allocation of priorities for national highway projects in the netherlands

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1 Introduction

1.1 General

The Netherlands is an extremely densely populated country in Western Europe. In 1985, the population was 14.4 million, living in an area of 41,000 sq. km. of which 7,000 sq. km. was water. This converts to a population density of some 420 per sq. km. of land, making the country one of the most densely populated in the world. On account of its geographical location on the North Sea around the estuaries of the Rhine and the Maas, the Netherlands has always been a centre of trade and transport. Trade has been a significant factor in the country's prosperity, which is reflected in the 4.9 million cars on the road in 1985, or 340 per 1,000 inhabitants.

In the past, water communications were of particular importance for transport. More recently, technical progress has made reasonable land communications possible as well, and the national road network has continually been adjusted in line with economic and social developments. By 1985, the Dutch paved road network had reached a total length of 95,000 km.

The number of passenger-kilometres travelled in the Netherlands in 1985 totalled 145,000 million, of which cars accounted for 80%.

In the same year domestic goods transport totalled 27,000 million tonne-kilometres, of which 70% took the form of road transport. As regards international goods transport, 80 million tonnes of freight went by road (amounting to 12% of the total), of which 45% was either bound for or on its way from West Germany. As the figures reveal, accidents are unavoidable – no matter what precautions are taken – given transport on this scale. In 1985 there were 44,000 road accidents involving death or injury, with some 1,450 fatalities and 48,500 injuries.

Dutch roads are administered by various highway authorities. Roads of national importance, or the national highway network, are under the authority of the national government. This network has a total length of 2,500 km, three-quarters of which are motorways. The plan is for the national highway network to be fully converted into motorways, with a total length of 3,000 km.

1.2 Allocation of priorities for national road projects

The extension of the Dutch national highway network takes place within a planning system as described in detail in annex 1. Within this planning system, the 'Structuurschema Verkeer en Vervoer' (= the Structure Scheme for Traffic and Transport (SVV))
and the 'Meerjaren Programma Personenvervoer' (= the Multi-Year Plan for Passenger Transport (MPP)) are of particular importance for road projects.
The first of these – the SVV – provides a long-term perspective on traffic and transport policies in the Netherlands, while the MPP elaborates these policies in the short and medium term. Among other things, the MPP establishes the priorities for the implementation and research planning of road projects.
Priorities have to be set under the MPP in order to make the most effective use of the N.Fl. 550 million set aside by the Dutch government each year for the construction and extension of national roads. The setting of priorities and resultant implementation and research planning is also essential for making best use of the available staff.
Since 1983 a new evaluation procedure has been used for setting priorities. Under the new system, priorities are determined in relation to projects already or about to get under way (i.e. implementation planning), and in relation to projects still requiring further study (i.e. research planning).
The nature of the evaluation procedure is described in Chapter 2, while Chapters 3 and 4 go into two technical factors, namely measurement techniques and ranking.
2 Nature of the evaluation procedure

2.1 General

As noted in the introduction, the priorities for national highway projects are determined with the aid of an evaluation procedure. This ‘Systeem voor de Prioriteitenstelling van Wegenprojecten’ (= Road Priority Determination System (SPW)) consists of various stages, namely:
1. Project enumeration and classification (2.2)
2. Determination of criteria (2.3)
3. Determination of the project impact on criteria (2.4)
4. Project ranking (2.5)
5. Project priority determination (2.5)
These steps are discussed in turn below.

2.2 The projects

The SPW covers all road projects (henceforth referred to simply as projects) forming part of the national highway network, in accordance with the first stage of the 1981 SVV. After enumeration the projects are classified into three categories. The first two of these relate to implementation planning:
Category A: Projects that are already under way or which have not yet been implemented but are closely related to projects previously completed or still under way (in the 1985-1989 MPP 31 projects).
Category B: Projects fitting into the first stage of the SVV on which a firm project decision has already been taken but which have not yet got under way (in the 1985-1989 MPP 70 projects).
A third category is distinguished in relation to research planning:
Category C: Other projects fitting into the first stage of the SVV. These are projects for which the project study, on which the decision to proceed or not will be based, remains to be completed (in the 1985-1989 MPP 77 projects). Where there are various possible variants for a research study, the variant deemed most likely by the Department of Public Works (RWS) has been used (with an indication that this has been done).
The classification of projects into those already under way and those to be implemented (categories A and B) has been made on the basis of the basic policy consideration that projects under way should always have priority over those still on the drawing board,
on the grounds that current projects should be completed as quickly as possible so as to make them pay and to ensure maximum continuity in official policy. In relation to the remaining projects, those in category A therefore enjoy the highest priority. As a result the projects in category A all come into the first MPP priority group, and the intermediate steps 2, 3, 4 in section 2.1 do not apply. Classifying all the A-projects into a single MPP priority group is feasible as long as there are sufficient funds for them. For the 1984-1988 and 1985-1989 MPPs this means that some 60% of the available funds are committed.

The remaining B and C category projects go independently through all the stages of the SPW, with the final result that some of the B-projects are allocated to the first three of the MPP priority groups and part of the C-projects to the fourth priority group. The precise procedure is outlined in the following sections.

2.3 Criteria

The criteria are the yardsticks used in ranking the projects. The criteria employed depend on the policies in question, in this case the MPP as part of the SVV. Criteria selection therefore derives ultimately from the SVV. The main aim of the SVV is to meet the demand for the transport of people and goods, while taking account of various other aspects. Under the system used for weighing up the various considerations, an indication of the extent to which a project helps meet the demand for transport is provided by the criterion of Accessibility and by one of the sub-elements of the Economie Activity criterion.

Under the main objective of the SVV, meeting the demand for transport must take account of other aspects, the most important of which have been included in the evaluation system, namely Road Safety, the Human Environment, Economie Activity and Physical Planning. In this way a set of criteria has been built up for assessing projects in the light of the main objective of the SVV. These criteria have been selected on the basis that they are the most important yardsticks laid down within the SVV and that, given the status of the SVV, road projects can consequently be ranked or ordered in meaningful social terms. The selection of these criteria remains, however, a political matter.

After designating the criteria below by means of keywords, their precise meaning is outlined in terms of the definition given to them in the SPW used for the 1985-1989 MPP.

The criterion of Accessibility is used to assess the changes in the traffic restraints on non-commercial traffic as brought about by a project. By non-commercial traffic is meant that traffic for which changes in traffic restraints produce no direct economic effect, e.g. recreational and commuter traffic. Changes in the traffic restraints on business traffic do produce a direct economic effect and are therefore included under the Economie Activity criterion.
The Road Safety criterion is used to assess the effect of a project from a humanitarian viewpoint. This criterion thus indicates the extent of the increase or decrease in physical and/or mental discomfort and suffering within the community as a whole as the result of a particular project.

The Human Environment criterion examines the impact of a project on living conditions in the built environment with special reference to the environmental factors of noise and air.

The Economic Activity criterion is used to assess the economic effect of a project, meaning the extent to which an investment in a road project pays for itself in terms of an increase in the overall level of economic activity. This measure is known as the 'economic worth of a project'.

Physical planning aims at the mutual adjustment of land use and society – in the interests of society – and the conditions that make this feasible. Two elements may be distinguished:

1. physical elements: the contribution made by the project to the (desired) environmental structure;
2. planning elements: the need for the project to be incorporated into existing town and country planning.

Project assessment is essentially concerned with the physical elements, based on national physical planning policies as laid down for example in the Urbanization Policy Document, the Rural Areas Policy Document and outline development plans and structure plans. These policies thus provide the framework for assessing any prospective project.

Planning factors are left out of consideration at the priority assessment stage, although this aspect is used for classifying the MPP priority groups (see section 3.6).

In the SPW used under the 1985-1989 MPP the set of criteria did not correspond completely with that used for the previous MPP. In relation to the year before, the content of the criteria as described above was altered; in the first year the criterion of Economic Activity was not included but only the much more limited criterion of Costs. The Factors of Road Safety and Accessibility consequently contained an economic component in the SPW for the 1984-1988 MPP.

2.4 Effects

As a third step, the effects of projects on the criteria are determined in an SPW. In doing so it is important to ensure that each criterion is measured in a standardized manner, so that the effects of various projects can be compared with one another. For this reason, measurement techniques have been devised for each criterion. On account of the policy-analysis approach adopted, these measurement techniques exhibit a certain uniformity. This method of determining the impact may be described as 'gap' analysis.
The first step under this approach is to decide on an indicator or representative variable for each criterion (representativeness being judged in the light of the definition). After an indicator has been decided upon, the assumptions under which measurements are made are then specified. Finally measurements are made per project for each criterion, the value of the indicator being estimated for the respective situations in which the project proceeds (the 1-situation) and does not proceed (the 0-situation). The difference between these two values, or gap, is the effect of the project on the criterion in question.

The measurement technique as outlined above is subject to a number of refinements. In the first place it was felt necessary to use three indicators for Road Safety in order to arrive at a balanced judgement of this criterion. These are fatalities, injuries and non-injury accidents. The same applies to the criterion of the Human Environment, where two indicators have been used, namely noise and air.

Secondly, the indicator used for the Economic Activity criterion is the resultant of a limited cost-benefit analysis designed to show the economic value of a project. Benefits are taken as the national economic effects resulting from changes in accessibility and road safety. Costs are measured in terms of maintenance and operating costs (the latter only in relation to tunnels). In addition construction costs have been taken as investments.

Thirdly it should be noted that, with one exception, effects have all been measured in cardinal terms (on an interval or ratio scale).

Only the Physical Planning criterion has been measured in ordinal terms, i.e. it is only possible to say whether one project is better or worse than another project, but not how much better or worse.

As was noted, assumptions have been made for each criterion with respect to measurement. A number of general assumptions apply for all measurement techniques, namely:

a. In so far as they are negative, any effects arising during the implementation stage are wherever possible eliminated by compensatory measures. Implementation effects (both positive and negative) have therefore been left out of account. Compensatory measures need to be reflected in the costs included under the criterion of Economic Activity.

b. Any completed project will be maintained until at least the year 2020.

c. All projects will be completed at approximately the same time (1990).

d. The projects do not influence one another and can therefore be analysed separately, unless the list of projects shows them to be specifically linked.

To examine the measurement techniques themselves would go beyond this general description of the SPW and this aspect is taken up in chapter 3.

2.5 Ranking and priority determination

Road projects are classified in two stages. First of all a theoretical priority is drawn up, which is then used to draw up a multi-year plan. The details of how this is done in
practice are discussed in chapter 4: in broad outline the system is as follows. Theoretical priority is determined by means of multi-criteria analysis (MCA). By means of this method road projects are ranked in terms of decreasing social value on the basis of their comparative effects in terms of the selected criteria. This is known as the theoretical priority, which then serves as the starting point for classifying road projects into MPP priority groups. Each MPP priority group relates to a particular period in which those projects are required to be implemented.

Classification into MPP priority groups is done by a form of optimalization subject to certain limiting conditions. In practical terms this means that the theoretical order is as far as possible retained for the classification into MPP priority groups, provided the limiting conditions so permit. The limiting conditions can lead to a more rapid implementation than that indicated by the theoretical list, e.g. if there is a political (Cabinet) commitment. Conversely they can also result in deferred implementation, e.g. if the project cannot be fitted into the existing planning framework in time. The final result of the ranking and priority determination is a classification of the road projects into a number of priority groups. With respect to projects already under way and those to be started during the 1985-1989 MPP planning period, this produced the situation shown in the detachable map at the end.
3 Measurement techniques

3.1 General

As noted in 2.4, this chapter discusses the measurement techniques used for each criterion, namely:
1. Accessibility (3.2)
2. Road safety (3.3)
3. Human Environment (3.4)
4. Economic Activity (3.5)
5. Physical Planning (3.6)
The following items are examined in each case:
A. Definition
B. Indicator
C. Assumptions
D. Measurement techniques
The principle of measurement techniques has already been examined in section 2.4, when the concept of indicator was clarified. At the same time a number of general assumptions were touched upon that apply to all the measurement techniques. The assumptions spelled out in this chapter (under C) are specific assumptions applying to each individual criterion.
N.B. It should be borne in mind that the assumptions are relevant for the Dutch situation; this might not be so elsewhere!

3.2 Accessibility*

A. Definition
Accessibility is used to assess the changes in the traffic restraints on non-commercial traffic brought about by a project. By non-commercial traffic is meant that traffic for which changes in traffic restraints produce no direct economic effect, e.g. recreational and commuter traffic. Changes in the traffic restraints on commercial traffic do produce a direct economic effect and are therefore included under the Economic Activity criterion. However, the assessment of those changes is discussed in this chapter.

* This measurement technique was developed together with M.R. Mulder and J. v.d. Valk.
B. Indicator

The effect of a road project on accessibility is defined by means of a quantitative value indicating the change in total travelling time over a 24-hour period on the network of roads affected by the project.

A distinction may be drawn between three groups of transport:
- Goods traffic
- Commercial passenger traffic
- Non-commercial traffic.

Accessibility in a network with k road sections may then be defined for each of these groups as follows:

\[ \sum_{n=1}^{k} \frac{I_{nt} \times l_n}{V_{nt}} \]

where

- \( I_{nt} \) = traffic intensity on road section \( n \) during the relevant time period \( t \)
- \( l_n \) = length of road section \( n \)
- \( V_{nt} \) = average speed on road section \( n \) during the relevant time period \( t \)

The dimension in which the effect is measured is motor-vehicle hours (mv.hr).

