Urban road safety initiatives

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State of the art on existing experience in The Netherlands

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Summary

The central theme of this contribution is the new direction which the government of The Netherlands has recently taken concerning its approach to road safety. This comes down to achieving a sustainable safe road traffic system in rural as well as urban districts. The most essential, but not the only, pillar in this approach is the bringing about of a sustainably safe road infrastructure.

Chapter 2 gives an analytical description of the size, nature, and development of road safety in The Netherlands during recent years. Estimates are made, not only of the present day costs society pays for its road safety, but also of the benefits that can accrue if all the plans are completely realised. A profit-and-loss analysis shows that introduction of such an approach is certainly cost-effective.

Chapter 3 gives an impression of the organisation and coordination of a road safety policy, in the widest sense of the word. A number of instruments are described which are available to the national and local governments. These enable them to keep their fingers on the pulse. The necessity for a new approach to achieve the policy goals is also substantiated.

Chapter 4 places the developments within the urban infrastructures in an historical perspective. The development is outlined of converting a fairly unstructured system into an infrastructure based on a sustainable road safety. This includes the variants in between. Where there is sufficient valid data, and the results of evaluation studies, effects are measured in terms of the reduction in the number of road accidents and victims.

Chapter 5 describes a number of recent and larger-scale evaluation studies. Special attention is paid a) to the design for monitoring a area-wide demonstration project and b) to conducting evaluations of several projects. These are part of the Bicycle Master Plan, which will last a number of years. This is a national basic plan for: stimulating bicycle use, encouraging the development of a local bicycle-friendly policy, and achieving a bicycle-friendly infrastructure.

Chapter 6 concludes this contribution with summary conclusions about:
1. The road safety state of affairs and the direction of their development.
2. The policy changes necessary and the direction of the new approach.
3. The most important road safety measures and activities together with their estimated effects.
4. Experiences with evaluations and monitoring.

Finally, it is concluded that in order to implement the future road safety policy approach, the necessary implements are to a large extent already available. Those road authorities responsible can already make a start on achieving a sustainable safe road system on their roads!

Contents

1. Introduction

More than 50,000 people are killed on the roads in the EU every year; more than half of these in urban areas. This represents a considerable social problem in terms of material and immaterial costs.
The overall objective of the DUMAS (Developing Urban Management And Safety) project is to produce a framework for the design and evaluation of urban safety initiatives. The project will follow on from earlier studies including the OECD report on 'Integrated Traffic Safety Management' and the UK guidelines for 'Urban Safety Management'.
DUMAS will bring together the existing knowledge on the effects of safety measures with the planning and management of urban safety programmes currently in use in the EU. Not only integration of measures into traffic safety schemes is of interest, but also the (local) policy and decision making process and the public acceptance.
The first objective of workpackage 1 (WP1) is to produce a state-of-the art on the design and evaluation of urban safety initiatives for each participating country. The second objective regards an overview report on the outcomes of their mentioned national reports. For the detailed objectives of the overall project and the objectives of WP 1 are refereed to the TA (version 3.0 November 1996) and the Initial Framework (SWOV, 19/02/ 1997 act.1.1 of WP1) of the DUMAS project.

2. Problem analysis and problem statement

2.1. Registration and processing accident data in The Netherlands

The registration of those accidents reported is primarily the task of the police. Those accidents for which the police complete and transmit a registration form are processed by the central Road Accident Registration (RAR) section of the Basic Data department of the Transport Research Centre (TRC) of the Ministry of Transport. RAR produces a national road accident database.
It has already been known for many years that the registration level of this database no longer answers the needs of policy makers or researchers (Derricks & Driessen, 1994). In order to obtain a completer view of the size and nature of road safety in The Netherlands, there has to be a representative picture or sample, whatever its completeness.

With this view in mind, studies have been made of the real numbers of those injured in road accidents, using a year-long survey among a randomly selected representative sample of households (Van Kampen & Harris, 1995). This survey (AIN) made a distinction between those accidents conforming to the international (and thus RAR) definition, and those not conforming; for example pedestrians slipping on pavements or roads.
By extrapolating the sample numbers to the population numbers, the real number of victims conforming to the definition was approx. 250,000. Those not conforming numbered approx. 400,000 (± 40,000).

If these numbers are compared with those based on the RAR processing, the conclusion is that the registration level of those injured in road accidents is not much higher than 20%! A further analysis showed that the under-registration varied according to severity, modal split, and age of those wounded.

As well as the above-mentioned telephone survey (Injuries in The Netherlands, measured again) a Home and Leisure Accident Surveillance System (PORS) has existed in The Netherlands for years. Since 1994, Road Accidents have been added to this registration system; called Road Accidents in PORS; better known as RIPORS (Van Kampen & Blokpoel, 1995 and Tromp, Van Kampen & Blokpoel, 1996). VIPORS is a registration system based on the data of those road accident victims who have been treated in the Accident & Emergency department (A&E) of a sample of 13 hospitals. The injury data is gathered as well as the accident data. The design of the system is such that comparisons can easily be made every month with the standard RAR data. This applies especially for those groups of accidents and/or victims where the under-reporting is large. A representative addition to the RAR data is thus constantly available.

Another source of accident, victim, and injury data is the National Patient Register (NPR). This is provided by all hospitals in The Netherlands and is processed by the Centre for Health Care Information. The NPR, like the RAR, also has its problems regarding the representativity. This applies especially to the modal split of road accident victims. Part of this can be

explained by the use of the E-codes of the International Classification of Diseases (ICD-9) of the World Health Organisation (WHO). When this has been replaced by the newly developed V-codes of ICD-10, it is expected that much of this representativity problem will have been solved.

When the resulting VIPORS studies are compared with the RAR and NPR data, it would appear that the VIPORS hospitals are a representative sample of all hospitals (approx. 150) in The Netherlands. There are however considerable difference in the distributions of VIPORS in comparison with RAR. These can, to a large extent, be explained by the limitations of the RAR. A study (Van Kampen & Blokpoel, 1995) has shown that VIPORS is sufficiently representative. Extrapolation using the population numbers results in an accident and victim database that provides a better insight of the number and nature of road accidents and their victims in The Netherlands. The RAR national data can be split into regions, provinces, and municipalities. Paragraph 2.3 will give more attention to the analysis system that SWOV has especially developed for municipalities.

2.2. The accidents picture and its development

Recent accident figures indicate that road safety in The Netherlands is not progressing as it should. If considerable additional effort is not invested, the objectives aimed at by policy will not be achieved. This is the conclusion, following extensive analysis of the available accident figures up to and including 1995, in combination with explanatory factors such as exposure data, population data, the number of cars on Dutch roads, etc.
The analysis also concerns developments in the number of road accident victims and the risks (measured in terms of victims per vehicle kilometre) run by the various categories of road user. The aim of the analysis is to pinpoint those modes of transport, age groups, or other relevant categories where extra problems are encountered. The available data are used to illustrate the situation for all groups.
Separate attention is paid to the ongoing largest group of fatal road accident victims as regards absolute size: motorists. Special attention is paid to the differences between age groups and gender with respect to risk (in this case, the probability of a motorist becoming involved in an injury accident per vehicle kilometre). Young, male motorists stand out in a negative sense in this area.
One element of significance for the overall road safety in The Netherlands is the changing composition of the population in terms of age groups. This is primarily the result of a decline in the number of births during the 1970s and the increase of the number of elderly people.
The ensuing 'dip' in births has slowly moved beyond the poorly scoring young age groups regarding accident risk (15 to 20 years). Due to the considerable reduction in the number of potential road users in this age group, a marked reduction in the number of road accident victims has also occurred. As the years progress, this reduction will become apparent in the category of road users aged 20 years and above.
Another demographic development, that of an increase in the proportion of elderly road users, will have a negative effect: as a result, the absolute level of road hazards for the elderly will increase in time, the more so because as age increases, there is also question of a rise in vulnerability.

A special analysis is devoted to explanations of long and medium term developments. Although no express statements can be made because the relevant theories have not been fully evaluated, it is likely that the reduction in the risk of road accident victims has, for the moment, come to an end. The ever increasing (mainly motorised) participation in traffic, linked to a plateau in the level of risk, unfortunately heralds a new period of growing road hazard. If considerable extra effort is not invested, the road safety objective (25% fewer fatalities and injured in the year 2000 in comparison with 1985) will probably not be realised. At the end of 1995, a reduction of only 7% with respect to the year of comparison, 1985, had been achieved. The short term developments are considered separately. It is probable that, due to the rise in the total level of road hazard for two years consecutively, this can no longer be viewed as an accidental fluctuation. However, the year 1994 does seem to be a negative exception in a number of respects.

To conduct the analysis, the familiar RAR database of the Basic Data department of the Transport Research Centre (TRC) of the Ministry of Transport was used. Where this database is unsuitable for obtaining a complete picture, additional databases have been used. These are CBS, NPR, RIPORS, and AIN. Details can be found in (Brouwer, Blokpoel, Van Kampen, Roszbach & Twisk, 1996).

The numbers of victims according to injury severity and the numbers of Material Damage Only (MDO) accidents are given in *Table 1*.

