Road Safety Impact Assessment: RIA

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R-94-20

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A proposal for tools and procedures for a RIA

A study commissioned by the European Commission DG VII

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Leidschendam, 1994
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Summary

Road safety is a quality aspect of road traffic and this aspect has to be balanced with aspects like: level of service, access for destinations, environmental impact, costs etc., when it comes to decisions in what infrastructural projects to invest. In decision making on infrastructural projects road safety arguments have to be considered as explicit as possible in the planning phase already. An instrument has been developed in this study with this aim: Road Safety Impact Assessment RIA. RIAs could be made on a more strategic level and on an individual project or scheme level. For both levels different tools are developed.

On a *strategic level*, we suggest to assess safety consequences of changes (redistributions) of traffic over a road network due to infrastructural projects (new roads, new lay out of roads) by using a *scenario technique*. This technique uses the fact that different categories of roads (with different road and traffic chracteristics) turn out to have different road safety records dependent on traffic volumes. By modelling road type, values of relevant safety indicators and traffic volumes road safety impacts can be calculated of different alternatives. A proposal has been developed for the content of (the first phase of) a RIA.

Secondly, on a *project level*, we suggest to use an *audit technique* to make as explicit as possible the safety consequences of certain choices in the detailed planning and the design process and to optimize a road design. The primary objective of using an audit technique is to ensure that road safety is optimally incorporated during the design and realisation phase of infrastructure projects. Independency of auditors is considered of great importance. Different checklists have to be developed in a follow up study.

We recommend to use the results of this study as a first draft for a RIA and to gain experiences with this tool for EU projects on a voluntary basis, before making a RIA compulsory. An EU-cooperative effort may be considered to reach some sort of agreement on the specifications of RIAs and to create a database with (EU)RIA-methodology and -results. When these results are satisfying, we recommend to integrate the procedure for a RIA in existing procedures for Environmental Impact Assessment (EIA), as indicated in EC Directive 85/337, and not to initiate new procedures for a RIA. This recommendation is based on the positive experiences with EIAs. By integration of the EIA and RIA procedures, we expect an improved quality of the decision process, without the drawback of more time consuming of distinct procedures. Of course, individual Member States could decide to use more stricter regulations.

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1. Introduction

Two primary objectives often predominate in (large) infrastructural projects: realising a high level of service and increased access for important destinations, economically or socially. An additional factor in many industrialised countries in recent years has been that plans should not place an excessive burden on the environment. The environmental effects of infrastructural projects must therefore be estimated in advance, through Environmental Impact Assessments (EIAs). These assessments are compulsory in the European Union for certain decisions, as can be understood from the EC Community Directive 85/337 (EU, 1985). If the political assessment of a particular project is negative, mitigation of environmental pollution could be agreed upon on the basis of the EIA-results. It has to be stated that there is no legal obligation with respect to the EIA-results. Recently, the OECD Road Transport Research Programme issued a report providing a review of traditional environmental impact assessment methods and procedures currently used in the road and transport sector (OECD, 1994). In this OECD-report a distinction has been made between impact assessments at a more strategic decision level (SEIA) and that of an individual project or scheme (EIA).

Road safety is another quality aspect of road traffic which represents an equally important consideration in decision-making on infrastructure. At best, traffic risks are only considered implicitly and qualitatively in current decision making on infrastructural projects, which means that the consequences for road safety are not visible. This can mean that - unintentionally, but also unwittingly - road safety is not given sufficient consideration in decision-making process. It also hampers rational consideration of alternative solutions.

Projects or programmes often fit within a transport and infrastructure policy or plan. As a rule, general goals and objectives are formulated, so that the extent to which these are realized can be assessed. We suggest the appropriate instrument for this might be called a Road Safety Impact Assessment (RIA).

The aim of this study is to provide an insight into the possible content and procedures of a Road Safety Impact Assessment, to be used in planning of infrastructural projects in a local or regional context (i.e. to compare different alternative road routes and to compare different design characteristics) This possibility lies on a strategic level. Secondly, on a detailed design level of new roads and of improvements of existing roads to make as explicit as possible the safety consequences of certain choices in the planning and the design process. The aim is to minimize the risk of creating safety problems or ending up with sub-optimal solutions with regard to road safety.

In short, we propose to assess safety impacts of changes in road infrastructure on two levels:
- the changes of the distribution of traffic over a certain road network due to changes of that network;
- the changes of design characteristics of roads.

This report starts with some general considerations dealing with infrastructure design and road safety. Chapters 3 and 4 contain the tools on both levels, indicated above: scenario methods, specifically developed to assess the safety consequences of redistributions of traffic over a road network (Chapter 3) and road safety audits as a means of examining the local design specifications (Chapter 4). The experiences with Environmental Impact Assessments are described in Chapter 5 to find out whether these experiences could be used in Road Safety Impact Assessments RIA. Some ideas why RIAs should be integrated in existing procedures and how this integration can be done are to be found in Chapter 6. Finally, Chapter 7 contains a proposal for the content of a Road Safety Impact Assessment.

2. General considerations

As in any system, design characteristics determine to a large extent the safety characteristics of the road traffic system. Accidents, as they happen, are to a large extent built-in. If, for instance, two lane rural roads allow and are designed for overtaking at speeds of around 90 km/h, the overtaking accident with differential speeds of around 150-200 km/h is bound to happen. Additionally, some secondary variants may be expected as a result of attempts to avoid the accident at the last moment, e.g. the run off the road accident at around 90 km/h. By means of ergonomic road design, improved vehicle performance and driver training one may, to a certain extent, reduce the relative frequency of such accidents. But, since this is an especially difficult task placing high demands on the driver, it would be next to impossible to reduce such relative frequency to values approaching zero.

Effective safety control, therefore, should be exercised in stages of planning and design rather than after the fact on the basis of implemented designs that have already been demonstrated to be unsafe.

This is, of course, a rather obvious notion, commonplace in other safety area's. One would not even think, for instance, of designing a nuclear power plant for energy production and subsequently improve on safety on the basis of the implemented design, or even on the basis of actual system failures. Regrettably, such an approach does characterize past and present states of affairs in road transport.

To change this situation one needs a procedure, method and content:
- *procedure*: - either legal or administrative - to be able to effectively introduce safety considerations into the transport decision process;
- *method*: to be able to asses the safety consequences of transport-decisional alternatives;
- *content and strategy*: to be able to devise preferable or optimal safety alternatives.

Within this threesome, the unspecified concept of road safety impact assessments is mainly procedure, comparable to and derived from the environmental impact assessment. As infrastructural planning and design are prominent in road transport decision making, the concept has been focussed on decisions regarding infrastructure. For actual application in this area this leaves questions of method and content to be answered, as well as questions about the specifics of entering the results of safety impact assessments into the decision process.

