ROAD SAFETY AUDIT AND SAFETY IMPACT ASSESSMENT

August 1997

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

Tel.: + 32 2 230 41 06 / 40 04
Fax : + 32 2 230 42 15

ISBN: 90-76024-02-2

Acknowledgements

ETSC gratefully acknowledges the contributions of members of ETSC's Road Infrastructure Working Party to this review and, in particular, the work of Professor Richard Allsop, Chairman of the Working Party and editor of the review:

Prof. Richard Allsop (WP Chairman)
Prof. Werner Brilon
Mr Finbarr Crowley
Mr Dominique Fleury
Prof. Siegfried Giesa
Dr Lene Herrstedt
Prof. António Lemonde de Macedo
Mr Geoff Maycock
Prof. Jef Mortelmans
Dr Aristoteles Naniopoulos
Mr Fred Wegman
Prof. Aniceto Zaragoza
Mrs Ingrid van Schagen (WP Secretary)

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

The European Transport Safety Council

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

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

Contents **Page**

Executive Summary

Road safety audit is a formal procedure for independent assessment of the accident potential and likely safety performance of a specific design for a road or traffic scheme - whether new construction or an alteration to an existing road.

Road safety impact assessment is a formal procedure for independent assessment of the likely effects of proposed road or traffic schemes, or indeed other schemes that have substantial effects on road traffic, upon accident occurrence throughout the road network upon which traffic conditions may be affected by the schemes.

These two procedures enable the skills of road safety engineering and accident analysis to be used for the prevention of accidents on new or modified roads. They thus complement the use of these same skills to reduce the occurrence of accidents on existing roads by means of local safety schemes, in many cases in the form of low-cost measures (ETSC, 1996).

This review aims to describe and illustrate the use of safety audits and safety impact assessment in helping to design and build safe road and traffic schemes, and at the planning stage in choosing which schemes to progress from among a range of possibilities.

Both procedures have strong contributions to make to rational and effective decision-making when considering alternative options, and safety audit is important to the achievement of a safe design for a chosen alternative. The two procedures are complementary - the aim is similar and the difference is in scope and timing.

The scope of safety audit is usually confined to an individual road scheme, which may be a new road or modification to an existing road. The basis for safety audit is the application of safety principles to the design of a new or a modified road section to prevent future accidents occurring or to reduce their severity. The procedure is usually carried out at some or all of five stages in carrying out a scheme: feasibility study, draft design, detailed design, pre-opening and a few months after opening. An essential element of the process is that it is carried out independently of the design team. It should be undertaken by a team of people who have experience and up-to-date expertise in road safety engineering and accident investigation.

The scope of safety impact assessment is dependent on the scale of the schemes being considered. For small-scale schemes, the impact of change can usually be expected to be confined largely within the scheme itself. In this situation safety impact assessment and safety audit share many procedural characteristics. For larger schemes, the impact on accident occurrence can be expected to be felt over a larger part of the road network. In that case, the impact may be estimated using a

scenario technique. By considering different road types, the corresponding values of relevant safety indicators and the forecast traffic volumes, the impact on accident occurrence can be estimated for different alternatives.

The development of safety audit for road and traffic schemes, and especially the fifth stage of monitoring the operation of such schemes after they have been open to traffic for some months, raises the question of the role of safety audit or analogous safety checking in respect of existing roads. There is a *prima facie* case that an independent assessment of conditions on an existing road would be likely to reveal deficiencies indicating scope for cost-effective measures for accident prevention additional to the accident remedial measures that are routinely identified by investigation of accident occurrence.

The benefits of safety audits and safety impact assessment are in:

- minimising the risk of accidents occurring in the future as a result of planning decisions on new transport infrastructure schemes;

- reducing the risk of accidents occurring in the future as a result of unintended effects of the design of road schemes;

- reducing the long-term costs associated with a planning decision or a road scheme;

- enhancing the awareness of road safety needs among policy-makers and scheme designers.

Well-documented experience in Europe and elsewhere shows that formal systematic safety audit procedures are a demonstrably effective and cost-beneficial tool to improve road safety. But they are used so far by only a minority of Member States. ETSC believes that sufficient information is available to warrant the EU and Member States taking a series of measures leading to routine application of safety audit procedures to schemes for new road construction and modification of existing roads in order to realise the full contribution that road infrastructure schemes can make to casualty reduction. Consideration should also be given to systematic safety checking of existing roads to complement accident investigation work.

Safety impact assessment procedures are not yet carried out anywhere on a national basis, although there has been some initial experience in The Netherlands and some aspects of safety impact assessment are included in appraisal procedures in some other Member States. Some Member States, however, have valuable experience in safety auditing techniques for road infrastructure projects and for these, the next step is to take a more strategic approach by looking at safety effects on the wider road network by means of safety impact assessment. There is also an important role for the EU in encouraging work in this area.

In urging action by Member States, ETSC wishes to emphasise that although the procedures of safety audit and safety impact assessment are complementary, neither is dependent upon the other. Early action to implement safety audit can therefore go ahead and be yielding benefits whilst work proceeds on the lengthier task of establishing procedures for safety impact assessment.

