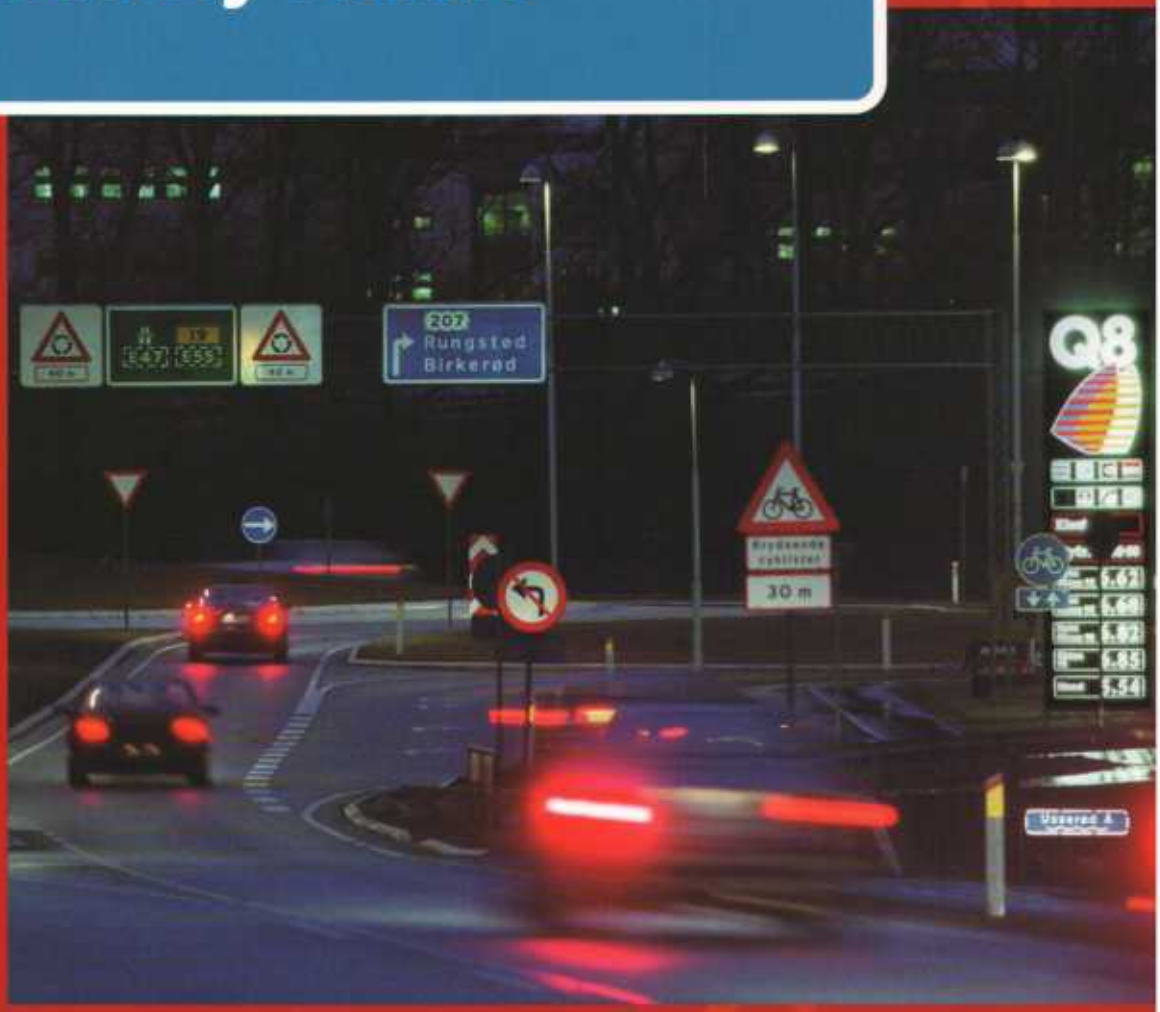
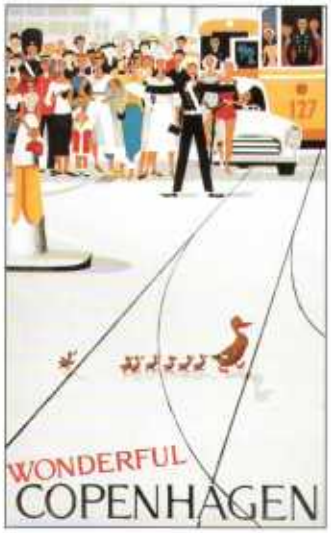
Manual of Road Safety Audit



Road Directorate
Ministry of Transport - Denmark



Viggo Vagnby, 1959

Manual: *Manual of Road Safety Audit, 2nd edition, 1997*

Authors: *Anders Gaardbo og Adriaan Schelling*

Project group: *Helle Blæsbjerg, civil engineer, Road Directorate*
Birgitte Fagerlund, B.A.
Anders Gaardbo, M.Sc., civil engineering, Road Directorate
Jens Holmboe, M.Sc., civil engineering, Road Directorate
Birger Munch, M.Sc., civil engineering, Road Directorate
Puk Kristine Nilsson, M.Sc., civil engineering, Road Directorate
Carl Dixen Pedersen, civil engineer, Road Directorate
Adriaan Schelling, M.Sc., civil engineering, Road Directorate (project leader)
Niels Schmidt, M.Sc., civil engineering, Municipality of Århus
Birger Villadsen, civil engineer, County of Sønderjylland
Jan Villumsen, architect, MAA, MDL, Road Directorate (upto January 1994)
Jacob Wrisberg, civil engineer, Road Directorate

Consultants: *Jannick B. Pedersen, Carl Bro*
Niels Chr. Alstrup, Carl Bro

Layout: *Eleven Danes*

Photography: *Lars Bahl*
Lene Storm (pp. 22)
Road Directorate (pp. 3, 17, 28, 37, 39 and 42)

Translation: *Vivian Bondy and Jason King*

Copies printed: *300*

Printing: *Anton M. Jensen*

Publisher: *Road Directorate, Road Safety and Environment Division*

Price: *DKK 250, including Danish V.A.T.*

ISBN No.: *87 7491 885 0*

Manual of Road Safety Audit

Road Directorate
Ministry of Transport - Denmark

Contents

Why?

Henning Christiansen, Director General

Prevention is better than cure, as the saying goes. This also applies to road accidents. This *Manual of Road Safety Audit* presents a method for the systematic prevention of road accidents.

All highway authorities – local councils, county councils and the Road Directorate itself - have the goal of reducing the numbers of fatalities and injuries on their roads. Road safety audit gives highway authorities a vital tool for attaining this end. Road safety audit also receives prominence in the Government's new road safety action plan, *"Every accident is one accident too many"*.

The Road Directorate has developed and tested this method in collaboration with county councils and local councils. The original inspiration came from England, where the use of *Road Safety Audit* is widespread. A pilot project has tested the Danish version of the method in a number of selected construction projects.

The pilot project was a success. Its evaluation – under the leadership of Professor N. O. Jørgensen, Technical University of Denmark – recommended road safety audit as being a very useful and profitable activity. The method should be introduced by all of the country's highway authorities as soon as possible.

As the Danish road sector authority, we consider it our self-evident task to continue to develop the method and to make road safety audit available to the Danish road sector. This manual is one of the results. In 1997, a training programme for road safety auditors will also be introduced and a database containing our most up-to-date road safety expertise will be set up on the Internet.

As one of its goals, the Road Directorate intends to introduce road safety audit as a general procedure for all construction work on trunk roads during the course of 1997.

This English version of the Manual is published as a response to the lively interest from the international road safety community in the Danish experience with road safety audit.

The Manual, however, is still a specific Danish one. It deals with the Danish road safety situation, and the Danish road design standards and organisations.

I am certain that this manual will inspire highway authorities throughout the world to introduce road safety audit, and to produce their own road safety audit manuals. Your comments on the Manual, checklists, procedures, etc., are welcome. Together with other experience gained, they will be incorporated into forthcoming editions of the Manual and will form a basis on which to adjust the system and the training programme. They will thus contribute to the development and improvement of road safety audit, for the benefit of safety on Danish streets and roads.

Henning Christiansen
Director General

How to Use This Manual

Why do we need a Manual?

This manual is aimed at decision makers and technicians throughout the Danish road sector, regardless of whether they work at the national, county or local levels – or for a consultancy. In short, at all people who can and should contribute to improving safety on Danish roads.

This manual describes a method of applying quality assurance to road projects, from the standpoint of road safety. The method is known as *"road safety audit"* or simply *"audit"*. When it becomes widespread in the Danish road sector, it is expected to make a significant contribution to the prevention of accidents on our roads. Thus, the purpose of this manual is to provide information of the method and to make it possible for everyone to apply it. It describes, for instance, how the road sector can introduce road safety audit. It is also an important aid for the technicians who will work with road safety audit.

Caption on road sign: 47 killed or injured, 5 years, 0-9000 m

Content of the Manual

The chapter entitled *"Introduction to Road Safety Audit"* describes the concept of road safety audit. It also describes the purpose and value of conducting road safety audits.

The chapter entitled *"How to Conduct a Road Safety Audit"* details the course of a typical road safety audit and defines certain concepts. It uses examples to illustrate some of the safety problems that can be dealt with through a road safety audit.

The chapter entitled *"How to Introduce Road Safety Audit"* describes the decisions that should be taken, the requirements set on organisation, procedures and qualifications and the sequence in which the various activities should be carried out.

The chapter entitled *"Principles of Road Safety Audit"* is a technical discussion of road safety. It describes the elements of road planning and design that have the greatest significance for road safety.

A number of appendices can be found at the end of the Manual. Appendix 6 reviews the 15 *checklists* that are published together with the Manual. These checklists can be used as aids when designing a road project or when undertaking a road safety audit.

Information sheets

Manual of Road Safety Audit

Loose forms for photocopying

Checklists

Status of Manual

Any highway authority can elect to avail itself in whole or in part of road safety audit. All of the Manual's instructions have the character of guidelines. The Manual does not stand alone, however. It is part of a long-term programme, the goal of which is to introduce road safety audit into as large a part of the Danish road sector as possible. Apart from the Manual, the external activities of this programme include:

- the establishment of a course on the undertaking of road safety audits,
- the establishment of a road safety database on the Internet.

In its capacity as highway authority for the trunk road network, the Road Directorate has also taken a decision in principle to introduce road safety audit. To that end, the Road Directorate is establishing its own local road safety audit system based on the general principles described in this manual. According to the plan, road safety audit will become mandatory for construction projects on trunk roads at the end of 1997.

We recommend the country's other highway authorities to set up their own road safety audit systems on the basis of the general principles of the Manual. It is our intention in the long term to establish road safety audit as a system within the Road Standards Board.

With the backing of the Road Standards Board, road safety audit could be expanded to proceed according to uniform, simple and clearly defined principles throughout the Danish road sector.

Introduction to Road Safety Audit

This chapter describes the concept, its purpose and the value of undertaking road safety audit

What is Road Safety Audit?

Road safety audit is systematic and independent assessment of the safety aspects of road projects. Its purpose is to make new and reconstructed roads as safe as possible – before construction is started and before accidents occur.

When conducting a road safety audit, individual projects are examined through "road safety glasses". Any inappropriate designs are revealed and proposals for improvements are formulated. Auditing can be carried out at one or more specific stages during the course of a project. The systematic approach taken means that consideration for road safety can be incorporated into a project at the earliest possible stage.

Road safety audit should be a self-evident phase of our highway authorities' *quality management* and it can be applied to all road projects – new constructions, as well as reconstructions. Road safety audit can also be applied to operating and maintenance activities on existing roads, to the extent that such activities can influence road safety.

> **"Road safety audit is systematic accident prevention"**

A road safety audit is carried out by one or more road safety *auditors*. One crucial factor is that the auditors be *impartial*. A road safety auditor must take no part in project design and it is not the *auditor's* task to weigh road safety considerations, for instance, against economic considerations – that is the responsibility of the client.

A road safety auditor must not question the justification for a project but must illuminate its consequences on road safety – and endeavour to ensure that the project as presented in the brief is as safe as possible.

Road safety audit must be conducted with due consideration for the abilities, knowledge and needs of the road users – and from the standpoint of all groups of road user. Road safety audit is *not* a check on the engineering quality of the project and nor is it any form of approval the project *per se*.

Accident Prevention

Road safety work is based on two main strategies: accident reduction and accident prevention.

In *accident reduction* we use our knowledge of accidents that have occurred on our existing roads to improve the design of the roads or to influence the behaviour of road users, so that similar accidents cannot occur again. Work on eliminating black spots is a typical example of accident reduction.

Accident prevention, on the other hand, is the application of our expertise in safe road design – road geometry, as well as the materials used – when we construct new streets and roads or redesign existing roads, regardless of the reasons for which an individual project has been undertaken. This expertise is the result of research and, to a significant extent, of practical experience gained in work on accident reduction.

Road safety audit is *systematic accident prevention*. It is a matter of systematically applying our present expertise in road safety – new and established expertise – to new projects, regardless of whether they are new installations, reconstructions or operating and maintenance activities.

Why Road Safety Audit?

