studies (e.g. ETSC, 1999b) and has led to a number of important policy recommendations.

3.1.4 The use of restraint systems or safety devices

Seat belts, airbags, head rests, child restraint systems and helmets all aim to mitigate the consequences of an accident, once it has occurred. The use of certain restraint systems is regulated by EU and national law.

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[1]. **SWOV originally organised the research on behalf of the Ministry of Transport. From 1999 onwards, the Ministry have organised the test, without changing the method and still in co-operation with the police.**

Over the years various studies have quantified seat belt effectiveness - summarised in ETSC (1996). The injury reducing effect of seat belts is around 50 per cent for fatal and serious injuries; the serious injury reducing effect of child restraints is around 90 per cent for rearward facing systems and around 60 per cent for forward facing systems.

3.1.4.1 What is the most appropriate indicator for the use of restraint systems?

In several countries the use of restraint systems by road users in traffic is systematically measured and monitored.

As mentioned previously in relation to speed, sometimes traffic offences (relative to the number of road users checked) are regarded as an alternative measurement; this however has clear limitation regarding the comparability of results, because the results are strongly influenced by police enforcement strategies.

Also, sometimes regarded as a cheap alternative, is self reported use of restraint systems. The answers are influenced by what is thought to be the desirable answer. As a consequence, self reported behaviour is difficult to interpret.

3.1.4.2 Selected examples of monitoring seat belt use in Finland, France, Germany, the Netherlands and Sweden

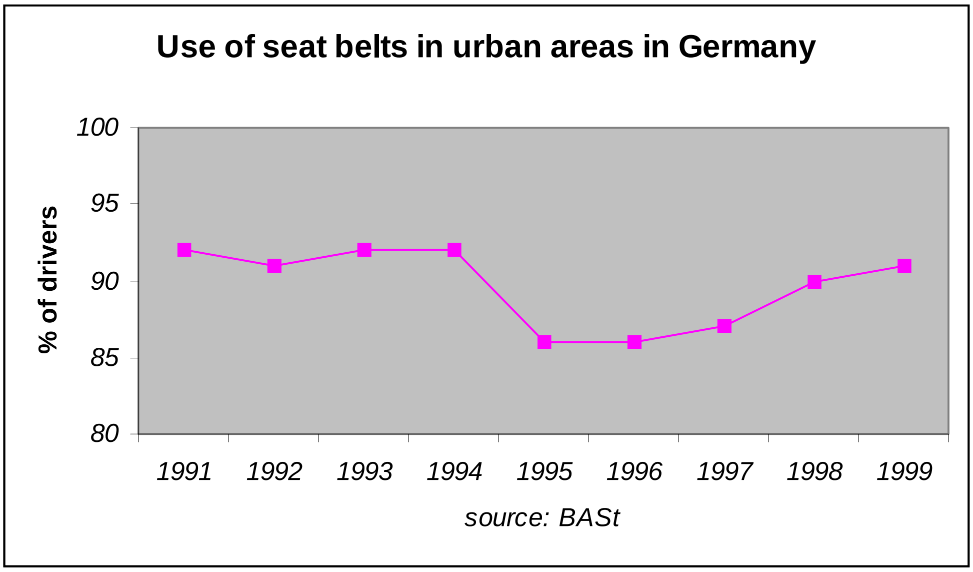
Finland. The data on seat belt usage by drivers and front seat passengers are collected for passenger cars and vans. Observation sites are situated all over the country, on highways, urban roads and on those streets not having a significant volume of through traffic. Total sample size is usually more than 30,000 observations of drivers and about 10,000 observations of front seat passengers (Sipinen & Heino, 1996). The total figure for the country is calculated by projecting the numbers of observations to the population of the provinces observed. These monitoring studies have been carried out since 1966. Seat belt usage on the rear seats of passenger cars is examined in several towns. The observer also estimates the age group of the driver and the gender of passengers over the age of six years. In 1994, the sample size was about 4,000 observations (Sipinen & Heino, 1996). Similar figures on the use of child restraints, but in rural areas, are estimated using data collected at several measuring points during the drink-driving surveillance operations by the National Traffic Police. When the police stopped a vehicle, the observer interviewed the child and marked on a form his age and use of safety belt (for school-aged children) and use of safety seat (for small children).