In relation to safety audit ETSC recommends that Member States should:

(a) examine their own procedures for the assessment of safety in road infrastructure projects to see how they can be made more effective in the light of practice in other Member States;

(b) where no formal procedure for safety audit exists, introduce a mandatory requirement that all major new road schemes be subjected to an independent safety audit;

(c) in time, extend formal procedures to smaller schemes and the safety checking of existing roads;

(d) prepare guidelines for use at national and local level laying down the terms of reference for safety audit including the roles and responsibilities of all concerned, with the help of experience in countries where safety audit is already practised;

(e) prepare a detailed manual of good practice which may be used in conjunction with the guidelines;

(f) send technically trained road safety professionals and their managers to learn at first hand from their counterparts in other Member States about their application of safety audit, and be ready to receive such visiting professionals from other Member States; and

(g) reconsider their allocation of trained staff and finance within their highway budgets to application of safety audit in the light of the benefit to cost ratios that it offers.

Regional and local authorities should:

be ready to share their experience of applying safety audit procedures with their counterparts in other Member States and to learn from them in return, especially by contributing to and drawing upon the EU's documentation of best practice and by exchange of visits by road safety engineers and managers.

In relation to safety impact assessment, ETSC recommends that Member States should:

(a) consider to what extent their existing arrangements for the appraisal of transport infrastructure projects take account of the likely impact of each project on accident occurrence throughout the affected road network;

(b) enhance their procedures for such appraisal so that they include all aspects of safety impact assessment.

Any new scheme on the TERN will, at the stage of feasibility study, be subject to mandatory Environmental Impact Assessment (EEC, 1985). ETSC believes that they should in a comparable way be subject to safety impact assessment covering the likely effects on accident occurrence, injury and damage not only on the relevant section of the TERN itself but also on all local roads on which traffic will be affected by the scheme. ETSC therefore welcomes the Commission's stated intention in its new action programme (CEC, 1997) to prepare new guidelines on safety impact assessment which would be applied in a first stage to the TERN and other EU financed projects.
The chosen scheme that emerges from the feasibility study should then be subject to safety audit at the stages of preliminary design and detailed design, and on site just before opening to traffic and after several months of operation.

In the context of its responsibility for transport safety, the EU can add value to the efforts of the Member States by acting to accelerate the rate at which citizens of the EU can benefit from more widespread and effective use of safety audits within each Member State.

Further steps by the EU which ETSC believes would be useful are as follows:

(a) as a first step promote international best practice by producing technical guidelines on safety audit;

(b) as a second step introduce an EU Directive requiring that all major new road schemes be subject to an independent safety audit;

(c) establish a European network of training in safety audit for road safety professionals and managers;

(d) encourage the transnational mobility of technically trained road safety professionals and their managers to accelerate the transfer among Member States of successful techniques and procedures for applying safety audits; and

(e) look for mechanisms by which its own allocation of funds to Member States for investment in roads can be used to encourage the recipient states to

allocate funding within their highway budgets to programmes of safety audit.

ETSC believes that the promotion of safety impact assessment through the establishment of guidelines for the TERN and all EU funded projects would be a helpful first stage in integrating safety considerations into the relevant decision-making processes.

As a second stage, ETSC recommends that a mandatory requirement for safety impact assessment covering all new transport infrastructure projects should exist alongside EU procedures for environmental impact assessment with immediate application to the TERN and subsequent application to all transport infrastructure projects in all Member States.

Eventually, safety impact assessment should extend to all land use planning decisions as is envisaged for the developing environmental impact assessment.

1. Introduction

Road safety audit is a formal procedure for independent assessment of the accident potential and likely safety performance of a specific design for a road or traffic scheme - whether new construction or an alteration to an existing road.

Road safety impact assessment is a formal procedure for independent assessment of the likely effects of proposed road or traffic schemes, or indeed other schemes that have substantial effects on road traffic, upon accident occurrence throughout the road network upon which traffic conditions may be affected by the schemes.

These two procedures enable the skills of road safety engineering and accident analysis to be used for the prevention of accidents on new or modified roads. They thus complement the use of these same skills to reduce the occurrence of accidents on existing roads by means of local safety schemes, in many cases in the form of low-cost measures (ETSC, 1996).

This review aims to describe and illustrate the use of safety audits and safety impact assessment in helping to design and build safe road and traffic schemes, and at the planning stage in choosing which schemes to progress from among a range of possibilities. Generally, roads are designed with a large number of criteria in mind, such as travel time, user comfort and convenience, fuel consumption, construction costs, environmental impact and objectives of urban or regional planning. Safety is one of the criteria, but is often implicitly assumed to be achieved by adhering to prescribed standards of alignment and layout for each element of the design. These standards are indeed laid down with safety in mind, and some of these include explicit safety checklists (e.g. FGSV, 1988), but experience shows that adherence to them is not sufficient to ensure that a resulting design is free from avoidable hazardous features. Formal safety audit and safety impact assessment procedures ensure that independent expertise is used to make explicit the safety implications of an entire design and, in doing so, lead to safer designs of both new and modified roads.

Both procedures have strong contributions to make to rational and effective decision-making when considering alternative options, and safety audit is important to the achievement of a safe design for a chosen alternative. The two procedures are complementary - the aim is similar and the difference is in scope and timing.

The scope of safety audit is usually confined to an individual road scheme, which may be a new road or modification to an existing road. The basis for safety audit is the application of safety principles to the design of a new or a modified road section to prevent future accidents occurring or to reduce their severity. The procedure is usually carried out at one or all of five stages in carrying out a scheme: feasibility study, draft design, detailed design, pre-opening and a few

months after opening. An essential element of the process is that it is carried out independently of the design team. It should be undertaken by a team of people who have experience and up-to-date expertise in road safety engineering and accident investigation.