Year	Deaths	Admitted as In-patients	Others injured	MDO:material damage only
1980	1.996	18.616	37.990	264.375
1981	1.807	17.557	35.942	261.056
1982	1.709	16.776	35.434	243.586
1983	1.757	16.964	35.530	257.519
1984	1.615	15.630	35.095	251.154
1985	1.438	14.520	34.035	268.343
1986	1.527	14.706	35.497	267.497
1987	1.485	13.966	35.240	265.866
1988	1.366	13.644	34.337	262.447
1989	1.456	13.660	36.693	263.795
1990	1.376	13.657	38.207	266.971
1991	1.281	12.020	35.258	250.516
1992	1.285	11.654	36.422	248.264
1993	1.252	11.562	36.176	248.541
1994	1.298	11.735	37.480	241.627
1995	1.334	11.688	39.023	243.992

Table 1. *Victims by injury severity and MDO accidents (1980-1995). Source: BIS-V:AVV/BG (SWOV database).*

During the last five years, the numbers of road deaths and in-patients in The Netherlands has more or less stabilised. There is, however, a slight

increase among the 'others injured'. As far as these victims is concerned it is not known to what extent this is the result of fluctuations in the registration level.

As far as the development of the MDO accidents is concerned, not much can be said apart from the fact that, according to various estimates, their registration level is only about 20-25%. Starting in 1997, the Central Bureau of Statistics (CBS) - nowadays known as Statistics Netherlands - has begun a continuous survey called Extrapolation of Road Accidents (ERA). It aims, among other things, to make an accurate estimate of these MDO accidents, by interviewing a sub-sample of its National Travel Survey (NTS).

It is interesting to look at the relationship between mobility (or 'exposure' as it is known among road safety researchers) and road safety. The mobility, expressed in the number of motor vehicle kilometres, has continued to increase during the last ten years. The Death Rate, expressed as the number of road deaths per motor vehicle kilometre, declined up to 1994. Since then, however, this decline seems to have stagnated.

Certain combinations of age and modal split appear to occur frequently. This is shown in *Table 2*, in which, per age group, the number of victims per modal split is expressed as a percentage of the total number of victims.

Age group	Car	Lorry	Delivery van	Motorbike/ scooter	Moped/ Light Moped	Bicycle	Pedes-trian	Rest	Total
0-14	16,05	0,34	0,60	0,68	5,23	43,69	32,61	0,77	100%
15-17	8,55	0.00	0,29	0,66	71,31	16,81	1,99	0,36	100%
18-24	49,79	0,44	4,34	13,32	22,54	10,19	3,00	0,40	100%
25-34	55,82	0.93	5,44	12,70	7,10	9,46	3,73	0,73	100%
35-49	49,86	1,44	3,39	11,53	7,69	20,54	5,15	0,36	100%
50-64	47,22	0,70	3,57	3,57	8,94	27,92	7,15	0,89	100%
65+	37,20	0,05	0,75	0,23	8,52	37,03	14,71	0,11	100%
Total	**41,73**	**0,62**	**3,04**	**7,49**	**17.07**	**21,19**	**8,12**	**0,69**	**100%**

Table 2. *Percentage of victims by modal split and age group. Source: BIS-V:AVV/BG (SWOV database).*

It would seem that cyclists and pedestrians up to 14 years old, mopedists of 16 and 17, and car occupants (apart from the oldest group) have a relatively large share.

The risk, per kilometre travelled, of being killed or admitted to hospital as a result of a road accident, varies according to age. This has to do with experience, vulnerability, and of course the modal split. Children and the aged have a relatively high risk.

Age group	Deaths	In-patients
12-14	7,75	100,94
15-17	12,68	247,58
18-24	8,68	88,04
25-29	7,14	62,87
30-39	4,22	40,82
40-49	3,62	34,08
50-59	4,26	38,47
60-64	6,17	47,71
65+	20,23	101,33
Total	6,99	62,33

Table 3. *Risk: the number of victims per 100 million kilometres travelled by injury severity and age (average of 1992-1994). Source: BIS-V: AVV/BG (SWOV database), CBS-NTS, RAR.*

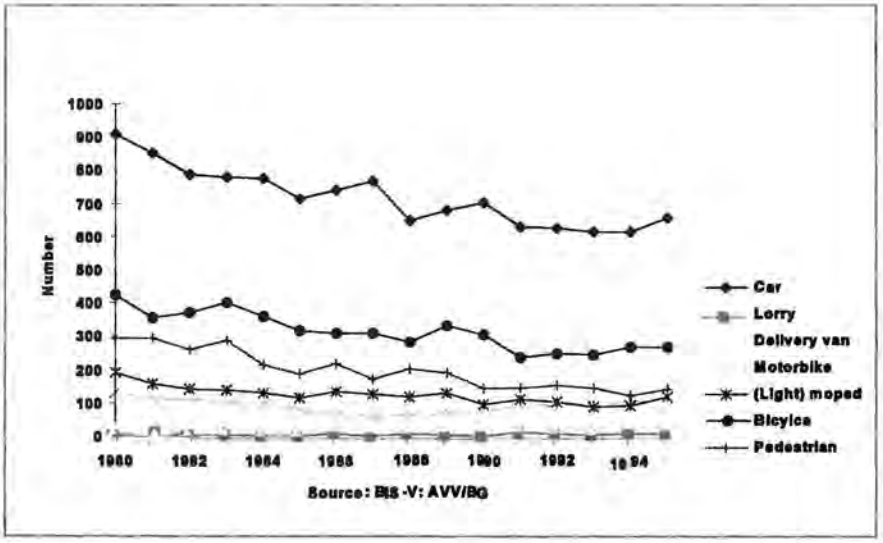

Figure 1. *Road deaths in The Netherlands 1980-1994 by means of transport.*

Fourty percent of all deaths and hospitalisations are car occupants. Between 1994 and 1995 this number increased by 5%. About one third are cyclists. Third are mopedists and riders of light mopeds. The number of deaths and in-patients among the riders of light mopeds has more than tripled since 1990. The number of motorbike victims was increasing sharply since 1987, but in 1995, for the first time since then, there was a slight decrease.

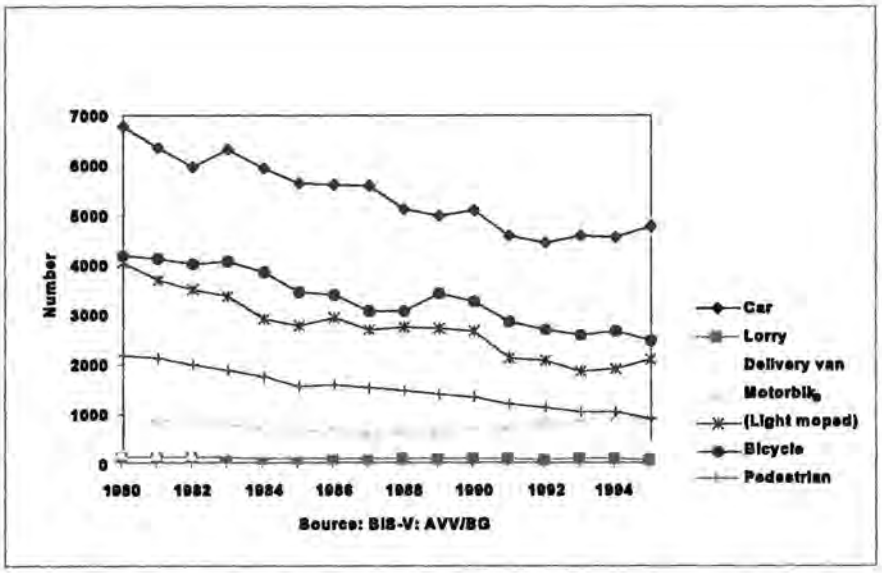

Figure 2. *Hospitalised road victims in The Netherlands 1980-1994, by means of transport.*

It is, however, too soon to say if this is a break in the trend or not. Lorries and delivery vans were the collision partner/crash opponent in circa 6% of all deaths or in-patients; but in the case of deaths only, circa 15%. Their share in the number of motor vehicle kilometres was also about 6-7%.

The risks per modal split vary considerably and are shown in *Table 4.*

Means of transport	Road deaths	In-patients
Car	4,2	31,0
Delivery van	4,5	29,7
Lorry	1,7	9,5
Bus	0.00	1,2
Motorbike	74,7	650,0
Moped	66,4	1364,3
Bicycle	20,5	206,1
Pedestrian	21,2	180,3
Total	6,3	57,5

Table 4. *Risk per 100 million kilometres travelled by injury severity and modal split (1994). Source: BIS-V:AVV/BG (SWOV database), CBS/RAR.*

Riders of motorised 2-wheelers clearly have, per vehicle kilometre travelled the highest risk of death or hospitalisation.

Most in-patients are from accidents on roads with a speed-limit of 50 km/ hour. These are mostly roads in built-up areas. In 1995 their numbers decreased. Due to very incomplete and select data about traffic quantities on roads inside the built-up area, it is difficult to make any statements about

any changes in risk on these roads. The limited amount of data available seems to indicate that the quantities have changed little during the past few years. Apart from this, there are certain signs that the risks are decreasing slightly.