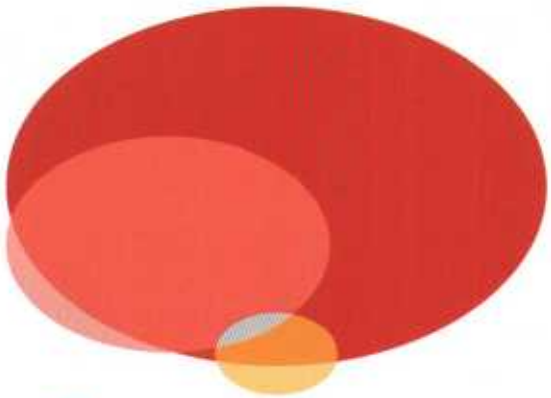
Engineers and other technicians engaged in road planning and design are aware that their projects must also be safe. That is why many new projects are already assessed from the road safety standpoint, but not all.

On many occasions, completely new projects have been designated as black spots after just a few years. There may be many reasons for this – including insufficient or absent road standards or the lack of up-to-date, easily accessible expertise in road safety. A road safety audit can be expected to correct this and, thus, to reduce the number of such black spots on new roads.

The goal of road safety audit is to ensure that all new road projects – and major operating and maintenance activities on existing roads – are assessed from the standpoint of road safety, so that any approaches that are unsuitable from this standpoint are detected and corrected in time.

In the first place, this means that we prevent people from being killed or injured on the roads before we react as a highway authority. In the second place, it is cheaper and easier to correct projects on the drawing board than it is after they have been implemented.

Road safety audit must consider the safety of all groups of road user



Road user, 65 %

Road user, road and surroundings, 24 %

Road and surroundings, 2.5 %

All elements, 1.5 %

Road user and vehicle, 4 %

Vehicles, 2.5 %

In road safety work, the concept of "accident factors" is applied to factors which, by their very presence, have contributed to the occurrence of an accident, or which, through their absence, could have prevented the accident in question. Such factors can be related to the road, the vehicles or to the road users. An analysis of accidents and accident data shows that such factors are distributed over accidents as shown in the figure.

Thinking in Terms of Road Safety

It should be the responsibility of any highway authority to ensure that the roads are safe. A road is considered safe when only a few – or, in the best case, no – accidents occur. If many accidents occur, a road is *not* safe, regardless of whether all standards and norms were observed during its planning and design, and regardless of whether any accidents can be attributed to contravention of the law or other inappropriate behaviour on the part of road users.

This is because road users are not perfect. Thus, the behaviour of road users appears as a contributing factor in practically all road accidents. This does not mean, however, that road engineering measures have no effect on the frequency of accidents; on the contrary, it demands that we guide road users into law-abiding and appropriate behaviour through the design of our roads.

A road safety audit cannot, therefore, take its point of departure solely in our view of how road users *may* and *shall* behave in traffic, it must also give careful consideration to experience of how road users *can be conceived* of behaving.

A road safety audit must assess projects on the basis of road users' knowledge, attitudes and skills, day and night, and in wet and dry road conditions. And it must give consideration to different groups of road users' abilities that depend on age, means of transport and any disabilities.

Road safety audit is only a study of safety aspects and an auditor may indicate road-safety problems inherent in designs that conform to our road standards. In the first place, this is due to the fact that our road standards are an expression of a socio-economic balance between road safety, accessibility, the environment and economy. In the second place, each road standard expresses our level of expertise at the time at which it was implemented and cannot allow for developments that have taken place since its implementation.

Value and Costs of Road Safety Audit

Although road safety audit can increase the costs of a project, this is far from invariably the case. And the sooner an unsuitable approach is detected and rectified, the cheaper. If we consider not only the costs of construction but also

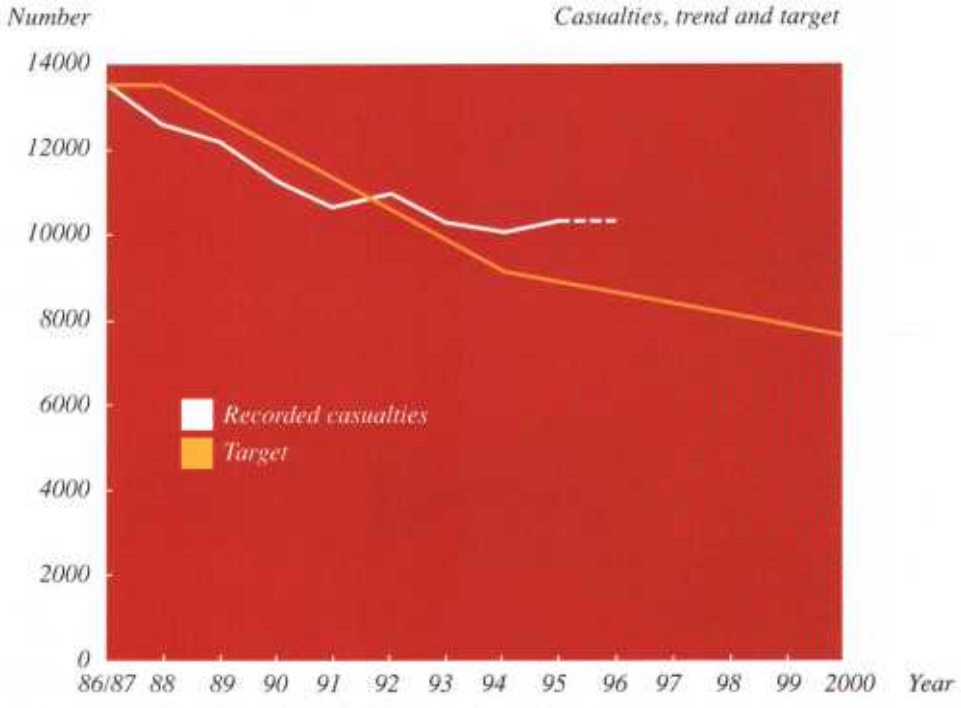
include the costs throughout a project's life cycle, including the costs of accidents, an increased construction cost can quickly prove to be a saving in the long term.

The value of road safety audit has already been ascertained. Based on the first years' experience of road safety audit in Denmark, it has been estimated, for instance, that road safety audit generates a theoretical first year's rate of return comparable to that of conventional work on eliminating black spots. And it is estimated that the cost of auditing, including the time of auditors and designers, typically amounts to about 1% of the construction costs – slightly more in the case of small projects, slightly less in the case of large projects. These estimates are taken from a report entitled *Evaluation of the Road Safety Audit Project*, written by a panel of independent experts. The main conclusions of the report are summarised in an information sheet, RSA-information 2/97, which can be ordered together with this manual.

Road Safety Audit in National and Local Perspectives

Road safety audit is a forward-looking and vital supplement to the advance work done to reduce the numbers of fatalities and injuries on our existing roads. This means that road safety audit is a tool available to individual highway authorities, in their efforts to attain the target stated in the Danish Road Safety Commission's Strategic Plan for reducing the numbers of fatalities and injuries by between 40 and 45%, starting from 1989, up to and including the year 2000.

The developments of recent years have not followed the target curve. There is, thus, a need for a renewed effort within the State, counties and municipalities, if the target is to be attained by the year 2000. This is where road safety audit can make a significant contribution and it has, therefore, been incorporated into the Government's road safety action plan, *Every accident is one accident too many.*



How to Conduct Road Safety Audit

This chapter describes how road safety audit can operate when it is carried out by a highway authority or a consultancy.

The first part describes the stages of a project at which road safety audit will be most beneficial. Next, the individual parties and their roles are described. Finally, there is a description of the typical course of a road safety audit – the individual activities during the audit process and the interactions of the parties involved.

Audit Stages

It will almost always be advantageous to undertake road safety audit on several occasions during the course of a project, except in the case of very small or very unusual projects. When constructing new roads, for instance, it is an obvious step to carry out an assessment of the impact on road safety of the planned locations and types of junction, before the individual junctions are designed and audited in detail.

For this reason, we describe five stages in the course of a project at which it can be appropriate to conduct a road safety audit – the so-called *audit stages* or simply *stages:*

Stage 1 Initial design (planning); an examination of the planning basis (such as choice of route options, standard, number of junctions and their types).

Stage 2 Draft (or preliminary) design; an examination, e.g. of alignment, cross-section and layout of junctions, before the political adoption of the project and before expropriations.

Stage 3 Detailed design; an examination conducted before tendering material is finalised (such as the detailed design of junctions, markings and equipment).

Stage 4 Opening; an examination of the completed project just before and/or just after it is opened.

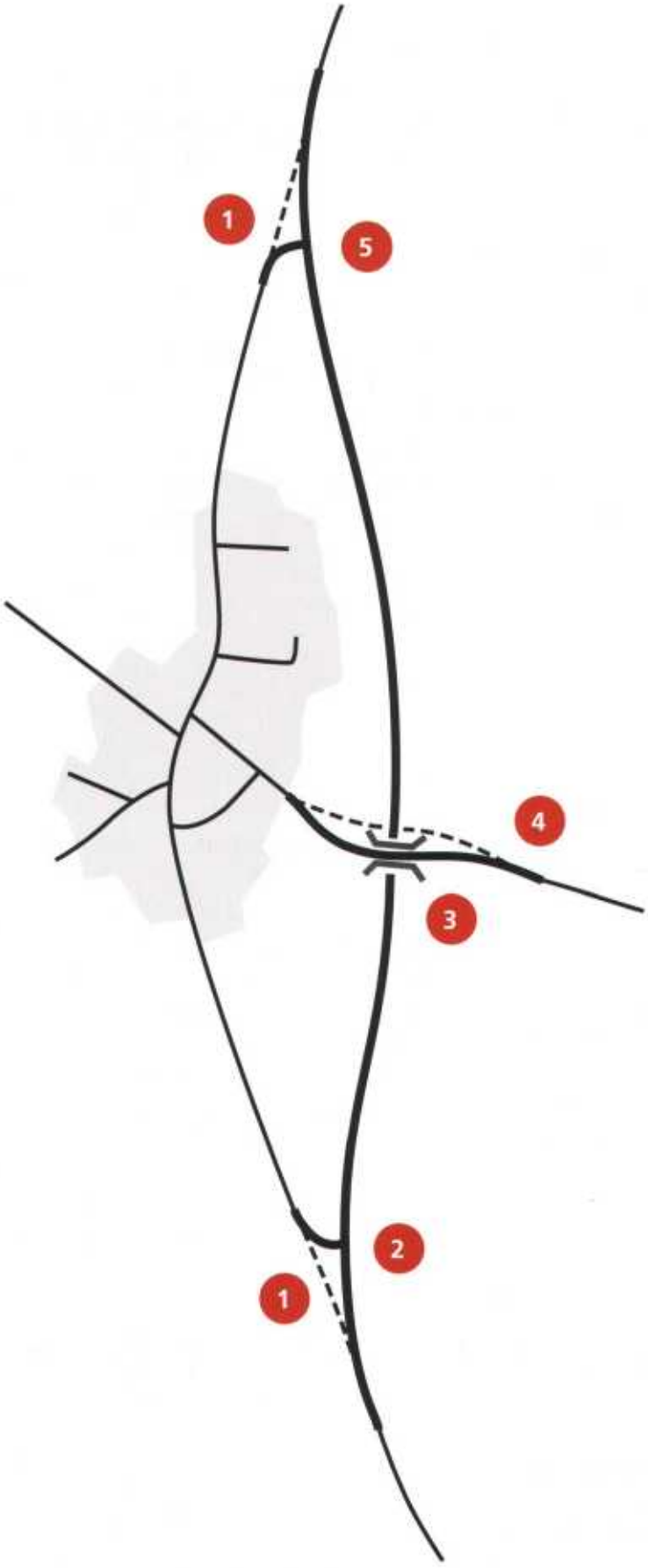
Stage 5 Monitoring (existing roads); regularly recurring assessment of the function, accident data, speed measurements, etc., of the road.

These five audit stages have been determined with a view to integrating road safety audit into the overall course of a project in the best possible way. The first three audit stages concern the project while it is still only on the drawing board. The last two stages concern the project after it has been completed. *Appendix 3* (at the back of this manual) contains more detailed descriptions of the individual stages.

In the case of small installations or reconstruction projects, separate initial, draft and detailed designs will only be prepared rarely. Thus, it can be relevant to omit auditing of the first stages or to combine it into a single audit, depending on the nature of the design process and the scope of the project.

The number of relevant audit stages will therefore depend on the *type* of project, and the auditing of all five stages will normally only be undertaken in major new projects. In the next chapter (pp. 21-24) you will find a more detailed proposal for classifying projects into categories.

The example overleaf illustrates the road safety topics that will be treated in a *Stage 1* road safety audit of a large bypass.



The figure shows an imaginary bypass project. A heavily-trafficked road passes through a small village of about 600 inhabitants and a new road is planned about 600 m to the east of the village.