C. Assumptions

1. Goods traffic is taken as meaning heavy goods vehicles exceeding 3½ tonnes (including unladen weight, articulated lorries and semi-trailers, and motor buses).
2. By passenger traffic is meant all remaining traffic.
3. By commercial passenger traffic is meant casual work or the loading and unloading of goods. Normal commuter traffic is excluded.
4. The effect on accessibility is determined by the relevant time period. This means:
   a. For new roads, the full 24-hour period is relevant for the improvement of accessibility.
   b. For reconstructions, such as the widening of certain sections, the relevant period is taken as 7 am – 7 pm.
   c. For projects that currently form a bottleneck with traffic jams the relevant period is generally peak-hour. If a bottleneck should also form a discontinuity in the (main) road network, the relevant period is the full 24-hour day.
5. Traffic volumes have been determined on the basis of data obtained from the most recent studies carried out by the Public Works Department and other bodies. Volumes for the year 2000 have been determined for the 24-hour day. For the period 7 am – 7 pm the volume is determined by taking 80% of the 24-hour volume (a proportion which traffic censuses have shown to be constant in both time and place). For peak-hour a 10% ratio is taken.
6. The division into the various categories of traffic has been done on the basis of the most recent traffic censuses conducted by the Public Works Department and others.

a. The percentages for goods traffic have been based on figure 3 of the '1980 Traffic Data' report produced by the Traffic Engineering Department of the Public Works Department. Where more recent figures exist for a project these have been used. The projects have been sub-divided into four categories:
   1. 0-10% goods traffic;
   2. 11-15% goods traffic;
   3. 16-20% goods traffic;
   4. more than 20% goods traffic.

b. Generally speaking there are no suitable data at project level for determining the percentages of commercial passenger traffic, for which reason the MPP projects have been compared with roads for which there are data. Taking account of road type, location, intensities and the share of goods traffic, an estimate has been made of the percentages, with the following classification:
   1. 0-25% commercial passenger traffic;
   2. 26-30% commercial passenger traffic;
   3. 31-35% commercial passenger traffic;
   4. more than 35% commercial passenger traffic.

7. Speed has been chosen on the basis of the relevant time period for the project. This means:
   a. For new road sections the speed associated with 6% of the daily traffic volume. This speed is regarded as representative for the 24-hour period.
   b. In the case of road reconstructions, etc., the 7% speed is regarded as representative for the 7 am – 7 pm period.
   c. For points of congestion, actual speed measurements are taken or, in their absence, an appropriate assumption is made.

Speed is converted in accordance with the characteristics of the road. The relation between road characteristics and average speed is derived from the Non-Motorway Design Guidelines (RONA) or, in the case of motorways, from integrated traffic and transport surveys.

8. Not all roads in the affected area have been taken into consideration for each project. The studied network is therefore a limited one. In the case of newly attracted traffic, in respect of which the travelling time gains cannot by directly deduced as a result of this limitation, the assumption has been made on theoretical grounds that the gains amount to 50% of those for traffic on the routes that are directly included in the calculations.

D. Measurement technique

Determination of 0-situation
- Determine the road or roads that will be affected by the project in question.
- Establish the road characteristics (length, category, number of lanes) and the traffic
volume in the year 2000 for this road or these roads in the event that the project does not go ahead.

- On the basis of these data and the assumptions and speed calculations, determine the aggregate travelling time on this road or these roads.

**Determination of the 1-situation**
- For the same road or roads, including the MPP project, determine the traffic volume in the year 2000. This means that the effect on the road or roads of the implementation of this project must be determined.
- On the basis of the road and traffic characteristics, determine the aggregate travelling time in the 1-situation.

**Determination of the effect**
Not infrequently, a project will attract more traffic than that originating from the old road(s) and observed road network. This is partly due to the fact that it is not possible for all roads to be included in a project's zone of impact. Part of the traffic that travelled outside the road network in question during the 0-situation will switch to these roads in the 1-situation on account of the improved facilities. Other factors include changes in the selected means of transport and destination. To make allowance for the effect of such 'newly attracted traffic', the previously noted assumption has been made that the travelling time gain for such traffic amounts to half that for the traffic included in the calculations.

The accessibility effect is determined by reducing the aggregate travelling times in the 0-situation by those in the 1-situation, supplemented by the gains from the 'newly attracted' traffic.

### 3.3 Road Safety

**A. Definition**
The Road Safety criterion examines the impact of a project from a humanitarian viewpoint. The criterion is used to indicate the increase or decrease in the amount of physical and/or mental suffering within the community as a whole as the result of a given project.

**B. Indicators**
1. Number of fatalities.
2. Number of injuries.
3. Number of accidents resulting in material damage only.

**C. Assumptions**
1. Road safety per road type depends primarily on traffic volume.
2. Future changes in the accident rate are not expected to exert any substantial effect on road safety.
3. The effect in the year 2000 provides an adequate representation of the total effect.
4. For practical reasons the measurement technique is applied to main roads forming part of the zone of impact. It is, however, possible for the volume of traffic on this main-road network to be higher in the 1-situation (after the project) than in the 0-situation, on account of:
   a. newly generated traffic;
   b. traffic drawn from the underlying road network.
In determining the effect it is assumed that extra traffic in the 1-situation on the main-road network is a result of possibility b above.

D. Measurement technique

General
1. Determine the zone of impact in which the road safety effect takes place. This area covers the project itself plus those roads on which the project results in changes in traffic volume.
2. For some projects the measurement technique cannot be used. In these cases the effects are determined in consultation with road safety experts.

Determination of the 0-situation
Calculate the 0-situation, making use of annex 2. The 0-situation is worked out for the zone of impact (before the project itself).
Under the Road Safety criterion, the following road situations are distinguished in annex 2:
I. road sections outside built-up areas;
II. intersections outside built-up areas;
III. the underlying road network and remaining roads (i.e. secondary and minor roads) outside built-up areas;
IV. the underlying road network within built-up areas.
For each indicator the effects are aggregated for each road situation.

Determination of the 1-situation
The 1-situation is similarly determined with the aid of annex 2 and covers the zone of impact including the project itself. For each indicator the effects are aggregated for each road situation.

Determination of the effect
For each indicator the effect is formed by the difference between the 0-situation and the 1-situation.
A rough estimate of the effect accidents with material damage only is made by multiplying the effect for accidents involving injury by 5.4.
3.4 Human Environment*

I. General

A. Definition
This criterion is used to indicate the effect of a project on the human environment, in so far as the built environment is governed by environmental factors.

B. Indicators
The indicators in this case consist of the effect of noise and air pollution caused by traffic on persons living near the project in question.

II. Noise

C. Assumptions
1. For determining the area for which an average noise level in excess of 50 dB(A) may be assumed on the basis of the traffic intensity categories (see D), the following assumptions have been made:
   a. road level 1.50 m above surface level
   b. speed of cars and motor cycles 100 kph
   c. speed of goods traffic 80 kph
   d. % light vehicles 79.5%
   e. % medium-weight vehicles 11%
   f. % heavy goods vehicles 9%
   g. % motor cycles 0.5%
   h. observation level 1.80 m above surface level
   i. traffic distribution
      daytime intensity (7 am – 7 pm) 6.6%
      nighttime intensity (9 pm – 7 am) 1%
2. Housing density has been estimated using maps dating from 1982 and earlier. No extrapolation to the year 2000 was applied.
3. A reconstruction – i.e. a physical re-shaping of an existing road – for which the same traffic volume is obtained in both the 0- and the 1-situation is regarded as neutral and left out of further account.
4. A slight re-routing of the projected road in relation to the old road can sometimes leave the same dwellings affected by noise in the 1-situation, but this time on a different side. In such circumstances the different sides are treated as separate dwellings.

* This measurement technique was developed together with T. Goeman, J.W.A. Langerak and A.G. de Vries.
D. Measurement technique

The traffic volumes used with reference to the criterion of Accessibility have been divided into categories. Calculations have been made for each category as to the areas or zones in which the noise level will exceed 50 dB(A) as the result of these traffic volumes.

Category 1: not exceeding 20,000 mv/day
zone: 250 m on both sides
2: 20,000-40,000 mv/day
zone: 400 m on both sides
3: 40,000-80,000 mv/day
zone: 600 m on both sides
4: over 80,000 mv/day
zone: 800 m on both sides

As a next step, the number of dwellings has been estimated for the corridor on both sides of the road formed by the width of the zone and the length of the road in question, in both the 0-situation (the old road(s) and the 1-situation (the new road and old road(s)). Once again a division has been made into categories:

Category 1: fewer than 1,000 dwellings
2: 1,000 – 5,000 dwellings
3: 5,000 – 10,000 dwellings
4: 10,000 – 15,000 dwellings
5: over 15,000 dwellings

Next the score $S_1$ was determined as follows:

$$S_1 = (l^1 \times H^1)_{\text{new}} + (l^1 \times H^1)_{\text{old}} - (l^0 \times H^0)_{\text{old}}$$

where:

- $l^1_{\text{new}}$ = Traffic intensity category for the project in the 1-situation
- $H^1_{\text{new}}$ = Housing density category in the zone of impact associated with $l^1$
- $l^1_{\text{old}}$ = Traffic intensity category in the 1-situation for the road affected by the project. If more than one road should be affected, the individual products are aggregated
- $H^1_{\text{old}}$ = Housing density category in the zone associated with $l^1_{\text{old}}$
- $l^0_{\text{old}}$ = Traffic intensity category for the old road(s) in the 0-situation
- $H^0_{\text{old}}$ = Housing density category for the zone associated with $l^0_{\text{old}}$

$S_1$ indicates whether the number of noise-nuisance situations (i.e. dwellings with a noise level exceeding 50 dB(A)) rises (= pos. score) or falls (= neg. score).

The change in the existing noise level is only partly reflected in $S_1$. (Particularly in those cases where $l^1$ and $l^0$ along the old road(s) fall into the same traffic intensity category, this effect is not taken account of.) To this end a second score $S_2$ has been introduced in order to show up the change in the existing noise levels.
decline in \( I \) less than 50\% : \( I = -1 \)
decline in \( I 50 - 100\% \) : \( I = -2 \)
increase in \( I \) less than 100\% : \( I = +1 \)
increase in \( I \) 100\% or more : \( I = +2/+3^* \)

\( S^2 \) is determined as follows:

\[
S^2 = (I \times H^1) \text{ new} + (I \times H^0) \text{ old}
\]

The score \( S^1 \), which provides an insight into the rise or fall in the number of noise-nuisance situations, carries greater weight than \( S^2 \), which reflects the decrease/increase in the noise level, without however indicating the level itself.

The final ranking is done on the basis of \( S^1 \) and \( S^2 \) as follows:

\[
\begin{align*}
2S^1 + S^2 &= -9 \text{ or less} \quad \text{++ very favourable} \\
-8 &- -3 \quad \text{++} \quad \text{favourable} \\
-2 &- +2 \quad \text{0} \quad \text{neutral} \\
+3 &- +8 \quad \text{-} \quad \text{unfavourable} \\
+9 \text{ or greater} &\quad \text{- -} \quad \text{very unfavourable}
\end{align*}
\]

III. Air pollution

C. Assumptions
1. Traffic is distributed evenly over the day and homogeneously over the road.
2. Traffic composition and road behaviour remains the same throughout the day.
3. Housing density in a one-km wide corridor the length of the road section in question is homogeneously distributed.
4. Calculations are made on the basis of average speed.
5. Calculations are based on an average vehicle that, irrespective of traffic speed, emits \( E \) kg of a certain (hypothetical) substance into the open air per km of road.
6. With regard to the distribution of traffic emissions as affected primarily by the parameters of wind direction, wind-velocity and atmospheric stability, wind direction has been used as the yardstick.

It is assumed that the wind blows (more or less) evenly from all directions. The (geographical) location of the road is therefore taken into account by combining the parameter of building density with the wind direction parameter. This ultimately

* In the case of a totally new route the percentage increase is infinite. In an area with a lot of dwellings there will already be a fairly high noise level. In an area with few dwellings, a similar increase in the noise level will have to be assigned greater weight. In that case +3 would be taken, at least where \( I^1 \) is greater than 10,000 mv/day.
means that calculations can be made on the basis of an average building density on both sides of the road.

D. Measurement technique

A traffic intensity \( I_n \), where \( I_h \) is the intensity per hour, moves at a given average speed of \( V \) kph along the road.

\[ V = \text{distance covered by a vehicle in one hour} \]

\[ L = \text{length of road section in question} \]

\[ \Delta L = \text{infinite small part of } L \text{ (and } V) \]

\( H \) (I, II) = respectively development on either side of the road in a one-km wide corridor the length of the road section \( L \).

The volume of traffic over a stretch \( \Delta L \) of \( V \) is equal to \( \frac{\Delta L}{V} \times I_h = p \) (mv).

The emission resulting from one vehicle over a stretch \( \Delta L \) (in km) amounts to \( \Delta L \times E = q \) (kg).

Along a stretch \( \Delta L \) of the road there are \( \frac{\Delta L}{L} \times H_I = r \) dwellings, on one side of the road (side I).

By definition the air pollution factor \( W \) is equated to the product of (i) the emission resulting from the volume of traffic concerned over a stretch \( \Delta L \) and (ii) the dwellings along this stretch \( \Delta L \), in other words:

\[ W_I = p \times q \times r = \left( \frac{\Delta L}{V} \times I_h \right) \times \left( \Delta L \times E \right) \times \frac{\Delta L}{L} \times H_I \]

(for one side of the road).