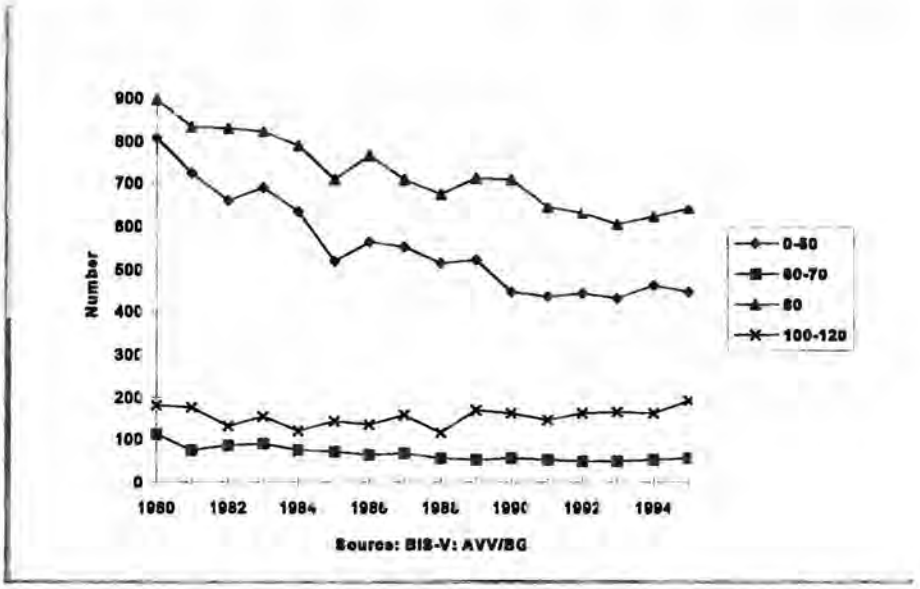

Figure 3. *Road deaths in The Netherlands 1980-1994 by road type (based on speed-limits).*

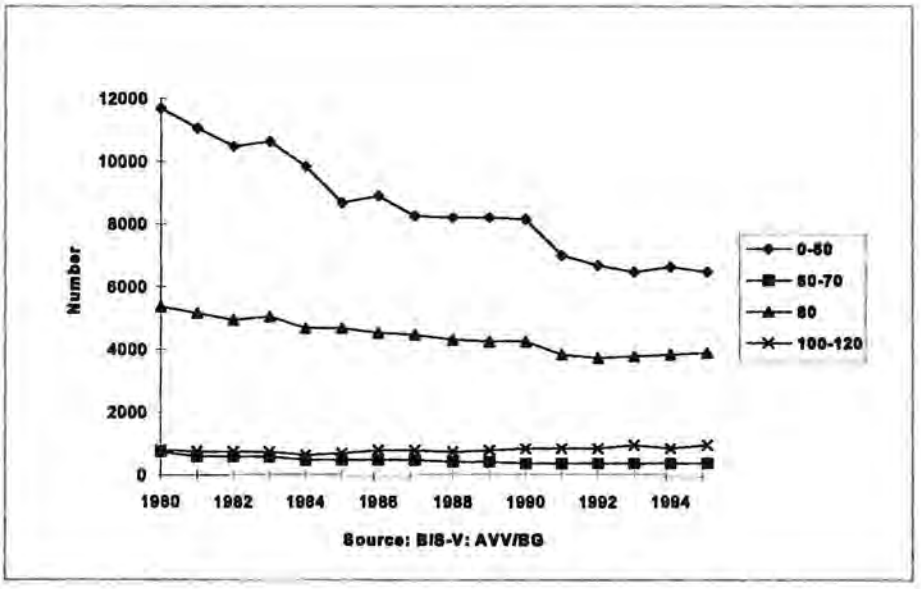

Figure 4. *Hospitalised road victims in The Netherlands, 1980-1994, by road type (based on speed-limits).*

	Junction	Road section	Total
0- 50 km/hour	12.625	11.507	24.132
60- 90 km/hour	3.396	5.389	8.785
100-120 km/hour	235	1.359	1.594
Total	16.256	18.255	34.511

Table 5. *Number of accidents with deaths or wounded, by crossroads/ stretch and speed-limit (1995). Source: BIS-V:AVV/BG (SWOV database)*

It is well known that, during the last few years, 65 to 70% of all road accidents occur in the built-up area. *Table 6* shows the victims (deaths plus in-patients and others injured) by modal split, divided by inside and outside built-up areas. Together with *Figures 3* and *4* this gives an impression of the size and nature of urban road safety.

	Victims (death & in-patients/hospitalised & others injured)							
	Outside built-up areas/rural				Built-up areas			
Modal Split	Fatal	Hosp.	Rest	Total	Fatal	Hosp.	Rest	Total
Cars	519	3118	7001	10638	96	1474	7194	8764
Vans	18	274	609	901	10	111	489	610
Lorries	10	62	159	231	0.00	15	72	87
Buses	0.00	6	21	27	2	13	107	122
Motor/scooter	81	458	713	1252	25	429	1192	1646
Mopeds	44	536	1236	1816	43	1338	6313	7694
Bicycles	99	556	1244	1899	144	2046	7543	9733
Pedestrians	49	131	139	319	97	933	1939	2969
Rest	7	27	74	108	8	35	131	174
Total	827	5168	11196	17191	425	6394	24980	31799

Table 6. *Victims by traffic participation in built-up areas and outside built-up areas in 1996. Source RAR, 1997.*

2.3. Costs of road hazard in The Netherlands

The last years there have been various developments in policy and the social perception of the negative external effects of road hazard (Muizelaar, Mathijssen & Wesemann, 1995). This justified a new calculation. The costs of road hazard can be classified into medical costs, lost of production, property damage, and costs of handling and prevention. In 1993 the medical costs rose to Dfl 440 million, the lost of production to Dfl 3.2 thousand million, the lost of production to Dfl 3.2 thousand million, the property damage to Dfl 4.2 thousand million, and the costs of treatment and prevention to Dfl 3.3 thousand million. In 1993 the total costs of road hazard have risen in the gross variant to Dfl 12.3 thousand million and in the net variant to Dfl 11.1 thousand million. Excluding the costs of prevention this is about 8 thousand million or about 2% of the Gross Domestic Product (GDP)!

3. Policies in traffic safety management

3.1. Organisation and coordination

The period in which road safety was purely the responsibility of the Ministry of Transport has long gone. Recent inventories have shown the areas in which the policies of various ministries overlap. This is especially true between, among others, spatial use, the environment and road safety. Therefore there needs to be a coordinated policy between the relevant ministries. As far as road safety is concerned, the key ministries are Transport, Justice, Internal Affairs, Housing, Town & Country Planning, Environment, Health and Defence. On the one hand there is a broad central deliberation, and on the other side bilateral deliberation between the Ministry of Transport and other relevant Ministries. An important goal is to ensure that road safety factors are considered whenever decisions are taken about matters which also can influence road safety. It would be extremely helpful if the road safety effects of policies of all the other relevant ministries were explicitly mentioned.

Several ministries have recorded their policy plans in a number of documents. A detailed discussion of these documents does not fit in to the context of this present overview. However, a global impression of the most relevant documents now follows. On top of this list is the Second Structure Scheme Traffic and Transport. More than 140 starting points, plans and/or measures are dealt with. Important clusters are: reduction of the air pollution by traffic (using cleaner and more economical engines and driving less kilometres), improving the livability/quality of life, reduction and control of the mobility, and maintenance of the (economic) accessibility. It is clear that environmental and road safety starting points are connected and can support each other to a certain extent. An important document is the third Long Term Policy for Road Safety (LTPRS III). In this plan 35 starting points, plans, and/of measures are discussed.
A third plan, the National Environment Plan, also contains more than 30 plans, starting points, and/or measures which, to a certain extent, share common ground with road safety. The fourth important document is the Fourth Town & Country Planning paper. The starting points, plans, and/of measures (nearly 30) which are discussed in this plan are indirectly relevant to road safety and its development. Finally, the Urban Renewal in the Future document is worth mentioning here.

There are many connections and/or overlaps with road safety among the starting points in the various documents. Important elements in the joint urban policy are:
1. redesign and adaptation of the infrastructure;
2. fighting congestion;
3. promotion or maintenances of the accessibility;
4. curbing the mobility (especially of the car);
5. redistribution of traffic over the road network (better use of main roads);
6. categorising the road network (based on its function);
7. improving public transport;
8. promoting the use of public transport and the bicycle;

9. separating goods traffic from the rest of the motorised traffic (especially in city-centres replacing heavy delivery transport by lighter vehicles).

The ministries involved are becoming more and more conscious of the fact that improvement in road safety, already at the Town & Country Planing phase, can and must be achieved. A carefully considered localisation policy (of housing, offices, and industry) is unmissable for keeping the increase in mobility within limits and under control.

The problem of developing and executing an integrated policy is mainly a question of organisation, and less of content. At the moment interdepartmental coordination is obscured and aims mainly at a consensus policy. One is trying to give shape to policy at the sector level as well as the facet level. Accomplishing an integrated policy seems to be fraught with difficulties.
There is also an additional field of tension between the what a national policy looks like and its local application. The impulse, launched during the last few years, to decentralise has played a considerable role in this.
The main points of a nationally formulated road safety policy must be safeguarded (because of consistence and a degree of uniformity) and laid down in central guidelines. However, the extent of central steering must be balanced against the present day ideas about what is socially acceptable.
To carry central steering too far can lead to an undermining of the central road safety policy at the local level This problem made its appearance while implementing the recent concept of 'sustainably safe'.
Although the central government can be regarded as the stimulating initiator, it is of the utmost importance to involve the decision makers at the local level, and the relevant private organisations, in the implementation process. In order to avoid a lack of commitment it is necessary that policy instruments are anchored in legal rules and specified procedures.
Examples of this are the Town & Country Planning Act, Environmental effect reports, Road Safety reports, the Trace Law, and various agreements which the Minister of Transport has signed with local government bodies and private organisations. The deliberation about the mutual completion of an integral, interministerial road safety policy is carried out within steering committees such as the Interministerial Steering Committee Road Safety (ISCRS) and Central Commission Road Safety (CCRS).