The road safety audit could typically contain the following comments:

***General.** The two new junctions will increase the risk of road accidents, so that any improvement in safety gained by diverting traffic around the village will be minimal. The safety of the project as a whole would be significantly improved if there were only a single access to the village, and under no circumstances should the junctions be located on bends.*

***1.** At both ends of the bypass there is a risk that road users will not perceive the bends but will continue straight ahead, as the old road is still clearly visible in the landscape. The draft project should therefore make extensive use of plantations, markings and modification of the terrain, so that the false perspective is broken.*

***2.** Located at a bend on the bypass, this T-junction presents a risk of accident to road users turning left off the new road, into the village. It is difficult for them to assess the speeds and distances of approaching vehicles. Furthermore, all cyclists travelling towards the village must cross the new road here. This crossing should be rendered safe by installing a cycle path in a subway or, at the very least, by a traffic island.*

***3.** On this otherwise almost straight section of the new road, there is a risk that the bridge for the road that crosses the bypass will block the view of oncoming vehicles, thus making overtaking impossible.*

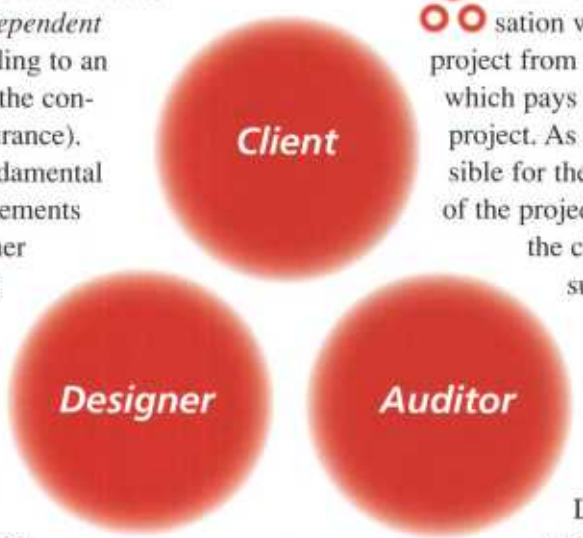
***4.** The local road that passes over the new bypass has sharp bends and steep inclines. It is dangerous for cycle traffic to and from the school. Traffic on the school road should therefore be safeguarded by cycle tracks, or at least by cycle lanes.*

***5.** At this T-junction, which is also located on a bend, there is a risk of accidents to road users who, leaving the village, turn left onto the bypass. This will be aggravated if a lane for right-turning traffic is implemented on the bypass, as vehicles in that lane could mask fast vehicles in the straight-ahead lane. This point also presents problems for cyclists crossing the road.*

Example - bypass

Organisation – the Parties and their Roles

Any audit proceeds in interaction between different parties, whose roles are predefined at specific stages. Road safety audit is based on the principle of an *independent* review (corresponding to an *external* review in the context of quality assurance). Moreover, one fundamental idea is that disagreements between the designer and the auditor are decided not by the designer but by the client, who has ordered the project from the designer. There are, thus, three parties to a road safety audit:



The design organisation (or simply the "designer") is the contractor, section or department responsible for planning/designing the project in hand. The designer bears the responsibility for ensuring that a road safety audit is conducted and that the necessary measures are agreed on the basis of the auditor's recommendations and/or the client's decisions.

During the course of the project, the designer is responsible for ensuring that the audit input information is unambiguously defined and that all circumstances are described in an easily-understood manner. The designer must also adopt a stand on the auditor's comments and must ensure that any disagreements between auditor and designer are presented to the *client* for a decision.

In the case of auditing at Stage 5 (roads in service), it is the operating organisation of the relevant highway authority which requests the auditor (the original auditor, if possible) to prepare an accident analysis of the project, and which arranges for the road operator to be notified of the results of the audit.

The *client* is the organisation which ordered the project from the designer, and which pays for and owns the project. As the party responsible for the basic conditions of the project, it is the task of the client (or its agent, such as a specialist consultant) to arbitrate in cases where the designer and auditor disagree. Disagreements are presented to the client, which sends its written decision to the designer and auditor. In the case of Stage 5 audits, the *road operator* assumes this responsibility.

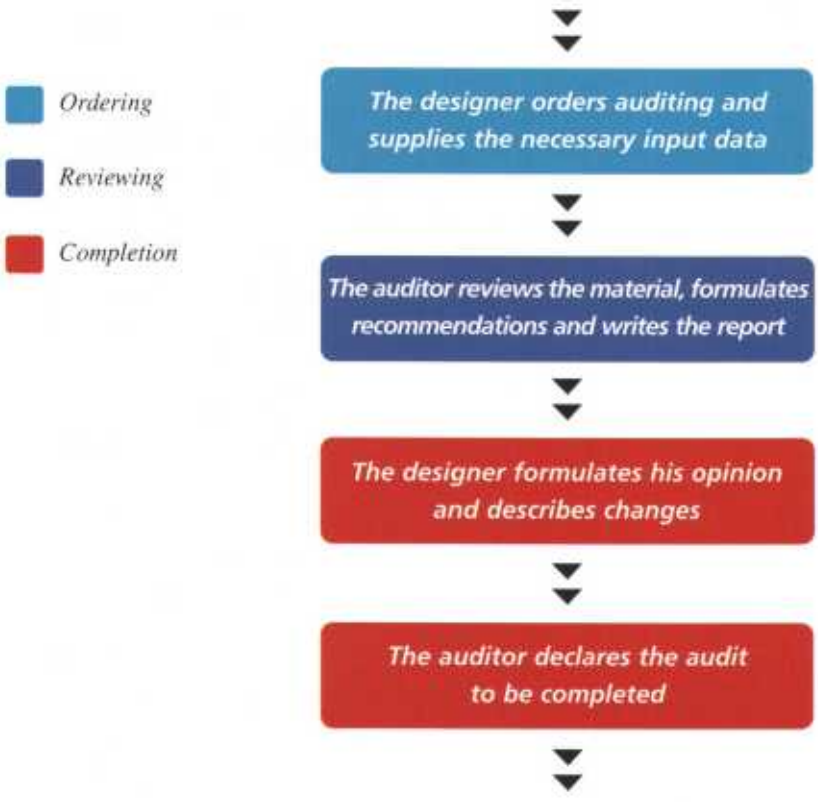
The *auditor* is the independent organisation or person who critically reviews and tests the designer's project material. It is the auditor's responsibility carefully to review the presented project material in its entirety, in the light of our best road-safety expertise and from the viewpoints of all relevant road users. The auditor shall indicate all circumstances that can cause any misgivings concerning road safety and shall describe and state the reasons for such misgivings.

It is not the primary task of the auditor to check whether or not a project conforms to road standards. Our road standards are an important tool and a vital reference for the auditor, but as mentioned on p. 8, the auditor must sometimes go beyond the road standards. It is a basic assumption that the designers themselves adopt a

position in relation to the norms, guidelines and instructions specified in the road standards, and that the designers report to the auditor in cases of non-compliance with the directives of a road standard and state the reasons therefore.

It is crucial that persons designated as road safety auditors work with, and have experience of, road accident analyses and road accident reduction. Furthermore, road safety auditors must be familiar with road planning, design, and construction work and must undertake to keep their expertise up-to-date.

In the long term, auditors should also hold a certificate. Auditor training will be offered in preparation for a forthcoming certification scheme. Apart from the above qualifications, an auditor should have completed this training and passed the final qualifying examination.



Audit Process

The organisation described in the foregoing section constitutes a vital foundation for the audit process. Starting from the fundamental principles of the organisation, road safety audit can be carried out according to the procedure illustrated on this page.

The following describes a typical audit process based on this diagram. Regardless of the scope and nature of a project, and regardless of the number of audit stages, it is always possible to conduct road safety audit as described by the diagram.

Ordering an audit

The designer gets in touch with an auditor and they enter into an agreement on auditing. Thus, it is the designer who takes the initiative, irrespective of whether the designer has personally selected the auditor or whether this was done by the client. Audits can possibly be ordered using a pre-printed requisition form, and the details of the agreement (including role assignments) can be confirmed on an agreement form. The latter could be designed, for instance, as shown in Appendix 1.

The designer then collects *all* drawings, obtains the necessary background information, etc., and provides this brief to the auditor. At the minimum, the brief should include:

- a brief project description
- an account of project conditions (design speed, radii of bends, super-elevation, sight criteria, etc.)
- reasons for any departure from the road standards
- traffic-density and accident data
- set of drawings (2 copies)
- an account of project changes since the previous audit.

What should the report contain?

- Name of project
- Audit stage
- Name and position of auditor
- Date of audit and dates and times of any inspections
- Relevant information on weather conditions during inspection
- All unusual circumstances (for instance, part of the project was in use at the time of the Stage 4 audit)
- Indication of all special traffic problems
- Sketches of proposals for eliminating or alleviating dangerous factors that have been indicated as problems
- Indication of all measures considered necessary for mitigating the effects of non-compliance with road standards
- Statement of the mutual significance of the recommendations and comments
- Parts of the plan that show the problems indicated. This is vital as it saves voluminous written descriptions of the relevant locations.

But

- Avoid verbosity (keep it simple and go straight to the point)
- No CV for the auditor
- No assertions to the effect that there are no problems
- No comments that do not pertain to the road safety of the project
- No copies of the documents obtained from the designer
- No checklists (use them, but do not append them)
- No extracts from the audit manual
- No comments from the designer

Scope

- Not more than 15 pages, plus appendices

Before starting the actual analysis, the auditor studies the brief. The auditor checks that all necessary information is available and obtains any supplementary information from the designer.

Reviewing

The auditor studies the project material. The auditor uses the relevant checklists to aid this study (the checklists can be ordered together with this manual; see p. 50, for a list of the checklists and an introduction to their use).

The auditor notes any obvious problems on the drawings. These problem areas are then structured, formulated, considered and documented in the first draft of the *audit report*.

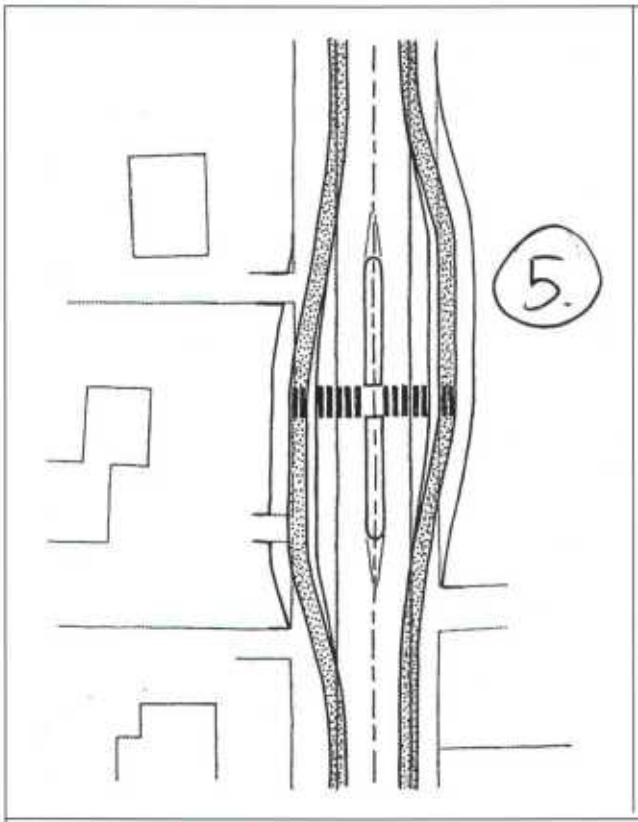
At this point in the process, the auditor gets in touch with the designer to ensure that they share an understanding of the project and its conditions.

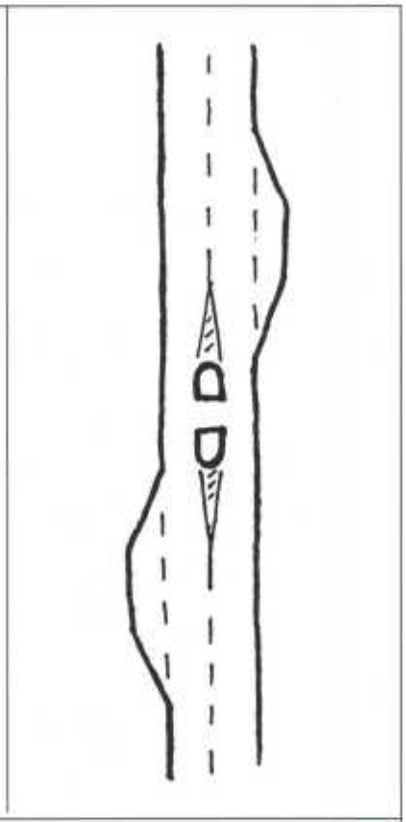
The auditor's comments should be structured on two levels: *problems and remarks*.

- The *problems* are the conditions that can be documented as entailing an increased accident risk. Problems must lead to project changes that can eliminate this risk or reduce it decisively.

It is the auditor's job to formulate proposals for alleviating problems. Such

Example - extract of an audit report
(project for reconstruction of a traffic road in an urban environment, Stage 2)





5. Bus stop and zebra crossing

Problem:
The zebra crossing (which, in itself, is a dubious measure, cf. General Comments) crosses the road where it is broadest and actually has four lanes (even though there is a traffic island).

Recommendation:
The laybys should be shifted relative to each other, so that there is a short 2-lane section which pedestrians can cross via the central island (see sketch).

proposals must illustrate that it is possible to improve the road safety of the project; however, it is not the auditor's job to design the changes.

• *Remarks* concerning the conditions that experience has shown should be given attention in continued designing, but for which it is not possible to document an increased risk to road users at the current audit stage.