Integrating \( W_I \) for \( \Delta L \) over the area from 0 to \( L \) for road section \( L \) results in:

\[ WL_1 = \frac{I_{\text{day}} \cdot H_I \cdot L^3 \cdot E}{96 \cdot V} \text{ for one side (side I) of the road.} \]

\( WL_2 \) is the air pollution factor for the other side.

The average factor for road section \( L \) then becomes:

\[ W = \frac{WL_1 + WL_2}{2}, \text{ i.e.} \]

\[ W = \frac{I_{\text{day}} \cdot H_{\text{av}} \cdot L^3 \cdot E}{96 \cdot V} \left( H_{\text{av}} = \frac{H_I + H_{II}}{2} \right) \]

The k-value (by definition) = \( \frac{W(\text{av. 1-sit})}{W(\text{av. 0-sit})} \) indicates whether implementation of the road project is favourable (that is, less than 1) or unfavourable (that is, larger than 1). The scores are grouped as follows:
$E_0 = E_1$ (the 'average' vehicle being the same)

In the case of reconstruction, $k = \frac{W(\text{av. 1-sit})}{W(\text{av. 0-sit})} = \frac{I_1 \cdot V_0}{I_0 \cdot V_1}$

The following categories have been used for processing the data:

<table>
<thead>
<tr>
<th>K</th>
<th>appraisal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.54 or less</td>
<td>++</td>
</tr>
<tr>
<td>0.55 - 0.84</td>
<td>+</td>
</tr>
<tr>
<td>0.85 - 1.14</td>
<td>0</td>
</tr>
<tr>
<td>1.15 - 1.44</td>
<td>-</td>
</tr>
<tr>
<td>1.45 or over</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Housing density (on one side in a 1 km corridor)</th>
<th>Av. speed in kph</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: less than 5,000</td>
<td>1: less than 30</td>
</tr>
<tr>
<td>2: 5,000 - 10,000</td>
<td>2: 30 - 50</td>
</tr>
<tr>
<td>3: 10,000 - 15,000</td>
<td>3: 50 - 70</td>
</tr>
<tr>
<td>4: 15,000 - 20,000</td>
<td>4: 70 - 90</td>
</tr>
<tr>
<td>5: 20,000 or more</td>
<td>5: 90 or more</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Road length in km</th>
<th>Traffic intensity I day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: 0 - 2.4</td>
<td>1: 0 - 4,999</td>
</tr>
<tr>
<td>2: 2.5 - 4.9</td>
<td>2: 5,000 - 9,999</td>
</tr>
<tr>
<td>3: 5 - 7.4</td>
<td>3: 10,000 - 14,999</td>
</tr>
<tr>
<td>4: 7.5 - 9.9</td>
<td>4: 15,000 - 19,999</td>
</tr>
<tr>
<td>5: 10 - 12.4</td>
<td>5: 20,000 - 24,999</td>
</tr>
<tr>
<td>etc.</td>
<td>etc.</td>
</tr>
</tbody>
</table>
3.5 Economic Activity*

3.5.1 General

A. Definition
The Economic Activity criterion is used to assess the economic effect of a project, meaning the extent to which an investment in a road project pays for itself in terms of an increase in the overall level of economic activity. This measure is known as the 'economic worth of a project'.

B. Indicator
The indicator for the economic effect of a road project may be defined as:

\[
\frac{\text{benefits} - \text{costs}}{\text{investment}}
\]

The benefits consist of the national economic effects of changes in (i) accessibility, and (ii) road safety, while the costs consist of (i) maintenance costs (for all road projects), and (ii) running costs (for tunnels). Investment consist of construction costs.

C. Assumption
1. The economic effects of changes in accessibility and road safety are regarded as an adequate indication of overall economic benefits.
2. Costs, benefits and investment are expressed in constant terms at 1.1.1984 levels.
3. Costs and benefits are discounted at a 10% rate of discount, the base year being 1990.

D. Measurement technique
The measurement techniques are outlined below for:
1. benefits (3.5.2)
2. costs (3.5.3)
3. investments (3.5.4)

---

* This measurement technique was developed together with J.H. van Donkelaar.
3.5.2 Benefits

3.5.2.1 Determining the National Economic Effects of a Change in Accessibility

A. Definition
The economic effect of a change in accessibility is defined as the national economic valuation of gains in travelling time and reduced distances.

B. Indicator
Dutch guilders.

C. Assumptions
1. Reductions in travelling time for goods traffic and commercial passenger traffic are fully exploited for productive purposes.
2. Reductions in travelling time for non-commercial passenger traffic are not exploited for productive ends and are not counted under this aspect.
3. When reductions in travelling time are used for productive purposes this entails an increase in gross value added.
4. Gross value added is costed at:
   - for goods traffic: N.fl. 41.70 per hour
   - for commercial passenger traffic: N.fl. 45.20 per hour.
5. Shortening the distance means a reduction in motoring costs (at least in those which are variable). These amount to
   - for goods traffic: N.fl. 0.39 per kilometre
   - for passenger traffic: N.fl. 0.23 per kilometre

D. Measurement Technique
For the calculation of reductions in travelling time for commercial passenger traffic and goods traffic, the reader is referred to the discussion of the measurement technique under the Accessibility criterion.

The following calculations can now be carried out:

a. Gains in travelling time (guilders) (only for commercial passenger traffic and goods traffic) = reduction in travelling time (hours) × gross value added.
b. Changes in fuel costs (for all types of traffic) = change in the number of vehicle kilometres × variable motoring costs per kilometre.
c. Annual economic effect = (a) gains in travelling time (in guilders) + (b) change in fuel costs (guilders).
d. The total economic effect (of changes in accessibility) = summation of discounted amounts (c) over 30 years.
3.5.2.2 DETERMINATION OF FINANCIAL/ECONOMIC CONSEQUENCES OF CHANGES IN ROAD SAFETY

A. Definition
The economic effect of a change in road safety is defined as the national economic valuation of that change.

B. Indicator
Dutch guilders.

C. Assumptions
1. Calculations are made on the basis of an average cost of an accident, which is assumed to provide a sufficient indication of the effect. (For the determination of that amount see annex 3.)

D. Measurement technique
The average cost of a traffic accident (see above) is multiplied by the safety effect as determined by the method discussed in section 3.3 to produce the annual sum. Discounted annual sums are aggregated for a 30-year period.

3.5.2.3 DETERMINATION OF TOTAL BENEFITS

Total benefits are formed by the sum of the benefits for the change in accessibility and road safety.

3.5.3 Costs

3.5.3.1 MAINTENANCE COSTS

A. Definition
By maintenance costs are meant all costs required to keep the project in, or restore it to, a sound state of repair during the life of the project. A distinction is drawn between annual and non-annual maintenance.

B. Indicator
Dutch guilders.

C. Assumptions
1. The effect of maintenance costs is calculated over 30 years. This is regarded as an adequate indication of total maintenance costs.
2. Maintenance costs are calculated over the section of infrastructure constructed in the 1-situation or added in the case of road-widening. Although the new section (or widening) will have an effect on the maintenance costs for existing roads, this is left out of account. This effect is not expected to affect project rank-order.

3. Non-annual maintenance costs are calculated in terms of maintenance work on the pavement only, there being no data on other types of irregular maintenance. Since work on the pavement forms the bulk of non-annual maintenance, this may for the present be taken as an acceptable assumption.

4. For the present, the non-annual maintenance costs associated with concrete pavements are worked out in the same way as those for asphalt pavements.

5. A standard sum of N.Fl. 0.7 million has been determined for the annual maintenance costs for tunnels.

6. The calculation of annual maintenance costs is based on a 35-metre grass strip beside each project.

D. Measurement technique

1. Annual maintenance
The calculation of annual maintenance costs is based on a distribution model for the annual maintenance costs of project roads, details of which are contained in annex 4. Since there may be assumed to be no maintenance costs in the 0-situation it is sufficient to estimate the maintenance costs in the 1-situation.

The model cannot be applied to projects consisting solely of a piece of engineering, such as a bridge. In such cases annual maintenance costs are worked out in consultation with the regional division of the Public Works Department, with the same components as those distinguished in the model.

The discounted annual maintenance costs are aggregated over 30 years in order to obtain the total annual maintenance effect.

2. Non-annual maintenance
As noted under the assumptions, non-annual maintenance has provisionally been confined to the asphalt pavement and need only be determined for the 1-situation.

In this model, which has been devised by the Rational Road Management Bureau of the Civil Engineering Department of the Public Works Department, the quality of the asphalt pavement is determined by:
1. the surface structure
2. rut formation
3. the structural condition.

These sums, discounted and aggregated, indicate non-annual maintenance costs.
3. Total maintenance costs
Total maintenance costs are formed by the sum of the discounted total annual and non-annual maintenance costs.

3.5.3.2 RUNNING COSTS

A. Definition
Running costs are costs necessarily incurred in servicing and supervising a piece of engineering.

B. Indicator
Dutch guilders.

C. Assumptions
Running costs apply only to tunnels.

D. Measurement technique
On the basis of ten workers per tunnel, a standard annual sum of N.Fl. 400,000 has been fixed for the running costs for tunnels. Total running costs are formed by aggregating the discounting annual sums over 30 years.

3.5.3.3 TOTAL COSTS EFFECT

The total cost effect is formed by the sum of total maintenance costs and total running costs.

3.5.4 Investments (construction costs)

A. Definition
Construction costs are taken as meaning all costs necessarily incurred in order to implement a project (including the cost of any compensatory measures).

B. Indicator
Dutch guilders.

C. Assumptions
1. Preparation costs (consultations, incorporation in planning etc.) are not included since these do not vary greatly from project to project.
2. All investments are to be made in 1990.
D. Measurement technique
Depending on the nature of the project, the construction costs may contain the following elements:
- compulsory purchase (including any buildings on the land);
- earthworks;
- road construction works;
- engineering works;
- other works.
All costs need to be discounted, after which they are aggregated.

3.6 Physical planning*

A. Definition
Physical planning aims at the mutual adjustment of land use and society – in the interests of society – and the conditions that make this feasible.
Two elements may be distinguished:
I. physical elements: the contribution made by the project to the (desired) environmental structure;
II. planning elements: the need for the project to be incorporated into existing physical planning.
Project assessment is essentially concerned with the physical elements, based on national physical planning policies as laid down for example in the Urbanization Policy Document, the Rural Areas Policy Document and outline development plans and structure plans. These policies thus provide the framework for any prospective project.
Planning factors are left out of consideration at the priority determination stage, although this aspect is used for determining the MPP priority groups (see 4).

B. Indicator
This is a qualitative description of the extent to which the project in question is consistent with national physical planning aims, as based on nationally formulated objectives with respect to:
- suburbanization/commuting;
- growth centres and towns;
- structure of large urban districts;
- traversing of open spaces/zoned areas;
- opening up development areas.

* The measurement technique was developed together with F.A.M. Paes.
C. Assumption
The government's physical planning policies as laid down in outline development plans form the point of departure for coordinating government policies with respect to sectors with physical planning implications. Such coordination is in turn worked out in structure schemes (Traffic and Transport, Nature and Landscape Conservation, Civil Aviation Airfields, Waterways, Outdoor Recreation, and so on).
In consequence we find that the sectoral policies laid down in the Traffic and Transport Structure Plan are not at variance with national physical planning policies but fit in with the objectives of those policies.
It should be noted that physical planning aspects of the relationship between land use and society overlap to some extent with the physical planning implications of other criteria used in the assessment system, namely accessibility, the human environment and economic activity. Such overlap is unavoidable.

D. Measurement technique
An estimate has to be made of the effect of a project as compared against the situation in the future in the absence of that project, with both future situations being based on the objectives of physical planning policy and/or the desired physical structure. The effect may be depicted as follows:

<table>
<thead>
<tr>
<th></th>
<th>favourable effect on the desired physical structure (especially growth centres and towns, opening up of development areas, structure of urban districts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>neutral</td>
</tr>
<tr>
<td></td>
<td>less favourable effect (suburbanization/commuting, traversing open spaces/zoned areas;</td>
</tr>
</tbody>
</table>
4 Project ranking

4.1 Choice of method

Numerous methods exist for ranking projects. In this case, multicriteria analysis has been chosen, for various reasons.

A first argument in favour of MCA methods is that as a result projects are directly ranked in terms of their relative priorities. This rank-order must then be interpreted in the light of the selected criteria and the weights assigned.

In addition these methods can handle both cardinal and ordinal data, which is important since not all the criteria used in determining priorities lend themselves to cardinal measurement. As regards the Physical Planning criterion, for example, it is only possible to assess project impact in terms of 'more' or 'less', i.e. ordinarily.

Another reason for choosing MCA methods is that they can work with various units (e.g. guilders, minutes, fatalities or ordinal units). Given the fact that various units are used in the priority system, this is an important advantage. The need for all the data to be reduced beforehand to a common denominator leads to transformation problems and means that imponderables have to be left out of account. No such problems arise with MCA methods since the effects on the various criteria or aspects are all measured in their own units.

Finally, MCA methods have been chosen since they are well-tried in practice. A scientifically sound system for determining priorities can therefore be devised without the need for substantial preliminary work.

There are many possible MCA variants, but since we are required here to deal with both cardinal and ordinal information, MCA methods suited to cardinal data only have been left out of consideration.