3.2. Instruments for policy and decision making

3.2.1. *The finger on the pulse; Road Safety Information System RIS; a compass for road safety policy*

Recently, policy had been implemented at an increasingly decentralised level by provinces, regions, municipalities, and also private organisations. In order to make optimal use of correct data and knowledge derived from research, with the evaluation and development of policy, a Road Safety Information System RIS was developed by SWOV to keep a finger on the pulse.
RIS is an instrument used to monitor road safety policy. The system gives policy information via a PC application. Besides there is a RIS Help and

Information Desk, where users can put their questions. Also road safety data are collected, accumulated and interpreted.
RIS makes the available road safety information accessible. These information is classified to spheres of interest within the field of road safety policy related to and in line with the so-called Spearheads of the Long Term Policy for Road Safety (LTPRS): Driving While Intoxicated (DWI), Speeding, Safety Devices, Cyclists and Moped Riders, Heavy Traffic, and Hazardous Situations.
The system describes the general developments in the field of road hazards and identifies undesirable developments. The road accidents are classified according to age, mode of transport, type of road, collision partner etc. Also the development in mobility is given, subdivided according to type of road and vehicle. With regard to recent information and developments of the 'sustainably safe' road traffic system the RIS gives information about measures, effects, and a literature review on this sustainably safe road traffic system.
The RIS has a specially developed search system and has been fully reviewed in consultation with the users. Besides there is a Telephone Help and Information Desk where users can come with any question relating to road safety (policy).

The information of RIS is carefully screened; data of various years are consistent and comparable and the representativity and validity are checked. The user has a great degree of freedom; it is not necessary to choose standard tables and it is possible to choose a presentation in tables or in graph form. Almost any required combination of data is possible. Another aspect is that all tables and graphs are explained: RIS offers answers and does not pose a puzzle to the users. Analysis are already done. The system also gives prognoses whether or not the tasks for the year 2000 or 2010 will be achieved by continuing the current policy, and where extra attention should be applied. The RIS also gives attention to effective measures and frequently occurring misconceptions, and their known effects are indicated.

Evaluation: The plans of the government describe what areas of attention in the field of road safety policy have a high probability of success and what measures should be taken to achieve the task set. The objectives for the years 2000 and 2010 are known; at any given moment. It is therefore possible to estimate whether there is a reasonable probability of these objectives being achieved. An interim evaluation will then indicate the progress made. Policy is in this way 'monitored', as it were. Unfavourable developments should be identified as quickly as possible. Policy that is not effective can then be discontinued or adjusted, while good policy can proceed with greater drive. RIS support this process!

3.2.2 *SWOVAGEM; A Traffic safety analysis for regions and municipalities*

As well as the Road Safety Information System, described in the last paragraph, SWOV has developed a system especially for local governments. This enables them to keep their finger on the pulse of the road safety developments in their own municipality. It can also be used for the analysis of regional developments and for groups of municipalities!
For local road safety policy it can also be used by subdividing the national accident data into the most important variables for regions and separate

municipalities. In practice it appears that the analysis and interpretation can often present problems. The possibilities of local accident data were mistakenly insufficiently used to substantiate municipal road safety policy. SWOV therefore has developed a computer program for this purpose by which the road safety in regions and/or municipalities can be analysed. By using this SWOVAGEM system, municipalities can visualise the road safety developments within their borders and compare this with a previous reference period as well as a group of comparable municipalities. These comparable municipalities are selected on the base of their comparability concerning a large number of relevant characteristics.
The results of such an analysis give a good idea where black spots are localised, which types of accident are more common than elsewhere, and which types of roads, crossroads, or road users need special attention. The developments, and comparisons with the comparable municipalities, can indicate that the local policy should be changed or that certain activities be intensified.
SWOVAGEM can be used for every region, group of municipalities, or individual municipalities. As SWOVAGEM uses adapted, existing computer programs and available accident data, the costs are low, and the results can be quickly reported to every customer. Apart from presenting the results of the analysis, SWOV also provides their interpretation, makes conclusions, and makes recommendations to the local government. Such a report can help municipalities formulate their own Municipal Road Safety Policy Plan.

3.2.3. *Monitoring the policy*

In 1993, SWOV was commissioned by thee Ministry of Transport to carry out a Policy Effect Report for road safety policy. A PER describes the road safety and makes a prognosis of its developments. These are related to the formulated policy goals so as, for example, expressed in the Second Structure Scheme Traffic and Transport and the Long Term Policy for Road Safety (LTPRS). From the PER it should be possible to conclude which goals have been achieved and which not. In the last case, there are indications in which direction the policy should be adapted to achieve these goals. In addition, if there are any developments which could lead to problems requiring new policy (together with the appropriate measures), these are signalled and quantified.

It is obvious the a PER for road safety (PER-RS) only makes sense if goals are explicitly mentioned: clearly, concrete, and preferably quantified. Furthermore, there should be relevant, measurable indicators which can be monitored. The development of these indicators must be validly and accurately registered and the result of this registration must be readily available.

The report mentioned signalled, among other things, the negative tendencies concerning the numbers of victims among occupants of lorries, delivery vans, motorcyclists, and older car occupants and cyclists. As far as absolute numbers are concerned, the victims among car occupants and cyclists remain the most important groups. Furthermore, increases were signalled in driving under influence, the stagnation in the use of restraints (such as

seatbelts and helmets), the number of older cyclists, and the more rapid increase in mobility than had been calculated.

The report also listed which problems could stand in the way of making such a PER-RS. Indirect indicators often have to be used. The rapidly executed decentralisation often prevents following and establishing the actual policy implementation. Many policy intentions appear difficult to evaluate. To measure effects at the sector level as well as the facet level, road safety policy must develop more instruments. These record: indirect indicators such as, for example, changes in mobility, traffic intensities, and modal split, and changes in numbers and severity of accidents and victims.

The importance of a PER-RS lies mainly in making recognisable and tangible especially the positive effects of the implemented policy. Stimulating implementation on a larger scale at the local level and increasing its support can be assisted by giving demonstrations and having example projects.

It has been established that the intended policy has been clearly described and the goals concrete and quantified. It is, however, more difficult to trace matters concerning the policy carried out. Effects appear to be detectable less directly, especially because there are often only indirect relationships with accidents and their victims. Preferably, the possibilities of monitoring and evaluating, together with the necessary conditions, should already play their part in the formulation phase. They should be part of the implementation path. To be successful, there must be consensus (to a large degree) and wide support. This applies to a number of policy areas and at various policy levels, as well as to private organisations. The impact of PER-RS's can be strengthened by removing its informal character, and to anchor this instrument in the laws and their resulting procedures.

In 1994 the Ministry of Transport commissioned a mid-term review regarding all intended projects and activities involved in the Second Structure Scheme Traffic and Transport. This review contained the goal, the state of affairs, effects at various policy levels, and the progress prognoses. The following were examined:

- The Spearpoint policy (among others: speeding, vulnerable road users, maintenance of the new Highway Code including covering policy, crash worthiness of vehicles, dangerous situations, heavy goods traffic, in-car electronics, the safety of mopedists and cyclists, right-of-way for cyclists, cyclists on roundabouts, improvements in bicycle construction, bicycle-friendly infrastructure, moped certificate, moped helmets, and demands on mopeds and light mopeds).
- Driving While Intoxicated (RWI) and Daytime Running Lights (DRL).
- Sustainably safe concept (implementation plan, development of a vision, and sustainably safe in town & country planning).
- Organisation of the road safety 'actors', coordination, support improvement, encouraging private organisations, stimulating local governments, consulting the platform of social and private organisations and international contacts.
- Development of knowledge infrastructure and networks.
- Education activities (aimed at road users, the youth, and schools.

- The point system, cooperation with insurance companies, the Driving Instructors Law.

Such a large scale effect report seems too ambitious. The effects can often not be established separately. Monitoring appears not to be possible in many cases. Measurable indicators don't exist. Effects are described in terms of 'contribute to', 'development of a vision is being continued', 'has contributed to broadening the support', 'has stimulated local governments', 'has had possible effects in the long term', and more of such vague descriptions.
There is still a lot more work to be done in developing a PER-RS into an effective policy instrument!

3.2.4. *Handbooks, design manuals, recommendations and standards*

3.2.4.1. *Recommendations for design of (infrastructural) traffic measurements and facilities in urban areas*

The ASVV (C.R.O.W, 1996) makes recommendations for urban areas. This handbook contains more than 1000 pages. There were two thoughts at the basis. First, it was meant to bring together existing knowledge which had sometimes been circulated but only available with difficulty. Second; this handbook aimed at a greater uniformity in applying and implementing measures; this under the assumption that the road safety would be improved. These recommendations were meant for designers of new traffic facilities as well as the improvement of existing traffic situations.
The design manual offers a wide variety of design elements. It also provides information about measurements, application possibilities, and (where possible) the results to be expected.