Many infrastructural plans and projects are characterized by a basic tension between mobility purposes and safety requirements. This tension centres most of the time around driving speeds. Apart from requirements concerning traffic flow and volumes, mobility purposes demand relatively high speeds in order to realize acceptable travel times. At the same time, any increase in speed constitutes a progressive increase in energy built-up, of which the uncontrolled release progressively increases the probability of injury. Where ever traffic participants interact, either with each other or with obstacles in the immediate environment, safety purposes essentially require low (differential) speeds. The basic task is therefore, to design in such a way that on the one hand high speeds may be realized for at least part of the road network, on the other hand interactions, encounters, conflicts etc. are then controlled in such a way that, if negotiated unsuccessfully, the corresponding accident does not result in major injury or death.

Present traffic environments, by and large, do not qualify in this respect. The overtaking situation, as mentioned above, is a somewhat extreme example. But it is not all that difficult to enumerate a substantial number of situations and conflict-types which, leading to accidents in an unmitigated form, offer little opportunity to survive to at least some of the participants involved. It is a known fact that no attempt to reduce speed was made in many accidents, either because the other vehicle or pedestrian was not perceived, or because an attempt was made to avoid the accident by accelerating or change of direction, rather than by braking. The speeds of collision, then, are comparable to the original travelling speeds.

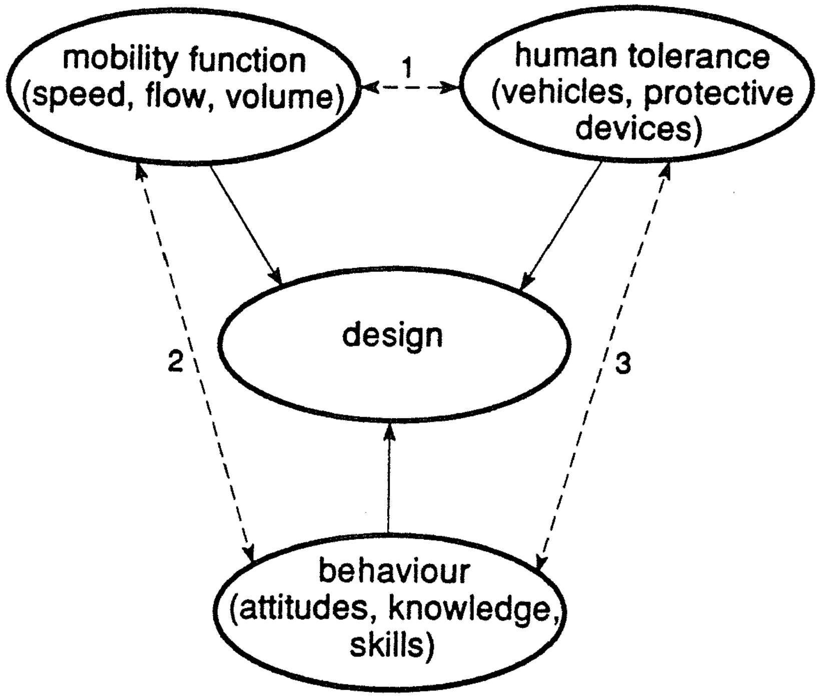
This holds true for e.g. the pedestrian crossing on 50 km/h-roads, cross-traffic on uncontrolled intersections of rural roads but also the emergency lane accident on motorways as a result of the presence of stationary vehicles or pedestrians in combination with unintentional line-crossing by passing (especially heavy) vehicles.

A basic rule of thumb might be that - in general - the uncontrolled encounter or conflict between unprotected slow moving traffic and motorized traffic with differential speeds over 30 km/h should be avoided, as well as uncontrolled conflicts among motorized traffic with differential speeds over 50 km/h. Heavy vehicles pose a special problem that is, however, not only to be solved by speed regulation but also - to a substantial degree - dependent on vehicle design.

The conflicting requirements from the points of view of mobility and safety, then, have to be combined in a road design that is understood by all drivers and other traffic participants, accepted and observed, and at the same time constitutes an acceptable task load. Design is here interpreted as a combination of physical road environment (geometry of carriageway, surface, road side, etc.), visual aids (signing and marking, etc.) and rules and regulations as applied and signalled.

Basically, three sets of criteria could be defined, in combination, to be incorporated into the design:
- criteria derived from a road's designated mobility function;
- criteria derived from human tolerances (taking vehicle characteristics and protective devices into account);
- criteria derived from behavioural principles.

This can be pictured as follows:



In this diagram, relation line (1) mainly relates to the combination of high speeds with the management and control of conflicts at moderate speeds by means of level crossings, roundabouts, controlled intersections, separation of slow moving and motorized traffic, etc. Line (2) relates mainly to public acceptance of designated mobility functions, consequences for the network structure, the distribution of trips over various road categories, acceptance of corresponding speed limits and regimes, etc. Line (3) more specifically relates specific local design and conflict-control to task demands and necessary skills on the part of the traffic participant.

In a recent Dutch document on the development of 'sustainable system safety' in road traffic this has been translated into three basic design principles. An elaboration on the contents of sustainable safety is given in different documents (SWOV, 1992 and SWOV, 1993).

- Prevent unintended use of road infrastructure, i.e. use that is inappropriate to the function of that road.
- Prevent encounters with the implicit risk of high differential speeds, i.e. large discrepancies in speed, direction and mass at moderate and high speeds.
- Prevent insecure or erratic behaviour of road users by enhancing the predictability of the road's course and road users' behaviour on the road.

These principles, in turn, have been translated in terms of the development of distinct, easily recognizable road categories derived from three main functions: flow, distributor and access function, with special attention for the conflict structure on flow and distributor roads (in terms of road user categories involved, differential speeds and directions).

This again, leads to two levels of implementation:
- defining the network structure and defining the category (and/or sub-category) specifications;
- defining the local design specifications.

Inversely, these two levels are also the levels on which the safety effects of decisions on road infrastructure may be evaluated, and around which reports on Road Safety Impact Assessment can be hierarchically organized.

It should be noted that these evaluation levels do not necessarily have to correspond directly to the type or level of decision making. Which is to say that, even where e.g. relatively simple decisions regarding a specific stretch of road are concerned, it would be preferable or advisable to look into the consequences for the distribution of traffic over that part of the network in which it is embedded, or even take up the opportunity to do some redistributing and redesign for that network-part as a corollary to the main project.

Generally, the basic strategy should be that for a fairly limited length of roads - given a flow or distributor function - much more severe constraints should be put on the design specifications in order to combine mobility, speed and safety requirements. At the same time, major parts of the network should be redesigned or 'downgraded' for the relative safety of low driving speeds. The combined process of upgrading and downgrading should thereby, apart from being a design for safety, also uphold the mobility function of the network as a whole.

Before turning to practical questions of how to implement road safety impact assessments, we will first have a more detailed look at:
- scenario methods, specifically developed to asses the safety consequences of redistributions of traffic over a road network (Chapter 3);
- road safety audits as a means of examining the local design specifications (Chapter 4).

3. Tool to optimize network design: risk scenario's

3.1. Description of a method

In general, road accidents are caused by a combination of factors although relationships between accidents and those factors causing them, or contributing to the causes, are not well understood. The interaction between road, vehicle and the road user obscures the determination of accident causes. In qualitative terms, it is a well known fact that physical features of a road network, together with the traffic volumes on that network are the main explanatory factors of the mean number of accidents happening on that network.