Of the remaining MCA methods, the SPW used for the 1984-1988 MPP has been based on concordance-analysis techniques. The first reason is methodological, namely that weighted-sum methods were regarded as less suitable for handling the information in ordinal form. On account of the numerous operations involved, permutation methods are unsuitable for choosing between much more than seven projects, as required here. Saaty’s method is ruled out on account of the form in which the information has to be fed in (i.e. comparing all the possible pairings). At the time, too little was as yet known about the regime method.

A second reason for choosing concordance analysis was that it had previously been applied by the Ministry of Transport and Public Works (in the North Sea Islands and Terminals Study), so that it enjoyed a certain degree of familiarity and acceptance. The latter was considered particularly important with respect to winning the confidence
of the bureaucracy and politicians in the system chosen, which can all too often come across as overly complex, at least initially.

For the purposes of establishing priorities with the 1984-1988 MPP two concordance methods were initially applied so as to obtain an impression of the uncertainties springing from the choice of method. A sensitivity analysis was used to investigate the respective rank-orders of the two methods, i.e. the ordinal scale method and qualitative concordance analysis. In the end the latter was chosen and, for reasons of continuity, it was also adhered to in the SPW for the 1985-1989 MPP.

For a proper understanding of the argumentation in favour of the qualitative-concordance method it is first necessary to indicate the operation of MCA methods in general and of the two concordance analysis methods referred to above in particular.

This is done in the next section, while the section following that indicates the way in which they are applied in practice and discusses the choice of method.

4.2 The method in theory

Under any MCA method, the information must be arranged in the same way, namely the effects per criteria must be determined for each project and summarized in a project-effects matrix (matrix 1). The preceding sections have indicated which criteria were selected and the way in which the effects were determined. This provides a matrix with the following form:

Matrix 1: Project-effects matrix

<table>
<thead>
<tr>
<th>Project</th>
<th>Criterion</th>
<th>Road Safety</th>
<th>Human Environment</th>
<th>Economic Activity</th>
<th>Etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 1</td>
<td>Effect</td>
<td>Effect</td>
<td>Effect</td>
<td>Etc.</td>
<td></td>
</tr>
<tr>
<td>Project 2</td>
<td>Effect</td>
<td>Effect</td>
<td>Effect</td>
<td>Etc.</td>
<td></td>
</tr>
<tr>
<td>Project 3</td>
<td>Effect</td>
<td>Effect</td>
<td>Effect</td>
<td>Etc.</td>
<td></td>
</tr>
</tbody>
</table>

Apart from the information in the project-effects matrix, weights have to be chosen for the various criteria. The weights assigned to the criteria will vary according to the importance attached to each criterion. Apart from the selection of the criteria themselves, therefore, the weights assigned will to a significant extent determine the policies to be adopted. As such, the weights are, ultimately, a political choice. Quite frequently, various sets of weights are tried out to help make the choice by showing the consequences of a particular set of weights for the rank-order. It is customary for the weights...
to be assigned over the various aspects in such a way that they add up to 100. Where several sets of weights are used this produces a matrix in the following form:

**Matrix 2: Weights matrix**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>View</th>
<th>Weighting set A</th>
<th>Weighting set B</th>
<th>Weighting set C</th>
<th>Etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road safety</td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
<td>Etc.</td>
<td></td>
</tr>
<tr>
<td>Human environment</td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
<td>Etc.</td>
<td></td>
</tr>
<tr>
<td>Economic activity</td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
<td>Etc.</td>
<td></td>
</tr>
</tbody>
</table>

With the aid of various MCA methods, the project-effects matrix and the weights matrix can be used to place the projects in rank-order. As noted in the previous section, two concordance analysis techniques were selected, namely the ordinal-scale method (Nijkamp, 1976) and the qualitative concordance method (Kolfoort and Nijkamp, 1977). Both methods compare the effects per criteria of selected projects, initially in pairs. This is done by pairing the projects and establishing which project in each pair is the more desirable in relation to a particular criterion. This is next repeated for all the criteria. The resultant data then show which project is the most desirable in relation to each of the criteria. On the basis of the weights assigned to the individual criteria, the projects can then be ranked and an evaluation made of the most desirable project in overall terms.

The difference between the two methods consists of the fact that the ordinal-scale system only indicates which project of a pair is the more favourable, whereas the qualitative-concordance analysis method makes more detailed use of the information by specifying (in classes or categories) the extent to which one project of a pair is to be preferred to the other. A detailed description of the operation of the two concordance-analysis methods may be found in annex 5.

The next step consists of drawing up an evaluation matrix. This matrix is formed by summarizing the sets of weights and associated project rank-order for each method in a matrix. Project rank-order can then be read off for each set of weights. This produces a matrix in the following form:
included the economic consequences of road safety and accessibility effects. These changes had an effect on the assignment of weights. In addition the 1985-1989 MPP measured the criterion of Road Safety in terms of three indicators (fatalities, injuries, and non-injury accidents), where formerly only one indicator had been used, while the two indicators for the Human Environment (noise and air pollution) were assigned separate weights where previously they had implicitly been weighted equally.

The construction of the weighting sets for the 1985-1989 MPP was based on three factors, namely:
1. the set of weights determined for the preceding year;
2. the fact that the composition, and hence weight, of two criteria (Physical Planning and the Human Environment) had remained unchanged;
3. the shifts in criteria composition all involved adding to the criterion of Economic Activity (formerly Costs), at the expense of Road Safety and Accessibility.

On the basis of these factors, three sets of weights were drawn up in addition to the one from the previous year, in which two criteria (Physical Planning and the Human Environment) retained the same weights while the weight assigned to Economic Activity at the expense of Road Safety and Accessibility rose from set to set. These sets of weights used for the 1985-1989 MPP therefore no longer represent an attempt to translate national interests as done in the 1984-1988 MPP. Apart from the weights assigned to the criteria, the weights of the indicators Road Safety and the Human Environment also play a role in the second year. To avoid creating too much information it was decided to propose a single weight for the indicators to the Minister.

In the case of road safety indicators, the weights were based on those officially used for many years in the Road Accident Rate Strategy (AVOC), while for the human-environment indicators the weights were based on the level of priority which noise nuisance clearly enjoys in view of the extensive legislation on this subject.

Once the various sets of weights have been drawn up, a definitive choice has to be made. For both the 1984-1988 and the 1985-1989 MPPs, this was a matter for Ministerial decision. One set of weights was selected at official level for ministerial advisory purposes. In the case of the 1984-1988 MPP, apart from the rank-order (into MPP priority groups) obtained with this advisory set, the major deviations in rank-order obtained with different 'views' (as compared with the rank-order obtained with the advisory set of weights) were submitted to the Minister. On the basis of these details, the Minister compiled a set of weights. In the case of the 1985-1989 MPP, the rank-order (into MPP priority groups) and an advisory set of weights were again submitted to the Minister, together with an indication of the major changes in rank-order in relation to the previous year.

In the first year, the sensitivity analysis on the weights was used to draw up a set of weights recommended by civil servants and to make a political choice. In the second year the sensitivity analysis once again led to a civil service-recommended set of weights, while the political choice was based on information on shifts in the rank-order.
of the recommended set of weights in relation to that of the previous year. The sets of weights for the criteria were as follows:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1984-88 MPP</th>
<th>1985-89 MPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road safety</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Accessibility</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Human environment</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Physical planning</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The weights for the indicators in the 1985-1989 MPP were as follows:

<table>
<thead>
<tr>
<th>Road safety</th>
<th>Human environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>fatalities 47.5</td>
<td>noise 60</td>
</tr>
<tr>
<td>injuries 47.5</td>
<td>air 40</td>
</tr>
<tr>
<td>accidents with material damage only 5.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

### 4.4 MPP priority groups

As noted in the introduction, four priority groups are distinguished in the MPP. In the 1985-1989 MPP, group 1 comprises 38 projects already under way or to be started in 1985. Of these, the projects already under way, i.e. the A-category (see section 2.2) fall into sub-group 1.1, while sub-group 1.2 consists of nine category-B projects to be started in 1985 (including two carried over from this sub-group in the previous year). Group 2 consists of the projects to be commenced during the period 1986-1989, numbering 21 in all. Once again these are projects from the B-category. Within this group, three further sub-groups have been defined in terms of declining priority. Group 3 consists of 13 category-B projects to be implemented during the period 1990-1994.

These first three groups comprise what is known as implementation planning and include all category-A projects and 41 of the 70 category-B projects. The remaining 29 category-B projects could not be implemented during this planning period. We may next examine how the MCA ranking-order has been converted into a ranking of the projects into these top three MPP priority, groups. The funds available for project implementation are established for each MPP priority-
group period, and the construction costs of each project are known. To begin with all
category-A projects are placed in MPP priority-group 1, after which the funds remain-
ing for new, category-B projects can be worked out.
In principle these will be te B-projects at the top of the MCA ranking list. The precise
number that can be implemented will be determined by the funds still available and
the construction costs of the projects in question. In certain circumstances, however,
the principle of filling in priority groups on the basis of the MCA rank-order is not
followed, namely:
1. if political undertakings have been made to start a project by a given date. Where
   necessary, politically-committed projects will take priority over more highly ranked
   ones, i.e. political commitment accelerates implementation;
2. if projects cannot be started up before a certain date on account of the need for
   them to be incorporated into overall planning schedules. It may therefore happen
   that a project should be commenced on the basis of its position in the MCA rank-
   order but that the necessary planning procedures will not be completed by the date
   in question, in which case the project is added to the priority group down for
   implementation in a later period. Lack of planning incorporation can, therefore,
   result in a project’s being delayed;
3. where projects are inter-related, for example if a given project x can only be im-
   plemented once another project y has been completed. Project x might thereotically
   take priority, but in practice it will have to be placed in a lower priority group
   pending the completion of project y. Links wit other projects can lead to delays but
   can also result in a project’s being brought forward.
This leaves MPP priority group 4, with which research planning is concerned. To begin
with all projects already being researched are included in this group. These are then
supplemented by the leading category-C projects on the MCA ranking list, the number
of projects to be added depending on the funds released as projects are completed and
disappear from priority group 1.
In this way all the MPP priority groups are filled in, and the description of the overall
SPW system is complete.
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Annex 1
Sectoral decision-making and wider planning considerations

1 General

In the Netherlands, decision-making with respect to road projects is based on two sets of factors, namely 'sectoral' (in this case, infrastructural) considerations, and wider planning considerations. The differences between these two are illustrated in diagram 1.

Diagram 1. Schematic representation of sectoral and wider planning considerations

Sectoral decision-making deals with traffic and transport objectives, resulting in an evaluation of all the relevant interests at stake in deciding whether or not to proceed with a road project. Such an evaluation — also known as integral evaluation — also takes place in the context of physical planning (i.e. general planning considerations). This applies especially to evaluation at provincial level in relation to provincial strategic plans and evaluation at municipal level in relation to structure and development plans. Regional strategic plans may be drawn up by the provinces in relation to one or more...
regions or to the entire area of the province in question and outline the future (physical) development of that region.

Structure plans are drawn up by the municipalities but are not required by law. They lay down future developments in the entire area covered by the municipality in question. With respect to that part of the municipality not forming part of the built-up zone, the municipality will also draw up a development plan.

Sectoral and wider planning evaluation each have their distinctive procedures. Coordinating the two forms an important part of road-project implementation. The outline below first examines infrastructural decision-making, followed by wider planning considerations.

2 Infrastructural decision-making

Long-term, integrated traffic and transport policies are laid down in the *Structure Scheme for Traffic and Transport* (SVV) issued in 1981. This forms the starting point for planning both within the traffic and transport sector and for traffic and transport planning in the field of physical planning. Before adoption, the SVV went through all the stages of a Crucial Planning Decision. These are decisions concerning the main lines of physical planning policy, which must be preceded by an exhaustive consultation, advisory and public participation procedure as shown in diagram 2.

The principal objective of the SVV (CPD 3.1) is:

Meeting the demand for the transport of people and goods provided this is to the net benefit of community welfare and provided also that:

a. the achievement of the desired physical planning structure is promoted and damage to agriculture and the natural environment avoided wherever possible;

b. the interests of road safety are given priority;

c. the requirements made of the human environment, e.g. in relation to parking disturbance, the emission of pollutants, noise and visual disamenities, are satisfied as far as possible;

d. the consumption of scarce raw materials is limited;

e. the requirement for public funds is kept down to a level consistent with government policy in general.

This principal objective has also been elaborated in the form of guidelines for each of these aspects.

In order to arrive at the main infrastructure associated with these aims, a so-called ‘policy scenario’ has to be decided upon. Among other things this scenario is concerned with influencing mobility patterns and transport habits.

Three scenarios have been worked up in the SVV delimiting the field in which a choice may be made. The most important features of the policy scenario ultimately chosen are:

- reducing distances travelled;
- limiting the use of cars where this causes excessive nuisance;
Diagram 2. Consultation, advisory and public participation procedure

- provision where necessary of facilities for public transport and slow traffic.

On the basis of the selected policy scenario and the guidelines derived from the principal objective, the desired future structure of the national highway network (which forms the responsibility of the national government) was then worked out. This structure scheme is limitative in nature, meaning that the State will not undertake any new road infrastructure of any importance unless it is included in the SVV. The scheme is also indicative, in the sense that new road links included under it can only be realized after the various interests have been weighed up at project level.