France. The monitoring of seat belt use, as with speed monitoring, is a part of the programme carried out by the National Board of Behaviour Measurement (ONISR/ISL). The system is based on selected sites, representative of road type, at which regular behavioural observations and measurements take place. The data are collected as quarterly samples on an annual basis and include many variables such as:

- seat belt and helmet use
- data relating to the use of seatbelts: front and rear seats and number of occupants
- data relating to the site/point of measurement, i.e. day, hour, month, luminosity, weather and pavement conditions (dry, wet, rain, etc.)
- type of vehicle

Germany. **After the stepwise implementation of the mandatory seat belt law, drivers and passengers using seatbelts, and later motorcyclists wearing helmets, and the use of child restraint systems has been routinely recorded and reported by the Bundesanstalt für Strassenwesen (BASt). These activities started in 1973. Since 1997, observations are made twice a year in six German regions, whereby a total of 18,600 cars with about 27,000 occupants are registered. Results are applied when elaborating new regulations. For example, the raising of financial penalties for improper use of restraint systems in June 1998 was based on the results of these studies. Differences can be observed between urban and rural roads; the wearing rates inside urban areas are shown in the following graph. The differences between "Old" and "New" German Federal states have been decreasing since 1993.**

Figure 7. Use of seat belts in urban areas in Germany (drivers)



***The Netherlands*. Behavioural measurements concerning protective equipment are conducted regularly in the Netherlands. Until 1999, this was organised by SWOV on behalf of the Ministry of Transport, but since 1999, the Ministry has organised the measurement itself. The aim is to monitor trends in the use of seat belts and other protective devices both at national and provincial levels.**

A sample of 48 locations at intersections with traffic lights is used to measure behaviour during the red light phase of cars and delivery van occupants. These observations are performed on four road types: motorways (at fuel stations), trunk roads, roads with mopeds and bicycles, and local roads. The observation is conducted in two ways: using the IMA ("looking in") method and the AMA ("distance") method. In the case of the IMA method, the researcher contacts the driver and asks about the presence of seat belts or child seats in the back of the car. When seat belts are present in the back seat, questions are asked about the type in

the different rear seating positions. The researcher also checks to see if all passengers are wearing seat belts, asks what their ages are and registers their gender. Where rear seat passengers in a private car are aged twelve years and above, both the driver and any rear seat passengers are given a questionnaire and requested to return it by post. Questionnaires are given to the drivers and front-seat passengers of delivery vans in the same way. With the AMA method, there is no direct contact with the driver; only seat belt use by the driver and the front passenger are observed.

Sweden. **The Swedish National Road and Transport Research Institute (VTI) reports on continuous observations of car seat belt use, which have taken place annually since 1983 (Cedersund, 1998). The observations are carried out in a number of towns in central Sweden. In 1997, approximately one day was spent at each observation site and over 70,000 vehicles were observed. Since 1995, seat belt wearing by taxi drivers and since 1996, drivers of other vehicle types such as trucks and vans have been included in the monitoring programme. A relationship between driver and passenger's seat belt use has been also observed.**

3.1.5 Conclusions

The examples above show that the need for the systematic monitoring of driver behaviour over time as a key part of policy framework has been recognised and has been standard practice in several countries for many years. Usually, monitoring has focused on a few important areas such as speeding, alcohol and seat belt use. Efforts have also been made to monitor a number of other areas of traffic behaviour.

Safety performance indicator information has been collected using different sampling and observational methods and in different ways over time. Such differences are found nationally and cross-nationally. In order to create an accurate and representative picture of traffic behaviour in Europe, a unified and standardised system of safety performance indicators is necessary. This should include speed behaviour, use of seat belts and child restraints and alcohol use in traffic.

The best features of the monitoring systems descibed above may be summarised as follows:

- **Monitoring is carried out by independent institutions on a regular basis, at least annually;**
- **Statistically stratified and representative samples are drawn to allow description of the situation at national and regional levels;**
- **Data collection methods are standardised to guarantee the quality and comparability of data over time;**
- **The data are analysed, reported and made publicly available; and**
- **The nomination of an appropriate party responsible for the scientific quality of the work.**

3.2 Road related safety performance indicators

The road network influences the probability of accident occurrence and can help to determine the level of injury severity because it determines the conditions under which road users meet. A network with a hierarchy of roads, in which the function of each road is clearly defined, is the preferred situation. Road design should match the function of a road, to enable road users to recognize it immediately and to clarify the expected behaviour of the individual and the other road users. The higher the speed, the more important homogeneity in and predictability of the road's course and behaviour of other road users are.

In general, the safety performance indicators for roads concern three groups of issues:

1. **Is there a safety norm or standard, e.g. a set of requirements for roads? If so, what is the norm or standard, and how many fatalities / accidents would be saved if the standards for safe roads were to be met?**

2. **Are there official plans to meet the norm or standard and if so, for which proportion of the road network is a plan defined for meeting the standards?**

3. **What proportion of the potential actually meets the norm or standard, or, if applicable, what is the actual value of an indicator, compared to the norm? Example: which proportion of the road network actually meets the requirements?**

If roads in a road network are not designed with a clear function in mind, road design indicators are not of real use.

There is no extensive use of indicators for the safety performance of roads, but as the examples show later in this section, several countries have started, or plan, to work with this kind of indicator.

Furthermore, some countries work with road safety audits; that means that traffic plans, road designs or existing roads are independently judged to establish whether they comply with traffic safety requirements. By doing so, eventual drawbacks are made explicit and can be better taken account of. From Denmark, the UK, New Zealand and Australia there is evidence that audits lead to better plans.