This enables us to develop a strategy to assess road safety impacts of changes of the road network itself and of its usage on a macro- and mesoscopic level, i.e. on a national or a regional scale. The strategy finds its origin in the different relationships between traffic volumes and the number of road accidents for different types of roads.

This method can be described in the following three steps:

1. The *first* step is to prepare the reference material. Establish a system of *categories of road types* for a certain jurisdiction (country, county or province). Do measure the road length per road type and try to measure (or make an estimation of) the relevant *road safety indicators per road type*. Two safety indicators are of relevance: the number of injury (including fatal) accidents per kilometre of road length, the number of injury accidents per million motor vehicle kilometres and the number of injuries per injury accident. Try to estimate the development in time of road safety indicators. Design a procedure to compare regional and national road safety indicators (taking in mind the distributions of variables in the indicators).

2. In *step two* the functional boundaries of a region are established. Per road type *an inventory of all roads* needs to be prepared. When possible, digitalize the road network, using a Geographic Information System. Try to make an estimation of *traffic volumes* based on traffic counts (and, if necessary, on traffic model results). Based on accident registration by the police, *locate registered accidents per road type* (per link and junction).

Compute the regional safety indicators and validate these regional indicators with national indicators. If necessary, try to establish 'regional validated indicators'.

3. For the same region used under 2. make an estimation of the road network and its traffic volumes for the *prognosis year*. This is the start of the *third* step. Make an estimation of the road safety indicators for the same year. Try to *establish the road safety effects* of changes of the road network and the traffic volumes.

Summarize all the results in the first phase of a 'Road safety impact analysis' (as indicated in Chapter 7) and make an interpretation (impact assessment) of the RIA-results. These results can be used in public discussions and in the political decision process.

The following steps have to be taken to estimate road safety impacts of changes of a road network and usage of that network.

STEP 1: Basic data
1.1. Categorising a road network
1.2. Road safety indicators per type of road
1.3. Relationship between road safety indicators and traffic volumes
1.4. Distribution of road safety indicators
1.5. Development of road safety indicators

STEP 2: Research area in reference year
2.1. Roads per road type
2.2. Traffic volumes per road type
2.3. Accidents per road type
2.4. Road safety indicator per road type
2.5. Comparing national and regional road safety indicators

STEP 3: Research area in future year
3.1. Road network per road type and estimations of traffic volumes
3.2. Estimations of road safety indicators
3.3. Estimations of road safety effects
3.4. Assessment of road safety impact

3.2. Example of risk scenario in the Netherlands

STEP 1.1. *Categorising a road network*

The following road characteristics are recommended to use:
- number of carriageways
- number of lanes per carriageway
- number of directions per carriageway
- existence of parallel facilities.

Furthermore, roads could be discriminated according the type of road users using the same physical space: fast motorized traffic, non motorized vehicles, agricultural vehicles.

Using these criteria the following eight road types *outside urban areas* are used:
- motorways with three lanes or more per carriageway
- motorways with two lanes per carriageway
- motor roads with dual carriageway
- motor roads with one carriageway
- all purpose road with dual carriageway (no slow traffic)
- all purpose road with one carriageway (no slow traffic)
- all purpose road, one carriageway, two lanes
- all purpose road, one carriageway, one lane

Inside urban areas the following categorization of roads has been introduced:
- dual carriageway, two directions, two parallel facilities

- dual carriageway, two directions, one parallel facility
- dual carriageway, two directions, no parallel facility
- one carriageway, two directions, two parallel facilities
- one carriageway, two directions, one parallel facility
- one carriageway, two directions, no parallel facility
- one carriageway, one direction, two parallel facilities
- one carriageway, one direction, one parallel facility
- one carriageway, one direction, no parallel facility

Of course, it might be possible that some of these road types do not exist.

STEP 1.2. *Road safety indicators per type of road*

Per type of road the following variables have to be measured to estimate road safety indicators *on a national level*:
- kilometre of road lengths
- number of motorized kilometres travelled
- number of injury accidents
- number of casualties
- number of deaths.

As road safety indicator we recommend to use:
- number of injury accidents per kilometre per year per road type
- number of casualties per injury accident
- number of deaths per 100 casualties.

Dutch road safety indicators per road type, for roads inside and outside urban areas are given in Table 1 (Dijkstra & Wegman, 1992).

STEP 1.3. *Relationship between road safety indicators and traffic volumes*

In Figure 1 we assume a linear relationship between the number of (motorized) kilometres travelled and the number of injury accidents per kilometre of road length, per road type (Janssen, 1991).

STEP 1.4. *Distribution of road safety indicators*

It is assumed that the number of injury accidents (nominator) follow a so-called Poisson-distribution. This means that the number of observed injury accidents are within a confidence interval of two times the square root of the observed number.
The distribution in the denominator (the number of kilometres travelled) is seldomly known per road type. Most of the times these observations are based on measurements of a few hours per year.

STEP 1.5. *Development of road safety indicators*

The reduction of the number of casualties could be explained partly by the fact that road traffic had become safer over the years (better trained and more experienced road users, better cars and better design of roads), but also by the increasing proportion of kilometres travelled on road with low accident rates (motorways).
Unfortunately, we do not know the contribution of both of these factors. For this reason we propose, in the mean time, not to assume the road safety indicators will remain constant over the years, but to assume that

the reduction in fatality and injury rates in a country (to be estimated with so-called macroscopic accident models) is the same for all road types.

STEP 2.1. *Roads per road type*

An inventory has to be made of all roads in a certain region as a start of this second step, according the road types defined in STEP 1.1. It would be well advised to use a Geographical Information System in order to make it easy and cheap to estimate the impact of different scenario's and to visualize these impacts.

STEP 2.2. *Traffic volumes per road type*

An inventory has to be made of the traffic volumes per road type in a self-chosen reference year.

STEP 2.3. *Accidents per road type*

Based on information from a national accident database all accidents have to be allocated to the road network. A procedure has to be developed how to decide on accidents on junctions of two roads in two different road categories.

STEP 2.4. *Road safety indicator per road type*

Road safety indicators per road type can be estimated in the area under consideration, using the data collected in STEP 2.2 and 2.3.

STEP 2.5. *Comparing national and regional road safety indicators*

One can compare road safety indicators for a certain area based on regional data with 'mean' national data, a procedure of validation. Of course, the results of this comparison will be different. A procedure has to be developed how to act by then, depending on the size of the differences found. Generally, it is recommended to use national road safety indicators and not regional ones. But, when differences occur, one should try to find explanations that account for the differences found.

STEP 3.1. *Road network per road type and estimations of traffic volumes*

The third step deals with a year in the future: e.g. 2000, 2010, 2025. For this year all the relevant changes of the road network have to be added to the reference-network: road length and road type are of importance. Using traffic forecasting techniques an estimation has to be developed for traffic volumes per road type.