It is essential for there to be an indicative and a limitative framework for the national highway network. The actual choice comes at a later stage, when the project or projected route is decided upon. At this point a careful evaluation is made of the requirement for extra road capacity and quality and the anticipated advantages and disadvan-
tages. In this evaluation, possibilities of using other forms of transport and the maintenance and improvement of the existing road network are weighed (either as separate solutions or in combination) against other possible solutions. In weighting the pros and cons, attention is paid to the need for and effects on the capacity and quality of other transport networks.

In addition, the SVV is programmatic in nature. With respect to roads to be improved or constructed, two stages may be distinguished:
a. stage 1, covering the main infrastructure for which there is expected to be an early requirement, and the construction of which therefore takes priority. This stage will be completed in the 1990s;
b. stage 2, covering the main infrastructure for which there is expected to be a requirement at a later stage.

The Structure Scheme outlines the following characteristics of the National Highway Network:
'a. The national Highway Network comprises those roads for which the State is responsible.
b. The National Highway Network is a coherent system of road communications between regions and between major centres of population and employment. By comparison with other, ancillary road systems it is therefore coarse-meshed.
c. The National Highway Network consists essentially of motorways permitting a particular level of traffic flow on week-days.
d. Lower traffic flow rates are accepted within city regions, and lower rates again within towns themselves.'

These characteristics indicate that traffic flow requirements are laid down for various elements of the National Highway Network. In addition the SVV stipulates other requirements that the network must satisfy, e.g. with respect to road safety and comfort.

The Multi-Year Plan for Passenger Transport (MPP) outlines integrated traffic and transportation policies for the short and medium term, taking into consideration physical planning aspects. As from 1984 the MPP has been adjusted annually and is presented as part of the Explanatory Memorandum accompanying the budget estimates for the Ministry of Transport and Public Works. The MPP is at its most detailed for the first year of the period it covers, when it serves as a commentary on the budget estimates. For the succeeding years – where the uncertainties are necessarily greater – the multi-year policies become more indicative in nature. With the actual disbursement of the budget, definitive decisions have to be made each year after due evaluation of relevant project data.

Apart from providing a preview of operational planning for road projects over a five-year planning period, the MPP also foreshadows policy preparation for subsequent years, laying down, as far as possible, an order of priority for all projects in the first stage of the SVV. On the basis of these priorities, it can then be determined for which projects (i) a project study needs to be undertaken, or (ii) planning procedures need
to be instituted in the context of provincial strategic plans and municipal development plans (see part 2 of this annex).

Apart from the two forms of planning outlined above—the SVV and MPP—a five-year Operational Programme is also drawn up as part of the budget for national highways. This programme covers roads expected to be completed in the next five years, all of which are of course included in the MPP.

Projects taking longer than five years to complete are not included in the Operational Programme. When a start is made on such projects the fact is separately noted in the budget, and once they reach a certain stage they are added to the Operational Programme.

Before the final (sectoral) decision is made on whether or not to proceed and on the location and actual form of a road project, a location or project procedure must first be followed. The first step in the decision-making process consists of the compilation of a project report by the Public Works Department in which all the relevant alternatives are analysed as a whole in relation to various relevant aspects by means of 'gap' analysis. Generally speaking the following aspects are involved:

a. traffic engineering aspects (road safety, accessibility);
b. physical planning and socio-economic structures;
c. nature and landscape (geomorphology, water management, vegetation, scenic aspects, monuments);
d. agriculture;
e. human environment (barrier effect, noise, air pollution);
f. drinking water supply;
g. recreation;
h. construction and maintenance costs.

Briefly, gap analysis amounts to the following. After describing the present state of the research area, a problem analysis is conducted. The first stage of this operation consists of specifying the objectives, i.e. what form the situation is desired to take in the future. Next it is indicated what the future situation would be if the project did not go ahead, taking account of any predictable (i.e. autonomous) developments in the research area, such as demographic changes, changes in mobility patterns, physical structures, and so on.

The differences between the two situations enable the problems to be identified, including those which would (and would not) be tackled by the proposed project. On the basis of the formulated objectives, variants are then worked up in which these problems are dealt with. Since it is often possible for various aspects of the desired situation to be catered for satisfactorily (if only partially) in various ways, there are commonly a number of possible variants. By way of example, there might be a choice between routes that sought to make use of the existing infrastructure as far as possible, and others that traversed new countryside. Similarly the scope for carry goods and people by other means (i.e. public transport) would need to be examined, where appropriate in combination with other variants. Finally, non-construction of a new road link (the
'zero' solution) or improvements to the existing infrastructure (the 'zero-plus' solution) form part of the variants to be taken into consideration. Once the variants have been selected, the specific advantages and disadvantages of the various solutions can be elaborated.

During the research phase, technical and administrative consultations are simultaneously held at regional level. Technical consultations are designed to amass all the available information and are chiefly held with provincial and municipal authorities, and less frequently with other government bodies or specialized institutes. Administrative consultations are held in order to take account of provincial and municipal suggestions and views. This is of course also important in terms of reconciling sectoral and wider planning considerations.

The project report is designed to set the stage for further decision-making. At this stage no effort is made to come down in favour of or against any of the specific solutions; instead a scientific analysis is carried out, ending up with a table summarizing the variants and their effects on the assessment criteria. The project report drawn up along these lines then serves as the basic document for the request for advice submitted to the Council of the Public Works Department by the Minister of Transport and Public Works. It is also made available by the Department in the public consultation process as the basic document for obtaining the reactions of the public, institutions and local government. The report is also tabled for information in both houses of Parliament by the Minister.

The Council of the Public Works Department is an independent advisory body reporting to the Minister of Transport and Public Works. It contains members with a wide range of expertise and experience in administrative, socio-economic and other areas, appointed in an individual capacity by the Minister.

The Council refers the project report to one of its standing committees, in this case the Road Consultation Committee (COW). This body asks the executives of the municipalities directly affected by the variants to make copies of the project report available for public inspection at municipal offices for 1 to 2 months. The report may also be obtained, on application, from the Council of the Public Works Department. Apart from making the report available for public inspection, the Department holds public meetings at which the plans are explained and questions answered.

Up to 14 days after the end of the public display period, the public may submit comments or objections in writing to the COW concerning the report and the variants outlined in it. Private individuals who have responded in writing to the Committee and relevant bodies are also able to elaborate orally on their comments and objections at public hearings convened by the COW. The procedure, including reference to the relevant dates, is published in the local press.

The COW generally makes a site inspection and, after due consideration of the comments and objections received, submits a recommendation to the Council of the Public Works Department. The Council in turn draws up a report for the Minister of Transport and Public Works who then determines his position on the need for and location and design of the road. These steps may be illustrated as follows:
Diagram 3. Location or project procedure

| Compilation of location/project report by PWD |
| Advice sought from Council of PWD |
| Road Consultation Committee (COW) of the Council of the PWD makes report available for public inspection |
| PWD explains plans at public meetings |
| Written submission of comments/objections to COW |
| COW convenes public hearings at which organizations and individuals are able to elaborate on views previously submitted in writings |
| COW reports to Council of PWD |
| Council submits recommendations to Minister of Transport and Public Works |
| Decision by Minister of Transport and Public Works |

The Speakers of both houses of Parliament, the authorities involved in the project, and any individuals or interest groups who lodged objections or submitted comments are then advised by the Minister of his decision. In doing so the Minister will explain the thinking behind his decision, drawing on the recommendations submitted by the Council of the PWD and the Road Consultation Committee. Where a decision to proceed is taken, the municipalities concerned are asked at the same time to incorporate the project into their development plans. Location or project decisions are also published in the press.

3 Wider planning considerations

As noted in 1.2, projects need to be evaluated in two ways, namely from a ‘sectoral’ (i.e. infrastructural) viewpoint and in relation to wider planning considerations. In this respect the elaboration of sectoral policies in an annually up-dated MPP provides an opportunity for responding flexibly to developments (and to changes in what developments are deemed desirable) and for fitting in with provincial and municipal planning procedures in the form of provincial regional plans and municipal development plans.
Regional plans in turn enable an integral evaluation to be made at provincial level in terms of physical planning considerations of the facilities outlined in the SVV and elaborated in more detail in the MPP. It will be evident that such an elaboration depends critically on the proper coordination of regional plans, the SVV and the MPP. To this end close consultation is required between the provincial authorities, being directly responsible for regional plans, and the central government, as the body directly responsible for the SVV and MPP. Ideally, the results of the decision-making for both sets of plans will be mutually coordinated, i.e. regional plans will need to take account of the SVV and MPP and vice versa. On no account must one decision render another impossible. Given the nature of the SVV and the MPP divergent approaches between these two planning stages and regional plans can be reconciled in relation to individual projects through consultation. Once the need for a new road or road improvement has been demonstrated, the provincial authorities can if necessary be asked to adjust their regional plan. In most cases, however, regional plans will make allowance for any links and communications provided for them in the first stage of the SVV, and wholesale revision of a regional plan will be required only by way of exception.

The situation differs in relation to municipal development plans. Before the proposed location for a road can be incorporated into a development plan it is necessary for the location plans to be worked up in more detail, taking into account the objections, suggestions and comments made during the public consultation process. Since the Minister, when determining the location of a road, only specifies the route, with no more than a general indication of such aspects as intersections and junctions, elevation and location and scale of noise barriers, the elaboration of a location plan must necessarily be conducted in close consultation with interested parties, such as municipalities, water boards and land-use authorities. Once the plan has been worked up to a certain stage it is sent to the municipalities so that the location of the road can be incorporated into development plans. These plans must, in turn, go through the statutory procedures laid down in the Town and Country Planning Act (i.e. preliminary planning consultations, endorsement by municipal executives, approval by the Provincial Executives, with, in the latter two cases, provision for public inspection, the lodging of objections and finally appeal to the Crown). Public explanation generally forms a part of the development plan procedure and certain aspects of the road design, such as sound barriers, will be finalized at this stage.

Depending on the circumstances, development plan procedures can be very drawn-out. At present a period of between three and five years has to be allowed for, although this can be several years longer again if, in the initial planning stages, the provincial and municipal authorities are not in agreement and appeals have been lodged with the Crown.

Both the sectoral/infrastructural and wider planning consideration stages form separate evaluation stages, but it is desirable for sectoral decision-making to precede planning harmonization. If infrastructural decision-making is anticipated or the two procedures take place in parallel, there is a danger that decision-making can come unstuck in both
cases, for example if the two procedures fail to examine the same variants or if the basic documentation used for public consultation and decision-making should differ, a situation that is obviously undesirable.

Sectoral decision-making and planning harmonization should, therefore take place in series. Proper coordination between those two stages will help keep the time required for planning harmonization to the minimum.
Annex 2
Road safety coefficients and road situation

N.B. The coefficients shown below are solely designed to be used for the mutual evaluation of projects under the SPW and are, as such, open to abuse.

I. Road sections outside the built-up area
2. a. Multiply the traffic flow by the relevant injury accident coefficient shown below. The product forms the number of injury accidents.

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>injury accidents coefficients (f.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>$2 \times 2$</td>
<td>$f = 1.12 \times 10^{-3}$</td>
</tr>
<tr>
<td></td>
<td>$2 \times 3$ or more</td>
<td>$f = 1.09 \times 10^{-3}$</td>
</tr>
<tr>
<td>highway$^1$</td>
<td>$1 \times 2$</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>$2 \times 2$</td>
<td>0.041</td>
</tr>
<tr>
<td>road with limited access$^2$</td>
<td>$1 \times 2$</td>
<td>0.252</td>
</tr>
<tr>
<td></td>
<td>$2 \times 2$</td>
<td>0.079</td>
</tr>
<tr>
<td>other roads</td>
<td>as for underlying road network outside built-up area (see III)</td>
<td></td>
</tr>
</tbody>
</table>

1 Road for motor vehicles with a minimum speed of 40 kph
2 Substandard road for motor vehicles excl. slow motorized traffic.

b. Multiply the number of injury accidents (2.a) by the appropriate coefficient (casualties per injury accident) as shown in the following table.

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>cas./acc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>$2 \times 2$</td>
<td>1.443</td>
</tr>
<tr>
<td></td>
<td>$2 \times 3$ or more</td>
<td>1.460</td>
</tr>
<tr>
<td>highway</td>
<td>$1 \times 2$</td>
<td>1.702</td>
</tr>
<tr>
<td></td>
<td>$2 \times 2$</td>
<td>1.167</td>
</tr>
<tr>
<td>road with limited access</td>
<td>$1 \times 2$</td>
<td>1.415</td>
</tr>
<tr>
<td></td>
<td>$2 \times 2$</td>
<td>1.217</td>
</tr>
<tr>
<td>other roads</td>
<td>as for underlying road network outside built-up area (see III)</td>
<td></td>
</tr>
</tbody>
</table>
c. Multiply the number of casualties (2.b) by the appropriate coefficient (fatalities per casualty) shown in the following table.

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>fats./cas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 × 2</td>
<td>0.057</td>
</tr>
<tr>
<td></td>
<td>2 × 3 or more</td>
<td>0.046</td>
</tr>
<tr>
<td>highway</td>
<td>1 × 2</td>
<td>0.114</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>0.071</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 × 2</td>
<td>0.060</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>0.055</td>
</tr>
<tr>
<td>other roads</td>
<td>as for underlying road network outside built-up area (see III)</td>
<td></td>
</tr>
</tbody>
</table>

d. Multiply the number of casualties (2.b) by the appropriate coefficient (injuries per casualty) as shown in the following table.