Road standards and traffic conditions differ from country to country. As a consequence, transfer of research findings from one country to another about the relationship between road networks and road designs has to be carried out carefully.

The EU DUMAS (Developing Urban Management and Safety) involves partners from nine Member States. It has been investigating the effectiveness of Urban Safety Management (USM). Road accidents in urban areas fall into one of two categories - concentrated at 'accident black sites' or 'scattered' randomly. Area-wide multi-disciplinary treatments are necessary to resolve the problem of these scattered accidents and this has led to the development of the USM method. (See the project website: http/www.trl.co.uk/dumas/ for further information.)

3.2.1 Road related safety performance indicators: selected examples from the Netherlands, Sweden, New Zealand, and Finland

- **The Netherlands**

In the Netherlands the safety principles underlying the concept of a sustainably safe road network are clearly described (Wegman and Elsenaar, 1997; Vliet and Schermers, 2000). For the whole road network, plans for the categorisation of roads according to function have to be drawn up and this process is monitored. It is estimated that low cost implementation of this classification and the ensuing changes in layout and design will reduce road fatalities by 60% (full implementation is estimated to reduce the number of fatalities by 80%).

For the first phase of implementation clear targets are formulated and plans are made for the monitoring of implementation (Start-up programme on sustainable safety, 1998):
- road classification programme (for the complete Dutch road network of more than 100,000 km road length), which enables the roads to fulfil their functions satisfactorily and forms a basis to solve the problems of contradictory design requirements;
- stimulate a low-cost introduction of 30 km/h-zones inside built-up area - an extension is agreed upon of the number of 30 km/h-zones from 10% of the possible zones (as is the case now) up to 50% by the year 2002;
- introduce by simple means a concept of 60 km/h-zones for minor rural roads - the aim is some 3,000 km of roads to be realised by the year 2002;

- if needed and possible, infrastructural measures like cycle facilities, roundabouts, small-scale measures to support 30 km/h-zones and 60 km/h-zones;
- indication of priority at every junction (outside the 30 km/h-zones) - the same priority rules for cyclists and mopeds as for motorised traffic will be introduced; and
- experiment with audits, to develop the protocol further and create support for it.

In the Netherlands, for some road types, the desired road design is specified (like forgiving roadsides on rural roads); for others, the criteria are under specification. The scientific base under the criteria can be further improved; research is in progress.

There are no separate targets formulated for safe road designs other than specified above; in general road design specifications are recommendations and not obligatory. Some monitoring takes place on a national scale.

- Sweden

In Sweden, the National Road Safety Programme for the period 1995-2000 contains at least two relevant indicators (and goals).

- The proportion of urban streets that do not satisfy safety standards must be reduced; and
- The proportion of rural roads that do not satisfy safety standards must be reduced.

Furthermore, following the principles of Vision Zero in the new Swedish programme, roads will be classified and redesigned. The following changes are assumed to be implemented, stated in a recent study of the Swedish road safety policy (Elvik and Amundsen, 2000):

- 370 km of motor traffic roads will be reconstructed to motorways; 280 km of national road with a average daily traffic of more than 8000 and a speed limit of 90 or 110 km/h will be reconstructed to 13 m roads with a wire median guard rail;
- wire median guard rail will be provided on 3,500 km of road with a width of 13 m and a speed limit of 90 or 110 km/h;
- 13,600 km of urban road with low traffic volume will be reconstructed according to the design principles for 30 km/h streets in Vision Zero;
- 9,000 km of urban road with a moderate to large traffic volume will be reconstructed according to the design principles for 50/30 streets in Vision Zero;
- 9,000 km of urban access road with very low traffic volume will be reconstructed according to the design principles for walking speed streets in Vision Zero.

- New Zealand

New Zealand's Road Safety Strategy 2010 (LTSA, 2000) states that targets will be developed that stipulate the proportions of the network that should be made to conform to certain safety performance standards.

To support the choice of the optimal intervention approach, distinct road types can be characterised by five variables.

- **road length**
- **traffic volume**
- **social cost (the aggregate measure of all costs that crashes inflict on the community, including pain and suffering)**
- **risk (social costs as proportion of traffic volume)**
- **cost density (social cost as proportion of road length)**

The intervention strategy for each road type is based on the following characteristics:

- **motorways: low risk thanks to relatively safe infrastructure but nevertheless high cost density because of the high traffic volumes; safety improvement to be obtained mainly by enforcement;**
- **state highways: high risk and high cost density, so improvement of infrastructure is required;**
- **major urban roads: high cost density; improve infrastructure to make it more suited to the large traffic volumes and improve traffic safety in that way;**
- **minor urban roads and minor open roads: high risks but low cost density because of low traffic volumes; economically hard to remedy, so treatments generally have to be simpler and less costly.**

The introduction of a Safety Management System (SMS) is considered in New Zealand; it would be a type of performance assessment of road authorities, setting out procedures for their work and rules for disclosure of information on road conditions and performance. Road safety audits are an essential part of this SMS.