STEP 3.2. *Estimations of road safety indicators*

Road safety indicators per road type are not remaining constant over the years, but are expected to improve. Estimations has to be made on the values of the different indicators for the prognosis year. Estimations of indicators per road type have to correspond with road accidents developments on a macroscopic level. Or, the other way around, from macroscopic developments road safety indicators per road type could be derived.

STEP 3.3. *Estimations of road safety effects*

When assuming values of road safety indicators per road type, and using the outcome of STEP 1.5, including the results of STEP 3.1, it is possible to estimate the effects on road safety.

STEP 3.4. *Assessment of road safety impact*

The results of different scenario's could be compared to each other and these results could be compared with the road safety objectives as well. Policy conclusions could be drawn and the results could contribute to public debate and to political decisions.

4. Tool to optimize road design: safety audit

4.1. Introduction

"The main objective of safety audits is to ensure that all highway schemes operate as safely as possible: this means safety should be given thorough consideration throughout the whole preparation of the project". This quotation is to be found in the 'Guidelines for: The safety audit of highways', issued by the British Institute of Highways and Transportation (IHT, 1990). A road safety audit could be considered as an important tool in accident prevention by paying attention to all phases of a road design process.

The background of safety audits is to carry out formal checks to ensure that designers of infrastructural projects explicitly have covered road safety aspects. *It is to be advised to carry out safety audits by specialists independent from the design team.* Audit teams should be multi-disciplined, well-trained and experienced. The independency of audit teams could be organised in different ways. It could be decided whether auditors are reporting directly to the initiating authority of a road project, or form a separate entity from the initiating party. The reports of auditors have to be available publicly. A road authority, as initiator of an infrastructure project, got to have a freedom of choice to follow an audit report or to neglect the results. It is to be advised that the road authority remains responsible for the decisions taken in the projects initiated.

Only a small number of countries are active in the field of road safety audits: the United Kingdom, the United States, Australia, New Zealand and a number of developing countries. The most extensive and more or less standardized form of safety audit can be found in the *United Kingdom*, where it is compulsory for all trunk roads and could also be applied for all other major and minor road schemes on a voluntary basis.

In the *United States*, guidelines have been drawn up concerning the design and operational practices on road safety since the late 1960s. Currently, the Federal Highway Administration (FHWA) is recommending 'safety reviews' for motorways at a local level. Such reviews are far from uniform and are widely divergent with respect to the level of detail. The interest in audits is increasing in the US and it is likely that they may become compulsory on a State level. They will call these activities 'Road safety management schemes' instead of road safety audits, although the aim of these schemes and the content are quite comparable to safety audits. The so-called tort liability of road authorities for accidents caused by improper road design and lay out is an important cause to tackle the same problem with a different tool.

In *Australia*, some States have already introduced guidelines and checklists, while others are in the process of doing so. A project has been set up designed for nationwide introduction.
New Zealand is currently in the process of developing guidelines for safety audits. A number of pilot projects have already been performed and training courses are in progress.

A cooperation agreement has been drawn up with Australia (Jadaan, 1993).

The safety audits performed to date in *France* only related to existing roads (Machu, 1994). This concerned a feasibility study with a view to determining hazardous situations on the basis of a reference manual. In connection with the study of *existing* roads, Machu has defined two problems: if a road authority does not act in response to the hazardous situations found, then he is in principle liable with respect to accidents occurring at that location. It is also anticipated that the road authority will only make efforts to improve road safety if an audit team has paid a visit.

Denmark is not included in the above overview. Proctor & Belcher (1993) indicate that a discussion on the introduction of safety audits is in progress in Denmark. In the *Netherlands* a discussion has been started as well, but little progress can be reported so far.

For reasons of the leading role the United Kingdom plays in the field of safety audits, an example of an English safety audit will be described below. In addition, an example of an audit as performed in Northamptonshire County will be given.

4.2. The safety audit as applied in the United Kingdom

In 1990, several reports concerning safety audits were issued in the United Kingdom, including backgrounds and guidelines (Department of Transport, 1990a; IHT, 1990). Subsequently, some opinions about the audit were published (Bulpitt, 1991; Drummond, 1991; Proctor & Belcher, 1993).

Purpose of the audits
The primary purpose of the audits is to ensure that:
- road safety is optimally incorporated during the design and realisation phase;
- the risk of accidents on connecting roads is minimized.

Application
The safety audit relates to:
- new (trunk) roads
- improvements to existing roads
- important maintenance work

Phases of an audit
1. Planning (route selection, relationship with existing networks, design requirements, junctions).
2. Concept stage.
3. Assessment of detailed subjects.
4. Check prior to opening the road.

However, the Department of Transport (1990b) in the United Kingdom dictated that the first point should not form part of an audit for *strategic roads,* since the road safety of all schemes should also be considered at the pre-public consultation stage as part of the strategic or conceptual evaluation of alternatives. This is not a Road Safety Audit within the terms of the Standard and Advice Note, at issue, but is an examination of many factors including road safety.

Performance of an audit
A safety audit is performed by specialized safety experts functioning independently from the (technical) design team. In the course of the work, the expert or the team employs very detailed checklists. *These checklists are in fact used more or less as a guide*; it is not the intention that they will be fully filled out. Upon completion of each phase, the expert or the audit team must draw up a report offering comments on the safety aspects and with proposals for improvement. It is formally arranged that if the proposals are not complied with, the reasons should be accounted for in writing.

The checklists consist of the following main subjects:
- geometric design
  - junctions
  - access control
  - horizontal and vertical alignment
  - cross section
  - facilities for slow traffic
- road surfaces
  - skid resistance
  - day and night visibility
  - evenness and profile
- road signs and lighting
- road markings and delineators
- road side (safety) features
- traffic management
  - speed limits, junction control
- road works and maintenance
- deviations from the guidelines.

Jadaan (1993) mentions that upon commencement of an audit, sufficient information must be available. In addition to design drawings and the like, the following are cited: accident history of the location, data of volumes of motor vehicles, cyclists and pedestrians, background information about the effectiveness of measures and an overview of deviations from the guidelines.

4.3. Example of a safety audit

The Northamptonshire County Council (1992) performed a safety audit during 1991 and 1992 concerning a new, single lane connecting road outside the centre of Brackley. The road measures 1.9 km in length. The connections to existing roads are formed by a level junction and a roundabout. Between the farthest points is a junction carrying little traffic on the approach roads. The connecting road was opened to traffic in April, 1992.

Since many of the interim plans were already discussed before the start of the audit, the audit commenced with the second phase and was completed according to plan up to and including the fourth phase.

The audit document contains a description and drawings of the road in question. In addition, phases 2 to 4 were reported by the auditor (only 1 to 2 pages) entitled: 'safety audit certificate'.
At the time the audit was carried out, it was not common practice to make checklists, but these were nevertheless used by the auditor as a guideline. It is noted that not one single audit report contains the thought processes of the auditor in such a way that the report can serve as blueprint for other audits. *The essence of the matter is that the auditor is able to arrive at a road design which is simple and recognizable for future road users, thereby minimizing potential for error.*

The audit described here was not carried out by teams, but rather accident investigators. It is stated that the up to date experience of assessing real world highway use problems and identifying remedial measures can be applied to schemes on the drawing board.
The report does not indicate the hierarchical organization of the audit. In sofar this can be determined, the auditor (a highway safety manager for the Highway Safety Group within the Northamptonshire County Council) reports to the head of project management, also part of the Northamptonshire County Council.