3.2.4.2. *Sign up for the bike; A design manual for a cycling-friendly infrastructure*

To bring up the quality of the bicycle infrastructure to the same level as other forms of road transport, it was necessary to modify the road network. All knowledge and experience available in The Netherlands was collecting in the mentioned design manual. The manual include arguments and ingredients which help the designer and engineer to give the bicycle a better position in the traffic and transport system. Parts of the manual regarding the design process, design of a bicycle network, road sections, road surface, intersections, speed inhibitors, parking hazards, bicycle storage facilities, furnishing cycle-routes, and the assessment of cycling-infrastructure.
The manual contains a great number of recommendations mostly in the form of examples.
The manual for dividing the roads in functional categories on the basis of the sustainably safe concept is published by the C.R.O.W (C.R.O.W, 1997).

Traffic can be regarded as a system within the infrastructure, regulations, vehicles and traffic participants. All elements within that system must be attuned to each other. There should be a coordination between use (actual function), function (intended tasks), and design (realised infrastructure) and regulations. A sustainable safe functional use of the road network takes into account choice of routes, different kinds of vehicles, traffic flow,

accessibility, and volume. By taking the application of the correct design and regulations, a regular traffic flow can be achieved and level of low speeds at crossings can be enforced. By taking into consideration the identification of traffic situations, the willingness of the traffic participants to accept the traffic rules and the simplicity of the lay out of the traffic situations, predictable traffic behaviour can be realised. To realise a sustainable road traffic system begins with the drawing up of a categorising plan. Functional requirements are necessary to achieve this. A step-by-step plan must be followed in order to realise the required mapping out of the (urban) roads. The manual sets out the operational demands of a sustainable safe road network.

3.2.4.3. *INFO-desk sustainably safe*

Although the central government remains responsible for the main lines and most important guide lines, the implementation of the road safety policy in The Netherlands is taking place at a time of far-reaching decentralisation. It is of utmost importance that centrally gathered and available knowledge be made operational for local governments. The central government is therefore considering the development of knowledge networks. The idea is to produce a flow in two directions of experience and knowledge.
One direction is from a central point to local governments involved with road safety. The other direction is of experience and knowledge from local governments to a central information and knowledge point. This last stream of information must be tested for consistency and representativity.
After this they can be generally formulated in order that they may be applied by other local governments in other municipalities. To achieve this, the central government aims to set up an 'INFO-desk Sustainably safe'. Road authorities can ask their questions, but also share their experiences in implementation and evaluation of the concept.

3.3. Setting a new course in road safety policy in The Netherlands sorely needed!

Various signals have indicated that the development of road safety in The Netherlands is not proceeding as well as had been expected (see also § 2.2). It has become uncertain whether the goals we set ourselves will be reached. These goals were:

1. 25% fewer road deaths and injured in the year 2000, compared with the figures for 1985, and
2. 50% fewer fatalities and 40% fewer injured in the year 2010, compared with 1986.

Firstly, it appears that the annual number of traffic fatalities has hardly declined since 1991; since that year, this figure has wavered between 1,250 and 1,300.
In addition, it seems that the drop in risk that characterises the development of road traffic is stagnating. While in the 1970s and 1980s, this drop was about 9% per year, in the last ten years this figure has been roughly halved. In the last few years this rate of decline is even lower. Because mobility is increasing by about the same percentage as the drop in risk, the number of road accident victims has in fact remained constant.

It is interesting to note that in recent years, a number of important factors of influence on road safety (driving under the influence, wearing seat belts, speeding behaviour) have tended more towards deterioration, rather than improvement.
In addition, no major successes have been registered of late with regard to measures that have managed to reduce road hazard to a considerable degree. Finally, social interest in road safety problems seems to have diminished somewhat as has (also in relation to this attitude) political and policy concern. This does not mean, however, that the disappointing developments in the field of road hazard are thereby easily explained. However, all these tendencies seem to point in the direction of stagnation.

When considered from various perspectives, road hazard still represents a considerable social problem. We are talking in terms of economic damage measuring about nine thousand million Dutch guilders a year, and about risks that are many times greater than those associated with other modes of transport.
This unfavourable development is therefore also a reason to intensify and broaden efforts in this field, or at least improve them. In other words, if the wind changes direction, it's time to set another course.

This report, written by the SWOV at the request of the Ministry of Transport, offers recommendations concerning such a change of course: what direction do we move in and how do we do it? The knowledge offered by this report can be used by all those who play a role in the realisation of the Long Term Programme for Road Safety and are involved in the implementation of that programme.
With regard to the set-up of the fourth Long Term Policy for Road Safety, the SWOV recommends that a strategy be adopted consisting of three parts.

- Firstly, a number of effective measures should be taken in the short term, focusing particularly on the already formulated spearheads of policy that should result in the goals set for the year 2000 being accomplished.
- Secondly, it should be ensured that road safety conditions are explicitly included and weighed at all levels of the decision making process affecting road safety: national, regional, and local; particularly in the field of policy concerning mobility and the infrastructure.
- Thirdly, the results and the success of implementation of the first and the second recommendation should be utilised to realise a sustainably safe road traffic system, step by step, over a longer period.

The recommendations included in this report consider what can be done, now and in the future, with respect to road safety, and how it can be done. In this context, the SWOV has confined itself to those measures about which statements can be made with some clarity in terms of the effects to be anticipated. Based on the collected information, it is realistic to expect that the set objectives are attainable - where it should be noted that the proposed measures will be particularly radical in nature if they are performed on the scale required to truly contribute towards reaching the objectives.

In the short term, the most effective approach appears to be to strengthen police enforcement; placed in a context of large-scale information campaigns with the participation of the mass media; aimed at the spearheads of alcohol, speeding, and seat belt use. In addition, attention could also be

directed at the so-called black-spot approach and a new impulse with the construction of 30 km/h areas. The two latter points could be further expanded in the long term. Furthermore, in the coming years it should be emphatically attempted to further implement the 'sustainably safe' traffic principles.

The following general characteristics can be given for the set of measures:
- Measures should be made clearly visible to the Dutch population,
- Measures should be prepared carefully and knowledgeably and performed in order to be as effective and efficient as possible,
- Measures should be systematically monitored, evaluated and, if necessary, adjusted;
- The character of the measures should be structural, rather than incidental, and preferably be of a preventative nature;
- It should be attempted to implement the measures in a sober fashion;
- Integration with other objectives (mobility and the environment) should be emphatically endeavoured.

It is recommended that in the coming years, a number of measures be taken that will considerably reduce the traffic risk within a short period of time. In this context, it is rational to consider national measures incorporating local and regional elements of implementation.

3.4. A sustainably safe road traffic system; payable and cost effective?

In § 3.3 is argued that a new course is required to achieve the goals of the road safety policy. Recommendations have been made for the approach both in the short term and the long term. Action points for measures with a high chance of success are presented. An implementation plan has been drawn up. Accomplishing this is not only the responsibility of the government, but also requires commitment from social and private organisations, commercial companies, and individuals. There must also be a realistic financial plan.

Commissioned by the government, SWOV together with others, has carried out a study of the financial possibilities for the implementation plan (Poppe & Muizelaar, 1996). In this study the following starting points have been used:
- To realise a sustainably safe infrastructure, an investment is needed of from 30,000 to 60,000 million guilders during a period of about 30 years.
- The Netherlands government spends about 5,000 to 6,000 million guilders a year to maintain and extend the present road network.
- The costs of the present road safety in The Netherlands is estimated at 9,000 to 11,000 million guilders a year; not including the immaterial costs.

Using these estimates as a starting point, a cost-benefit analysis has been made. For the 30,000 million variant, the social yield amounts to about 6%. For the 60,000 million variant, they amount to about 9%. If the immaterial costs are also included, the yield is higher. A problem is that the investments are nearly all governmental. It is, however, mainly companies, employers, insurers, and individuals who profit the most from these investments. Government also undertakes initiatives to find investors

outside the government to realise its implementation programme. It is after all so that we all have an interest in the realisation of sustainably safe traffic system!

4. Design and implementation

4.1. Residential areas

4.1.1. *The development of the infrastructure in residential areas in its historical perspective*

4.1.1.1. *From unstructured development to principles of functional classification*

For decades, urban developers and traffic planners in many countries have been working on the development of concepts for urban infrastructure which meet the increasing need for mobility and which at the same time take into account the quality of life of the residents. In doing so they are confronted with conflicting demands; on the one hand traffic flow and accessibility, on the other the liveability of such an environment. It has, however, not proved an easy task to develop a concept that meets both aspects and that does not detract from traffic safety.
It was quickly realised that because of the multi-functional character of the urban infrastructure, it would be difficult to avoid making compromises. This used to be the case and it appears to be valid for the present day although on another level.

After the Second World War - and in countries where mass motorisation had already occurred before that time - various points of view were put forward concerning the desired urban design. Some ideas were immediately discarded, others, albeit adapted, were implemented and are still valid today while some ideas are enjoying renewed interest. Concepts put forward by Le Corbusier, Buchanan, Goudappel & Perlot have left their mark on the development of urban design.
The SCAFT guidelines (Scandinavian guidelines for road design in urban areas) and the Radburn principle (a structure for the road system of residential areas, used for example in the first of the English new towns) have been the models for the design of various urban infrastructures.
In general, the concepts then developed and which continue to remain valid, all include to some extent a certain functional classification of the road system. However, the optimum harmonisation of (intended) function, design and (actual) utilisation has certainly not been achieved in all cases.