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>inj./cas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 × 2</td>
<td>0.943</td>
</tr>
<tr>
<td></td>
<td>2 × 3 or more</td>
<td>0.954</td>
</tr>
<tr>
<td>highway</td>
<td>1 × 2</td>
<td>0.886</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>0.929</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 × 2</td>
<td>0.940</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>0.945</td>
</tr>
<tr>
<td>other roads</td>
<td>as for underlying road network outside built-up area (see III)</td>
<td></td>
</tr>
</tbody>
</table>
II. Intersections outside the built-up area

With respect to the coefficients for intersections outside the built-up area, a distinction has been drawn between accidents solely involving motor vehicles (group 1) and other accidents (group 2).

3. a. The number of injury accidents per intersection outside the built-up area is shown in the following tables.

**Table 5.a. Injury accidents (group 1) per intersection**

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>inj. acc. coeff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 x 2</td>
<td>0.536</td>
</tr>
<tr>
<td></td>
<td>2 x 3 or more</td>
<td>0.920</td>
</tr>
<tr>
<td>highway</td>
<td>1 x 2</td>
<td>0.541</td>
</tr>
<tr>
<td></td>
<td>2 x 2</td>
<td>0.809</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 x 2</td>
<td>0.240</td>
</tr>
<tr>
<td></td>
<td>2 x 2</td>
<td>0.387</td>
</tr>
<tr>
<td>other roads</td>
<td>as for underlying road network outside built-up area (see III)</td>
<td></td>
</tr>
</tbody>
</table>

**Group 2**

**Table 5.b. Injury accidents (group 2) per intersection**

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>inj. acc. coeff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 x 2</td>
<td>0.287</td>
</tr>
<tr>
<td></td>
<td>2 x 3 or more</td>
<td>0.113</td>
</tr>
<tr>
<td>highway</td>
<td>1 x 2</td>
<td>0.154</td>
</tr>
<tr>
<td></td>
<td>2 x 2</td>
<td>0.460</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 x 2</td>
<td>0.118</td>
</tr>
<tr>
<td></td>
<td>2 x 2</td>
<td>0.289</td>
</tr>
<tr>
<td>other roads</td>
<td>as for underlying road network outside built-up area (see III)</td>
<td></td>
</tr>
</tbody>
</table>
The sum of the accidents in group 1 and group 2 forms the total number of injury accidents.
b. Multiply (per group) the number of injury accidents (3.a) by the appropriate coefficient (casualties per injury accident) as shown in the following tables.

**Group 1**

Table 6.a. Number of casualties per injury accident (group 1) at intersections

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>cas./acc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 × 2</td>
<td>1.408</td>
</tr>
<tr>
<td></td>
<td>2 × 3 or more</td>
<td>1.450</td>
</tr>
<tr>
<td>highway</td>
<td>1 × 2</td>
<td>1.549</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>1.510</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 × 2</td>
<td>1.612</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>1.545</td>
</tr>
<tr>
<td>other roads</td>
<td></td>
<td>as for underlying road network outside built-up area (see III)</td>
</tr>
</tbody>
</table>

**Group 2**

Table 6.b. Number of casualties per injury accident (group 2) at intersection

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>cas./acc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 × 2</td>
<td>1.042</td>
</tr>
<tr>
<td></td>
<td>2 × 3 or more</td>
<td>1.000</td>
</tr>
<tr>
<td>highway</td>
<td>1 × 2</td>
<td>1.079</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>1.000</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 × 2</td>
<td>1.083</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>1.024</td>
</tr>
<tr>
<td>other roads</td>
<td></td>
<td>as for underlying road network outside built-up area (see III)</td>
</tr>
</tbody>
</table>
The sum of the casualties in group 1 and group 2 forms the total number of casualties.
c. Multiply the number of casualties (3.b) per group by the appropriate coefficient (fatalities per casualty) as shown in the following tables.

**Group 1**

Table 7.a. Proportion of fatal injuries (group 1) at intersections

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>fats./cas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 x 2</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td>2 x 3 or more</td>
<td>0.025</td>
</tr>
<tr>
<td>highway</td>
<td>1 x 2</td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td>2 x 2</td>
<td>0.013</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 x 2</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>2 x 2</td>
<td>0.047</td>
</tr>
<tr>
<td>other roads</td>
<td>as for underlying road network outside built-up area (see III)</td>
<td></td>
</tr>
</tbody>
</table>

**Group 2**

Table 7.b. Proportion of fatal injuries (group 2) at intersections

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>fats./cas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 x 2</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>2 x 3 or more</td>
<td>0.000</td>
</tr>
<tr>
<td>highway</td>
<td>1 x 2</td>
<td>0.171</td>
</tr>
<tr>
<td></td>
<td>2 x 2</td>
<td>0.172</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 x 2</td>
<td>0.077</td>
</tr>
<tr>
<td></td>
<td>2 x 2</td>
<td>0.071</td>
</tr>
<tr>
<td>other roads</td>
<td>as for underlying road network (see III)</td>
<td></td>
</tr>
</tbody>
</table>
The sum of the fatalities in groups 1 and 2 forms the total number of fatalities.

d. Multiply the number of casualties (3.b) by the appropriate coefficient (injuries per casualty) as shown in the following tables.

**Group 1**

Table 8.a. Proportion of non-fatal injuries (group 1) at intersections

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>inj./cas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 × 2</td>
<td>0.976</td>
</tr>
<tr>
<td></td>
<td>2 × 3 or more</td>
<td>0.975</td>
</tr>
<tr>
<td>highway</td>
<td>1 × 2</td>
<td>0.951</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>0.987</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 × 2</td>
<td>0.975</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>0.953</td>
</tr>
<tr>
<td>other roads</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>as for underlying road network (see III)</td>
<td></td>
</tr>
</tbody>
</table>

**Group 2**

Table 8.b. Proportion of non-fatal injuries (group 2) at intersections

<table>
<thead>
<tr>
<th>type of road</th>
<th>no. of lanes</th>
<th>inj./cas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>motorway</td>
<td>2 × 2</td>
<td>0.966</td>
</tr>
<tr>
<td></td>
<td>2 × 3 or more</td>
<td>1.000</td>
</tr>
<tr>
<td>highway</td>
<td>1 × 2</td>
<td>0.829</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>0.828</td>
</tr>
<tr>
<td>road with limited access</td>
<td>1 × 2</td>
<td>0.923</td>
</tr>
<tr>
<td></td>
<td>2 × 2</td>
<td>0.929</td>
</tr>
<tr>
<td>other roads</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>as for underlying road network (see III)</td>
<td></td>
</tr>
</tbody>
</table>

The sum of the injuries in groups 1 and 2 forms the total number of injuries.
III. The underlying road network and other roads outside the built-up area

4. Estimate the traffic flow for the year 2000 (in $10^6$ motor-vehicle kilometres) (for the underlying road network: see assumption 4 in 3.3, road safety), for other roads flow = daily flow $\times$ 365.

5. a. Multiply the traffic flow by the injury accident coefficient of 0.366 to obtain the number of injury accidents.

   b. Multiply the number of injury accidents (5.a) by 1.366, being the coefficient for the number of casualties per injury accident, to obtain the number of casualties.

   c. Multiply the number of casualties (5.b) by 0.070, being the coefficient for the number of fatalities per casualty, to obtain the number of fatalities.

   d. Multiply the number of casualties (5.b) by 0.930, being the coefficient for the number of injuries per casualty, to obtain the total number of injuries.

IV. The underlying road network within the built-up area


7. a. Multiply the traffic flow by the injury accident coefficient of 1.790 to obtain the number of injury accidents.

   b. Multiply the number of injury accidents (7.a) by 1.130, being the coefficient for the number of casualties per injury accident, to obtain the number of casualties.

   c. Multiply the number of casualties (7.b) by 0.019, being the coefficient for the number of fatalities per casualty, to obtain the number of fatalities.

   d. Multiply the number of casualties (7.b) by 0.981, being the coefficient for the number of injuries per casualty, to obtain the number of injuries.
Annex 3
Determining the average cost of a traffic accident

The costs of traffic accidents may be divided into various categories, namely:
1. material damage;
2. settlement expenses;
3. medical expenses;
4. lost production.
In order to determine the average cost of damage, amounts have been decided upon for each of the four categories.

1. Material damage
A number of sample surveys have been conducted into the material damage resulting from traffic accidents. These include:
- Urpo Leppänen (Finland, 1966):
  average material damage N.Fl. 7,314 (1982 prices);
- various Dutch surveys:
  average material damage between N.Fl. 2,000 and N.Fl. 9,000;
- W. Emde et al., Einheitliche Kostensätze für die volkswirtschaftliche Bewertung von Strassenverkehrsunfällen:
  average material damage DM 2,100 for light damage, DM 10,000 for severe damage.
On the basis of this range of findings, N.Fl. 5,000 has been taken as the average material damage per accident.

2. Settlement costs
These include the hire of replacement equipment, and police, legal and insurance costs. The German survey referred to above (Emde et al.) put these costs at the same level as that of physical damage. In the absence of any other data we may assume the same, i.e. N.Fl. 5,000 per accident.

3. Medical expenses
In estimating medical expenses a distinction has been drawn between injured persons requiring hospitalization, injured persons not requiring hospitalization, and fatalities. Costs have been estimated on the basis of data in the 1983 NVVR. Injured persons:
- with hospitalization:
  average of 22 days hospitalization = 22 × N.fl. 500 = N.fl. 11,000
  average of 1.9 days in nursing home = 1.9 × N.fl. 200 = N.fl. 380
  N.fl. 11,380

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- **without hospitalization:**
  
  no data available. Costs may be assumed to be negligible.

**Invalidity:**

Central Bureau of Statistics figures reveal that 1.9% of all accident victims are not yet fully recovered one year after the accident. These persons may be assumed to be permanently injured. The average length of invalidity is put at ten years and the costs at N.Fl. 5 per day, i.e. a (discounted) sum per person of N.Fl. 11,213. The anticipated costs of permanent invalidity are therefore $0.019 \times 11,213 = \text{N.Fl. 213}$. Roughly one-third of injured persons are hospitalized, resulting in average costs for an injured person of $\frac{1}{3} \times \text{N.Fl. 11,380} = \text{N.Fl. 3,800}$, plus the anticipated costs of invalidity (N.Fl. 213), resulting in a sum of N.Fl. 4,000 (rounded off) per injured person.

**Fatalities:**

Traffic fatalities are defined as victims who die from a traffic accident within 15 days. On average they are assumed to spend ten days in hospital before dying. Costs: $10 \times \text{N.Fl. 500} = \text{N.Fl. 5,000}$.

4. **Lost production**

On account of the high rate of unemployment it is assumed that there is no actual loss of production associated with the withdrawal of productive persons from the labour market after a traffic accident. Accidents may therefore be said to occasion the following costs:

- non-injury accidents: N.fl. 10,000
- injury accidents: N.fl. 10,000
- injured persons: N.fl. 4,000
- fatalities: N.fl. 5,000
Annex 4
Calculation of annual and non-annual maintenance costs

a. Annual maintenance costs

In the model, the total annual maintenance costs for the remaining projects are determined by three elements, namely:

- the pavement ('black' maintenance);
- the non-metalled area ('green' maintenance);
- miscellaneous.

The level of annual maintenance costs for the pavement of project roads depends primarily on the total surface area (01) and the parameters having a direct bearing on the pavement, such as the strength of the subgrade (E3) and the traffic factor (VF).

The level of annual maintenance costs for the non-metalled area of project roads depends primarily on the total surface area (02), as well as on the verge factor (BF) and the traffic factor (VF).

Other annual maintenance costs, such as anti-skid measures, road furniture (noise barriers, safety barriers, traffic signs and signals, road markings, traffic lights, lighting, roadside markers, etc.), transport, buildings (highway maintenance depots), water management (ditches and drainage) and engineering works are affected by the total pavement area (01), the total unmetalled area (02), total road length (LW), the traffic factor (VF) and the strength of the subgrade (E3).

Apart from these parameters for the three elements, a basic factor for each element has also been calculated with the aid of a regression model:

- a basic factor (K1) per square metre of pavement (1983: 1.207);
- a basic factor (K2) per square metre of unmetalled surface (1983: 0.028);
- a basic factor (K3) per linear metre of average road width (1983: 12267.382).

With the aid of the basic factors (K1, K2, K3) and the parameters the following unit prices may be calculated per project:

1. F1 = costs per m² of pavement;
2. F2 = costs per m² of non-metalled area;
3. F3 = costs per m¹ of road length.

1. **F1**

For each project F1 is a function of K1, E3 and VF and may be described in the following form:

\[ F1 = K1 \cdot E3 \cdot VF \]  \hspace{1cm} (1)
where:

\( K_1 \) = Basic factor calculated by means of regression model;
\( VF \) = A traffic factor;
\( E_3 \) = Strength of the subgrade.

2. \( F_2 \)
In each project \( F_2 \) is a function of \( K_2, BF \) and \( VF \) and may be described in the following form:

\[
F_2 = K_2 \cdot BF \cdot VF
\]

(2)

where:

\( K_2 \) = Basic factor calculated by means of regression model;
\( BF \) = Verge factor;
\( VF \) = Traffic factor.