With the findings described below, which were drawn up during a phase of the audit, sketches with indicated improvements were often added, with the exception of the first phase.

First phase: Feasibility/initial design
In the study report, the first phase of the audit is completed with the comment that the following aspects were already considered: route selection, number and type of junctions and integration into the existing road network. Upon commencement of the second phase, a report on the preliminary phase of the design was not available. In the introduction to the report, the hope is expressed that the discussions held during the preliminary phase could contribute towards solving the problems which were encountered at a later stage.

Second phase: Preliminary design
The auditor considered the following aspects:
- horizontal and vertical alignments
- junction provision and layout
- termination points of scheme

In some cases, changes are proposed such as the construction of lanes to offer motorists clear entry and exit points and measures to reduce speed at roundabouts. In other cases, it is noted that the design of the elements investigated was found to be satisfactory.

Third phase: Traffic signs
Comments were given concerning the size of the signs, the information noted thereof and the location distance from the side of the road.
N.B.: The date on which the certificate for this third phase was issued is the same as that on the certificate for the second phase. The report does not note this fact, however.

Fourth phase: Inspection of the road
In this phase, the comments remained confined to two road signs and the

width and marking of an access road to a roundabout. One junction was not yet completed and would be subjected to a 'stage 4 safety audit' at a later stage. However, this fact was not mentioned in the report.

4.4. Review of the safety audits

The example given above does not relate to an audit performed in accordance with the UK-guidelines: there was no initial phase and the second and third phase were combined. Apart from this, two worthwhile elements can be distinguished for the audit performed.
The first is that *'independent' safety experts* should assess the plans and realization of the work on the basis of safety aspects. The second is that a report must be issued at fixed times upon completion of a project stage, with an associated certification.

In his assessment of safety audits, Bulpitt (1991) concludes that the audit expert should not become involved in technical specifications and calculations. Neither should an audit become a mechanical process of filling in lists. Common sense should prevail, where the assessment is based on the perspective of how the future road user will experience the design. Checklists do serve a purpose in ensuring that no essential material is forgotten. A supplementary assessment of the design function during night-time conditions was considered particularly useful by the author.

Proctor & Belcher (1993) note a problem with which safety experts are confronted. Due to the limited quantity of information, the expert is unable to assess the effect the completed measure will have. In a general sense, something may be said about future safety problems, but quantification in terms of various accident types and their severity is not feasible.

For the safety audit, he proposes the setting up of a database similar to the one used by the American Federal Highway Administration (FHWA). These data are public information, because they are periodically published by the FHWA in the 'Annual Report on Highway Safety Improvement Programs'.

4.5. Conclusions and recommendations

A safety audit is a useful instrument for assessing those aspects relevant to road safety at an early stage and during all subsequent phases of the road design. We recommend not to start road safety audits before the results are available of the first phase of a RIA: network scenario's. As essential characteristics of safety audits could be considered:
- independency of auditors;
- reports of auditors have to be available publicly;
- a safety audit must start with the results of the scenarios as indicated in Chapter 3;
- audit reports has to be published after completion of the preliminary design, after completion of the detailed design and just before the opening of the road;
- audit reports are to be considered as an advice to the initiators of a road project; the initiator remains fully responsible.

A safety audit gains in impact if each subsequent phase may only commence when the previous one is formally completed.

When road safety audits are going to be introduced we recommend to develop different checklists, preferably by an international committee of experts. We recommend to use all expertise and existing knowledge available in the literature, also in the field of so-called black spot manuals, when preparing these checklists, and not 'to reinvent this wheel'.

We suggest to develop different checklists for every phase (preliminary design, detailed design and checklist to be used before opening). Furthermore, it could be useful to distinguish different types of infrastructural schemes, because the checklist per scheme could be completely different. One may consider to develop these schemes for the construction of new major roads and the improvement of existing major roads (assuming no EU-interest in minor schemes).

5. Experiences with Environmental Impact Assessment: EIA

5.1. Introduction

It might be of interest to learn from the activities, approaches, procedures etc. in the field of Environment Impact Assessments (EIAs) when designing Road Safety Impact Assessments (RIAs). For this reason this chapter deals with experiences with EIA in the Netherlands.

Over the past decades, both the public and the country's administrations have come to realize that the increasing affluence of society also has negative consequences for the world we live in. This realization has led to regulations in which measures that bring about radical change, have to be reviewed in advance to determine their consequences for the environment.

The United States pioneered the initiation of such regulatory control. At the end of the 1960s, this led to the introduction of an Environmental Impact Assessment (EIA), which enabled the systematic weighing up of pros and cons (from an environmental perspective) in relation to certain decisions. After Canada had followed the American example in the mid-1970s, a similar process was also put in motion in other countries. This process led to a bill for the implementation of the EIA in the Netherlands in 1981. Prior to its introduction, this was subject to a provision that allowed an EIA to be carried out on government projects on a voluntary basis in order to gain experience. As a result of these trials, the performance of an EIA in the Netherlands was made compulsory in 1987, and the act incorporated a list of those activities and decisions to which the obligation applied. The EC Directive on the EIA which came into force in 1993 - in some aspects more stringent than the Dutch legislation, while in others it was not as far-reaching - was fully integrated into the Dutch legislation in 1993.

5.2. Advantages of an EIA

One of the advantages of an EIA is based on the fact that it exerts a *preventative influence*. Project initiators and governments involved in the decision making process surrounding these projects are forced to consider all the possible consequences in advance, not only with respect to the project itself, but also with respect to the alternatives.
In addition, an EIA ensures that sufficient account is taken of the interests of other parties aside from the actual initiator or the decision making bodies. Also, the resultant streamlining of decision making procedures and a means of coordinating decisions relating to the project should be regarded as concomitant advantages.

The advantages of an EIA become quite evident when one realizes that a decision about a project (which can have consequences for the environment) cannot be taken until an EIA procedure has been carried out which not only describes the project, listing the alternatives and their relative consequences, but also indicates that all procedural requirements have been met.

5.3. EIA characteristics

Projects or activities which have significant deleterious consequences for the environment have already been determined in advance by the legislator and been made subject to an EIA obligation. This relates to the following categories:

- roads, railways and waterways
- harbours, artificial islands and airfields
- military terrain
- pipelines
- recreational and tourist facilities
- housing construction
- hydraulic works
- changes in the water level
- water catchment and water supply
- mineral extraction
- removal/discharge of waste materials
- industrial activities
- energy supply
- storage and transfer of fuels
- key planning decisions

All decisions which relate to activities concerning the above mentioned subjects are obliged to draft a preliminary EIA. This does not mean that an EIA cannot also be performed on a voluntary basis. In that case, all legal rules are applicable. This option is also applied in the Netherlands to a limited extent. In addition to the national regulation, individual provinces in the Netherlands can also determine which projects or activities should be subjected to the compulsory drafting of an EIA. Generally, this concerns areas located within these provinces which have a special significance, or areas which were already heavily burdened from an environmental perspective.