The scope of safety impact assessment is dependent on the scale of the schemes being considered. For small-scale schemes, the impact of change can usually be expected to be confined largely within the scheme itself. In this situation safety impact assessment and safety audit share many procedural characteristics. For larger schemes, the impact on accident occurrence can be expected to be felt over a larger part of the road network. In that case, the impact may be estimated using a scenario technique. By considering different road types, the corresponding values of relevant safety indicators and the forecast traffic volumes, the impact on accident occurrence can be estimated for different alternatives.

The following two Sections deal in more detail with safety audit and safety impact assessment respectively, presenting information on procedural, methodological and organisational aspects, illustrated by means of specific case studies. Section 4 provides some information about the cost-effectiveness of safety audit as estimated in different countries where this approach has already been in use for some time. Section 5 considers the role of Member States and the European Union in promoting safety audit and safety impact assessment. Direct implementation could play an important role in the further development of the Trans-European Road Network, and implementation in Member States could be promoted in similar ways to that of the now mandatory environmental impact assessment procedures. In the last Section, the main conclusions are set out.

2. Road safety audits

2.1 The aim and nature of a safety audit

In safety audits "The main objective is to ensure that all new highway schemes operate as safely as is practicable. This means that safety should be considered throughout the whole preparation and construction of any project" (IHT, 1996). More specific aims are:

- to minimise the number and severity of accidents that will occur on the new or modified road;

- to avoid the possibility of the scheme giving rise to accidents elsewhere in the road network; and

- to enable all kinds of users of the new or modified road to perceive clearly how to use it safely.

Whatever the reason for the scheme, a safety audit always begins with a road design. An audit is intended to identify potential road safety problems by looking at the scheme as if through the eyes of the potential users of all kinds, and to make suggestions for solving these problems by applying the principles of road safety engineering (AUSTROADS, 1994; Danish Road Directorate, 1993; IHT, 1996). This means that an audit goes much farther than just assessing whether or not the relevant design standards are properly applied. An example of the application of safety audit in the work of a British local authority is given in Annex 1.

By minimising at the design stage the risk of accidents during the lifetime of a road scheme, there is less likelihood of having to take accident remedial measures later, and the whole-life cost of the scheme can be reduced.

Road safety audit is an important means for paying explicit attention to road safety during the design of road schemes. This explicit attention should help everyone involved in making decisions regarding changes to road infrastructure to assess the safety implications of the many choices that arise during the design process, and thus increase the road safety awareness of infrastructure planners, designers and authorities.

2.2 Organising and carrying out an audit

The process of safety audit as applied to an individual road scheme can be seen as taking place at up to five stages (Wrisberg and Nilsson, 1996), some of which can be combined for smaller schemes:

- *The feasibility stage.* During this stage, the nature and extent of the scheme are assessed, and the starting points for the actual design are determined, such as route options, the relevant design standards, the relationship of the scheme to the existing road network, the number and type of intersections, and whether or not any new road is to be open to all kinds of traffic.

- *The draft design stage.* Horizontal and vertical alignments and junction layout are broadly determined. At the completion of this stage, the design should be well enough established so that, if necessary, decisions can be made about land acquisition.

- *The detailed design stage.* Layout, signing, marking, lighting, other roadside equipment and landscaping are determined.

- *The pre-opening stage.* Immediately before the opening, a new or modified road should be driven, cycled and walked. It is advisable to do this under different conditions such as darkness and bad weather.

- *Monitoring of the road in use.* When a new or improved road has been in operation for a few months, it is possible to assess whether it is being used as intended and whether any adjustments to the design are required in the light of the actual behaviour of the users.

Checklists have been designed for use during each stage of auditing (AUSTROADS, 1994; IHT, 1996). In practice, these checklists have proved very useful as reminders for the auditors, but there is also a risk that they are used too blindly as recipes without sufficient consideration for individual situations. What is required is a combination of judgement, skill and systematic working.

The essence of road safety audit is that it is carried out by auditors who are independent of the design team, have expertise in both highway design and road safety, and are properly trained and experienced in carrying out audits. This means that not only must they possess sufficient specialised professional knowledge and have the required experience, but they must also possess the communication skills necessary to present audit results constructively and encourage a positive response to them from the design team. Experience has shown that it is preferable to hire a small auditing team rather than a single auditor. The members of an auditing team can jointly offer more skills than an individual, and a team can operate its own system of checks and balances and thus be less susceptible to its assessments being swayed by personal preferences.

The results of audit should be documented and reported at each stage to the design team and in turn to the client for the scheme. They will usually include recommendations for improvements to the design. There is much to be said for linking a form of certification to the entire auditing process, and having the audit results made public so that citizens, prospective users of the new or modified road, and other interested parties can make informed contributions to further decision-making. Whether this can be done or not depends greatly on the way in which the decision-making process relating to the scheme is organised. It is therefore impossible to give a generally applicable rule in this regard.

The conduct of safety audits can sometimes lead to tensions between the audit team, the design team and the client for the scheme. What is necessary from the start, therefore, is to create a sufficiently solid, formal basis (whether or not anchored in law) that enables safety audits to be carried out successfully and the recommendations based on the audits to be implemented. There also needs to be commitment to the procedures on the part of the organisations involved. The procedures should include arrangements for dealing with situations in which the design team and the audit team are nevertheless at odds about carrying out the audit recommendations. What is required in these cases is a decision by the client for the scheme, and this may be assisted by some form of arbitration.