The auditor then prepares proposals for possible approaches to resolving the problems ascertained. The best proposal for each individual problem is then described, justified and documented in the final draft for the audit report.

The auditor has the audit report reviewed from the standpoint of his own QA system and corrects the report.

The audit report is now finished and must be signed by the auditor (if several auditors have participated in the audit, a single auditor signs as being responsible for the audit).

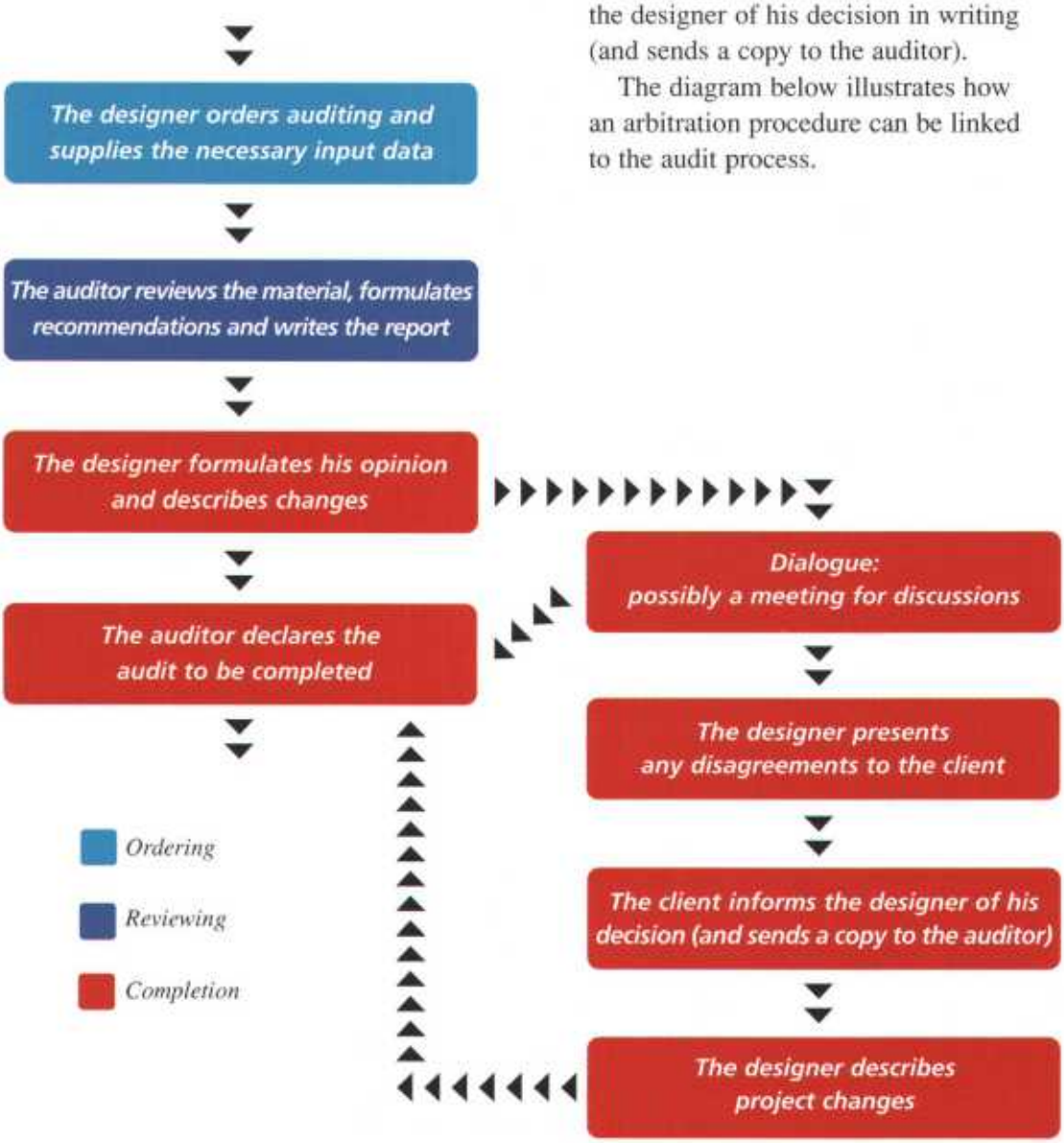
Completion

The auditor sends the audit report to the designer (and a copy to the client). The designer now formulates his opinion of each individual *problem* mentioned in the auditor's report, stating whether or not the auditor's recommendations will be adopted (the designer can possibly prepare alternative proposals for changes).

The auditor determines whether or not agreement has been reached on the problems. The auditor could possibly present the audit report to the designer at a meeting.

In the event of disagreement on the problems and/or their proposed solutions, it is the *designer's* job to inform the client in writing of the disagreement (and to send a copy to the auditor), and to request a decision. The client notifies the designer of his decision in writing (and sends a copy to the auditor).

The diagram below illustrates how an arbitration procedure can be linked to the audit process.



When the client's decision is available, the designer notifies the auditor in writing of all changes to the project.

This can mean that the audit process must be repeated for the changed parts of the project. When the audit has been completed, either through agreement or through the intervention of the client, the auditor issues a written declaration to that effect. It is, therefore, the auditor – not the designer – who formally declares that the audit is finished.

Road safety is also a question of attention to detail - such as this drain grating in a new cycle track.

When the next audit stage is to be carried out in the project, it is simply initiated by a new order, when the designer is ready. It is a great advantage to use the same auditor as was used in the earlier stages. The auditor should not under any circumstances resume a discussion that has already be decided during a previous stage – unless project changes implemented since the preceding audit stage make renewed discussion relevant.

Road safety audit is a formal process which should be documented in documents and the protocols of meetings. All of the auditor's comments and the subsequent decisions should be given in writing. In practice, we strongly recommend informal contact during the process, to obviate misunderstandings and to mitigate any conflicts.

Appendix 5 shows a suggested *audit form*. This form can be used as a requisition when ordering auditing, and as documentation of the relevant stage of the audit process. The designer can, thus, use the form to control and summarise the course of the case at the relevant stage, thereby documenting the safety-related quality assurance of the project.

How to Introduce Road Safety Audit

This chapter describes how to introduce road safety audit. What must be decided and what organisation, procedures and qualifications are needed?

Road safety audit – co-ordinated and applied in accordance with a highway authority's size and level of activity – constitutes an invaluable contribution to that highway authority's endeavours to reduce the numbers of fatalities and injuries on its roads.

As we have already mentioned, one of the goals of road safety audit is to ensure that projects are studied from the road safety angle. To qualify as a road safety audit, such a study must be conducted competently and independently and it must proceed systematically, according to an agreed procedure.

Based on these fundamental principles, a set of guidelines for implementing a road safety audit is described below. These guidelines are known as the *general system*.

The General System

It consists of three parts:

1. The necessary *organisation* (the parties);
2. The basic *procedure;*
3. A standard description of the phases in the course of a project at which auditing can be carried out, i.e. *the audit stages.*

The general system defines road safety audit. It covers the requirements that should always be satisfied, if specific road safety advice is to be called road safety audit.

When a highway authority wishes to introduce road safety audit, that authority should take its point of departure in the general system.

In the general system, the *organisation* comprises three parties, i.e. the client, the designer and the auditor, who are described in detail in the previous chapter, in the section entitled *Organisation* (p. 12). *Table 1* on the next page shows the general system's definition of the parties and the roles they play.

The division of responsibility between three parties serves several purposes. First and foremost, it makes it possible to specify the distribution of competence in advance of each individual audit, so that decisions in the event of disagreement between the auditor and designer can be resolved at the level that bears the overall responsibility, i.e. by the client. In this way the division of responsibility contributes to ensuring the independence of auditing. This is important, since it may be the case that all three parties are to be found within the same highway authority. As we have already mentioned, *Appendix 1* shows a suggested agreement form, which can be signed by the parties in confirmation of the agreement and of the roles assigned to them, This form has been designed so that it can be used for the individual audit stages or as a "standard agreement" for several projects and audits.

The procedure of the general system is shown in *Table 2* on the next page. The procedure is simple and should be suited to any highway administration. *Appendix 2* shows a proposal for a more detailed description of the procedure, which corresponds to the process description of the previous chapter, under the section entitled *Audit Process* (p.13).

A preliminary description of the five *audit stages* is given in the previous chapter, under the section entitled *Audit Stages* (p. 10). This description corresponds

Table 1

General System: Organisation (parties and role distribution)	
Parties	*Role*
Client (operator)	Orders and finances the project. Responsible for project pre-conditions. Decides disagreements between the designer and auditor.
Designer (operating organisation)	Designs the project according to the pre-conditions. Responsible for initiating the audit and for modifying the project according to the auditor's recommendations. In the event of disagreement, presents the case to the client for a decision.
Auditor	Reviews the project. Indicates road safety problems and formulates recommendations.

Table 2

General System: Procedure	
Phase of process	*Activities*
Ordering	The designer gets in touch with an auditor, orders audit and dispatches all necessary material. Possibly sends supplementary material, should the auditor so desire.
Reviewing	The auditor examines the supplied brief and carries out any eventual inspection. The auditor indicates any problematic parts of the project and develops proposals for remedial approaches. The results are collected in a report which is sent to the designer, with a copy to the client.
Completion	The designer notifies the auditor in writing of his opinions. A clarifying meeting may be needed. The designer presents any remaining disagreements to the client, who makes the decisions and notifies the designer of them in writing, with a copy to the auditor. The designer then describes modifications to the project to the auditor, who subsequently declares the audit completed.

Table 3

General System: Audit stages

Stage No.	Designation	Content
Stage 1	Initial design (planning)	Review of the brief (such as choice of route options, standard, number of junctions and their types).
Stage 2	Draft design	Examination, e.g. of alignment, cross-section and junction layout, prior to political adoption of the project and prior to expropriations.
Stage 3	Detailed design	Review before tendering material is finished (e.g. detailed design of junctions, road markings and equipment).
Stage 4	Opening	Examination of the finished construction immediately before or after opening.
Stage 5	Monitoring (existing roads)	Regular reassessment of the function, accident data, speed measurements, etc.

to the definition of the general system, which can be seen from *Table 3*. *Appendix 3* gives a more detailed description of the content of the individual stages.

It is now possible to establish a *local system* on the basis of the guidelines of the general system. While doing this, the highway authority should decide which types of project to audit, at which stages and by whom. The procedure is stated in the general system.

Highway authorities' local systems should also be arranged so that they can be included in the particular authority's present or forthcoming QA system.

Implementation

Once a highway authority has taken the decision to introduce road safety audit, we recommend the following approach when setting up a local system.

1. Appoint a project leader

We recommend that a project leader be appointed prior to the introduction of road safety audit. The project leader will be responsible for the progress of the project, prepare budgets, time schedules, etc., and deal with information intended for employees affected by the project and for the organisation in general. It can be highly advantageous for a project leader to ally himself with a highway authority that has already introduced road safety audit.

2. Specify stages and project types

The types of project of relevance to a highway authority should be defined and the stages at which the individual types of project will be audited should be described. More detailed guidance in this can be found in the next section (p. 21). The description of project types and stages should be approved by the management – as when introducing quality management,

the support of the management is quite decisive.

3. Specify local organisation
Draft a description of the persons, sections and departments in the local highway authority that can fill the individual roles in the local organisation. When doing this, consider whether or not one or more of the highway authority's own employees should be trained and take the examination to qualify as auditor(s).

Within a highway authority, it will rarely be possible to find qualified employees, who are at all times independent of the sections or departments which plan or implement projects. If the highway authority's own employees are used it is therefore necessary to specify when (on which project types and audit stages) a particular auditor can be considered to be impartial. Employees should be involved in the specification of the local organisation, and the organisation plan should be approved by the management.

4. Prepare a list of auditors
To assist the designers, draw up a list of potential auditors. This list can include the highway authority's own road-safety workers, consultants or, for instance, road-safety workers from another highway authority with which an agreement – possibly reciprocal – could be made.

5. *Draft a local road safety audit manual*
It should describe the local system, its organisation, types of project and stages, etc.

6. Complete the instruction and training of all concerned employees
It is vital that the employees be thoroughly informed about the audit system, including its background, purpose and its expected effect. It is important in this context to clarify all questions of competence (powers of decision) before taking the system into operation.

Even minor measures can be significant - in this case, a recessed stop line.

7. Evaluate and adjust the local system
Routines should be established for regular evaluation of the local system.

Choice of Project Types and Stages

We recommend that road safety audits be implemented on all new constructions and reconstructions of a certain size. These choices should compare the degree of complexity of the projects to the highway authority's level of experience.

Even small and relatively inexpensive projects can be audited to advantage if experience of their design is only limited. An auditor will always be able to indicate the most recently documented safety-related experience of specific designs.

We also recommend you to ensure the quality (from the road safety standpoint) of a number of types of project other than projects for new constructions and reconstructions. We recommend that all major maintenance works, existing roads, road safety improvement schemes, as well as regional, municipal and local development plans that presume road and path accesses or other traffic-related changes, be included in road safety audits.

New motorway - a typical major project

We thoroughly recommend all five audit stages, from planning, to monitoring of the roads after opening. In the case of minor projects and projects of a special nature, however, it is often advantageous to merge several stages.