In some cases, *the project initiator can be exempted from the obligation to draft an EIA*. This is the case, for example, if the initiator has already had an EIA drawn up for that project, continues the same project or when it is evident that a follow-up EIA will not offer any new data. An exemption can also be granted from the point of view of the public good. The EU Directive concerning the application of the EIA no longer permits exemptions which until recently were granted in the Netherlands, i.e. if it could be demonstrated that no major deleterious consequences were anticipated.

A number of parties play a role in the drafting of an EIA; each according to his own area of participation:

- the initiator
- the competent authority
- the advisors
- the EIA commission
- public participants

The initiator can be a private or government organization wishing to undertake an activity on which the competent authority must take a decision. Advisors can offer the competent authority advice about the EIA under consideration. To this end, certain organisations may be appointed

in the course of the decision making procedure concerning the project or the activity. Where it concerns matters in which the competent authorities do not represent the state government, certain government bodies must in any event be consulted.
If the national government does in fact represent the competent authority, the Ministry of Housing, Physical Planning and the Environment (VROM) and Agriculture and Fisheries (L&V) appoint the appropriate officials to perform this consulting task. The results of the recommendation are forwarded to the EIA commission. In return, the EIA commission issues recommendations specific to each EIA to the competent authority. The working group members are selected from the independent experts from the EIA commission. The commission in its turn consists of a large number of experts in the field of the environment and in the field of activities subject to an EIA obligation, who are appointed by the Crown. For each EIA, the chairman of the Commission for the EIA determines, in consultation with his deputies, the composition of the EIA commission, where guarantees are incorporated in order to prevent a conflict of interests occurring through direct or indirect involvement. Finally, the participants represent those persons or organisations who are not included amongst the above named parties. They are interested in an EIA for other reasons and indicate that they wish to be heard in the decision making process.

5.4. Procedure with the drafting of an EIA

The EIA procedure consists of seven phases.
In the *first* phase, the initiator investigates whether the proposed project is subject to an EIA obligation. If so, this is specified in an initial note and submitted to the competent authority.
In the *second* phase, the competent authority publicises this fact and appoints a committee and advisors to draw up a recommendation. Public notice is also given, to offer other interested parties an opportunity to comment on the directives which the EIA must satisfy. This second phase is subject to a legally established maximum period.
In the *third* phase, which is not subject to a fixed term, the initiator draws up the EIA. Here, he can make full or partial use of externally procured know-how (important if there is a lack of know-how or manpower in house) while continuing to bear ultimate responsibility for the content of the EIA.
In the *fourth* phase, the competent authority checks the completeness and accuracy of the EIA and its acceptability is then pronounced within predetermined periods. If accepted, the EIA is published. This simultaneously enables assessment and participation in the fifth phase.
During this *fifth* phase, the legal advisors and the Commission for the EIA are offered the opportunity to issue their recommendation. In addition, a hearing is set in which others can also offer an opinion about the EIA. The Commission incorporates the results of this hearing in its ultimate recommendation. This fifth phase is also subject to legally fixed terms.
The *sixth* phase represents the decision process of the competent authority. This decision process describes how the information collected during the entire preceding procedure is utilised. In some cases (about 30%), no decision is taken because it is noted that further information is needed.
It has become common practice that at the time of the assessment of the EIA by the Commission, it is empowered to indicate which information is still required to enable a decision to be made.

The final, *seventh* phase in the procedure concerns the evaluation. The decision issued by the competent authority should indicate what needs to be evaluated and by which means, and also within which time period this should occur. The evaluation study is performed by the competent authority who will receive the cooperation of the initiator.
Based on the results of such a study, the competent authority can take measures if the consequences of the decision prove to be significantly more serious than was apparent from the results of the EIA.

5.5. Conclusions and recommendations

From the points described above, it can be seen that the decision making process concerning major projects or activities can be significantly intensified or delayed by a procedure associated with so many requirements. Nevertheless, a positive effect seems to have resulted from the regulation. Not only are decision making procedures streamlined, as it is clear which decisions are subject to an EIA and as information collection, consultation, participation and decision making are specified; there is also question of a preventative effect which is mainly determined by the increased environmental awareness of the initiators and governments involved. Finally, the need to draw up an EIA seems to contribute to the development of less detrimental alternatives.

Keeping in mind the experiences with EIA and the usage of the EU Directive *we conclude that a similar procedure could be used for a RIA as well.* Two exeptions have to be made. First of all we recommend to establish an *independent commission* (audit team) to prepare a RIA. Furthermore we recommend to start the procedure with an *initial note* as a starting point of the procedure in order to prevent fundamental discussions in follow-up phases, where these discussions are not appropriate, anymore.

6. Procedures for integrating RIAs in decision making

Basic to the implementation of road safety impact assessments are the questions of whether these should be voluntary or mandatory, and, whether these should have an independent basis or be integrated in existing law and procedures.

Existing procedures are already often felt to be too complicated and time-consuming, sometimes hampering effective decision making rather than contributing to it. In fact, in many respects efforts are being made to simplify and shorten procedures. Therefore, in principle, not much support is to be expected for adding issues to such procedures unless not only the necessity is absolutely clear, but also content and method can be adequately specified in order to be able to assess the consequences for the process of decision making.

If one takes a closer look at existing procedures, in particular at environmental impact assessments as they are performed in the Netherlands, it must be recognized that as such safety considerations (and, where applicable, road safety considerations) are allowed for in the process. As a matter of fact, where major new roads or the upgrading of existing roads is concerned, road safety is often one of the main arguments used for the proposed decision. From this point of view the question would rather be why the safety parts of such reports usually are so flimsy. One may speculate as to the reasons for this phenomenon and look at these from the point of view of e.g. public interest, priorities, acceptance etc. One may, however, also relate these more specifically to properties of road safety as such, and look at it from the point of view of predictability, assumed level of control, locus of control, strategic consensus etc.

One of the basic problems in controlling safety effects is that one is dealing with probabilistic rather than deterministic events. This makes prediction and control harder, and in this respect sets it apart from environmental variables that may be more deterministically assessed. Of course, in this respect road safety is not different from other safety area's. What may be different in the case of road safety is that much more responsibility and control is assumed to lay with the public (the road user) than in the case of e.g. industrial safety with the workforce. This again, may bear on the level of control that is assumed from a governmental or institutional point of view. Finally, it may then be harder to reach an agreed upon strategy to bring about safety effects.

Apart from such considerations, some degree of consensus with respect to strategy, concepts and methods would seem to be a prerequisite to any formal solution (or any informal solution, for that matter). Some of such consensus is developing in the Netherlands around the concept of a 'sustainably safe traffic system', particularly as applied to design and reconstruction of road infrastructure. It is especially within this framework that the concept of road safety impact assessments has evolved and is being developed, as one of it's basic tenets is that road safety should be incorporated explicitly in the traffic planning and decision process, rather than be something to be dealt with 'after the fact'.