- **Finland**

According to the Finnish Road Safety Programme 2005 (Finnra 1999), evaluation programmes of the safety effects of road management will be developed and maintained. [2]

3.2.2 Road safety indicators that have the potential of being internationally comparable

One indicator that is potentially suited for international comparisons is the proportion of accidents occurring at high risk sites compared to all accidents; but it would require agreement on the exact definition of high risk sites. The lower the proportion of high-risk site accidents, the better the safety performance. Some Member States, e.g. Germany, the Netherlands and the UK, have developed procedures for the analysis of stretches of roads or geographical areas (e.g. urban or residential) that present a higher accident risk.

Another safety performance indicator that can be used for comparison between countries, is the difference in risk between the least safe and the 'mean' road in each category. In the Netherlands, a similar method is being developed to support

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[2] **Of interest in this programme is the emphasis on equality of road users. From the viewpoint of effective use of resources, built-up area and main roads take precedence; however this is not considered the only criterion.**

regional road safety policy. The risk is calculated from number of fatalities (or accidents) and exposure. This indicator presupposes exposure data (kilometres driven, traffic volume). Road length could be considered instead of exposure, because exposure will in many cases not be available.

The smaller the difference between roads in a category, the more homogeneous and safe is the road network.

3.2.3 Conclusions

Indicators and targets concerning road design are, to date, only formulated in special cases where a policy plan explicitly addresses a certain measure, for example controlling traffic at junctions or installing guard rails.

It will not be easy to arrive at internationally comparable road safety performance indicators, because of differences in road types, safety policy and standards. The first need is for Member States to set up some kind of systematic evaluation of the safety of their own road network and use performance indicators to asses the progress over time.

3.3 Vehicle-related indicators

Many countries have EU and national legislation setting out safety standards for motor vehicles.

Regular vehicle inspections are set up to check compliance with some of these standards helping to prevent a substantial number of vehicle defects. In western European countries, vehicle defects are a contributory factor in only a small proportion of accidents. Although in many EU countries the results of vehicle inspections are accessible for monitoring, this is not done from a road safety perspective because of the limited association with crash causation.

While vehicle defects may play a small role in accident and injury causation, the crash protection perfomance of the vehicle is very important. In EU countries, vehicle safety policy is to a large extent European rather than national. Regulations and standards are determined in Geneva and in Brussels through the EU Whole Vehicle Type Approval System.

An important element of common action on vehicle safety is the EuroNCAP crash test programme, in which the crashworthiness of cars is tested. This programme is financially supported by the European Commission, some Member States and international consumer and motoring organisations. Based on research it is claimed that if all cars in a country earned, on average, one star more, this would lead to 12% less casualties (Lie and Tingvall, 2000).

An indicator that can be measured in all countries in a comparable way, is the frequency of number of stars for the vehicle fleet in each country. The Swedish National Road Safety Programme already explicitly mentions the crashworthiness of cars as an indicator with a quantitative target.

3.4 Trauma management related indicators

The better the post accident care by emergency services, the greater the chance of survival and, on survival, the better the quality of life.

The OECD report Safety Strategy for Rural Roads (1999) shows the importance of emergency services by pointing to studies revealing differences between the survival in serious accidents in urban and in rural areas; in rural areas relatively more people die before receiving treatment (after initially surviving the crash).

It is estimated that several thousands deaths in the EU could be prevented by optimal post impact care. (ETSC, 1999c). Further evidence comes from a UK study in which it was estimated that 12% of patients who had sustained serious skeletal trauma went on to have significant preventable disability (McKibben et al, 1992). Special trauma centres are designated for multi-trauma patients and ensure the best possible treatment.

European countries generally have norms for emergency services, but they differ over countries and over areas in a country. In Finland for instance four risk areas are distinguished, having response times from 6 to 30 minutes.

Compliance with the norms regarding response times is assumed to be assessed by special inspections; indicators for response times are generally not used in road safety programmes.

3.5 Road safety performance indicators: a proposal for best practice

Performance indicators are a vital component of a traffic safety management system. Besides some incidental attempts to work with performance indicators, it is not general practice in any Member State. For the European Union as a whole, this approach is unknown.

Every policy and management system needs to define its own indicators at local, national and international levels. However, it is strongly recommended to look for agreement on the methodology of data collection in order to create possibilities for meaningful international comparisons and common action. It is suggested that the Commission should fund an international study to define in detail this methodology and to invite Member States to follow the recommendations from such a study. This report presents initial proposals which could be developed further in this international study.

Based on research and experience of the safety policies in the European Union and its Member States, a best practice in the road transport sector has been identified in Table 4 which describes the most important performance indicators. It is recommended that this Table is used as a starting point for data collection throughout Europe.