3. \( F_3 \)
For each project \( F_3 \) is a function of \( K_3, E_3, VF, B_3 \) and \( LW \). The basic factor \( K_3 \) is expressed as a sum per metre of average road width \((B_3 = (01 + 02)/LW)\). In order to obtain the unit sum per linear metre of road length, \( K_3 \) must be multiplied by \( E_3 \cdot VF \cdot (B_3/LW) \). The unit sum \( F_3 \) is accordingly defined as:

\[
F_3 = K_3 \cdot E_3 \cdot VF \cdot B_3
\]

(3)

where

\( K_3 \) = Basic factor calculated by means of regression model;
\( E_3 \) = Strength of subgrade;
\( VF \) = Traffic factor;
\( B_3 \) = \((01 + 02/LW)\) Average total width;
01 = Total pavement area;
02 = Total unmetalled area;
\( LW \) = Total length of project road.

Unit sums for annual maintenance
The level of annual maintenance costs for each project \( F \) may now be simply derived by equation 4, drawn from equation 1, 2 and 3:

\[
F = K_1 \cdot E_3 \cdot VF \cdot 01 + K_2 \cdot BF \cdot VF \cdot 02 + K_3 \cdot E_3 \cdot VF \cdot B_3
\]

(4)

The basic values for the various parameters are summed up for each province in Table 1.
Table 1

Basic values (1983) for project roads in the distribution model

<table>
<thead>
<tr>
<th>Province</th>
<th>E3</th>
<th>VF</th>
<th>BF</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groningen</td>
<td>1.26</td>
<td>1.22</td>
<td>7.83</td>
<td>14.2</td>
<td>30.3</td>
<td>44.5</td>
</tr>
<tr>
<td>Friesland</td>
<td>1.20</td>
<td>1.08</td>
<td>6.14</td>
<td>20.2</td>
<td>45.0</td>
<td>65.1</td>
</tr>
<tr>
<td>Drenthe</td>
<td>1.05</td>
<td>1.04</td>
<td>5.83</td>
<td>18.1</td>
<td>34.8</td>
<td>52.8</td>
</tr>
<tr>
<td>Overijssel</td>
<td>1.08</td>
<td>1.12</td>
<td>8.29</td>
<td>17.1</td>
<td>36.4</td>
<td>53.4</td>
</tr>
<tr>
<td>Gelderland</td>
<td>1.08</td>
<td>1.21</td>
<td>9.37</td>
<td>25.3</td>
<td>47.6</td>
<td>72.8</td>
</tr>
<tr>
<td>Utrecht</td>
<td>1.19</td>
<td>1.53</td>
<td>11.21</td>
<td>37.2</td>
<td>83.5</td>
<td>121.4</td>
</tr>
<tr>
<td>North Holland</td>
<td>1.36</td>
<td>1.65</td>
<td>11.67</td>
<td>27.2</td>
<td>39.5</td>
<td>66.7</td>
</tr>
<tr>
<td>South Holland</td>
<td>1.37</td>
<td>1.68</td>
<td>11.05</td>
<td>37.2</td>
<td>69.5</td>
<td>106.7</td>
</tr>
<tr>
<td>Zealand</td>
<td>1.37</td>
<td>1.00</td>
<td>7.83</td>
<td>20.4</td>
<td>47.3</td>
<td>67.7</td>
</tr>
<tr>
<td>North Brabant</td>
<td>1.06</td>
<td>1.28</td>
<td>11.83</td>
<td>28.5</td>
<td>46.2</td>
<td>74.7</td>
</tr>
<tr>
<td>Limburg</td>
<td>1.12</td>
<td>1.24</td>
<td>8.91</td>
<td>35.0</td>
<td>36.1</td>
<td>71.1</td>
</tr>
</tbody>
</table>

Table 2 below shows the calculation of the unit sums per province for the three elements of annual maintenance, as derived from the basic data in Table 1.

Table 2

<table>
<thead>
<tr>
<th>Basic factors</th>
<th>Formulae for unit sums in guilders</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1 = 1.207</td>
<td>Sum per m² pavement = F1 = K1 \cdot E3 \cdot VF</td>
</tr>
<tr>
<td>K2 = 0.028</td>
<td>Sum per m² non-metalled area = F2 = K2 \cdot BF \cdot VF</td>
</tr>
<tr>
<td>K3 = 12267.382</td>
<td>Sum per m³ road = F3 = K3 \cdot E3 \cdot VF \cdot B3/LW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project roads</th>
<th>Calculated unit sums</th>
</tr>
</thead>
<tbody>
<tr>
<td>Province</td>
<td>F1</td>
</tr>
<tr>
<td>Groningen</td>
<td>1.856</td>
</tr>
<tr>
<td>Friesland</td>
<td>1.564</td>
</tr>
<tr>
<td>Drenthe</td>
<td>1.318</td>
</tr>
<tr>
<td>Overijssel</td>
<td>1.460</td>
</tr>
<tr>
<td>Gelderland</td>
<td>1.578</td>
</tr>
<tr>
<td>Utrecht</td>
<td>2.198</td>
</tr>
<tr>
<td>North Holland</td>
<td>2.709</td>
</tr>
<tr>
<td>South Holland</td>
<td>2.778</td>
</tr>
<tr>
<td>Zealand</td>
<td>1.654</td>
</tr>
<tr>
<td>North Brabant</td>
<td>1.638</td>
</tr>
<tr>
<td>Limburg</td>
<td>1.691</td>
</tr>
<tr>
<td>Flevopolders (= av.)</td>
<td>1.858</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total</th>
<th>Unit sums in guilders</th>
</tr>
</thead>
</table>

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With the aid of the unit sums for each province, the annual maintenance costs per project \( F \) (with the exception of projects consisting solely of a piece of engineering) may now be worked out with the aid of the following formula:

\[
F = F_1 \cdot 01 + F_2 \cdot 02 + F_3 \cdot LW
\]  

(5)

**Non-annual maintenance costs**

Under this model, which is being developed by the Bureau for Rational Road Management, the quality of the asphalt pavement is determined by:

1. the surface structure
2. rut formation
3. the structural condition.

The condition of the pavement is described by \( T_1, T_2 \) and \( T_3 \), a vector built up of the residual lives with respect to features 1, 2 and 3 above. Depending on the maintenance measure chosen, the initial situation \((T_1, T_2, T_3)\) at the end of the maintenance year changes into the follow-up situation \((T'_1, T'_2, T'_3)\). The relationship between these two situations and the costs of switch from the initial to the follow-up situation are as follows:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Costs gld/m²</th>
<th>( T'_1 )</th>
<th>( T'_2 )</th>
<th>( T'_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A : Do nothing</td>
<td>0.00</td>
<td>( T_1 - 1 )</td>
<td>( T_2 - 1 )</td>
<td>( T_3 - 1 )</td>
</tr>
<tr>
<td>B : Double surface</td>
<td>3.50</td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C : Patching and</td>
<td>6.00</td>
<td>9</td>
<td>5</td>
<td>( T_3 - 1 )</td>
</tr>
<tr>
<td>double-s. treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D : Repave</td>
<td>9.00</td>
<td>12</td>
<td>( T_3 + 4 )</td>
<td>( T_3 + 4 )</td>
</tr>
<tr>
<td>E : Wearing course</td>
<td>12.50</td>
<td>14</td>
<td>( T_2 + 7 )</td>
<td>( T_3 + 7 )</td>
</tr>
<tr>
<td>F : Wearing &amp; regul-</td>
<td>15.00</td>
<td>14</td>
<td>12</td>
<td>( T_3 + 8 )</td>
</tr>
<tr>
<td>ating course</td>
<td>19.50</td>
<td>14</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>G : Wearing &amp; reg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>course + basecourse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The repeated application of measures resulting in a comparatively lengthy extension of life \( T_1 + K \) can result in arbitrarily large residual life-spans. For mathematical reasons the number of situations must be finite, for which reason an upper limit of 14, 12 and 15 years has been imposed on residual life-spans \( T'_1, T'_2 \) and \( T'_3 \) respectively. The maintenance system therefore comprises \( 14 \times 12 \times 15 = 2,520 \) permissible situations. With the aid of these limiting conditions, the optimal non-annual maintenance cycle for an asphalt pavement has been worked out, as shown in Table 4.
Table 4. Optimal cycle of non-annual maintenance of asphalt pavement of newly constructed roads

<table>
<thead>
<tr>
<th>Current situation</th>
<th>Activity</th>
<th>Resulting situation</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 14.12.15</td>
<td>A</td>
<td>13.11.14</td>
<td>0.00</td>
</tr>
<tr>
<td>2. 13.11.14</td>
<td>A</td>
<td>12.10.13</td>
<td>0.00</td>
</tr>
<tr>
<td>3. 12.10.13</td>
<td>A</td>
<td>11.09.12</td>
<td>0.00</td>
</tr>
<tr>
<td>4. 11.09.12</td>
<td>A</td>
<td>10.08.11</td>
<td>0.00</td>
</tr>
<tr>
<td>5. 10.08.11</td>
<td>A</td>
<td>09.07.10</td>
<td>0.00</td>
</tr>
<tr>
<td>6. 09.07.10</td>
<td>A</td>
<td>08.06.09</td>
<td>0.00</td>
</tr>
<tr>
<td>7. 08.06.09</td>
<td>A</td>
<td>07.05.08</td>
<td>0.00</td>
</tr>
<tr>
<td>8. 07.05.08</td>
<td>A</td>
<td>06.04.07</td>
<td>0.00</td>
</tr>
<tr>
<td>9. 06.04.07</td>
<td>A</td>
<td>05.03.06</td>
<td>0.00</td>
</tr>
<tr>
<td>10. 05.03.06</td>
<td>A</td>
<td>04.02.05</td>
<td>0.00</td>
</tr>
<tr>
<td>11. 04.02.05</td>
<td>A</td>
<td>03.01.04</td>
<td>0.00</td>
</tr>
<tr>
<td>12. 03.01.04</td>
<td>F</td>
<td>14.12.12</td>
<td>15.00</td>
</tr>
<tr>
<td>13. 14.12.12</td>
<td>A</td>
<td>13.11.11</td>
<td>0.00</td>
</tr>
<tr>
<td>14. 13.11.11</td>
<td>A</td>
<td>12.10.10</td>
<td>0.00</td>
</tr>
<tr>
<td>15. 12.10.10</td>
<td>A</td>
<td>11.09.09</td>
<td>0.00</td>
</tr>
<tr>
<td>16. 11.09.09</td>
<td>A</td>
<td>10.08.08</td>
<td>0.00</td>
</tr>
<tr>
<td>17. 10.08.08</td>
<td>A</td>
<td>09.07.07</td>
<td>0.00</td>
</tr>
<tr>
<td>18. 09.07.07</td>
<td>A</td>
<td>08.06.06</td>
<td>0.00</td>
</tr>
<tr>
<td>19. 08.06.06</td>
<td>A</td>
<td>07.05.05</td>
<td>0.00</td>
</tr>
<tr>
<td>20. 07.05.05</td>
<td>A</td>
<td>06.04.04</td>
<td>0.00</td>
</tr>
<tr>
<td>21. 06.04.04</td>
<td>A</td>
<td>04.02.02</td>
<td>0.00</td>
</tr>
<tr>
<td>22. 05.03.03</td>
<td>A</td>
<td>04.02.02</td>
<td>0.00</td>
</tr>
<tr>
<td>23. 04.02.02</td>
<td>A</td>
<td>03.01.01</td>
<td>0.00</td>
</tr>
<tr>
<td>24. 03.01.01</td>
<td>G</td>
<td>14.12.15</td>
<td>19.50</td>
</tr>
</tbody>
</table>

This optimal cycle is used in determining the cost of non-annual maintenance. This means that two sums have to be worked out for each project:
1. after 12 years an amount of N.Fl. 15 × the total metalled area of the project in m² for filling in hollows and laying a wearing course;
2. after 24 years a sum of N.Fl. 19.50 × the total metalled area of the project in m² for the wearing and regulating courses and basecourse.
Annex 5
Concordance analysis method

1 General

In using concordance analysis methods, the effects of the projects in question are first compared for pairs of projects in relation to particular criteria, i.e. each pair of projects is compared to see which of the two is preferable in terms of each criterion. The next step consists of working out which project is to be preferred in its totality (i.e. integral comparison).

There are four alternative approaches:
- take account/do not take account of the degree of difference in the effect scores (this constitutes the distinction between the two concordance analysis methods used in the first SPW);
- take account/do not take account of varying weights for the various criteria. (Both methods in the first SPW do take account of varying weights.)

2 Numerical example

To begin with the project-effects matrix of a number of projects (P) and criteria (A) is drawn up showing the weights (G) assigned to the criteria or aspects.

Project-effects matrix

<table>
<thead>
<tr>
<th>G</th>
<th>A(x)</th>
<th>P(x)</th>
<th>P¹</th>
<th>P²</th>
<th>P³</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>A¹</td>
<td>-10</td>
<td>+6</td>
<td>-3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>A²</td>
<td>+5</td>
<td>+1</td>
<td>-9</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>A³</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

2.1 The ordinal scale method

2.1.1 Putting the matrix in ordinal form (I)

The project-effects matrix and the set of weights are put into ordinal form by assigning 1 to the lowest score for each criterion, 2 to the next score, and so on. This produces matrix (2):
2.1.2 Pairwise comparison per criterion

The projects are then compared in relation to each criterion, thus producing matrix (3).

\[
\begin{array}{cccc}
G & A(x) & P(x) & p^1 - p^2 \\
2 & A^1 & & 1 \\
2 & A^2 & & 3 \\
1 & A^3 & & 1 \\
\end{array}
\]

\[
\begin{array}{cccccccc}
\end{array}
\]

(3)

x < y means that a lower value is placed on x than y.

x \geq y means that x is not assigned a lower value than y.