4.1.1.2. *From an hierarchic structure to a sustainably safe urban road traffic system*

Problems in urban areas
As in other western countries, the massive growth in car-ownership and use meant that motorised traffic in The Netherlands assumed an increasingly dominant position. Slow-moving traffic and therefore vulnerable traffic participants had increasing difficulties. Motorised traffic became more and more of a nuisance and laid claim to an unreasonable share of the diminishing open spaces in the urban area. Activities typical to residential areas were crowded out while the urban dweller felt increasingly threatened by motorised traffic.

Separating road systems from residential areas
In the first instance, a fundamental decision was made to roughly divide (or reallocate) urban areas into traffic zones and residential areas. Through traffic, that is traffic flow, is an important element of road systems whereas local traffic only should be allowed into residential areas where living, shopping and walking are the central elements. In these areas, traffic was cast in a subordinate role; priority was given to the freedom of movement (and safety) of cyclists, pedestrians and children playing. That, at any rate, was the intention. These points of departure, found in the SCAFT guidelines and the Radburn principle, basically provided for a separation of the different functions.
Some quite stringent examples carried out in The Netherlands are to be seen in Lelystad and on the Bijlmermeer estate in Amsterdam where traffic and living are partly played out on different levels. However, in most urban areas, many streets kept on their multi-functional character, leading to one of the two functions (traffic and living) being allocated the dominant role or, as it developed in some cases, had the dominant role more or less thrust upon it. In this way, combinations were created which reduced traffic safety. For example, a highly-developed traffic function in combination with a distinct shopping or living function.

Integration of traffic categories: the 'woonerf'
During the seventies an entirely different principle to that of separation was developed for residential areas in The Netherlands. It was, on the contrary, based on the total integration of the different types of traffic participants. The concept has also become internationally known by the Dutch term, 'woonerf': in these zones living is the central function. Motorised traffic - excluding through traffic - is accepted but is subordinate to the other 'woonerf' users. Motorised traffic is permitted speeds of about 8-15 km/hour. Separate provisions for pedestrians (such as pavements) are absent, while a different right-of-way rule is enforced: slow-moving traffic from the right has priority over motorised traffic. In The Netherlands, the general rule is that at a crossroads where no priority rule is in force, slow-moving traffic should give right of way to fast-moving motorised traffic.
In 1976 the 'woonerf' concept achieved legal status while in 1988 it became legal to apply the concept to shopping areas or village situations.

The disadvantages of the 'woonerf'
Where safety and the quality of life were concerned, inhabitants regarded the introduction of the 'woonerf' as an important improvement to their living environment while, from the objective point of view, the number of accidents seemed to drop. However, there did appear to be disadvantages. In practice, the realisation of 'woonerven' created spatial and financial problems. At the same time, inhabitants missed the separate pedestrian provisions. It was also found that the concept was less suitable for larger, continuously built-up areas.

Inception 30 km/hour concept
It became increasingly necessary to find a solution that would emphasise the benefits of the 'woonerf' but eliminate its disadvantages. Would it be possible to create residential areas with speed limits not exceeding 30 km/hour? If such speed limits were introduced, collisions between cars and vulnerable traffic participants would seldom result in any serious

injury. The idea received wide support both on a national and international scale. Various countries have put the 30 km/hour regulation into practice, both for individual streets and as a zoning rule for entire residential areas.

30 km/hour rule not without physical measures
It quickly became obvious that, partly depending on the area in which the regulation was enforced, the projected speed limit could not be achieved solely by placing a traffic sign to announce the legal measure and that police surveillance would not be of sufficient capacity to ensure the limit was upheld. In older residential areas intersected by main roads carrying through traffic, it proved to be particularly necessary to redesign the streets; physical deterrents to limit speed were introduced and infrastructure adapted to exclude through traffic.
The 30 km/hour regulation achieved legal status in The Netherlands in 1983. In 1984, zoning was introduced for entire residential areas; traffic signs announced the new speed limit. Zones designated as 30 km/hour zones had to meet a number of requirements.

Basic requirements 30 km/hour zones
- The projected speed limit must justify the design characteristics of the streets or area involved (underscored by eventual physical deterrents).
- The streets or the streets in an area may not serve as a thoroughfare for traffic; they may only serve local traffic going to and from the streets or area concerned.
- Public transport if any or emergency services may not be (excessively) impeded.
- Physical speed-restricting engineering measures may not constitute a hazard.
- A legally prescribed traffic sign must be used to indicate the 30 km/hour limit.

Before wide-scale introduction could be recommended, various experimental projects were carried out and the concept developed further.
The effects were assessed in a number of studies and on the grounds of the results, wide-scale implementation advocated. In the meantime, many municipalities in The Netherlands have introduced 30 km/hour zones.

Introduction of 30 km/hour speed limit for entire built-up area
Generally speaking, ever since its introduction in The Netherlands, the 30 km/hour rule has been regarded positively. At the moment its universal implementation in all built-up areas, excepting on roads with an explicit traffic function, such as link roads and flow roads, and the existing 'woonerven', is being debated.
The Dutch Government has requested SWOV to list the conditions for introducing a universal speed limit in all built-up areas that would not adversely affect the traffic safety of all types of traffic participants.
Also involved are the provisions (relating to infrastructure) that would first have to be carried out as well as an estimation of their costs.
In view of the aforementioned requirements that areas have to meet before 30 km/hour zones are implemented, it is obvious that through traffic is barred (as far as possible). At the same time there must be a realistic expectation of the limit being observed without too many controls.

It will without doubt be only too apparent that in innumerable places the design and structure of the present urban area will urgently require modification.

Developing a 'sustainably safe' urban road system
And finally (over a period of a few decades), the intention is to realise a 'sustainably safe' traffic system on a national scale. It is not within the scope of this memorandum to include a detailed description of the 'sustainably safe' concept developed by SWOV in collaboration with other research workers and institutes. The reader is referred to the publication, Towards a sustainable safe traffic system in The Netherlands (SWOV, 1993), attached to this memorandum. However, the most important points of departure forming the cornerstone of the view presented in this publication are briefly outlined below.

The most important basic principles of the 'sustainably safe' road system
- Prevent unintentional use of roads (i.e. use not corresponding with intended function).
- Prevent great differences in the speed, direction and mass of the diverse traffic participants, particularly the quite higher speeds (hence decreasing the risk of serious conflicts beforehand).
- Prevent road users' ambiguous behaviour (promote clarity of road design, driving behaviour and motoring performance).

In order to bring about a 'sustainably safe' road system, it is considered essential to categorise according to a mono-functional principle. This means that in theory each road category is allocated a single function.
The 'sustainably safe' concept argues the case for a tripartite division into flow roads, link roads and access streets to residential areas (Vis, 1994; Van Minnen & Slop, 1994).
The function of the first road type is to ensure the smooth flow of (motorised) traffic. In principle, traffic exchanges - except via more level junctions at relatively long distances from each other - are not acceptable.
The second road type serves to open up areas and forms the link between the flow system and the third road category. Traffic exchanges at crossroads - preferably in the form of roundabouts - are acceptable.
The third road type serves as the access road to dwellings, properties, car parks and business premises, etc. It is solely meant for local traffic.
The basic assumption behind the first two road types is that slow (vulnerable) traffic and motorised traffic will be separated. The third road type assumes a mixture of motorised and slow traffic. The idea is that its function and design will ensure a maximum speed limit of 30 km/hour and that no considerable efforts will be required to uphold it.

Realising points of departure of the 'sustainably safe' concept in relation to infrastructure
Where infrastructure is concerned, the further realisation of the 'sustainably safe' concept is best summarised in the following points of departure.
- Limit as far as possible the amount of movement.
- Limit to the utmost the proportion of each journey over relatively unsafe roads.
- Limit as far as possible the length of each journey.
- Ensure that the shortest journey is also the safest.

- Ensure that directions are clearly signposted.
- Make road categories identifiable (to traffic participants!).
- Seek the fewest and preferably the most uniform solutions (in comparable situations).
- Curb conflicts between cross traffic (or better still eliminate completely).
- Prevent conflicts between oncoming (and other) traffic.
- Separate as far as possible the (dissimilar) types of traffic
- Reduce the speed at potential confrontation points.
- Ensure there are no dangerous obstacles along the road.
- Seek uniformity of infrastructure as well as the continuity and homogeneity of traffic flows and the consistency of the traffic picture.

Implementation demands broad-based support from all those concerned
A salient feature of the 'sustainably safe' traffic concept is its integral approach: up till now all the knowledge that has been acquired and all the experiences gained from the various disciplines involved in traffic and traffic safety have been incorporated in to the concept.
The - further evaluated - 30 km/hour principle remains for the residential areas and the access road category an important point of departure.
Unquestionably, and partly because of the costs involved, the implementation route will stretch out over quite a few decades. However, it is important in the short term to create among all those concerned a strong and broad-based support. The developed concept should be widely accepted as an indicator of the direction which further development of the urban road system is to take.
Interim evaluation studies should ensure that experiences gained during the implementation process, as well as other relevant new developments, are incorporated in to the concept.