Table 4: Best Practice Road Safety Performance Indicators

Category	Subject	Indicator	Details
Behaviour	Speed	% above legal limit	1) Representative speed monitoring has to be carried out throughout a country using a stratified sample: different vehicle classes and road categories. Actual speeds have to be compared with existing speed limits and policy targets, if appropriate. Agreements have to be made about data collection protocols.
	Alcohol	% above limit	2) To monitor drinking and driving requires a methodology by which, in a stratified sample, random tests are carried out by the police. In order to allow for international comparisons, existing data collection protocols have to be harmonised (road user, road category, measurement period, etc.). Drinking and driving behaviour has to be compared with the alcohol laws and the policy targets, if appropriate.
	Seat belts	% car occupants	3) Data on seat belt usage must make the following distinctions: drivers, front seat passengers, back seat passengers, child restraints. Observations have to give a representative picture all over the country for different road categories and for different vehicle classes.
Vehicles	Passive safety	EuroNCAP	4) EuroNCAP tests the crashworthiness of cars and a combination of the star rating in EuroNCAP and the composition of the vehicle fleet in a country indicates the quality of the passive safety of a country. Annual measurements are recommended to collect data by a European effort.
Road	Road design quality	% of roads meeting design standards	5) Many countries do have road design guidelines for different road categories. This indicator tries to assess the quality of the existing road network in the perspective of existing guidelines or standards. Per definition, international comparisons are not meaningful, because guidelines and standards differ per country. Of interest is to measure the actual safety quality and compare this with the self-induced 'reference'. Of course, this yardstick has to distinguish different road categories.
	Road network quality	% of roads fitting in road network hierarchy	6) Accepting the philosophy behind a 'functional hierarchy of roads' as a component of a road safety policy, a performance indicator has to be developed to measure the safety quality of a road network. It is recommended that such an indicator should be developed
Trauma management	Arrival time	% meeting targets or regulations/law	7) A combination of notification time and response time result in an arrival time. Emergency services, especially qualified doctors, have to reach the accident spot within a (legally established) period. A comparison has to be made between this 'target' and actual arrival times indicating the performance (compliance) of the trauma management system.
	Quality of	% meeting	8) For life-threatening accidents, a (timely) high quality medical care is of importance as is the

	medical treatment	target or regulations/law	availability of specialised trauma centres. It is recommended to develop a performance indicator for the quality of medical treatment of severe injuries. This indicator should be developed not just for road transport, but for other transport modes and occupational accidents as well.

4. OTHER TRANSPORT MODES

The marine, rail and air transport sectors are managed differently than road transport. Road transport is an open system (every citizen may enter the system and only some travel modes require some training) with many, independent actors (road authorities, enforcement authorities, different tiers of government, etc.) to manage the system. The other transport modes have professionals operating the system, a limited amount of responsible actors with a strong tradition of system management by regulations, laws and inspections. This means a different concept of the safety responsibilities for the various actors and these differences need to be reflected in the performance indicators for the different transport systems.

4.1. Marine safety performance indicators

Port State Control
Port State Control (PSC) is an inspection regime for vessels calling at the ports of those states that are signatories to the Paris Memorandum of Understanding (MOU). With the purpose of eliminating substandard vessels[3], the aim is to inspect each vessel in a period of two years.

Inspections and deficiencies
An inspection covers many aspects such as:
- **Ships' certificates**
- **Crew matters (certificates of competency, minimum crew, etc.)**
- **Working spaces**
- **Lifesaving appliances (lifeboats, rafts buoys, EPIRBs (a locating device in emergency conditions), etc)**
- **Fire fighting appliances**
- **Accident prevention (personal equipment, protective equipment, pipes, etc.)**
- **General safety (watertight doors, safety plans and signs, escape routes, steering gear, pilot ladders, etc.)**
- **Alarm signals (general alarm and fire alarm)**

A vessel can be detained if the deficiencies found in one of the categories are considered serious. The detention period should be used to remedy the deficiencies and a new inspection is required to lift the detention.

Paris memorandum of understanding (MOU)
The following marine safety performance indicators have been defined in the Paris MOU:

- **Number of inspections related to the estimated number of calls.**
- **Number of inspections with deficiencies related to the number of inspections.**
- **Number of detentions related to the number of inspections.**
- **Number of deficiencies per inspection.**
- **Number of individual deficiencies related to the number of inspections.**

The following table indicates the major statistics of the Paris MOU on Port State Control.