2.3 Safety audit and existing roads

The development of safety audit for road and traffic schemes, and especially the fifth stage of monitoring the operation of such schemes after they have been open to traffic for some months, raises the question of the role of safety audit or analogous safety checking in respect of existing roads. There is a *prima facie* case that an independent assessment of conditions on an existing road would be likely to reveal deficiencies indicating scope for cost-effective measures for accident prevention additional to the accident remedial measures that are routinely identified by investigation of accident occurrence. Yet the task of checking all existing roads is demanding in terms of scarce resources of expertise.

This issue has been investigated in France (Machu, 1996) by means of a pilot study covering nearly 2,000 km of roads ranging from motorways to local roads. The results provide useful indications concerning complementarity between safety checking and accident analysis, the range of deficiencies which it is practicable for the checking to cover, and ways of putting road sections of different kinds into an order of priority for checking during the many years it is likely to take to cover the whole network.

3. Road safety impact assessment

3.1 The aim and nature of safety impact assessment

Being able to estimate explicitly the impact on road safety that results from building new roads or making substantial modifications to the existing road infrastructure that alter the capacity of the road network in a certain geographic area is of crucial importance if road safety is not to suffer unintentionally from such changes. The same applies to other schemes and developments that have substantial effects on the pattern of road traffic. The procedure that has been designed for this purpose is known as road safety impact assessment (Wegman *et al*, 1994). This procedure is intended to be applied at the planning stage, often proceeding to a definite design for the scheme. Safety impact assessment thus precedes and complements the eventual safety audit of any specific design for the scheme. A parallel to these two procedures can be seen in the Strategic Environmental Impact Assessment and the ordinary Environmental Impact Assessment (OECD, 1994). The two procedures together first provide an estimate of the impact of possible schemes on safety for an entire geographic area at the strategic level and then follow this with an audit of the safety of the specific design of the chosen scheme. For smaller schemes, the two procedures can be combined by extending the feasibility stage of the safety audit to include the likely effects of the scheme on accident occurrence in the surrounding network.

The results of safety impact assessment should be considered in the planning process alongside other information relevant to decision-making about which schemes should be implemented, and thus improve the quality of such decision-making.

3.2 Carrying out a safety impact assessment

A scenario method is used to carry out a safety impact assessment. The starting point is the existing road network, the current pattern of traffic on that network, and the level of reported road accidents there. It is helpful, though not essential, to have the information in a digital form within a geographic information system (GIS), as in the German system Euska (GDV, 1997). This information relates to a road network which is made up of roads of a number of types that have different road safety characteristics. Each road consists of junctions and stretches of road between the junctions, with associated traffic volumes, and numbers of accidents and casualties. Alternative scenarios to this current situation are the possible changes being studied in respect of the physical infrastructure and the associated traffic volumes in the road network in the future. If, for example, a new road is to be added to the existing network, the traffic and transport models can be used to estimate what this will mean for the traffic volumes throughout the network in the future.

The central step is to interpret these changes in terms of the impacts they will have on the numbers of accidents and casualties. To accomplish this, what are needed are quantitative indicators of risk (such as casualty rates per million vehicle-km) for each type of road, supplemented if possible by corresponding indicators for each main type of junction. One way of obtaining such indicators is to estimate them at a national level and adjust them if necessary using data for the area in question. In addition, thought should be given to any expected changes over time in the level of risk for each type of road or junction. These kinds of information enable safety impacts to be estimated. An example from The Netherlands is given in Annex 2.

If the various data are accessible from a computer, calculations of safety impacts for a range of scenarios and comparisons between impacts of different scenarios can be made quite readily. The procedure can be adapted in order to help to identify what changes are needed in a given scenario in order to bring its safety impact within some target range.

When implementing this scenario technique it is important to bear in mind the quality of the information being used. It is also important for the information to be accessible in such a way that calculations for a range of scenarios can be elaborated at relatively modest costs within a short period of time. For this purpose, the traffic and transport models should be set up in such a way that a road safety impact assessment module to apply the relevant indicators of risk for future years can be linked up with them readily.

4. Cost-effectiveness

The cost-effectiveness of road safety audits and safety impact assessments are at present difficult to quantify rigorously. Both techniques are relatively recent, and it is difficult to find well documented cases in which both the benefits and the costs of the procedures have been established, but there is nevertheless useful evidence of the cost-effectiveness of safety audit. Whereas it is not too difficult to assess the costs of carrying out either procedure, estimating the benefits requires an estimate to be made of difference in the accident costs occurring on schemes which have been subject to impact assessment and/or audit, compared with the costs on similar schemes which have not.

The main immediate benefits of the procedures will be accident savings. In principle however, there are other longer term and more broadly based potential benefits; these include not just the immediate accident savings on the schemes subjected to the procedures, but more generally, improvements to the management of design and construction, reduced whole-life cost of road schemes, the development of good safety engineering practice, the explicit recognition of the safety needs of road users, and the improvement of design standards for safety (Ogden and Jordan, 1993).

As regards the quantification of the immediate road safety benefits, there has been some experience in the UK, Denmark, Australia and New Zealand, which can give a broad indication of the value of road safety audit (AUSTROADS, 1994; IHT, 1996; Schelling, 1995; Transit New Zealand, 1993).