It would seem natural, therefore, to incorporate road safety impact assessment in current procedures, rather than set it apart in it's own decisional surrounding. Environmental impact assessment would thereby seem to be the most likely - and universally present - candidate, but there may also be more specific legislation, varying from country to country, lending itself for the inclusion of safety assessments.

In the Dutch situation, there are already two provisions within environmental law that would allow for road safety impact assessments to be incorporated. As a rule, the committee on environmental im-pact assessments brings out an advice on the contents of any specific assessment, which may then be taken up by the authorities and given the status of directive. Road safety impact assessment may be part of such a directive, and sometimes it is. In a more general way, rules on the contents of environmental impact assessments are - under the law - laid down by executive order. It would be relatively easy - in terms of procedure - to specify in such an executive order that projects relating to road infrastructure should be subject to a road safety assessment as well.

For the European situation one might think of a recommendation of similar content on the basis of Directive 85/337. Additionally, one might explore specific national legislations within the working area of Directive 85/337, in order to identify specific procedures where road safety impact assessments might be incorporated.

As some practical experience with such methods would have to be gained, however, the initial emphasis should lay on the development of instrumental support rather than mandatory procedure, instrumental support such as this report is trying to bring one step further.

In a broad sense this instrumental support should be directed at questions of concepts and strategies, as well as developing specific method and application. On an organizational level the process may be strengthened *by engaging safety professionals* for the performance of specific road safety impact assessments on a frequent and consistent basis.

As a precursor to *some degree of standardization* on a European level one might assume that it may help if central road safety research institutes (BASt, INRETS, SWOV, TRL, etc.) could reach some sort of agreement as to the specifications of road safety impact assessments. *A cooperative effort on this subject matter may be considered appropriate.*

Such a cooperative effort could be aimed in two directions:
- the development of method as such;
- information exchange on specific safety assessments that have been performed.

From the latter activity some sort of *database might be derived including decisional framework, methodology, results, effects on final decisions.* On the one hand this might provide for easy reference when handling similar problems, on the other hand such information can be used to help shape standardized methods.

We recommend to use the results of this study as a first draft for a RIA and to gain experiences with this tool for EU projects on a voluntary basis before making a RIA compulsory.

We suggest *to compare the advantages and drawbacks of a voluntary and compulsory procedure* for RIA. It might be of interest *to integrate a RIA-procedure in the existing decision taking process about road infrastructure* to prevent extra time delays. This means *integration of RIA in the existing EIA-procedures*, when this suggestion is followed.

7. Proposal for the content of a RIA

7.1. Introduction

We distinguish two phases in a Road Safety Impact Assessment in this report. *First phase*: by using scenario-techniques road networks could be optimized by assessing safety effects due to infrastructural changes in a network and, eventually, redistribution of traffic in a network. *Second phase*: by using auditing techniques road design could be optimized.

The 'audit report' will lead to more discussion amongst design-professionals and between professionals and decisions-makers. It is to be expected that the general public will accept the results. The audit report uses checklists as agreed upon by the professional community (relevant institutions of design professionals) and by road authorities. A proposal for the content of a 'audit report' has been described in Chapter 4.

Based on the content of and the experiences with environmental impact assessments and taking in mind the requirements of a RIA the following guidelines for a standard chapter classification could be useful for the 'scenario-report':
- introduction
- problem setting and objective
- decisions to be taken and decisions previously taken
- proposed activity and alternatives
- current situation, autonomous development and effects
- comparison of the alternatives
- gaps in know-how, retrospective evaluation
- design and presentation
- summary

7.2. RIA-proposal

Introduction
The content is self-explanatory

Problem setting and objective
Principle: A RIA contains at least *"a description of what is aimed for with the proposed activity"*.
This describes which problem areas, developments and prognoses have led to the proposed activity and which problems will be solved. The formulation of the objectives should be subject to a system in which hierarchical connections are established between the main objectives and the derived objectives, conflicts are noted and concrete criteria are established, at which the proposed activity (and alternatives) can be assessed. The objectives have to be formulated as explicit as possible and quantification is preferred.

Decisions to be taken and decisions previously taken
Principle: A RIA contains at least *"an indication of the decisions which underlie the preparation of the report and an overview of decisions previously taken by government bodies and relating to the proposed activity*

and the described alternatives".
This chapter contains a brief and succinct description of the decision making process, the decision to which the RIA applies, the phasing of the decision making process, an overview of the implementation decisions taken, the relationship to any other (RIA)-procedures and whether any policy and regulations are in force which restrict the proposed activity.

Proposed activity and alternatives
Principle: A RIA contains at least *"a description of the proposed activity and of the manner in which this will be carried out, as well as a description of the alternatives to this activity which should reasonably be taken into consideration"* and *"the alternatives to be described should in any case include those which enable realization of the best options available for the improvement of road safety".*

Firstly, this describes the consequences if the proposed activity is not performed, possibly on the basis of various scenarios, where other plans related to the surrounding area could also be included.
In addition, the various alternatives are dealt with, including the so-called 'most favourable alternative'. It should be argued why certain alternatives are not considered. This chapter should also consider to what extent other measures can contribute to a solution for the problems noted.

Current situation, autonomous developments and effects
Principle: A RIA contains at least *"a description of the current situation, in sofar the proposed activity or its alternatives can have consequences for this situation, and of the anticipated development if neither the activity nor the alternatives are carried out"* and *"a description of the consequences which the proposed activity or alternatives can have, as well as a rationale for the way in which these consequences are determined and described".*

This should determine the extent to which the influence of the proposed activity and its alternatives reaches. The existing situation and the autonomous development (the development which occurs if the project is not realized) are described on the basis of the literature.
The effects are described on the basis of the following guidelines:
- the method of calculation;
- not only negative effects, but also positive effects and beneficial development opportunities;
- relationship between, and cumulation of effects;
- description of overall traffic safety;
- indirect effects, such as amended area zoning and changes in the accessibility of areas.

Comparison of the alternatives
Principle: A RIA contains at least *"a comparison of the changes to be anticipated as a consequence of the proposed activity and in association with the consequences described for each of the alternatives".*

It should be indicated here which standard quality requirements, target values and objectives of the policy are considered, giving a preferential sequence for each aspect. In addition, it should be indicated to what degree each of the alternatives is expected to contribute to the realization of the objectives.

Gaps in know-how, retrospective evaluation
Principle: A RIA contains at least *"an overview of the gaps in the situation descriptions, the developments and the effects as a result of the lack of necessary data"* and *"the competent authority which has taken a decision during which preparation the RIA was drafted, investigates the consequences of the activity in question if it is undertaken, or after it has been initiated".*

It is described here which information cannot be supplied, what the margins of error are in the information presented, what is the cause of the gap in know-how (uncertain prognostication methods, lack of useable methods) and whether these gaps can be compensated for in the short term.
An important point in this regard is that gaps in knowledge should not relate to that information which is essential to the decision to be taken. These should then be completed in cooperation with the competent authority as a matter of priority.
In addition, an evaluation programme should be drawn up in order to measure the changes that occur, where the established gaps in know-how and the points of doubt should be included, as well as the efficiency of the measures and provisions taken.