Appendix 4 clarifies when and where road safety audit is recommended. The projects are subdivided into types in the overview. They include new constructions and reconstructions, regardless of whether they are financed through a construction or maintenance grant.

Major projects
This type includes schemes for large, new roads, i.e. motorways, expressways and other major installations, such as bypasses. Auditing should be carried out at all stages.

Medium-sized projects
This type covers schemes for the reconstruction and widening of existing roads (such as traffic calming on roads through urban areas) new constructions and major reconstruction of existing junctions and interchanges. Audits should be carried out at Stages 1/2, 3, 4 and 5.

Minor projects
This type covers schemes concerning minor widenings and remodeling (such as where a bend is straightened or where road width is changed), lateral expansion, the construction of cycle paths, minor traffic-calming projects, minor recon-

struction of junctions, etc. Audits should be carried out at Stages 1/2/3, 4 and 5.

Operating and maintenance work
Operating and maintenance consists of many widely diverging activities, which include everything, from extensive maintenance work on existing roads, to everyday maintenance.

In all maintenance projects that entail permanent changes to roads, it is desirable to apply road safety audit as a means of ensuring that all aspects of road safety are taken into consideration.

This serves a dual purpose: in the first place, it is necessary to ensure that any road safety problems on the existing road are not still present after renovation, and in the second place, the implementation of the project must be prevented from introducing new road safety problems.

Our pilot project has not tested road safety audit on existing roads, including the operating and maintenance of such roads. This means that we have not yet studied the optimum extent of road safety audit in conjunction with specific operating and maintenance work.

For the time being, we recommend the following guidelines for road safety audit in maintenance work on existing roads.
a) Road safety audit is carried out on all operating and maintenance guidelines applied by the individual highway authority (road standards, tendering and maintenance directives, working instructions, etc.).
b) Road safety audit is carried out on maintenance works which can be considered as independent projects and which have a significant effect on road safety. For instance, resurfacing and reinforcement work, restoration after work on underground cables or pipes, plantation projects, renewal of road equipment (such as guardrails, lighting installations and gantry signs), and all traffic management schemes (such as carriageway markings, signs and traffic signals).

Any road accesses included in local plan proposals should be audited.

Road safety audits of operating and maintenance work can be carried out at one or more stages, depending on the scope and nature of the work being done.

Regional, municipal and local development plans
Physical planning (regional, municipal and local development plans) can have significant consequences for the traffic conditions of existing roads and, thus, for road safety. We therefore recommend that a road safety audit (Stage 1) be carried out prior to the public hearing phase. This audit should be arranged by the relevant planning authority, regardless of whether the concerned highway authorities present comments on the plan.

Any projects included in the plans for new installations and reconstruction on roads and junctions should subsequently be audited at the relevant stages when the project is implemented.

Traffic calming – typical minor or medium-sized project

Road safety improvement schemes
In this context, road safety improvement schemes refers to projects that have the improvement of road safety as their sole purpose, such as proposals for the reconstruction of black spots. Such projects are often decided on the basis of systematically assigned priorities and it is vital that these priorities be assigned on the firmest possible basis; for this reason, the proposed reconstruction of black spots and other road safety improvement schemes should be subjected to road safety audits, even though the projects are in principle "born safe". A Stage 1 audit should be conducted, with the sole purpose of assessing whether or not the proposals serve the desired purpose – i.e. aim to resolve the ascertained safety problems without creating fresh ones – and are in fact the best possible from the standpoint of road safety. The individual projects should subsequently be audited at the relevant stages when they are implemented.

Existing Roads

Our expertise in safe road design undergoes constant development and even relatively new roads do not always attain the desired standard of safety recommended for new schemes today. Vehicle designs and traffic flow patterns change over the years, so that many roads are used today in ways that diverge from the original plans. A programme of continuous monitoring and improvement of our road network offers enormous potential for accident prevention.

Road safety audits of existing roads correspond to – and are conducted according to the same principles as – the auditing of new roads at Stage 5. As in the case of new projects, the purpose is to indicate elements of the existing design, layout, and road equipment, which are incompatible with the way in which road users use the road – and which can be expected to cause, or have been ascertained as causing, accidents.

The result of auditing is a report that is sent to the operating organisation and – in the case of recent constructions – with a copy to the designers.

When there is agreement on any problems, or when any disagreements have been resolved, the operating organisation can set the priorities (i.e. times) of implementation, depending on how serious the problems are. This can be a question of conditions that must be corrected immediately, conditions that must be corrected at the first convenient opportunity in connection with continuous maintenance, and changes that will be included when deciding the priorities of construction works.

It can be advantageous to incorporate road safety audits of existing roads into a highway authority's action plans for road safety, in the form of a special programme in which the entire road network is examined according to set priorities and which is repeated at regular intervals.

Principles of Road Safety

This chapter summarises the technical content of the audit process - what will be the impact of giving consideration to road safety?

Where road safety audit (as described in the foregoing chapters) is the formal framework which describes *how* road safety considerations are brought into scheme design at the proper time and how road safety is weighed against other considerations at the correct level of the responsible organisations, the principles of road safety form the basis of the technical *content* of the design and audit process. This chapter deals with the conditions which are of particular significance to road safety when designing road geometry and traffic regulation.

This description does not delve into the details. That would be far beyond the scope of this manual, and the collected body of expertise in this area undergoes constant development, anyway. We must instead refer interested readers to the *database*, for specific, up-to-date, situation-related information on road safety.

Road safety is a result of the complicated interaction that occurs between many elements, and the literal application of norms and rules certainly does not always lead to the safest possible design. This is particularly the case where the rules (also) take into account conditions other than safety.

> ***"Road users make mistakes: minimise the opportunities for errors! If mistakes are still made, minimise the consequences!"***

The safest road designs are obtained if, during designing (and even before auditing enters the picture), constant consideration is given to road safety, by asking:

- can the road design be misunderstood by road users?
- can the design cause confusion?
- can it give rise to ambiguity?
- does the road design give insufficient information?
- does it give too much information
- does the road design give insufficient visibility or does it obstruct the view of the road?
- does the project include obstructions or "traps"?

If the answer is yes, the source of the problem should be sought by asking a number of open questions (such as "How?", "Why?", "When?", "Where?", etc.).

Road Users as Pre-conditions

As we have already mentioned, road users and their behaviour are a contributory cause in by far the greater part of all road accidents. Road users represent a broad cross-section of the public and there are limits to what we, as road users, can cope with when converting information – from the layout of the road, signs and road markings, other road users and conditions in general – into action. As is the case with anyone else, road users overestimate their own abilities and misunderstand each other's intentions when the situation becomes too complex, unclear or unusual and there is too little time in which to think and react. It is therefore a vital task of the designers and road safety auditors to design our road installations according to human criteria and not to demand too many actions per unit time, first and foremost by avoiding:

- excessive speed differentials,

• differences in direction,
• high absolute speed,
• unpredictable situations.

To put it another way, road users must perceive and process information, make decisions and react, all within a limited time. Comfortable, safe driving is obtained when road users can do these things at a tempo which is well below the stress level, but which is sufficiently high to be stimulating. This is one of the fundamental conditions for establishing and maintaining safe road environments.

Safe road environments
• warn road users of all conditions that do not conform to the norm or are in any way unusual,
• inform road users of the conditions they will encounter,
• guide road users through unusual sections,
• guide road users through conflict points or areas,
• forgive road users' errors and inappropriate behaviour.

Situations that are similar must be treated in similar ways. It is important to avoid:
• insufficient or deficient treatment (something is done about a situation, but not enough),
• incorrect or misplaced treatment (the wrong treatment is applied to a situation),
• exaggerated treatment (too much is done to ensure safety, with the risk that other, similar situations that have been correctly treated become veiled).

Avoid overloading road users. Overloading can cause vital information to be overlooked. Overloading can be caused by a plethora of traffic signals, conflicting messages and a lack of clarity about the course of the road. A safe road environment is therefore one which:
• does not contain surprises from the standpoint of road design or traffic regulation (i.e. which lives up to the expectations of the road users),
• gives a controlled stream of relevant information (not too much at once),
• gives repeated information when a danger factor is to be emphasised.

"Avoid overloading road users"

Planning of the Road Network

When planning and auditing at Stage 1, careful consideration should be given to the principles of planning the road network in its entirety with consideration for road safety. Consideration should be given to the special needs of the different groups of road user, e.g. the need for facilities for pedestrians and cyclists, especially in urban areas. This can be done by establishing appropriate traffic routes, imposing restrictions on vehicles and separating different types of road user. Effects caused by the project on neighbouring road networks (such as noticeable increases in traffic volumes) should also be assessed. See *Road Standards for Urban Traffic Areas, Volume 0 (1).*

Geometric Design

The geometric design elements that have special influence on road safety can be roughly divided into:
• design of junctions,
• access control,
• alignment (layout, vertical alignment and their mutual interaction),
• cross-section.

Road users' correct use of road installations is normally conditional on the presence of markings. All markings and road equipment must therefore be included as an integral part of the geometric design project. This also ensures that the geometry is designed so that it is possible to apply clear, easily-understood markings.

Overloading can cause vital information to be overlooked

Junctions

A very large proportion of accidents occur at junctions (up to 60% in urban areas and 40% in rural areas). The road network should therefore be planned so that the number of junctions is as limited as possible. The choice of junction type, design and regulation should be governed by:

- the fact that the number of possible conflict points must be minimised. T-junctions have lower accident rates than four-armed junctions, and junctions with four or more arms must either be avoided or they must be designed as roundabouts;
- the avoidance of recognition problems. Junctions must be clearly visible to road users approaching the junction. Be attentive to the vertical alignments of intersecting roads as they approach the junction. To avoid misleading visual impressions, it may be necessary to emphasise the presence of a junction with a plantation, extra signs and traffic signals or background markings;
- the need to ensure adequate visibility and a good overview. Acute angles at Y-junctions, and skewed junctions with a limited sight distance in the direction of travel, pose greater accident risks than regular junctions, especially for elderly road users. Junctions at which the visibility splay is highly asymmetrical lead to an increased accident risk and must be avoided;
- the establishment of facilities for traffic turning off the major road. Protected lanes for left-turning vehicles can reduce the number of accidents. On the other hand, dedicated lanes for right-turning

traffic do not necessarily improve safety. See *Road Safety Manual (2).*

- the number of gaps in the central reserve (on dual carrigeway roads). These should be restricted to the places where left turns and U-turns can be executed with the greatest safety, e.g. at roundabouts;
- use of the most appropriate form of junction control commensurate with attaining the optimum road safety for all road users – see pp. 39-40;
- care to provide safe crossing opportunities for pedestrians and cyclists at places where pedestrian and cycle traffic warrant such care – for instance, through the use of islands. See *Road Standards for Urban Traffic Areas, Volume 5 (1).*

Visibility obscured by road equipment

Access control

The regulation of access conditions and control of the areas adjoining roads are important means of minimising accidents. Roads with direct frontage access generally have accident rates of almost double those of roads from which there is little access *(2).* In areas where there is intensive frontage development, accident rates can be up to 20 times higher than on roads with little access. See *Guidelines for The Safety Audit of Highways (3).*

a) Access to new traffic roads should be subject to restrictions, which should also cover private accesses.

b) New local distributor roads should only be accessible from frontage if, in each individual case, there are special reasons for such access.

c) The number of access points to a road must be kept to the minimum. Accident rates on rural roads can increase by 5% for each new access/kilometre of road. See *Safety Effects of Highway Design Features, Vol I (4).*

d) To limit the number of conflict points, connections to local roads should be avoided in the vicinity of junctions between main roads.

e) Regardless of whether access points are access to property or junctions, they should not be located on or near sharp bends of limited sight distance. This applies equally to horizontal and vertical bends. The visibility requirements set on private accesses are the same as those set on junctions.

f) Side roads which are cul-de-sacs should incorporate turning space, to obviate the need for reversing out onto the main roads.

Alignment

Road alignment standards are only set on roads in urban areas. See *Road Standards for Urban Traffic Areas, Volume 2 (1).* In the case of roads in rural areas, highway authorities apply their own internal "standards" (i.e. the Road Directorate's design rules for motorways) and older works (the 1964 draft road standards) or various text books.

Applying road delineation to improve an unpredictable alignment

Accident rates are affected by horizontal and vertical alignment and the interaction between them.

a) Sudden changes of alignment standards should be avoided. If tight horizontal and vertical bends are unavoidable, road users must be prepared for them by reducing the radii of bends smoothly along a section on both sides of the sharpest bends.

Vertical alignment: the risk of accident is greatest at the profile's crests and dips and is especially well correlated to long sections with steep gradients.

b) Due consideration must be given to slow-moving vehicles on ascending gradients. Advance warning should be given of steep gradients on fast roads.

c) Any limitation on sight distances should be reduced as much as possible at the crests of hills.

Horizontal alignment: the number of accidents increases as bends become sharper. This is a significant factor in rural areas when bend radii are less than about 450 metres. The sight distance is the critical factor here.

d) The horizontal alignment must be suited to the desired speed level. But horizontal bends with radii of less than about 300 metres should only be used with caution and should be avoided outside urban areas.

e) Combinations of horizontal and vertical alignment that can lead to misunderstandings and optical illusions should be avoided. For instance, accident rates are higher at places where a horizontal bend starts just after a peak in the vertical alignment.