In 1994 a study was undertaken in an English county in which two groups of matched schemes, one group having been audited and the other not, were compared (Surrey County Council, 1994). This study estimated that the audited schemes showed a saving of about 1 accident per site per year compared with the schemes which were not audited - a saving which represents an accident cost saving per scheme well in excess of the cost of auditing the schemes.
Estimates have also been made of the benefits to a local highway authority of applying road safety audits to all of its road schemes. The Lothian Regional Council (a former local highway authority in Scotland) which had about 3,000 injury accident per year, estimated that the consistent application of road safety audits would give a 1 per cent accident saving, and that such a saving would represent a benefit to cost ratio of about 14:1. In New Zealand a potential benefit to cost ratio of 20 has been estimated for the application of road safety audit procedures (Transit New Zealand, 1993).

One way of forming a judgement about the likely cost-effectiveness of road safety audits in the absence of objective accident savings data, is to compare the costs of carrying out an audit with the economic cost of a single injury accident. It then

becomes apparent how large an accident saving would be needed to cover the audit costs. In 1995, a review of road safety audit practice was undertaken by the Institution of Highways and Transportation (IHT) and the University of Southampton (Crafer, 1995). This review estimated that an average of 25 hours of the time of professional road safety engineers was required to complete an audit; 21 per cent of schemes took less that 10 hours and 7 per cent took more than 40 hours. Audit costs were estimated to be in the range of from £ 100 to £ 6,000 (at 1993 prices). In the UK, the 1994 value of preventing an injury accident was £55,650 , so the actual cost of carrying out a relatively extensive audit is a fraction of the value of preventing a single injury accident. In Australia, each stage of an audit of a scheme typically costs between AUS $ 1,000 to AUS $ 4,000 depending on the size of the scheme (Jordan, 1994).

It has to be borne in mind however, that the actual costs of safety audit are not only the costs involved in completing the audit itself. Having audited the scheme, it is necessary in those cases where a design change is recommended, to make the appropriate design changes. The extent of such changes depends upon the quality of the original design. In the IHT review mentioned above, some redesign was required in about half of the schemes audited. Although the actual cost of redesign varied considerably from scheme to scheme, it was estimated that redesign costs ranged from about 0.5 per cent of the cost for the larger schemes to about 3 per cent of the cost for the smaller schemes. Australian and New Zealand experience suggests that safety audit adds about 4 per cent to road design costs (ITE, 1994). Even including the costs of both the audit and any subsequent redesign, it is clear from these figures that the saving of only one injury accident will more than repay the cost of the audit and its redesign consequences.

Both the actual costs of the audit process and the redesign costs were included in a study conducted in Denmark in which the usefulness of safety audits was assessed in cost-benefit terms by a panel of experts (Schelling, 1995). The panel considered 13 schemes with construction costs ranging from 2M DKK to 400M DKK. To assess the safety benefits of the audit process, the auditors estimated to the satisfaction of the panel the number of accidents which would be expected on the schemes with and without the changes in design recommended by the audit. The total reduction on the 13 schemes was estimated to be 34.5 accidents per year involving 21.3 casualties. The time costs involved for those carrying out the audits and for the resulting redesign amounted to about 0.5 per cent of the scheme costs - the proportion being rather larger for the small schemes and considerably smaller for the larger schemes. Construction costs were estimated to increase by about 1 per cent as a result of the audit. As is to be expected, the rate of return varied considerably from scheme to scheme, but overall the cost involved in auditing the 13 schemes amounted to 13.5M DKK and the resulting design changes were expected to lead to a reduction in casualty costs of 20M DKK per year, giving a first year rate of return of well over 100 per cent. The study therefore concluded that safety audit is very effective in cost-benefit terms.

5. The roles of the EU and Member States

Well-documented experience in Europe and elsewhere shows that formal systematic safety audit procedures are a demonstrably effective and cost-beneficial tool to improve road safety. But they are used so far by only a minority of Member States. ETSC believes that sufficient information is available to warrant the EU and Member States taking a series of measures leading to routine application of safety audit procedures to schemes for new road construction and modification of existing roads in order to realise the full contribution that road infrastructure schemes can make to casualty reduction. Consideration should also be given to systematic safety checking of existing roads to complement accident investigation work.

Safety impact assessment procedures are not yet carried out anywhere on a national basis, although there has been some initial experience in The Netherlands and some aspects of safety impact assessment are included in appraisal procedures in some other Member States. Some Member States, however, have valuable experience in safety auditing techniques for road infrastructure projects and for these, the next step is to take a more strategic approach by looking at safety effects on the wider road network by means of safety impact assessment. There is also an important role for the EU in encouraging work in this area.

5.1 Implementation in Member States

In urging action by Member States, ETSC wishes to emphasise that although the procedures of safety audit and safety impact assessment are complementary, neither is dependent upon the other. Early action to implement safety audit can therefore go ahead and be yielding benefits whilst work proceeds on the lengthier task of establishing procedures for safety impact assessment.

5.1.1 Safety audit

In relation to safety audit ETSC recommends that Member States should:

(a) examine their own procedures for the assessment of safety in road infrastructure projects to see how they can be made more effective in the light of practice in other Member States;

(b) where no formal procedure for safety audit exists, introduce a mandatory requirement that all major new road schemes be subjected to an independent safety audit;

(c) in time, extend formal procedures to smaller schemes and the safety checking of existing roads;

(d) prepare guidelines for use at national and local level laying down the terms of reference for safety audit including the roles and responsibilities of all concerned, with the help of experience in countries where safety audit is already practised.