Design and presentation
Principle: A RIA should contain at least *"a summary which offers the general public sufficient insight to enable its assessment and to evaluate the consequences of the proposed activity and of the alternatives described therein".*

In this document, which can be read independently, i.e. 'stands alone', the following must be dealt with:
- rationale of the objective and importance of the proposed activity;
- in which decision making process the RIA plays a role;
- choice and rationale underlying the alternatives considered;
- description of the baseline situation;
- description of the anticipated effects (of the various alternatives).

7.3. Principal characteristics of the content of a RIA

A RIA contains two phases, as indicated before: in the first phase a scenario-technique could be used to help decision makers to make as explicit as possible the objectives of an infrastructureplan and to reduce the uncertainties regarding the road safety impact of alternative solutions. Under para. 7.2 a proposal has been formulated for this part of a RIA. This report has to give the general public enough insight and not only the professionals and decision makers.

To summarize the principal characteristics of a RIA:
- Does not result in a choice, but offers a supported overview of all sensible alternatives which can be considered in the decision making process, based on a sound description of the baseline situation.
- Leads to the optimum concrete and operational description of the objectives.

- Considers all reasonable alternatives.
- Offers an overview of the uncertainties and gaps in know-how which, if relevant to the decision making process, should be solved as a matter of priority.
- Leads to an evaluation plan.

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Dutch road network 1986

Road type	Km of road	Motor vehicle per day	Motor vehicle $kmx10^6$
MW>41	242	81252	7177
MW 41	1761	31451	20216
MR 2c	197	16957	1220
MR 1c	2108	5877	4522
AR 2c	252	18314	1683
AR 1c	6537	4927	11756
LR 21	11719	1396	5970
LR 11	31702	314	3631
AU	11519	4471	18798
LU	32142	649	7619
WE	1339	318	155
Totaal	99519	2278	82748

Road type	Injury accidents	Casualties	Fatalities
MW>41	476	698	30
MW 41	1500	2157	111
MR 2c	182	282	17
MR 1c	475	653	79
AR 2c	455	550	40
AR 1c	3540	4826	239
LR 21	3055	3802	224
LR 11	3102	3880	217
AU	25010	27207	477
LU	5754	7517	94
WE	32	37	0
Totaal	43581	51610	1529

Safety indicators, 1986

Road type	Injury accidents per 100 km of road	Injury accidents per motor veh. $kmx10^9$	Casualties per injury accident	Fatalities per 100 casualties
MW>41	197	66	1,47	4.31
MW 41	85	74	1,44	5.13
MR 2c	93	150	1,55	5.94
MR 1c	23	105	1,38	12.12
AR 2c	181	270	1,21	7.22
AR 1c	54	301	1,36	4.96
LR 21	26	512	1,24	5.90
LR 11	10	854	1,25	5.60
AU	217	1330	1,09	1.75
LU	18	755	1,31	1.26
WE	2	205	1,16	1.26
Totaal	44	527	1,18	2.96

Table 1. *Dutch road safety indicators per road type, for roads inside and outside urban areas (SWOV).*

Explanation

MW>4l : motorway; more than four lanes
MW 4l : four-lane motorway
MR 2c : dual carriageway motor road
MR 1c : single carriageway motor road
AR 2c : dual carriageway rural arterial
AR 1c : single carriageway rural arterial
LR 2l : two-lane rural local road
LR 1l : one-lane rural local road
AU : urban arterial
LU : urban local road
WE : 'woonerf' and 30 km/h-zone

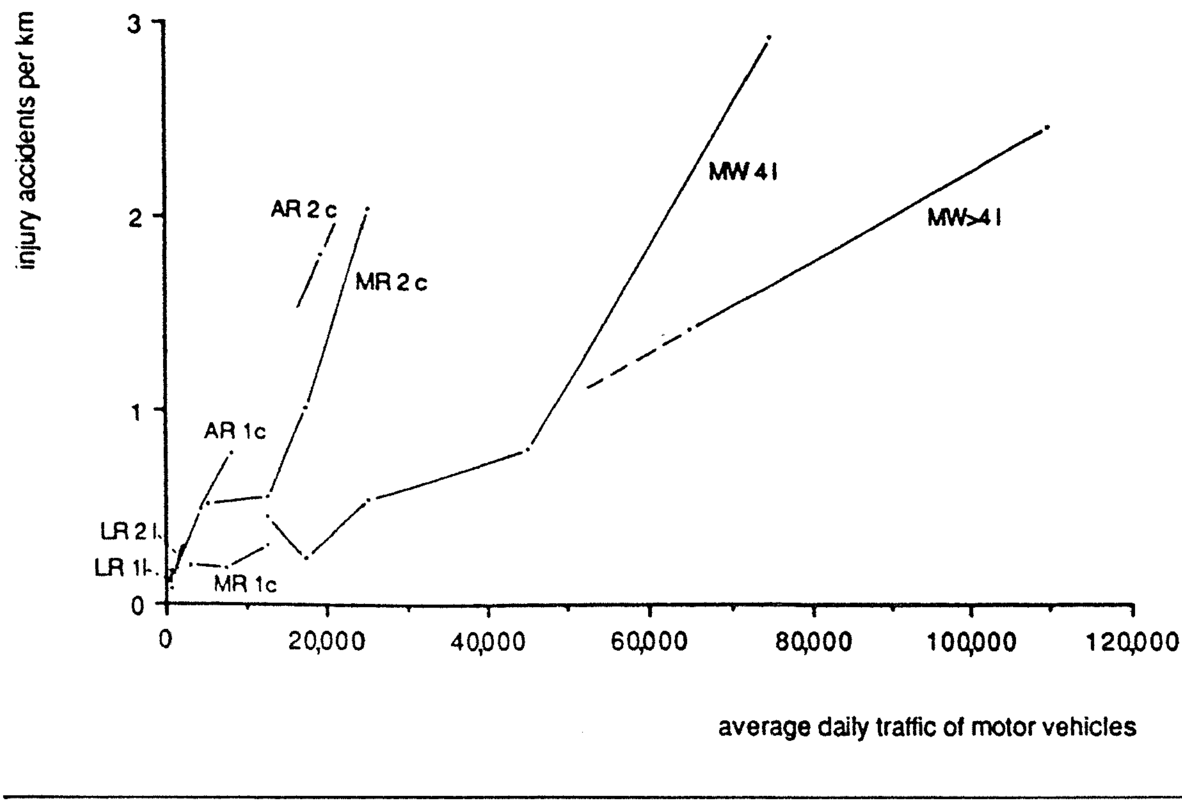

Figure 1. *Indicators on rural roads in the Netherlands, 1986 (SWOV).*