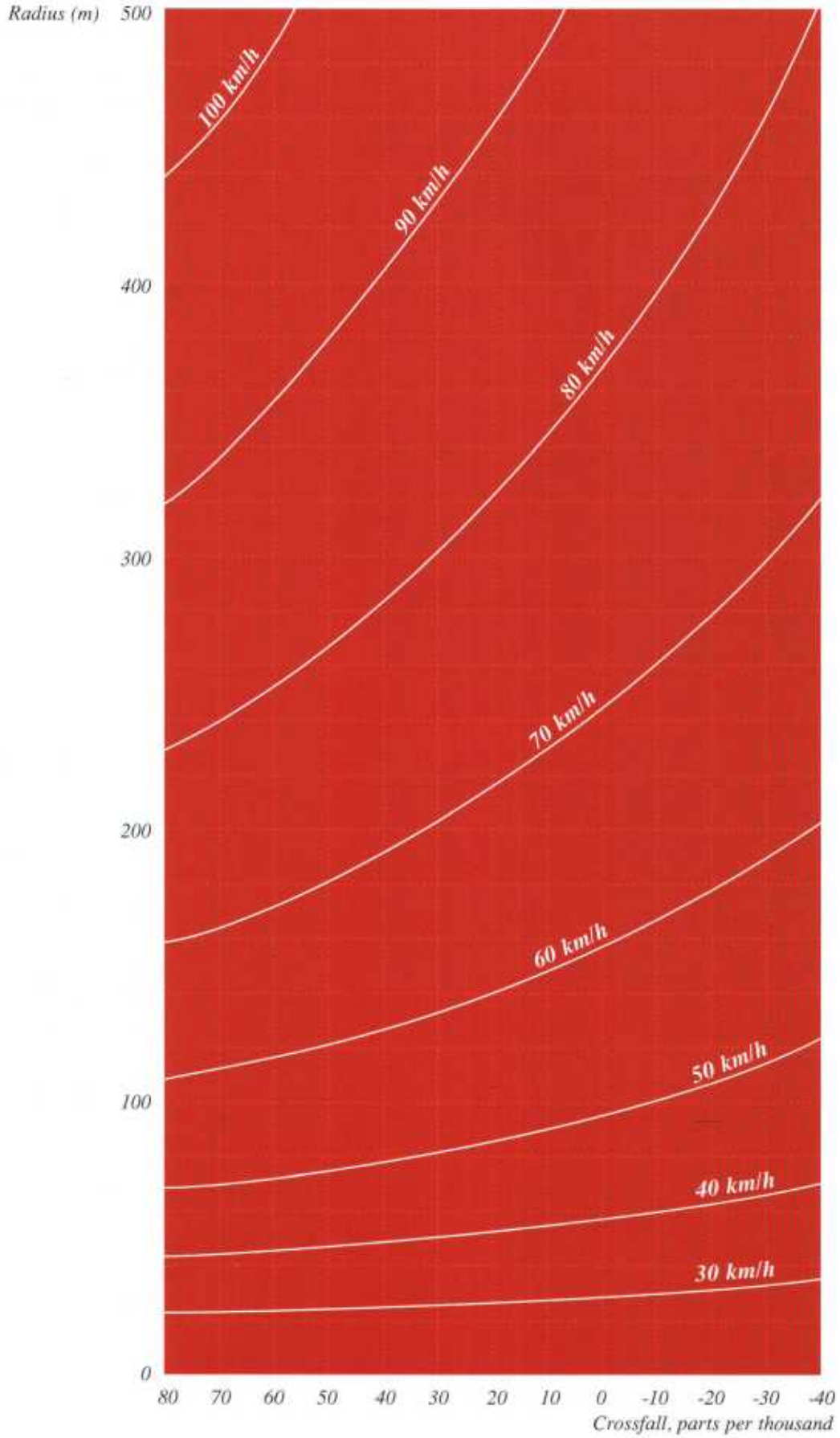
Crossfall

Crossfall is provided to lead water away from the road surface and to counteract centrifugal forces on bends. See *Road Standards for Urban Traffic Areas, Volume 2 (1).*

a) Crossfall on straight sections, established solely for the purpose of drainage, should be a minimum of 20‰ and a maximum of 30‰, depending on the type of surface. 25‰ is normally used. Crossfall should also be constructed on roads with longitudinal gradients. Double-sided crossfall gives the best drainage.

b) A gutter gradient of at least 5‰ (artificial gutter gradient) should be constructed on kerbed sections of road which have longitudinal gradients of less than 7‰.

Relationship between bend radius (m), crossfall (‰) and maximum justifiable speed (km/h).



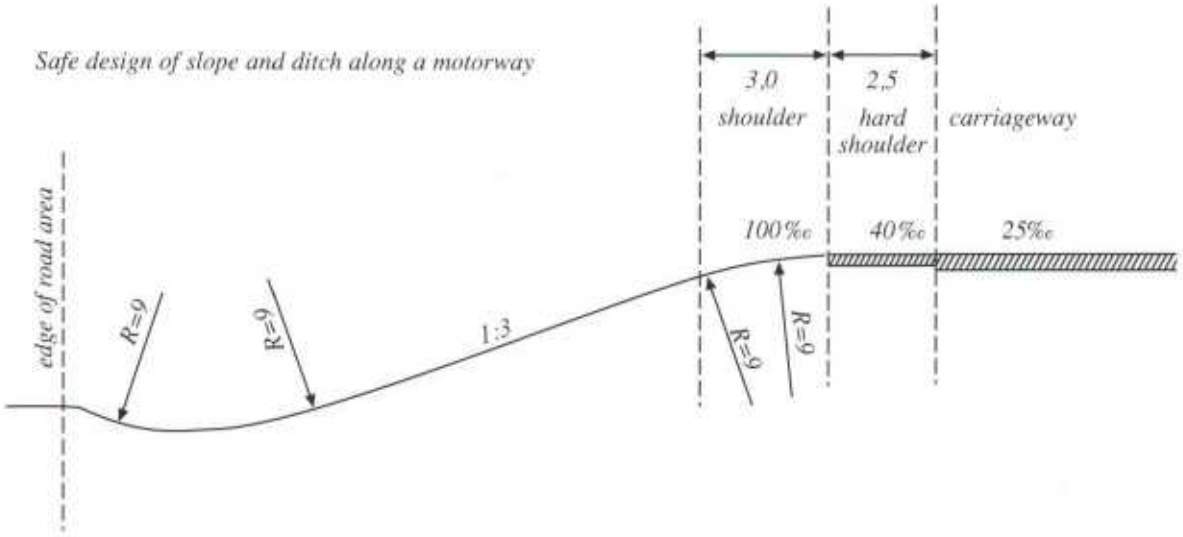
c) The resulting gradient should not exceed 60‰.
d) The one-sided crossfall necessary to ensure safe use of the road on bends is determined by the design speed and friction of the road surface when wet. See *Road Standards for Urban Traffic Areas, Volume 2 (1).*
e) The best drainage is obtained where a superelevation ramp is constructed as a "moving crown line". Revolving of carriageway edges results in large areas of the carriageway that are almost entirely without a crossfall. This leads to the accumulation of water, even on sections with longitudinal gradients, and should therefore be avoided. See *Road Standards for Urban Traffic Areas, Volume 2 (1).*

Cross section
Road safety is affected by the number and width of lanes, the central reserve, presence of cycle tracks or lanes, as well as by the design of parking lanes, hard shoulders, banks, etc. The interaction between these parameters and the traffic density is complex and the advice given in the road standards should be studied carefully. A few general principles are:
a) The more lanes on a road, the lower the increase in the number of accidents as traffic increases. Where significant increases in traffic volume are expected, rural roads should therefore be planned so that it is possible to expand them to accommodate more lanes than were originally planned, unless completely new roads are also being planned;
b) Lane widths in urban areas are determined on the basis of the desired speed. See *Road Standards for Urban Traffic Areas, Volume 3 (1).* Lanes that are too wide lead to speeds that are too high and should therefore be avoided. Passage for large vehicles can be ensured through the partial or total paving of verges and islands, over which such vehicles can drive at low speed;
c) The construction of cycle tracks and cycle lanes on streets and roads can reduce the number of accidents in which cyclists and moped riders are involved by 35 to 50% on road stretches between junctions. However, what is gained on such stretches is lost again at the junctions. See *Cycle Tracks in Urban Areas, the safety effect (5), Safety of Cyclists in Urban Areas (6) and Road Safety Effect of Cycle Lanes in Urban Areas (7).* All things considered, junctions must be made safer if the construction of cycle tracks or cycle lanes is to improve road safety; see pp. 39-40. You should also be aware that:
- conflicts can occur at bus-stops and where vehicles are parked on or beside cycle lanes;
- fewer serious accidents involving personal injury occur on cycle tracks than on cycle lanes. Cycle tracks work better for children than for adults;
- bi-directional cycle tracks along roads invariably lead to unconventional manoeuvres at junctions and where such paths terminate. These situations entail a significant risk of accidents. Bi-directional paths along roads should be avoided wherever possible;

d) There is a safety advantage in striving for 3.5 m wide lanes on two-lane roads in rural areas, although wider lanes offer no advantage.
e) Three-lane roads should be avoided, unless the overtaking sections are limited and are protected by appropriate carriageway markings, such as 2+1 markings. See *Tests of 2+1 layout (8).*

2+1 is a safe type of road layout

Safe design of slope and ditch along a motorway



f) Surfaced edge strips contribute to road safety in rural areas, irrespective of whether the road has a central reserve:

- surfaced edge strips narrower than 0.5 m increase the risk of accidents and should be avoided. See *Edge Lines Improve Safety of Motorists and Cyclists (9).*
- surfaced edge strips still reduce the risk of accidents, even when they reduce the lane width to 3 m *(9).*

g) The installation of central reserves on roads with four or more lanes reduces accident rates. The following applies to central reserves:

- widths of less than 3 m should be avoided. Where guardrails are installed on motorways, the width should not be less than 4 m,
- greater widths are beneficial, although only limited extra benefit is given by widths of over 10 m,
- the use of guard rails on central reserves narrower than 10 m is determined by the quantity of traffic and the actual width of the central reserve itself. See *Road Standards for the Erection of Guard Rails on Roads and Bridges (10).*

h) It can be advantageous to omit the kerb where the width of the central reserve is sufficient, as this makes it easier and safer for drivers who have temporarily lost control to regain control over their vehicles.

i) Shoulders should slope away from the carriageway.

j) As far as possible, slopes and ditches should be designed so that guard rails can be avoided:

- slopes should be as flat as possible (gradient 1:3 or flatter),
- ditches should be formed as rounded troughs,
- the transition between the shoulder and slope should be rounded.

Road Surfaces

The nature of the road surface is of particular importance to road safety. The accident risk can be considerably reduced through the use of surfaces that have good friction when wet *(2).* The visibility of markings in wet conditions can be improved and the dazzle due to shifting reflections in the dark can be reduced through the use of a suitable surface structure. Unevenness in surface structure, such as depressions and rutting, undermine road safety. The relevant road standard requirements on road surfaces (coefficient of friction, deviations in cross-sectional profile, rutting and light properties) are described in *Tender and Construction Precepts for Hot-Mixed Asphalt;* see *Guidelines, Section 8 (11) and General Specification of Works, Sections 2, 3 and 4 (12).*

Markings on carriageway should be designed and implemented in such a way that their message is always obvious.

Carriageway Markings and Reflector Posts

Carriageway markings and reflector posts at the edge of the carriageway reduce the number and severity of accidents at a comparatively low cost. Markings serve three primary purposes:

- to guide traffic by showing the direction and use of roads and their lanes.
- to warn road users of dangerous or unusual conditions in the geometric design of the road.
- to regulate traffic.

Markings on carriageway

Carriageway markings should:

a) Be visible under all conditions, in daylight and darkness. This demands good colour and structural contrast and good retro-reflecting properties. Vibralines are easier to see in wet weather than smooth markings, and vibralines emit sound when vehicles drive over them. They should not be used in the vicinity of residences, however, because of the noise, and they can be difficult to see when the light is behind them.

b) Be durable, to avoid frequent maintenance. Worn markings should be replaced as soon as possible.

c) Not be slippery in wet weather, not even for pedestrians or cyclists. See *Tender and Construction Precepts for Carriageway Markings (13).*

d) Be designed and implemented in such a way that their message is clear.

Reflectors and studs

Studs can be used to improve the effect of traditional markings. They are more visible than ordinary markings under the combined conditions of wet weather and darkness, and they warn motorists who have inadvertently wandered from their lane. The requisite properties are:

- Visibility under all conditions;
- Correct location, to ensure that they do not present difficulties for two-wheeled vehicles;
- Durability and security of fastening.

Reflector posts

Road standards for edge and background markings are in preparation. See *Proposed Road Standard for Edge and Background Markings (14).* Studies have not been able to demonstrate that there is any clear safety advantage in the installation of reflector posts alone; but reflector posts can reinforce the effect of carriageway markings where it is necessary to emphasise peculiarities in the design of a road – a sharp bend, for instance – or to indicate the direction of the road under special circumstances, such as in snow or flooding. Special requirements are:

- they must not be so robust that they can cause personal injury in the event of a collision;

• good visibility in bad weather – which can necessitate much cleaning;
• withstand vandalism and the climate.