(e) prepare a detailed manual of good practice which may be used in conjunction with guidelines;

(f) send technically trained road safety professionals and their managers to learn at first hand from their counterparts in other Member States about their application of safety audit, and be ready to receive such visiting professionals from other Member States; and

(g) reconsider their allocation of trained staff and finance within their highway budgets to application of safety audit in the light of the benefit to cost ratios that it offers.

Regional and local authorities should:

be ready to share their experience of applying safety audit procedures with their counterparts in other Member States and to learn from them in return, especially by contributing to and drawing upon the EU's documentation of best practice and by exchange of visits by road safety engineers and managers.

5.1.2 Safety impact assessment

In relation to safety impact assessment, ETSC recommends that Member States should:

(a) consider to what extent their existing arrangements for the appraisal of transport infrastructure projects take account of the likely impact of each project on accident occurrence throughout the affected road network.

(b) enhance their procedures for such appraisal so that they include all aspects of safety impact assessment.

5.2 EU responsibilities and opportunities

5.2.1 Implementation in the TERN

The Trans-European Road Network (TERN), established by the Maastricht Treaty in 1993, provides an opportunity for the EU to promote best practice in road safety engineering work.

By its very nature, each section of the TERN will be used not only by residents of the Member State in which that section lies, but also by an appreciable proportion, on some sections a substantial proportion, of cross-border traffic from other Member States. The vision of the TERN as a unified European road network implies that cross-border users can expect to find levels of risk at least as low as on comparable roads in their home country, and concern for safety in the provision and operation of the network at least as great.

In July 1996, a decision by the Council of Ministers and the European Parliament authorised the European Commission to propose guidelines such that the TERN should "guarantee users a high, uniform and continuous level of services, comfort and safety" on this network (European Parliament and Council of the European Union, 1996).

Any new scheme on the TERN will, at the stage of feasibility study, be subject to mandatory Environmental Impact Assessment (EEC, 1985). ETSC believes that they should in a comparable way be subject to safety impact assessment covering the likely effects on accident occurrence, injury and damage not only on the relevant section of the TERN itself but also on all local roads on which traffic will be affected by the scheme. ETSC therefore welcomes the Commission's stated intention in its new action programme (CEC, 1997) to prepare new guidelines on safety impact assessment which would be applied in a first stage to the TERN and other EU financed projects.

The chosen scheme that emerges from the feasibility study should then be subject to safety audit at the stages of preliminary design and detailed design, and on site just before opening to traffic and after several months of operation.

5.2.2 Promotion of safety audit

In the context of its responsibility for transport safety, the EU can add value to the efforts of the Member States by acting to accelerate the rate at which citizens of the EU can benefit from more widespread and effective use of safety audits within each Member State.

This has been acknowledged to some extent already by the Commission in the support given to the SAFE STAR Fourth Framework project which aims to document best practice in safety audit from all the Member States and in its support for this ETSC review.

Further steps by the EU which ETSC believes would be useful are as follows:

(a) as a first step promote international best practice by producing technical guidelines on safety audit;

(b) as a second step introduce an EU Directive requiring that all major new road schemes be subject to an independent safety audit;

(c) establish a European network of training in safety audit for road safety professionals and managers;

(d) encourage the transnational mobility of technically trained road safety professionals and their managers to accelerate the transfer among Member States of successful techniques and procedures for applying safety audits; and

(e) look for mechanisms by which its own allocation of funds to Member States for investment in roads can be used to encourage the recipient states to allocate funding within their highway budgets to programmes of safety audit.

5.2.3 Promotion of safety impact assessment

ETSC believes that the promotion of safety impact assessment through the establishment of guidelines for the TERN and all EU funded projects, as indicated in Section 5.2.1 would be a helpful first stage in integrating safety considerations into the relevant decision-making processes.

As a second stage, ETSC recommends that a mandatory requirement for safety impact assessment covering all new transport infrastructure projects should exist alongside EU procedures for environmental impact assessment with immediate application to the TERN and subsequent application to all transport infrastructure projects in all Member States.

Eventually, safety impact assessment should extend to all land use planning decisions as is envisaged for the developing environmental impact assessment.

6. Conclusions

The road safety implications of planning decisions and infrastructure projects need to be taken explicitly into account in general policy-making at Community, national and local levels. The purpose is to avoid the cost of any unnecessary future accident and casualty problems.

At the strategic level, this entails assessment of the road safety implications of planning decisions that relate to modal choice, land use, the characteristics of city centres, transport infrastructure and services, and the interaction between public provision and private choice. Formal safety impact assessment procedures provide

an appropriate mechanism to this end but, as yet, they have not been adopted in their entirety in any Member State.

Road safety impact assessment procedures are designed to assess the likely effects of the scheme or transport planning decision on accident occurrence, injury and damage over the whole of the road network which will be affected. Following this procedure, any highway scheme that emerges from the feasibility study should then be subject to safety audit at the stages of preliminary design and detailed design, and on site just before opening to traffic and after several months of operation.

Safety audit of a specific design for a new or modified road assesses the accident potential and likely safety performance of the design with a view to enabling the scheme to operate as safely as is practicable by identifying and recommending any necessary changes to the design.

For both safety impact assessment and safety audit, the application of safety principles is achieved through formal audit procedures carried out by expertise independent of the planning or road infrastructure project design team. Experience shows that audit work is best carried out as a team task with the team having specialist expertise in the road safety engineering and accident investigation and prevention fields.