It is then indicated by means of a + where the project in question is not rated below the project with which it is being compared. This produces the following matrix (4).

\[
\begin{array}{cccc}
P & A(x) & P(x) & p^1 - p^3 \\
2 & A^1 & & + \\
2 & A^2 & & + \\
1 & A^3 & & + \\
\end{array}
\]

(4)

2.1.3 Integral comparison

A concordance index is drawn up for each pairwise comparison in relation to all the criteria by noting the weight of the criterion in question where a + sign is shown and then adding together all these weights for each pairwise comparison. This produces matrix (5).

\[
\begin{array}{cccccccc}
2 & A^1 & & 2 & 2 & 2 \\
2 & A^2 & & 2 & 2 & 2 \\
1 & A^3 & & 1 & 1 & 1 \\
\end{array}
\]

(5)

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The final step consists of calculating the net concordance index per project. This index indicates the degree of preference for the project in question in relation to all other projects considered. The index is composed with the aid of matrix (5). For the index for p\textsuperscript{1} this consists of aggregating the totals of p\textsuperscript{1} in relation to p\textsuperscript{2} and p\textsuperscript{1} in relation to p\textsuperscript{3} and deducting the sum of p\textsuperscript{2} in relation to p\textsuperscript{1} and p\textsuperscript{3} in relation to p\textsuperscript{1}. For the three projects this produces the following picture:

\[
\begin{align*}
p\textsuperscript{1}: (2 + 2) - (3 + 3) &= -2 \\
p\textsuperscript{2}: (5 + 3) - (2 + 1) &= 5 \\
p\textsuperscript{3}: (3 + 1) - (5 + 2) &= -3
\end{align*}
\]

thus producing the following rank-order:

\[
\begin{align*}
p\textsuperscript{2} &+ 5 \\
p\textsuperscript{1} &- 2 \\
p\textsuperscript{3} &- 3
\end{align*}
\]

2.2 The qualitative concordance analysis method

2.2.1 Adjustment of matrix (1)

This method is more complex than the preceding one. To begin with the matrix has to be made suitable for use. All negative scores are eliminated by converting the lowest negative number to zero and increasing the other numbers by a corresponding (positive) amount.

In the case of ordinal values, the lowest value is set at zero. This produces the following matrix (6).

\[
\begin{array}{cccc}
P & A(x) & P(x) & p\textsuperscript{1} & p\textsuperscript{2} & p\textsuperscript{3} \\
\hline
4 & A\textsuperscript{1} & 0 & 16 & 7 \\
4 & A\textsuperscript{2} & 14 & 10 & 0 \\
2 & A\textsuperscript{3} & 0 & 1 & 1 \\
\end{array}
\]

(6)

2.2.2 Standardization of the matrix (6)

The values in the matrix (6) are now standardized by dividing each effect score for each criterion by the highest effect scores. The standardization of the effect score for project 3 in relation to criterion 1 proceeds as follows: 7/16 = 0.44

The weights too are standardized, producing matrix (7):
2.2.3 Classification of the weights

Under the method the weights are divided into three classes:
0.2 - 0.27 : class 1
0.27 - 0.33 : class 1
0.33 - 0.4 : class 3

This produces the following weighting classification:
A\(^1\) : class 2; A\(^2\) : class 2; A\(^3\) : class 1.

2.2.4 Pairwise comparison per criterion

To begin with the projects are compared in pairs on the basis of matrix (7), thus producing matrix (8). It is next indicated where the project in question is to be preferred to the project with which it is being compared for that criterion, and how much more it is preferred. This value is calculated by deducting the values from matrix (7) from one another.

Example: p\(^1\) is preferred to p\(^2\) in relation to criterion 2, where p\(^1\) has a value of 1 and p\(^2\) a value of 0.71, producing a preference for p\(^1\) over p\(^2\) for criterion 2 of 1 - 0.71 = 0.29. When all the comparisons are worked out, this produces the following matrix (8) of differences for pairwise comparisons.

<table>
<thead>
<tr>
<th>G (A(x))</th>
<th>P(x)</th>
<th>(p^1 - p^2)</th>
<th>(p^1 - p^3)</th>
<th>(p^2 - p^3)</th>
<th>(p^2 - p^1)</th>
<th>(p^3 - p^1)</th>
<th>(p^3 - p^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4 (A^1)</td>
<td>0</td>
<td>1</td>
<td>0.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4 (A^2)</td>
<td>1</td>
<td>0.71</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 (A^3)</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The differences shown in matrix (8) are divided into three classes:
0 - 0.33 = class 1
0.33 - 0.67 = class 2
0.67 - 1 = class 3.

This produces the following matrix (9):
2.2.5 The integral comparison

To begin with the weights in classes are combined with the difference classes for each pairwise comparison in matrix (9). In theory this produces nine possibilities (A to I).

A = lowest weight class (1), with lowest difference class (1)
I = highest weight class (3), with highest difference class (3).

These 9 possibilities are set out in matrix (10).

\[
\begin{array}{ccc|ccc|ccc}
 \text{Weight class} & 1 & 2 & 3 & 1 & 2 & 3 & 1 & 2 & 3 \\
\hline
1 & A & B & C & \ & \ & \ & \ & \ & \ \\
2 & D & E & F & \ & \ & \ & \ & \ & \ \\
3 & G & H & I & \ & \ & \ & \ & \ & \ \\
\end{array}
\]

In order to combine the difference classes for each pairwise comparison, six matrices in the form of matrix (10) would be needed. This may be simplified by combining these matrices into the one matrix (11).

As an example of how matrix (11) has been arrived at (on the basis of matrix (9)), we may take \( p_1 \) in relation to \( p_2 \). For this pairwise comparison there is a difference class only under \( A^2 \), namely 1. The weight class for \( A^2 \) is 3. Using these two figures we find a corresponding letter in matrix (10), namely G. An entry for \( p_1 \) in relation to \( p_2 \) is then made under G. When all such entries have been made the result is as shown in matrix (11).

\[
\begin{array}{cccccccc}
 A & B & C & D & E & F & G & H & I \\
\hline
 p_1 \text{ in relat. to } p_2 & \ & \ & \ & \ & \ & 1 & \ & \ \\
p_1 \text{ in relat. to } p_3 & \ & \ & \ & \ & \ & 1 & \ & \ \\
p_2 \text{ in relat. to } p_3 & \ & \ & \ & \ & \ & 1 & 1 & \ \\
p_2 \text{ in relat. to } p_1 & \ & \ & \ & 1 & \ & 1 & \ & \ \\
p_3 \text{ in relat. to } p_1 & \ & \ & \ & 1 & \ & \ & 1 & \ \\
p_3 \text{ in relat. to } p_2 & \ & \ & \ & 1 & \ & \ & \ & 1 \\
 p_3 \text{ in relat. to } p_3 & \ & \ & \ & \ & \ & \ & \ & \ \\
\end{array}
\]
On the basis of matrix (11), two further matrices, (12) and (13), are drawn up. Matrix (12) indicates the dominance of a project over all other projects for the categories A-I. Example: project $p_1$ dominates over $p_2$ in G and over $p_3$ in I, resulting in an annotation for $p_1$ under G and I.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>$p_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>$p_3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Matrix (13) shows the dominance of all other projects over a project for categories A to I. Example: $p_1$ is dominated by $p_2$ in C and I, and by $p_3$ in C and H, resulting in a 2 under C and a 1 under H and I.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_1$</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>$p_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$p_3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

The difference between the extent to which a project dominates over all other projects (matrix (12)) and is dominated by them (matrix (13)) produces matrix (14). An example of how this is derived:

In category C in matrix (12) $p_1$ has nothing.

In category C in matrix (13) $p_1$ scores 2.

$0 - 2 = -2$.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_1$</td>
<td>-2</td>
<td></td>
<td>+1</td>
<td>-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>$p_2$</td>
<td></td>
<td>+1</td>
<td>-1</td>
<td>+1</td>
<td>+2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_3$</td>
<td></td>
<td>+1</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>-2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Weights are then assigned to categories A to I from matrix (10). A subsequent approach is given here by way of example. The weight class is taken as being the mean of the original weights in that class. The difference class is taken as being a ratio which more or less takes into account the valuation of the effect score differences. The extent to which one wishes to take the effect score differences into account is determined, inter alia, by the degree of detail/reliability assigned to these differences. If the ratio between difference classes 1, 2 and 3 is 3:4:5, this results in the following weights for categories A to I:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>8</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>16</td>
<td>20</td>
</tr>
</tbody>
</table>

Example:
A = 2 (weight class) × 3 (effect score difference) = 6
H = 4 (weight class) × 4 (effect score difference) = 16
D, E, F are not applicable as there is no entry for weight class 2.
For each project the scores from matrix (14) are then multiplied by the selected weights from matrix (15) and aggregated.
Example:
Project 2: 
\[
\begin{align*}
+1 & \times 10 = +10 \\
-1 & \times 12 = -12 \\
+1 & \times 16 = +16 \\
+2 & \times 20 = +40 \\
\end{align*}
\]
Total = +54

Calculations for all the projects produce matrix (16).

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>TOTAL</th>
</tr>
</thead>
</table>
| p^1 | -20 | +12 | -16 | -24 \\
| p^2 | +10 | -12 | +16 | +40 | +54 \\
| p^3 | +10 | -40 | -30 \\
| weight | 6 | 8 | 10 | - | - | 12 | 16 | 20 |

This produces the following rank-order:
p^2 + 54
p^1 - 24
p^3 - 30

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No. 1. *Tidal Computations in Shallow Water*
Dr. J. J. Dronkers* and prof. dr. ir. J. C. Schönfeld
*Report on Hydrostatic Leveling across the Westerschelde*
Ir. A. Waalewijn, 1959

No. 2. *Computations of the Decca Pattern for the Netherlands Delta Works*
Ir. H. Ph. van der Schaaft and P. Vetterli, Ing. Dipl. E. T. H., 1960

No. 3. *The Aging of asphaltic Bitumen*
Ir. A. J. P. van der Burgh, J. P. Bouwman en G. M. A. Steffelaar, 1962

No. 4. *Mud Distribution and Land Reclamation in the Eastern Wadden Shallows*
Dr. L. F. Kamp*, 1962

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No. 6. *A Structure Plan for the Southern IJsselmeerpolders*
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Section River Studies, Directie Bovenrivieren van Rijkswaterstaat, 1969

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Ir. A. C. de Gaay and ir. P. Bloklandt*, 1970

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Dr. ir. G. Abraham, ir. P. van der Burg en ir. P. de Vos, 1973
No. 18. *Experiences with Mathematical Models used for Water Quality and Water Problems*
    Ir. J. Voogt and dr. ir. C. B. Vreugdenhil, 1974

No. 19 *Sand Stabilization and Dune Building*
    Dr. M. J. Adriani and dr. J. H. J. Terwindt, 1974

No. 20. *The Road-Picture as a Touchstone for the three dimensional Design of Roads*
    Ir. J. F. Springer and ir. K. E. Huizinga (also in German), 1975

No. 21. *Push Tows in Canals*
    Ir. J. Koster, 1975

No. 22. Lock Capacity and Traffic Resistance of Locks
    Ir. C. Kooman and P. A. de Bruijn, 1975

No. 23. *Computer Calculations of a Complex Steel Bridge verified by Model Investigations*
    Ir. Th. H. Kayser and ir. J. Brinkhorst, 1975

No. 24. *The Kreekrak Locks on the Scheldt-Rhine Connection*
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No. 25. *Motorway Tunnels built by the Immersed Tube Method*
    Ir. A. Glerum, ir. B. P. Rigter, ir. W. D. Eysink and W. F. Heins, 1976

No. 26. *Salt Distribution in Estuaries*
    Rijkswaterstaat, Delft University of Technology, Delft Hydraulics Laboratory, 1976

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    Committee on the Compaction of Asphalt Revetments of Dyke Slopes, 1977

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    Dr. ir. P. van der Veer, 1978

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    Ir. C. van de Fliert and ir. H. Schram, 1979

No. 30. *Digital Large Scale Restitution and Map Compilation*

No. 31. *Policy Analysis for the National Water Management of the Netherlands*
    (Netherlands Contributions, related to the PAWN-study, for the ECE-seminar on Economic Instruments for the Rational Utilization of Water Resources – Veldhoven, Netherlands – 1980)

No. 32. *Changing Estuaries*
    Dr. H. L. F. Saeijs, 1982

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    North Sea directorate, 1982

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Technical Advisory Committee on Waterdefences, 1985

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L. C. van Rijn and G. L. Tan, 1985

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National Institute for Water Supply et al., 1985

No. 40.  *Biological Research Ems-Dollard Estuary*
Biological Study of the Ems-Dollard Estuary (BOEDE), 1985

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Dr. J. H. van den Berg

No. 44.  *Ecotoxicological aspects of dithiocarbamates*
Dr. C. J. van Leeuwen, 1986
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- Sub-group 1.1 Projects under way
- Sub-group 1.2 Projects to be commenced in 1985

GROUP 2: To be commenced in 1986-1989
- Sub-group 2.1
- Sub-group 2.2
- Sub-group 2.3

Other primary routes existing or to be constructed, forming part of the 1984 National Roads Plan (1st stage of the 1981 Structure Scheme for Traffic and Transport)

Primary routes not forming part of National Roads Plan and still to be constructed (2nd stage of 1981 Structure Scheme for Traffic and Transport)

Other (National) roads with sections due for construction in 1985-1989 MPP

( ) Numbering under 1968 National Roads Plan