Road Equipment: Traffic Signs, Street Furniture, Cabinets, etc.

Road equipment covers a broad range of road-safety elements. Road lighting, antidazzle screens, islands and warning signs assist road users to comprehend and recognise the traffic situations in which they find themselves, and they are warned against potential hazards. Guard rails and bridge parapets are protective measures that limit the severity of collisions, protect vehicles from plummeting from the road and prevent inappropriate behaviour. It is vital to position road equipment so that it does not, itself, constitute an unnecessary hazard.

Frangible lighting column.

Road lighting

The road standards for road lighting describe a number of lighting classes, which should be used according to the class of the road, the design speed and expected traffic conditions. Ideally, road lighting should give a uniformly illuminated road surface, against which cyclists, pedestrians and objects can be seen in silhouette. To attain optimum lighting quality and optimum levels of lighting, the design of the light fittings and the geometry of the lighting installation should be matched to the reflective properties of the road surface.
a) Lighting installations should be planned in conformity with the road standards for road lighting.
b) When renovating a road surface, take care that the light properties of the new surface correspond to the conditions for which the lighting installation was planned.
c) The location of lighting columns should not create unnecessary hazards. This can be ensured by locating them away from the edges of the carriageway and cycle path, the use of frangible columns, protective guard rails and the installation of catenary lighting, to limit the number of columns needed.

Antidazzle screens

On unlit roads, the dazzle caused by oncoming vehicles is a nuisance and a potential hazard to road users. These problems can be mitigated by the use of sufficiently broad central reserves (over 10 m), by installing road lighting or by plantations.

Proper treatment of the exposed end of a guardrail is important - this untreated end should be buried.

It may be relevant to counteract this problem through the use of screens installed on the central reserve (where they can be mounted on the guardrail) and where roads merge or approach each other. The design of the screens should leave a reasonably unobstructed view across the road, while offering screening against opposing traffic – closed screens should not be used.

Traffic islands

Traffic islands delineated by kerbstones should generally be of a design that facilitates the location of signs and other road equipment on them. They should also be spacious enough to accommodate cyclists wheeling their bicycles and pedestrians with perambulators. Traffic islands can be used to advantage:

- On roads where it is desirable to separate the opposing streams of traffic and to prevent overtaking.
- When channeling traffic on major roads, in order to guide and protect the intersecting traffic stream and turning traffic, and to make it possible for cyclists and pedestrians (including passengers going to and from bus-stops) to cross the road.
- Where it is desirable to prevent certain turning manoeuvres.
- At busy junctions on minor roads, to emphasise the major road ahead.

Warning signs, informatory signs and bollards

If a project includes potentially hazardous places or situations that cannot be modified in any other way, the use of signs to warn road users of the hazard can still yield a safety advantage. Signs and bollards should have reflecting surfaces and/or be appropriately illuminated. Where signs are mounted on gantries, care should be taken to ensure suitable, safe access for maintenance, preferably by ensuring that

a maintenance vehicle can be parked off the carriageway.

It is important for signs to be designed and installed in a way that avoids creating a hazardous situation and, therefore, so that they are clearly legible, thus assisting drivers to plan and execute their manoeuvres with the greatest possible safety.

Guardrails

The purpose of guardrails is:

a) to prevent head-on collisions;

b) to prevent vehicles from colliding with rigid obstacles. Such obstacles include, for instance:

- retaining walls and other walls,
- most types of noise screen,
- bridge pylons and bridge abutments,
- concrete foundations, wells/drains or large rocks, the tops of which are more than five cm above the ground,
- concrete posts, regardless of their dimensions,
- steel posts (road lighting columns, traffic-signal posts, gantry pylons and suchlike) with diameters in excess of 60 mm, without breakaway safety devices,
- trees and wooden columns with diameters in excess of 110 mm as measured at ground level,
- electrical distribution cabinets permanently mounted on concrete foundations or other buried foundations,
- anything that can unseat a cyclist;

c) to protect vehicles from plummeting from the road, which includes protecting the driver and passengers from drowning;

d) to protect other vehicles against vehicles which are out of control.

"Remove-soften -protect"

Although guardrails should be strong enough to prevent vehicles from breaking through them, they must not be so rigid or robust that they cause as much damage in a collision as whatever they protect against.

Alternatives to guardrails

Guardrails are, themselves, rigid obstacles and should therefore only be used when a problem cannot be solved in any other way, e.g. by:

- moving the road,
- straightening sharp bends,
- constructing less steep slopes,
- rounding the feet and crowns of slopes.
- removing ditches and replacing them with some other type of drain,
- widening the central reserve,
- removing rigid obstacles, or by moving them further from the carriageway,
- incorporating breakaway safety devices into columns and posts, or by making them from more yielding materials,
- improving road markings,
- imposing speed limits.

Crash cushions can be used as an alternative to guardrails. Despite their high cost, crash cushions give very effective protection against personal injury in collisions with rigid obstacles.

Crash cushion

Railings

Pedestrians railings can be used in urban areas to separate pedestrians from the vehicles on the carriageway, although they cannot be used to halt runaway vehicles. Railings should not be so high or so opaque that they obstruct drivers' view of pedestrians waiting at crossings or of the end of the railing. Special measures must be adopted to ensure the visibility of children.

Cabinets, etc.

It is necessary to ensure that cabinets, cable wells and other technical installations that require periodic attention are located on or beyond the footway or behind guard rails. Where this is not possible, inspection wells and suchlike should either be located on, or protected by, islands, which makes them safer for service personnel and road users alike.

Traffic Regulation

The aspects of traffic regulation of relevance to road safety are primarily speed limits and physical speed reduction measures, junction control, pedestrian crossings, one-way systems and the regulation of parking.

Speed limits and speed reduction

Speed reduction leads to a drop in the number of serious accidents. The way in which speed limits affect speed is however more complex. It depends on the geometric design of the roads, the density and composition of traffic and the method and intensity of surveillance. Although these relationships are not yet fully understood, experience has produced certain practical criteria that can provide a basis for determining speed limits.

a) With consideration for the land use along the roads, the geometric standard of roads and accident rates on comparable roads, speed limits should be set to the 85th-percentile speed (V_{85}), i.e. the speed which is not exceeded by 85% of private cars in wet weather. The applicable general speed limits are 50 km/h in urban areas, 80 km/h in rural areas and 110 km/h on motorways.

b) The desired travel speed (V_d) should be the point of departure during planning. It is vital that the stated speed correspond to individual road users' perception of the road and traffic conditions and that it be used with full consideration for road safety. The parameters of geometric elements, which are specified from the standpoint of comfort, should be specified directly on the basis of the desired speed. This applies, for instance, to:

- the relationship between radius and crossfall,
- clothoid parameters,
- vertical gradient.

c) For geometric elements which are specified with consideration for safety, a planning speed (V_p) is used, which is obtained by adding a safety factor to the desired speed. This applies to such geometric elements as:

- visibility at junctions,
- sight distance for overtaking,
- sight distance for stopping,
- distance to rigid obstacles.

Thus, the planning speed (V_p) is calculated as follows:

$V_p = V_d + 10$ km/h for $V_d > 80$ km/h

$V_p = V_d + 20$ km/h for $V_d \leq 80$ km/h

$V_p = V_d$ on all roads in urban areas.

Thus, V_p corresponds to V_{85}.

d) Higher local speed limits (i.e. 60-70 km/h) than the general speed limit in urban areas should only be used in special circumstances on a few main roads. Such roads should:

- have restricted frontage access,

Complex traffic-signal control can confuse road users

- have roadside development which, by virtue of its character or distance, is insensitive to the noise generated by such fast vehicular traffic,
- only permit vulnerable road users to cross at another level or at traffic signals,
- no unregulated four-armed junctions,
- only permit left turns at signalised junctions or at roundabouts,
- have a kerb, at the minimum, to separate light road users from other traffic on the road.

e) On local roads in urban areas and on streets in the centres of urban areas, where a speed level of 40 km/h or less can be appropriate, physical speed reducers are usually a necessary means of encouraging observance of the desired speed. See *Road Standards for Urban Traffic Areas, Volumes 0 and 7 (1).*

Junction control

The right of way at junctions can be regulated with give-way signs or stop signs, roundabouts, traffic signals or by the use of exit constructions. The general rule of giving way to traffic from the right can confuse road users and create conflicts that lead to accidents. It is therefore decisive at all road junctions that the right of way be indicated by marking the carriageway with give-way lines ("shark's teeth"), at the minimum.

a) Give-way signs are appropriate on less busy roads and where visibility is good.

b) Stop signs should be used in cases where the traffic situation or design of the road demands that road users on the minor road come to a total stop, so that they can take proper stock of the situation. See *Effect of Stop Signs (15).*

c) Cycle tracks or cycle lanes which

continue right up to a junction can cause safety problems for cycle and moped traffic (5, 6 and 7). See also *Cycle Crossings – Safety Effect at Signalised Junctions (16):*

- at priority-controlled junctions, the number of accidents involving cyclists and moped riders increases when the cycle track continues all the way up to the junction,
- tests in progress at priority-controlled junctions, of the special marking of cycle tracks/lanes, have demonstrated behavioural changes which could prove to result in fewer accidents,
- at signalised junctions, the installation of blue cycle crossings can reduce the numbers of cyclists killed or injured, especially in connection with accidents when turning left,
- recessed stop lines at signalised junctions exert an influence on accidents occurring between vehicles turning right and cyclists travelling straight ahead, when these accidents occur at the start of the green period,
- truncated cycle tracks at signalised junctions also result in fewer accidents involving vehicles turning right, although cyclists consider this approach insecure,
- tests in progress at signalised junctions, of the special marking of cycle tracks/lanes, have demonstrated behavioural changes which could prove to result in fewer accidents.

d) Junctions on high-speed roads should not be controlled by traffic signals. When traffic signals are installed at such junctions, make sure that the speed limit is not greater than 60 km/h. Under no circumstances should traffic signals be installed on roads where the average speed, or speed limit, is greater than 70 km/h See *Speed and Accident Risk at Junctions (17).*

e) At signalised junctions, special phases – e.g. for turning traffic – can improve safety; but complex traffic-signal programming, with many phases, long waiting times and a dense population of traffic signals, can confuse road users and thus contribute to an increased risk of accidents.

Roundabouts can play an important part in limiting the number of personal injuries at junctions – provided that the design rules can be observed, especially from the standpoint of the curvature of access roads and suitable visibility splays. The installation of small or mini-roundabouts at junctions can be particularly effective, and roundabouts are always better than traffic signals, from the standpoint of road safety in rural areas. As far as motorists are concerned, roundabouts reduce the risk of accidents involving personal injury by 85%. Roundabouts do not reduce the number of accidents involving cyclists and moped riders, but they do reduce the severity of such accidents.

When designing roundabouts, give due consideration to cycle and moped traffic. More than a single lane in the entry, the exit, or in the circulating carrigeway is irreconcilable with the presence of cyclists and moped riders (on the circulating carrigeway itself or on tracks/lanes around it); separate path systems should be established for cycle and moped traffic at such roundabouts. It has not been possible to ascertain any differences in the level of safety for cyclists and moped riders on roundabouts with cycle paths, with cycle lanes and without any cycle installation. See *Road Standards for Urban Traffic Areas, Volume 4, Section 3.6 (1) and Road Safety at 82 Danish Roundabouts (18).*

Traffic island as a refuge for pedestrians

Crossings for pedestrians and cyclists
Suitable crossing facilities should be established on road stretches and at crossings where pedestrian and cycle traffic is not insignificant. See *Road Standards for Urban Traffic Areas, Volume 5 (1).*
a) Although zebra crossings and signalised crossings can improve road safety on road stretches, stretches that have pedestrian crossings (with or without traffic signals) do not generally have lower accident rates than comparable stretches that lack such facilities *(2)*. The establishment of zebra crossings on road stretches should therefore be replaced by, or combined with, other measures, such as:
- the installation of traffic islands as refuges,
- the installation of plinths, which reduce the width of the carriageway
- the reduction of vehicle speeds.

b) The construction of bridges or subways should be considered at crossings where the flows of pedestrians and vehicles are high.
c) In general, the section of road within 50 m of signalised junctions is the most dangerous for pedestrians to cross. The installation of pedestrian railings can be beneficial in such places.
d) Special, conflict-free, phases for pedestrians are desirable for improving road safety at signalised junctions.

One-way systems
The establishment of one-way road systems can limit road accidents, although such plans should be implemented with great care. Diversions for cyclists, increasing speeds

It is important to consider all groups of road user where road works are in progress (the caption on the road-works sign asks pedestrians to use the other footway).

or the removal of traffic to roads which have higher accident rates are typical examples of undesired effects – and are particularly detrimental to the safety of cyclists and pedestrians.

One-way systems should normally only apply to vehicular traffic; the disadvantage of permitting bi-directional cycle traffic – with appropriate markings and protection – is usually less than the disadvantage of compelling them to take a diversion or of having them cycle in contravention of the rules.