[3] **It is accepted by the policymakers that a substandard vessel is more accidentprone than a vessel satisfying a set of operational standards.**

Table 5: Basic Statistics of the Paris MOU on Port State Control (Paris MOU 1999)

Year	Calls	Ships	Inspections.	Ships with Deficiencies	Detained ships	# deficiencies
1997		10719	16813	8863	1624	53311
1998		11168	17643	9677	1598	57831
1999	66210	11248	18399	10255	1684	60670

The second column of Table 5 shows the number of calls in Member States used to determine the inspection effort. One should note that these numbers are not the values of the number of ship calls: this is in excess of 300,000 per year.[4] The third column indicates the number of individual vessels inspected. The number of inspections increases with the number of detentions. Vessels with non-serious deficiencies that are allowed to depart need to show in the next port of call that the defects have been remedied also increasing the number of inspections. This leads to a new inspection of the vessel on top of the agreed 25 %. The fifth column indicates the number of inspected vessels having one or more deficiencies and the number of detentions is given in column 6. The total number of deficiencies is given in the last column. Of those vessels with deficiencies, the average number of defects is six.

In 1999, the Port State Control Committee decided that the detention percentage should be used to classify countries, listing them as black, grey or white according to the level of risk associated with their vessels.

4.2. Rail safety performance indicators

The problem areas for rail safety can be categorised as follows:

1. **Accidents that harm rail passengers;**
2. **Level crossing accidents;**
3. **Railway employees (track workers, shunting, train drivers);**
4. **Suicides;**
5. **Trespasser accidents; and**
6. **External risk (transporting dangerous goods by train and the resulting risk to people and property).**

Table 6 lists the possible indicators that could be developed for each of these categories. Obtaining the required information is easier for some indicators than others, and some indicators reflect safety performance better than others do. Few indicators are good in both respects.

[4] **For example the number of annual calls in the port of Rotterdam is about 33,000. These calls are made by about 6,500 different vessels. The total number of merchant vessels is about 35,000. It is not known how many of these vessels never call at a European port.**

There has been no attempt to statistically validate the suggested indicators. Logically, however, the link between the suggested indicators and actual safety is (at least in most cases) to be expected. The strength of this link, however, varies and is unknown for most (if not all) suggested indicators.

Other potential indicators have been omitted due to:

a) the difficulty in obtaining the required information (e.g. the % of unprotected level crossings where the road user cannot see the approaching train before it is less than 10 seconds away from the crossing); or
b) the difficulty in expressing the state of the subject (e.g. structure of safety management.

In the UK, Railway Safety Ltd (RSL - formerly Railtrack Safety and Standards Directorate) has recently published their Safety Risk Model (SRM). This is an elaborate probability-based computer model that aims to estimate the frequency and consequences of accidents in terms of the frequency of what they label 'precursors'. For example, one of the many possible precursors of train collisions is a signal passed at danger (SPAD), and thus the model's estimate of the frequency of train collisions depends in part on the estimate of the frequency of SPADs. Independent expert analysis of rail accident statistics gives an estimate of rail death and injury that significantly disagrees with the model's estimate. Dialogue between the two parties continues to try to identify the source of the differences.

Table 6: List of potential rail transport safety performance indicators

Problem		Potential Indicator
Accidents that harm rail passengers	Quality of infrastructure	% of train kilometres on tracks with ATP (Automatic Train Protection) number of detected broken rails % of lines equipped with track circuits and interlocking signals % of boarding and alighting operations on platforms that are at the same level as train floor (approximately)
	Quality of rolling stock	% of trains equipped with ATP % of passenger trains with electronic brake control % of passenger trips by trains with automatic doors
	Quality of operation	% of the planned safety audits completed Number of planned safety inspections (definition needed) % of the planned safety inspections completed Number of planned medical checks of safety critical post holders (definition needed) % of planned medical checks of safety critical post holders completed Number of persons days in safety related training % accidents of all reported accidents and incidents % of injury accidents of all reported accidents % of major of accidents (definition needed) investigated by independent investigation body
Crashes at level crossings		Number of level crossings Type of protection % of level crossings with gates or other protection Maximum speed of train at level crossing
Accidents involving employees		No. of near-miss collisions reported % of rolling stock with automatic couplers
Suicides		reports of suspicious persons
Trespasser		% unfenced track

accidents	
External risk	**reported leakage of dangerous goods wagons** **quantity and type of dangerous goods**

4.3. Aviation safety performance indicators

The infrequency of (fatal) accidents in the aviation sector means that assessing the level of safety and understanding the safety problem using only these data is meaningless, if not impossible. This necessitates the development of other measures. According to a Dutch study (Roelen and van der Nat, 1998), the aviation sector needs a comprehensive set of safety performance indicators for the entire aviation system. The study concludes that components of the aviation sector regularly use performance indicators, but no comprehensive system is yet available.

The overall safety level of the aviation sector is influenced by all actors in that system including: manufacturers, operators, regulators, air traffic management organisations, airports and the public. Different actors need different indicators to monitor the safety within their area of responsibility. Safety in the aviation sector has a long history and strong tradition of regulation and inspection to assess compliance with regulations; both influencing each other.

Inspection reports by governmental agencies could be considered as the backbone of safety in the aviation sector. In the past, these reports relied heavily on accident and incident rates, measures of efficiency (reliability, delay rates) and inspector activities. However, these (annual or monthly) reports could not be used to compare the safety perfomance of the different actors. Moreover, these reports do not readily improve the understanding of the causes of poor safety performance.