Mandatory and cost-beneficial safety audit procedures programmed at well-defined stages during the planning, design and construction of road schemes have been used in the UK, Denmark, Australia and New Zealand for several years and have contributed to identifiable improvements in road safety. Experience has shown that on most schemes it is necessary to prevent only one injury accident to more than repay the cost of the audit itself and any consequential design changes.

The benefits of safety audits and safety impact assessment are in:

- minimising the risk of accidents occurring in the future as a result of planning decisions on new transport infrastructure schemes;

- reducing the risk of accidents occurring in the future as a result of unintended effects of the design of road schemes;

- reducing the long-term costs associated with a planning decision or a road scheme;

- enhancing the awareness of road safety needs among policy-makers and scheme designers.

Recommendations to the EU and Members States to realise these benefits throughout the EU have been set out in Chapter 5.

References

AUSTROADS (1994) Road safety audit. Sydney: AUSTROADS National Office.

CEC (1997) Promoting road safety in the EU: The programme for 1997-2001, COM(97)131 final, Brussels: Commission of the European Communities.

CRAFER, A. (1995) Review of road safety audit procedures. *Occasional Paper*. London: Institution of Highways and Transportation.

DANISH ROAD DIRECTORATE (1993) Safety audit handbook. Copenhagen: Danish Road Directorate.

EEC (1985) Council Directive on assessment of the effects of certain public and private projects on the environment, (85/337/EEC), Official Journal of the European Communities , L 175,40.

ETSC (1996) Low-cost road and traffic engineering measures for casualty reduction, Brussels: European Transport Safety Council.

EUROPEAN PARLIAMENT AND COUNCIL OF THE EUROPEAN UNION (1996) Community guidelines for the development of the Trans-European transport network. Decision No. 1692/96/EC, Official Journal of the European Communities, L 228, 39.

FGSV (1988) Richtlinien für die Anlage von Strassen, Teil Knotenpunkte, Abschnitt 1 (RAS-K-1), Köln: Forschungsgesellschaft für Strassen unde Verkehrswesen.

GDV (1997) Euska, Zeitgemässe Verkehrssicherheitsarbeit. Bonn: Institut für Strassenverkehr - Gesamtverband der Deutscher Versicherungswirtschafte.

IHT (1996) Guidelines for road safety audit. London: Institution of Highways and Transportation.

ITE (1994) Informational report: road safety audit. Committee 4S-7, July 1994. Washington DC: Institute of Transportation Engineers.

JORDAN, P.W. (1994) Road safety audit: the AUSTROADS approach. Road and Transport Research 3(1), 4-11.

MACHU, C. (1996) A new approach to improved road safety: safety checking of road infrastructure in Proceedings of the FERSI International Conference "Road Safety in Europe", Birmingham, September 1996. VTI Konferens 7A(4), 19-28.

OECD (1994) Environmental impact assessment of roads. Paris: Organisation for Economic Co-operation and Development.

OGDEN, K.W., JORDAN, P.W. (1993) Road safety audit: an overview. In the proceedings of the Pacific Rim Transport Technology Conference, Seattle, July 1993.

SCHELLING, A. (1995) Road safety audit, the Danish experience. In the proceedings of the FERSI International Conference Road Safety in Europe and Strategic Highway Research Program, Prague, September 1995. VTI Konferens 4A(4), 1-8.

SURREY COUNTY COUNCIL (1994) Road safety audit: an investigation into casualty savings. Kingston upon Thames: Surrey County Council.

TRANSIT NEW ZEALAND (1992) Accident countermeasures: literature review. TNZ Research Report Number 10. Wellington: Transit New Zealand.

WEGMAN, F.C.M., ROSZBACH, R., MULDER, J.A.G., SCHOON, C.C., POPPE, F. (1994) Road safety impact assessment: RIA. Report R-94-20. Leidschendam: SWOV Institute for Road Safety Research.

WRISBERG, J., NILSSON, P.K. (1996) Safety audit in Denmark - a cost-effective activity. Copenhagen: Danish Road Directorate.

Annex 1: Safety Audit: a British example

This example describes the road safety audit arrangements for roads in the English County of Staffordshire, where the County Council contracted a small independent road safety consultancy firm, TMS Consultancy, to carry out audits throughout the county. The firm initially carried out audits on schemes on roads of national importance in Staffordshire, and currently produces reports on all local road schemes in the county.

1. The safety audit process in Staffordshire

Requests for safety audit are sent to the consultant through the County Council. The design teams for the schemes come from a variety of backgrounds within the County and its District Councils.

One of the main advantages of this method of operation is that the audit team is completely independent, not only of the design team but also of the organisation responsible for the scheme. The consultants use a minimum of two experienced safety auditors for each scheme. For stages of audit prior to construction the process is as follows:

- audit brief and scheme plans sent to consultant, together with accident and traffic records as appropriate;
- site visit by at least one member of audit team;
- detailed examination of scheme plans by audit team members using in-house checking procedures;
- audit team discussion to determine which items should go forward into audit report;
- production of audit report in 'problem and recommendation' format dealing only with easily identified road safety problems; and
- submission of report to the County Council.

The audit report to the client is accompanied by feedback forms on which the client can record action taken in response to each recommendation.

For post-construction stages of audit, the consultants arrange a site visit with members of the police and the authority responsible for maintaining the road. At least two audit team members visit the site and record all comments made during the visit. A report in 'problem and recommendation' format is provided to the client together with feedback forms.