Parking at kerb

Parked vehicles affect road safety in two ways:

a) Through the risk of collision between driving and parking or manoeuvring vehicles.

b) By masking pedestrians, cyclists or other vehicles. The relegation of parking to laybys on the approaches to junctions or pedestrian crossings can prove beneficial to road safety if parking is absolutely necessary at these places. But it still does not resolve the problem of cyclists on cycle tracks hidden behind parked vehicles.

Road Works and Maintenance

Places where road works are in progress should be considered to be potential accident sites. It is vital at road works to ensure the safety of all groups of road user, including the disabled and the works crew. It is therefore necessary to pay special attention to the road standards governing the marking of road works. However, the standards cannot provide off-the-shelf solutions, as individual situations differ so widely. See *Road Standards for Marking of Road Works (19)*. Road works demand close and frequent supervision, which also includes on-site inspection. Traffic regulation should be implemented with sufficient flexibility to permit changes for reasons of road safety – at short notice, if necessary.

Agreement on road safety audit

Parties

Client .....

Designer .....

Road safety auditor .....

Scope of agreement

Project(s)	**stage**	**1**	**2**	**3**	**4**	**5**
.....		☐	☐	☐	☐	☐
.....		☐	☐	☐	☐	☐
.....		☐	☐	☐	☐	☐
.....		☐	☐	☐	☐	☐
.....		☐	☐	☐	☐	☐

☐ **or see appended list** .....

Comments on agreement .....

.....

Date and signatures

Client .....

Designer .....

Road safety auditor .....

Procedure

Order	Description	Audit tools	Check tools
1. A. Requisitioning	• Complete the requisition form • Give a precise specification of what is to be audited • Be careful to state all of the project's conditions: – design speed – radii of bends – superelevation – areas of visibility – departures from road standards (state reasons) – accident and traffic data, etc. • Send all drawings in duplicate	Receipt of requisition	
B. Any supplementary information	Supply the auditor with any desired supplementary information	Ordering of supplementary information, as needed	

Review	Description	Audit tools	Check tools
2. Analysis		• Choice of relevant checklists • Analysis/examination of the project • Inspection, if necessary	
3. Structuring		• Summing up/structuring • General or specific? • Problems or comments? • Reasoning *1st draft of audit report*	
4. Proposed approaches		Develop proposals for alleviating problems *2nd draft of audit report*	
5. Quality assurance		Assurance of audit report quality, according to the auditor's QA system *Final audit report*	

Procedure

Completion	Designer's role	Auditor's role	Client's role
6. A. Delivery	Report received from the auditor	Deliver report to planner. Send a copy to the client	Receive a copy of the audit report
B. Consideration of audit report	• Does the designer agree with the auditor's assertions? • Formulate and notify the auditor of the planner's opinions	Receive the designer's comments	
C. Dialogue	Joint review of the audit report. In the event of disagreement, go to Item D.		
D. Arbitration of any disagreements	• Present disagreements to client and request a decision • Receive the client's written decision	Receive a copy of the client's written decision	Notify the designer in writing of the decision (send a copy to the auditor)
7. Finalisation		Feedback from the designer on any changes to the project (this can lead to repetition of part of the process). The auditor declares the audit finished	

Audit stages

Audit stage	Designation	Description
Stage 1	Initial design (planning)	Review of initial project/planning study. Important subjects for assessment at this stage could include: – choice of route options – standard and cross-section – effects on existing network – number of junctions and their types (typically 1:25,000, 1:10,000 or 1:4000) The road safety auditor should not question planning information or reassess matters of strategy. The auditor should only concern himself with the presented planning information.
Stage 2	Draft design	Examination when draft design is completed, i.e. where the alignment has largely been decided, but can still be modified, and before the political adoption of the project and expropriations. Important subjects for assessment at this stage are: – project changes since stage 1 – alignment (layout, vertical alignment and visibility conditions) – cross-section (including ditches and banks) – arrangement of junctions (including visibility conditions) – ramps and lay-bys – any interim measures (typically 1:4000, 1:1000 eller 1:500) All groups of road user, including those who have special needs, and users of the adjoining areas should be taken into consideration. If there is any risk of special road safety problems occurring during the construction phase, this risk must be assessed.
Stage 3	Detailed design	Examination when the detailed design is finished and the limits of expropriation have been set, but before the tendering material is completed and before tenders are invited. Vital subjects for assessment at this stage are: – project changes since stage 2 – detailed design of junctions – crossfall (driving and drainage characteristics) – markings and signs – traffic signals – lighting and other equipment – plantations – interim measures (interim regulation and marking) (typically 1:1000, 1:500, 1:200) Tendering material must not be sent out until auditing at this stage has been completed and all agreed changes have been incorporated into the project.

page 1/2

Audit stages

Audit stage	Designation	Description
Stage 4	Opening	a) A final review of the finished construction, to check from the standpoint of road safety that it is ready to be opened for traffic. It is particularly important to check the locations and visibility of markings, especially where changes were made during the construction period. The finished scheme should be assessed from the viewpoints of all road users, in daylight and darkness. b) After opening (within one or two months, in the case of large projects, and before application of the wearing course, for small and medium-sized projects), the auditor should examine the scheme to determine whether or not road users are using it in an appropriate manner. Many schemes are constructed with the road open to traffic throughout the entire construction phase. When there is no question of an actual opening for traffic, an overall examination can be carried out when the markings are in place (e.g. when temporary lane markings have been made). This examination can be carried out by the auditor alone, or in collaboration with the police, site engineer or the designer.
Stage 5	Monitoring (existing roads)	An analysis of any accident data and inspection of the scheme every third year, with a view to determining whether or not road users use the scheme appropriately. Subjects for monitoring include, e.g: - does the prevailing speed correspond to the design speed? - are the visibility criteria still satisfied? - do vulnerable road users use the installation as expected? - have any changes been made which could affect road safety? The monitoring of new installations should start after about one year.

Types of project and audit stages

Types of project	Stage 1 plan or programme	Stage 2 preliminary design	Stage 3 detailed design	Stage 4 pre-opening	Stage 5 post-opening
New schemes and reconstructions					
major	■	■	■	■	■
medium	■	■	■	■	■
minor	■	■	■	■	■
Operating and maintenance work	■	■	■		
Regional, municipal and local development plans	■				
Road safety improvement schemes	■				

Audit form

Ordering of road safety audit

Project ..... **Stage** .....

Designer .....

Client .....

Auditor .....

☐ **cf. agreement** ..... **Reply preferably before** .....

Material (see any appended) .....

.....

Comments .....

Date and signature ..... **Ref. No.** .....

Result of audit

Date of receipt of material ..... **Ref. No.** .....

Audit comments (see any appended) .....

.....

Date and signature .....

Effect of audit

Project changes (see any appended) .....

.....

Date and signature .....

Declaration of completion

Date and signature .....

Checklists

Checklists have been prepared to assist the designers and auditors. These checklists describe the problems and situations that can affect the road safety of selected types of project and audit stage.

Although the checklists are conceived of as *aides memoire*, using the relevant lists simply as "tick" lists cannot replace a road safety audit.

You should not expect these checklists to be all-embracing, neither within the individual types of project and stage nor for the set of all possible types of project. It can be advantageous for the individual highway authority to supplement and/or add to the lists on the basis of its own choice of types of project and audit stages.

Overview of checklists

References

(1) (1) Byernes Trafikarealer
(Urban Traffic Areas,
volumes 0, 4, 7 and 10:
English-language)
Road Directorate - Road Standards Board, March 1992

(2) Trafikksikkerhetshåndbok
(Road Safety Manual,
Norwegian-language only)
Transportøkonomisk Institutt – TØI, Oslo 1989

(3) Guidelines for The Safety Audit
Of Highways
The Institution of Highways and Transportation, September 1990

(4) Safety Effects of Highway
Design Features
Volume I: Access Control
Volume II: Alignment
Volume III: Cross Sections
Volume IV: Interchanges
Volume V: Intersections
Volume VI: Pedestrians and
Bicyclists
U.S. Department of Transportation; Federal Highway Administration, 1992

(5) Cykelstier i byer – den sikkerheds-
mæssige effekt
(Cycle Tracks in Urban Areas, the
safety effect; Danish-language only)
Road Directorate, SSV, 1985

(6) Safety of Cyclists in Urban Areas
Report No. 10, Road Directorate, TSM, 1994

(7) Trafiksikkerhedseffekten af
cykelbaner i byområder
(Road Safety Effect of Cycle
Lanes in Urban Areas;
Danish-language only)
Report No. 50, Road Directorate, TSM, 1996

(8) Forsøg med 2+1-afstribning,
indvirkning på uheld
(Tests of 2+1 layout,
Effect on Accidents;
Danish-language only)
Report No. 71, Road Directorate, TSM, December 1996

(9) Kantlinier forbedrer både bilisters
og cyklisters sikkerhed
(Edge Lines Improve Safety of
Motorists and Cyclists;
Danish-language only)
Ole Rosbach,
Dansk Vejtidskrift nr. 11, 1984

(10) 9.30.02 Udstyr, Autoværn,
Vejregler for opsætning af vej- og
broautoværn,
(Equipment, Guard Rails, Road
Standards for the Erection of Guard
Rails on Roads and Bridges;
Danish-language only)
Road Directorate - Road Standards Board, September 1987

(11) Udbuds- og anlægsforskrifter,
Varmblandet asfalt, vejledning
(Tender and Construction Precepts,
Hot-Mixed Asphalt, Guidelines;
Danish-language only)
Road Directorate - Road Standards Board, November 1990

(12) Udbuds- og anlægsforskrifter, Varmblandet asfalt, Almindelig arbejdsbeskrivelse (AAB)
(Tender and Construction Precepts, Hot-Mixed Asphalt, General Specifications of Works)
Road Directorate - Road Standards Board, November 1990

(13) Udbuds- og anlægsforskrifter, Kørebaneafmærkning
(Tender and Construction Precepts, Road Markings; Danish-language only)
Road Directorate - Road Standards Board, August 1993

(14) Vejudstyr
Vejregler for kant- og baggrundsafmærkning
(Road Equipment
Road Standards for Edge and Background Markings; Danish-language only)
Proposed Road Standard, Road Directorate - Road Standards Board, August 1994

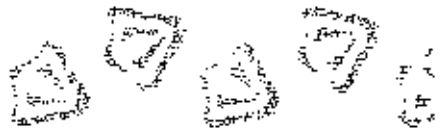
(15) Effekt af stoptavler
Effektvurdering af forsøgsopstilling i 4-benede kryds i åbent land
(Effect of Stop Signs
Assessment of tests at 4-armed junctions in Rural Areas; Danish-language only)
Working report 8/1996, Danish Road Safety Research Council, August 1996

(16) Cykelfelter - Sikkerhedsmæssig effekt i signalregulerede kryds
(Cycle Crossings - Safety Effect at Signalised Junctions; Danish-language only)
Report No. 51, Road Directorate, TSM, 1996

(17) Hastighed og ulykkesrisiko i kryds, signalregulerede kryds med forskellige hastighedsgrænser
(Speed and Accident Risk at Junctions; Danish-language only)
Memorandum No. 28, Road Directorate, 1996

(18) Trafiksikkerhed i 82 danske rundkørsler
(Road Safety at 82 Danish Roundabouts; Danish-language only)
Else Jørgensen and N. O. Jørgensen, Report No. 4, Road Directorate, 1994

(19) 9.10.05 Udstyr, Afmærkning, Vejregler for afmærkning af vejarbejder
(Equipment, Markings, Road Standards for Marking of Road Works; Danish-language only)
Road Directorate - Road Standards Board, January 1987



Index

Agreement on road safety audit

Parties

Client .....

Designer .....

Road safety auditor .....

Scope of agreement

Project(s)	**stage**	**1**	**2**	**3**	**4**	**5**
.....		☐	☐	☐	☐	☐
.....		☐	☐	☐	☐	☐
.....		☐	☐	☐	☐	☐
.....		☐	☐	☐	☐	☐
.....		☐	☐	☐	☐	☐

☐ **or see appended list** .....

Comments on agreement .....

.....

Date and signatures

Client .....

Designer .....

Road safety auditor .....

Audit form

Ordering of road safety audit

Project ..... **Stage** .....

Designer .....

Client .....

Auditor .....

☐ **cf. agreement** ..... **Reply preferably before** .....

Material (see any appended) .....

.....

Comments .....

Date and signature ..... **Ref. No.** .....

Result of audit

Date of receipt of material ..... **Ref. No.** .....

Audit comments (see any appended) .....

.....

Date and signature .....

Effect of audit

Project changes (see any appended) .....

.....

Date and signature .....

Declaration of completion

Date and signature .....

Road Directorate
Niels Juels Gade 13
P.O. Box 1569
DK-1020 Copenhagen K
Denmark
Telephone: +45 33 93 33 38
Telefax: +45 33 15 63 35

Road Directorate
Elisagårdsvej 5
P.O. Box 235
DK-4000 Roskilde
Denmark
Telephone: +45 46 30 01 00
Telefax: +45 46 30 01 05

Road Directorate
Thomas Helsteds Vej 11
P.O. Box 529
DK-8660 Skanderborg
Denmark
Telephone: +45 89 93 22 00
Telefax: +45 86 52 20 13