In another approach, underlying forces were identified as potential explanations for safety perfomances. Not only obvious indicators like pilot competence and maintenance quality were used, but also factors such as the maturity of the carrier, the financial conditions of a company, the fleet size etc. Again, this failed to establish any reliable indicator based on a sound causal relationship with observed accident rates.

There are two prerequisites for the development of aviation safety performance indicators: a good understanding of why accidents occur and how these accidents can be prevented. The second requires an holistic approach to understanding the necessary intervention in the chain of events leading to an accident by considering all the actors in the aviation sector.

An interesting approach has been developed by research teams from the United Kingdom (James Reason from the University of Manchester) and the Netherlands (Willem Wagenaar from the University of Leiden). According to them, risk within a system originates from three main elements: activities (operators, pilots, drivers); the internal organisation (defining the safety conditions of a 'work place'); and the environment (defining the decision space of those who decide on the workplace-conditions). Reason and Wagenaar built a model for human error: active failures are the unsafe activities that occur before or during an accident as a result of people in the front line of the system making errors and/or violations. Latent failures are created a long time before an accident but are triggered by an active failure. The environment, in this model, depends on the system boundaries under consideration. In the aviation system as a whole, the political climate may be seen as an important environmental condition, for an airport or air company the existing regulations can be considered as important elements of their environment. For designing a sound

and comprehensive set of performance indicators it is crucial to develop and adapt such a model and to include systems failure as well as human error.

As with the other transport modes, a procedure for aviation safety performance indicators comprises three steps:
- identification of the performance indicators to be measured;
- development of the methodology to monitor a performance indicator; and
- quantification of the performance indicator.

Examples of current practice

Two developments are worth mentioning to describe initial steps in the field of performance indicators in the aviation sector. BASIS (British Airways Safety Information System) is an incident reporting system, started at British Airways in 1990 and, by the end of 1997, approximately 140 air companies were using BASIS. Appendix A comprises the main parameter groups. BASIS operators use the system to enter reports from flight crew, maintenance engineers and exceedances (performance outside a defined threshold) from a flight data recorder. Derived from BASIS, OASIS (Operational Airport Safety Information Systems) is under construction. OASIS is used by Amsterdam Airport Schiphol and all actors (airlines, ATC, ground handlers etc.) are expected to report.

The airworthiness authorities in Europe perform platform inspections. These are carried out by Safety Assessment of Foreign Aircraft (SAFA) teams and check for compliance with (ICAO) standards.

BASIS and its parameters should be included in the initial set of aviation safety performance indicators but it must be noted that the defintion of performance indicators in this report does not comply fully with the concept of BASIS/OASIS, which are based on reported incidents.

A Commission proposal (CEC,2000a) is currently under discussion to require Member States to introduce legislation to establish mandatory and confidential reporting of incidents in civil aviation. The proposal lists examples of reportable occurrences grouped under: Aircraft Flight Operations; Aircraft Technical; Aircraft Maintenance and Repair; and Air Traffic Services, Facilities and Ground Services, but states the list is non-exhaustive.

In order to make a next step from the existing systems of (incidental) incidence reports and inspection activities to a comprehensive system of aviation safety performance indicators, major organisational steps have to be set. Special attention must be paid to the problem of confidentiality.

The aviation industry has long recognised the need to consider factors other than accident rates to define the level of safety.The gathering and analysis of these factors is, in the main, an established practice that is constantly being updated and improved. It is far easier to collect the information needed to measure technical performance than that necessary to measure human performance. Aviation safety depends on the safe operations of many actors, and a comprehensive set of safety performance indicators for the entire aviation field will contain elements from each. Further work is needed to define the necessary safety performance indicators and the means for monitoring them. It is recommended that a set of performance

indicators should be established based on the model, described previously, but which combines both technical failures and human errors.

5. CONCLUSIONS AND RECOMMENDATIONS

General remarks

The use of transport safety performance indicators is not current practice either in road transport or in the other transport modes.

Improving transport safety is a complex management process. Benchmarking safety strategies in respect to reaching specific safety targets has proven to be one of the most difficult tasks in this process. The exclusive use of crash counts provides a rather poor basis for such an analysis.

There are a number of other indicators in transport that causally correlate with crash frequency and severity but are easier to access and evaluate. Among the road safety performance indicators, most commonly used are those that relate to behavioural characteristics such as speed levels, the rate of drink driving and the use of seat belts. In addition, a number of infrastructure, vehicle or trauma related indicators are relevant. These provide a more straightforward means of monitoring the impact of a measure or programme and enable early, target-oriented adjustments of specific interventions. In addition, they allow for a more detailed understanding of the reasons for safety problems than is possible by looking at crash frequency alone.