2. Audits carried out

Between 1994 and 1997 the consultant has carried out a total of 166 stages of road safety audit in Staffordshire, on a wide range of schemes. Scheme types include new bypasses, cycle routes, junction improvements, installation of traffic signals, installation of

roundabouts, traffic calming, bend realignment, safety fence schemes and pedestrian crossing facilities. Schemes have been undertaken in both urban and rural situations.

The number of schemes for each stage of audit is as follows:

- Stage 0 - Feasibility: 5
- Stage 1 - Draft design: 18
- Stage 1/2 - Draft/detailed design: 28
- Stage 2 - Detailed design: 46
- Stage 3 - Pre-opening: 69

A total of 32 schemes have been audited at more than one stage. Fifteen of schemes audited at Stage 3 have also been audited by the consultants at previous stages. Continuity has been provided by the same audit team working on subsequent stages of the same scheme.

3. Case study of stages of audit

An example of a scheme audited at Stages 1, 2 and 3 is the implementation of a complex set of traffic signals at a staggered four-arm junction between a dual carriageway main road and two minor roads. The scheme was audited at these stages during a design and implementation process that took fifteen months.

A total of fourteen safety comments were made at Stage 1, fourteen at Stage 2, and just four at Stage 3.

The Stage 1 (draft design) audit commented on some of the fundamental aspects of the scheme, such as the need for the speed discrimination equipment at the signals, for traffic orders to prohibit potentially dangerous turning movements, and for changes to kerb lines to accommodate safer positions for bus lay-bys and pedestrian movements.

The Stage 2 (detailed design) audit looked at the detail of the scheme, commenting particularly on road markings, signs and pedestrian signal positions.

The Stage 3 (pre-opening) audit made comments on surfacing, signing and markings.

Many of the comments made at Stages 1 and 2 were acted upon by the design team. For example, at Stage 1, it was suggested that a bus lay-by should be moved, and this was carried out by the time the detailed design had been prepared. A pre-Stage 3 visit showed that nine of the fourteen points raised by the audit team at Stage 2 had either been implemented or were about to be implemented on site. Where action was not taken, the audit team consistently repeated their concern throughout the process. For example at all three stages the team repeated their concern that U-turning should be prohibited at the signals.

4. Wider implications

Two more general aspects of the safety audit process arise in relation to this example. Litigation following accidents on road schemes has concentrated the minds of both auditors and designers. The consultancy has taken legal advice and improved its in-house procedures as a result.

Secondly, and more importantly, safety audit should be seen as part of a road safety culture within design organisations. It is hoped that designers learn to build in safety features through having schemes audited. At the start of the firm's work with Staffordshire, the consultants put on a series of safety audit seminars for County highways staff. Over 100 members of staff attended the seminars which were aimed at raising awareness of safety issues and explaining safety audit procedures.

Annex 2: Safety impact assessment: a Dutch example

If new stretches of road are added to the existing network or if traffic management measures are considered to reduce traffic volumes on a certain stretch of road, or if measures are taken to improve the capacity of a junction, the consequences in terms of traffic volumes and, consequently in terms of road accidents, could well extend to other parts of the road network. This is because the choices of the individual road users might lead them to select another route, or another time to travel, or another means of transport.

By influencing traffic flows over a network, road safety consequences may well occur throughout that network. A safety impact assessment uses the well-known fact that physical features of a road network and its component elements together with the associated traffic volumes are the main explanatory factors for the average numbers of accidents happening on the components of that network. Different road types could be characterised by different average levels of accident risk, for example different average numbers of accidents per million kilometres driven. For the Dutch road network, safety indicators have been estimated for each type of road. These estimates are given in Table 1.

Road type	Speed limit (km/h)	Mixed traffic	Intersecting or oncoming traffic	Injury rate per 10^6 km
Residential areas	30	yes	yes	0.20
Urban street	50	yes	yes	0.75
Urban artery	50 / 70	yes / no	yes	1.33
Rural road	80	yes / no	yes	0.64
Express road or road closed to slow moving vehicles	80	no	yes	0.30
Motor road	100	no	yes / no	0.11
Motor way	100 / 120	no	no	0.07

Table 1. *Injury rates on different road types in The Netherlands in 1986.*

A road safety impact assessment, as carried out in The Netherlands, contains three steps. First of all basic data have to be collected on the network to be studied: the categorisation of roads and streets of that network, traffic volumes, road safety indicators, and their development over time. This requires a consensus on how to categorise roads. Furthermore, relevant data have to be collected for a certain administrative area.

In the second step the possible changes to the existing network are defined. This, again, will be done in terms of network composition, traffic volumes for the different network components and the road safety indicators. An important step is to compare regional road safety indicators with the national indicators and to draw conclusions on the differences which are found. Sometimes the national indicators are used because their quality is higher than is currently practicable for the regional indicators. Sometimes regional indicators are used because the national indicators do not offer a correct picture for a region.

In the third phase the possible future network, traffic volumes and road safety indicators are described or estimated in order to compare the existing situation with different scenarios in the future. The results of this comparison (the existing situation with at least one situation in the future) can be brought to the consideration of those who have to decide on the basis of all kinds of impacts of each scenario. In other words: safety impact assessments allow for a better consideration to be given to safety implications of possible measures in the context of their other effects.

The results of safety impact assessments can be translated into monetary terms by using values attached to preventing accidents and casualties, and thus provide an input to monetary cost-benefit analysis.