4.1.2. *Effects of the concepts discussed on traffic safety and liveability*

4.1.2.1. *The 'woonerf'*

In the 'woonerf', the dominant role played by motorised traffic has successfully been switched to a subordinate one. Cyclists, pedestrians, children playing and the elderly feel less threatened. Moreover, the number of conflicts and accidents particularly between motorised traffic and vulnerable traffic participants, has declined. In practice, any quantification of this decline in numbers is difficult to prove since a relatively limited number of accidents occurred in these areas.

4.1.2.2. *30 km/hour zones*

Results of first large scale trial areas
Before the implementation of 30 km/hour zones on a larger scale could be put into practice, it was necessary to carry out field studies involving a limited number of trial areas. Various options were explored ranging from simple measures affecting traffic circulation to layouts reminiscent of the 'woonerf'. With regard to accidents, a decline of more than 50% (even 80%) was recorded.
In retrospect, it is now clear that the reduction in accidents was probably linked to the trial areas' many features. For example, size, the presence of

through traffic, the concentration and quality of facilities, the fact that a relatively hazardous situation existed beforehand and other such area related features. It should also be borne in mind that analyses were based on a relatively limited number of accidents. We should therefore beware of generalising the findings relating to the reduction in accidents and applying them to other urban areas since we may over- or underestimate the effects (a view confirmed in subsequent studies).

Results of fifteen 30 km/hour trial areas
In order to gain more insight into the effects of diverse series of measures on various types of residential areas, the Ministry of Transport and Public Works selected trial areas in fifteen municipalities throughout the country. The selected areas were then converted into 30 km/hour zones.
SWOV was commissioned by the government to carry out an evaluation study which was to include a survey of the most important features of the area, the sort of problems occurring in situ and the most important changes in infrastructure required to convert the selected areas into trial zones.

Mostly humps, narrowings, turning bans, raised sections and axis realignments were introduced; in general they proved to be the most effective in reducing speed.
In retrospect, the wide dissimilarity between the areas and the package of measures implemented in each area, did not allow for a precise interpretation of the effects and their dispersion.

Despite this handicap, the following general effects were recorded:
- In general the speed level of motorised traffic appeared to have decreased; the traffic picture appeared to quieten down.
- In those areas where through traffic and traffic taking short cuts were previously recorded, it seemed that such traffic had considerably decreased or had even completely disappeared.
- The number of accidents in all the fifteen areas was reduced by about 15%. However the dispersion of the effects seemed to be quite wide; from almost no effect to more than a 50% reduction.
- The impression was that the reduction of accidents with injury was about double that of all other accidents, but the number of accidents with injury proved too negligible for analysis.
- The number of casualties among pedestrians in particular appeared to have been roughly halved.
- Apart from a few exceptions, the residents felt that the measures had had a positive effect on traffic safety and liveability in their area and that the menace of motorised traffic had decreased.

Great dispersion of effects recorded
The positive effect of the 30 km/hour measure seems to have been established. However, one important question remains unanswered and that is, how can the wide dispersion of effects be interpreted? If more insight were to be gained into this aspect, the optimum effect could be achieved when the measure is introduced on a larger scale. Probably, the wide dispersion of effects can already be partly explained by the fact that the areas were far from homogeneous, that extremely diverse packages of measures relating to infrastructure were employed and that the quality and the concentration of measures differed from each other.

Situations that were already basically hazardous before the areas were converted may also have had some influence on the ultimate reduction in the number of accidents. In relatively safe areas (that is, areas where hardly any accidents occur), a reduction in the number of accidents during the limited period of evaluation cannot be established with any objectivity.

In estimating the influences of the various aspects, including those described above, the greatest effect may be expected in areas where the following conditions are found:

- Areas with a relatively high traffic performance or a high density of motorised traffic.
- Areas with a relatively large proportion of through traffic or traffic taking short cuts.
- Areas where motorised traffic achieves a relatively high speed level.
- Areas with a considerable volume of heavy traffic.
- More extensive areas.

Greater effect from integral approach

As a rule, special provisions are required in areas with public transport. Not only must through traffic, heavy traffic and traffic taking short cuts be barred from residential areas but quick and safe alternatives have to be offered outside the 30 km/hour zone. In many cases, this means the surrounding road networks have to be adapted. But all too often the measures taken are insufficient and may generate negative 'radiating' effects. These considerations argue for a comprehensive plan for the entire urban area, otherwise the potentially positive effect of converting a residential area cannot be entirely achieved.

Generalisation of effects demands larger scale evaluation

Because of the wide dispersion of effects, the entirely speculative interpretation of this and the uncertainty of the representativeness of the fifteen trial 30 km/hour zones, any generalisation of the effects was just not possible. For this reason, a follow-up study on a larger scale was carried out (Vis & Kaal, SWOV, 1993).

For this study about 400 municipalities (of the 650 in The Netherlands at that time), with 10,000 or more inhabitants were requested to submit information over residential areas which were 30 km/hour zones.

The response was about 50%. Half of this 50% had as yet not implemented any 30 km/hour zones. Ultimately, 72 municipalities (the larger municipalities being in the majority) provided sufficient documented information on 151 30 km/hour zones so that a detailed analysis of the development of traffic safety from about 1983 to 1991 could be undertaken. In comparison to the study of the fifteen trial areas, this study involved 30 km/hour zones picked at random.

Confirmation of results in larger scale evaluation

The 151 areas greatly varied in size: in area from 0.09 to 130 ha and in road length from a few hundred metres to 44 km (more than 50 percent 20 ha or less and 5 km or less)! The combined number of accidents in these areas in the period under study before and after conversion, were sufficient to be able to undertake a separate analysis of accidents with injury only.

The estimated reduction of the number of accidents with injury by approximately 30%, made in the previous evaluation study in the fifteen

experimental municipalities, was confirmed. Also confirmed was the wide dispersion of effects observed in the previous study. For that matter, this is not to be wondered at, the variation in a great number of features in the 151 areas was even greater than in the fifteen trial areas. Other effects observed in the first study were also broadly confirmed in the larger scale study.

Underestimation of accident reduction cannot be excluded
The nature of the results of the evaluation studies does not make it possible to forecast exactly the effects of converting individual residential areas into 30 km/hour zones. However, it is clear that the extent of the reduction of the number of accidents becomes greater as the injury becomes more serious. Therefore, the reduction of accidents with serious injury can also be more than the 30% found for all accidents with injury. It follows that the reduction in the number of fatalities is also probably greater. However, in the short term this hypothesis cannot be tested on the basis of an accident analysis since in the areas involved - before and after conversion - hardly any fatalities occurred.
In both studies, account was taken of a correction for any autonomous developments that could not be subscribed to the 30 km/hour rule. Partly due to practical considerations, the rest of the municipality functioned as a control area in both studies.
Restrictions were attached to this choice of control area. In such studies, listing data from exactly comparable control areas is a general problem. The reduction of accidents recorded in the control areas were treated as autonomous effects and as such subtracted from the effects in the areas of study. However, it is possible that this correction was entirely or partly erroneous. The problem arises because the effect of other traffic measures in the control areas (that also included traffic routes) could have been different (e.g. greater) than the effect in the 30 km/hour zones. Therefore, the estimated (average) reduction percentages resulting from the conversion of a residential area into a 30 km/hour zone, could be underestimations.

Implementation 30 km/hour limit in entire built-up area justified
Despite the aforementioned drawbacks of the evaluation studies, the positive effects are so obvious that The Netherlands is considering putting all eligible areas and streets under a 30 km/hour regime. Flow roads and link roads are excluded; speeds of 50 and 70 km/hour respectively, are being considered as an acceptable maximum on these roads.
In the present situation and structure, it is estimated that the introduction of the 30 km/hour limit would decrease the number of traffic casualties in these zones in the built-up area by about 30%. Quite probably, this effect could be increased if a number of roads now designated as link roads, were to be downgraded and allocated an 'access' function. By downgrading their function, these roads could be brought under the 30 km/hour regime (SWOV, in preparation).

Flow and link system should not be forgotten
Many analyses show that the majority of traffic casualties occur in built-up areas on roads which at present are considered main roads and link roads. The 'sustainably safe' concept argues that as a first step, the road system should be classified on the basis of the so-called mono-functional principle. Subsequently, an eventual flow system if desired, and a selected link system

should be adapted in accordance with the points of departure formulated in the concept.
If both these steps are taken, a substantial decrease in the number of traffic casualties will occur. Only then can the maximum effect of the 30 km/hour principle be achieved.

4.1.3. *Number and size realised of 30 km/hour zones in The Netherlands*

National inventory following first round of evaluation
In the scope of the first evaluation round, figures obtained from planning decrees centrally registered in 1986, showed that in the period mid 1983 - mid 1986, about 100 streets and almost 200 zones had been given a 30 km/hour status in 131 municipalities, that is, in more than 20% of the municipalities in The Netherlands (Ministry of Transport & Public Works, 1986).