For other transport modes, safety performance indicators have also been established, but it has partly not been possible, or feasible, to correlate them with crash data. The following sections therefore concentrate on road safety, but the findings are in principle transferable to other transport modes.

Some Member States of the EU – usually those that have lately performed best in reducing casualties – have shown how safety performance indicators can efficiently be used in targeted safety programmes. In fact, some countries have specified certain behavioural characteristics as concrete targets in their national safety programmes, in addition to pure casualty reduction targets.

Currently, collection methods vary significantly between countries, making meaningful data comparison hard to accomplish. One of the main targets of a European-wide approach should therefore be harmonisation of the collection and evaluation procedures as well as co-ordination of the authorities involved, the financing sources, the institutes carrying out the monitoring and the utilisation of results.

Such harmonised procedures will be beneficial to all bodies that are concerned with safety management, from national safety institutes and road administrations to federal ministries and EU institutions. Additionally, a sound dissemination of trends in safety indicators has shown to have a significant motivating effect, e.g. on national police forces.

Recommendations

For decades, the concept of utilising indicators for the continuous monitoring and analysis of processes has been standard practice in industrial quality management. The safety community should exploit this simple and robust concept. As soon as it has been introduced and established for all the transport modes, the application of

safety performance indicators will further stimulate safety work and thus reduce crash rates across Europe.

The European Commission should encourage Member States to agree upon and regularly collect a scientifically established set of safety indicators for all transport modes. At the same time, recommendations on harmonised sampling and application methodologies should be given. It is recommended that this implementation of safety performance indicators be built systematically over time and reviewed regularly.

In road transport, a natural starting point would be the main behavioural indicators – speed levels, drink driving rates and seat belt and helmet use – the comparability of which over time and between countries is of utmost importance. Thereafter, quality indicators such as road networks, vehicle fleets and emergency services should be added. There will be considerable benefit from the harmonisation of collection methods and the extension of the list of regular indicators. Initially, this will be easiest to accomplish among those Member States that currently do not collect safety indicators, and within the applicant countries.

In view of the above, ETSC recommends to the EU:

- **To set up and specify a set of relevant safety performance indicators (SPI) to be used at European and national level as a means of assessing the trends in safety levels and the success of casualty reduction programmes;**
- **To convene, for this purpose, a working group of the High Level Group on Road Safety, comprising road safety experts and representatives of the Member States to consider the list of 'best practice SPI' as suggested in section 5 of this report, i.e. behavioural indicators on speed, alcohol, restraint systems and safety devices as well as SPI in the areas of quality management of road networks, vehicle fleets and emergency services;**
- **To support feasibility and pilot studies on SPI collection and application at Member State level;**
- **To require, on the basis of the above studies, the Member States to collect SPI in a regular and harmonised way and to encourage them to make continuous safety monitoring an integral part of their national safety strategies;**
- **To give guidance to the Member States as regards data collection and observation methodologies (such as sampling frequencies, sample size and time, measuring protocols) as well as on data administration and fusion, in order to produce harmonised sets of SPI that are comparable over time and between countries at a European scale; to recommend that independent bodies collect data on SPI;**
- **To help disseminate current best practice in collection and use of safety performance indicators across the Member States and make annual results and trends available in statistical publications as well as through the electronic media such as the Internet and the Commission's future Road Safety Information System;**
- **To require the Member States to deliver regularly an agreed set of national SPI data to the Commission for international communication, taking the Commission's "Road Safety Quick Indicator" and the CARE database as an example;**
- **To include a task in the 6th R&D framework programme of carrying out further research into running and benchmarking integrated safety management**

programmes, with a view to the causal relationships between safety performance indicators and crashes or injuries;

- **To negotiate, during the consultations on the coming action programme, a common set of relevant SPI with the Member States and to implement quantified targets for SPI into the programme; and**
- **For the other transport modes, there is a need to develop a comprehensive set of performance indicators covering the whole sector and to use that information to improve safety and for more transparent and rational decision making. This requires a general accepted model of why accidents occur and how to prevent them effectively and efficiently. It is recommended to develop such a model and to derive from that model performance indicators.**

The added value for the European Union lies in a harmonised and comprehensive system of transport safety performance indicators allowing the EU to use these data for its own policies and to provide a facility for Member States to reflect on their own performance.

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ANNEX 1 BASIS PARAMETER GROUPS

The main BASIS parameter groups are:

Airmiss
APU
ATC
Structures
Bird strike
Doors
Medical
Windows
Passenger behaviour
Propellers
Weather
Engine
Airport
Military influence
Aircraft damage
Go-around
GPWS
Ground support
Handling
Operating procedures
Rejected take-off
Safety equipment
Security
Stall warning
Air conditioning and pressurisation
Autoflight
Communications equipment
Electrics
Cabin equipment
Fire protection
Flight controls
Fuel
Hydraulics
Ice/rain protection
Instruments
Landing gear
Lights
Navigation equipment
Oxygen
Pneumatics
Water/waste