Reference points based on surveys of municipalities selected at random
After this inventory, central registration became watered down. Developments, therefore, could only be indirectly followed from data obtained from periodical surveys among municipalities selected at random.
Data from a survey on the development of municipal traffic safety policies were used as an indication of the continued increase of the number of zones and municipalities in which zones were implemented.
In the period 1990-1994, all Dutch municipalities (over 600) were periodically asked to fill in questionnaires (Westra & Lourens, 1990, Oude Egberink & Lourens, 1992 and De Bruijn, Oude Egberink & Lourens, 1994).
The response was roughly 50%. Larger municipalities were heavily represented in the response group; probably in these municipalities traffic safety policy had already achieved a higher degree of independence.
In 1992, it appeared that about half the responding municipalities had implemented one or more 30 km/hour zones.
About one-third were considering converting residential link roads, or had already done so. In 1994 it appeared that about half the responding municipalities were considering barring cars or reducing the number of cars from residential areas. Also in 1994, almost two-thirds of the responding municipalities appeared to have implemented 30 km/hour zones.
Meanwhile, the number of municipalities in favour of converting residential link roads into 30 km/hour streets had risen to about 45%. These figures alone clearly indicate an increasing willingness on the side of municipalities to extend the 30 km/hour limit.

Another reference point to go by was the SWOV study of 151 30 km/hour zones selected at random in more than 70 Dutch municipalities (Vis & Kaal, 1993). This study involved approaching all 400 municipalities of 10,000 or more inhabitants with a written questionnaire. The response was also about 50%. Half appeared to have had introduced one or more 30 km/hour zones.
It was found that data from 72 municipalities appeared to be comprehensive enough to carry out a (rough) accident analysis. It can be assumed from the results of this analysis that the municipalities involved had already introduced one or more 30 km/hour zones.

Indication of development based on requests for subsidies
Apart from the aforementioned reference points, there are only limited indications known of further developments in the number of 30 km/hour zones and the number of municipalities in which they are being introduced. Due to deregulation and the regionalisation of traffic safety policy in The Netherlands, which gives local road managers responsibility for traffic safety policy and measures, central and uniform registration no longer takes place.

Registrations of requests for contributions from municipalities towards the cost of implementing 30 km/hour zones, give some rough indication of recent developments in this field. In the period 1986-1993, in a single province (comprising 95 municipalities), the number of zones appeared to have doubled and the number of municipalities with 30 km/hour zones to have increased to about 40%. In the period 1991-1995, in another province (120 municipalities), about one quarter of the municipalities had submitted a subsidy application.
It is not possible to ascertain from the data available whether all these instances involved 'new' municipalities.
In any case, it appeared from both registrations that the number of municipalities implementing 30 km/hour zones continues to increase.
The same is valid for the average number of zones per municipality.
Moreover, it is quite likely that zones are implemented without subsidy. These zones would, therefore, only be registered at local level.

Estimate of current number and size of 30 km/hour zones
If we base our figures on the aforementioned reference points and indications, it is reasonable to estimate that in the meantime three quarters (about 450) of the municipalities have implemented one or more 30 km/ hour zone. Assuming the available data is reasonably representative, it can be deduced that 20% of these municipalities have an average of seven 30 km/hour zones, 30% an average of three and the remaining 50% at least one. Hence, 450 of the circa 600 municipalities, should have at least one 30 km/hour zone inside their boundaries.

Following on from these figures, we can then deduce that there are about 1,300 30 km/hour zones in The Netherlands. Perhaps this estimate is rather optimistic since the smaller municipalities have also been included, although relatively few formal 30 km/hour zones will have been implemented by them.
A possible overestimate is partly compensated by the fact that zones with comparable features, but not with the formal status of a 30 km/hour zone, have not been included.

In the Vis & Kaal study (1993) - again assuming the 30 km/hour zones in the 200 responding municipalities were reasonably representative - the average area is given as 15 ha and the average road length as 4 km. This would again mean that all the 30 km/hour zones in The Netherlands put together take up 20,000 ha and form a road length of 5,000 km. Seeing that all roads in the built-up areas in The Netherlands come to about 50,000 km (Road Statistics; CBS, 1992), an estimated average 10% of the urban road system has already been converted into 30 km/hour zones.

In comparison, the same source gives the number of 'woonerven' in The Netherlands as more than 6,600 with a combined length of more than 2,000 km.

Assuming that, on the strength of the recently developed concept of a 'sustainably safe' urban road system, about 80% of the roads in built-up areas will, in time, be designated as 30 km/hour regimes (Roszbach, in preparation), we can therefore expect road conversions on a large scale in the next few years.

4.1.4. *Modern roundabouts favourable for road safety*

Experience in various countries in the EC has taught us that the majority of problems arising with regard to flow and road safety could be reduced through the application of roundabouts, also inside built-up areas. On this moment nearly each municipality in The Netherlands have been realised one of more new style roundabouts. This modern roundabouts offers a considerable reduction in the number of accidents and road accident victims, while it also enables an improved traffic flow.

The SWOV carries out a first accident study in 1990 related to 46 roundabouts. Although emphasis was placed on road safety, the study also considered the effects on traffic flow. The capacity of roundabouts with no more than a single lane on the connecting roads and the plaza itself proved to be relatively high. Compared to traditional intersections the new roundabouts are very safe. In 1990 the SWOV found a reduction of about 50 % in the number of accidents and a more than 75 % reduction in the number of victims. Head-on-collisions diminished and pedestrian crossing were also simplified. But to a significant extent, the gain in safety was also due to the drop in speed shown by the motorised traffic. No statement could be made about which types of engineering facility were most suitable for cyclists and moped riders.

A second study was carried out by the SWOV in 1993 related to 201 roundabouts. These roundabouts were all constructed on the basis of the new priority rule (priority to the traffic on the roundabout), with one lane and radially oriented access roads. Two man subjects were investigated: First the safety level after conversion of an intersection to a roundabout, and second the differences in safety between the various designs. The second point devoted particular attention to the three possible engineering facilities catering to cyclists and moped riders: a separate cycle path, a bicycle lane on the roundabout or no specific facility.

The substitution of an intersection by a roundabout (also intersections controlled by traffic lights) gives a reduction of 47 % in the number of accidents and 71 % in the number of victims (after trend correction!). A large reduction (about 90 %) in road accident victims was noted amongst occupants of passenger cars and pedestrians. For cyclists was this only 30 %. It was also noted that when comparing the three types of engineering facilities no significant differences in the number of accidents could be demonstrated. Based on the registered number of casualties, it was determined that at a daily traffic volume of over 8000 motor vehicles a separate cycle path scores more favourably than both other types of cycle facility.

At lower intensities, it was not possible to indicate which facility was preferable for cyclists. Selection should be based on the design of the connecting roads.

A specific point concerns the regulation of the priority for cycle traffic on separate cycle paths around roundabouts. In a follow up study of the SWOV in 1994 the road hazard on 17 roundabouts where cyclists have priority was compared with the road hazard on 62 roundabouts where cyclists do not have the right of way. It was determined that more accidents and road accidents victims were registered, on average, on roundabouts where cyclists (and moped riders) had the right of way. More than 90% of the victims related to cyclists and moped riders. The large variation in the number of accidents and victims represents an indication that the design and organisation of the roundabout could have a major influence on safety where this priority rule applies. Apart from the safety, the priority rule for cyclists deleted the capacity of very busy roundabout for motorised traffic.

A problem forms the change in priority for existing older and larger roundabouts. In that cases accident studies on roundabouts where the priority was amended, whether or not in combination with reconstruction, show a continuous fall in the number of accidents, while the number of victims, generally relates to cyclists and moped riders, sometimes increases. The opinion of experts is that the priority rule should be linked to a reconstruction of the roundabout in the sense of radially-oriented approach roads, tighter curves and narrowing of the carriageway. It is recommended to impose priority for traffic on the roundabouts for all roundabouts in the short term, provided that a safe solution for cycle traffic is ensured at the same time, in the form of separate cycle paths, flyovers or alternative cycle roads.

4.1.5. *Infrastructural measures for pedestrian protection*

Recently (in 1996) SWOV carried out a study of the effects of infrastructural measures in residential areas and certain types of through-roads in urban areas. This was a before-and-after study, in which a correction was made for autonomous developments based on data from control areas. The analysis used all injury accidents in which pedestrians were involved and were victims. A distinction was also made between measures applying to locations (there were 43) and those applying to areas (there were 136). The measures themselves were further divided into 23 different types or combinations of types (narrowings, humps, median islands, bendings outwards, buslocks, mini-roundabouts, axis realignments, and various combinations). The roads were divided into 4 types:

1. those with a daily motor vehicle volume of less than 2,700 and many crossing pedestrians;
2. those with a daily motor vehicle volume of less than 2,700 and few crossing pedestrians;
3. those with a daily motor vehicle volume of more than 2,900 and many crossing pedestrians; and
4. those with a daily motor vehicle volume of more than 2,900 and few crossing pedestrians.

In other words, roads that practically only occur in residential areas.
The analysis used data over the years 1983-1995. A period of about six months around the implementation was ignored. Apart from the developments of the number of accidents, the injury severity (Pedestrian Severity Index) and the cost-effectiveness was examined.

As far as the location measures were concerned (the 43), the decrease in accidents, based on a comparison with the actual number and the expected number during the pre-period, was approx. 6%. Here, the correction based on developments in the control areas was used.
Estimating in the same way the effect on accidents involving pedestrians and accidents with pedestrians as victims, there was an increase of 23% and 34% respectively. At a first glance this would seem not to be a positive result for pedestrians. Its basis is, as far as the numbers of accidents are concerned, rather small. There was a positive effect on the road safety in general. Although the severity index for pedestrians did not alter much, there was a slight shift from deaths to in-patients. Based on the costs of the study (for the measures as well as the victims) it means that the measures were cost-effective.

As far as the area measures were concerned (the 136), the total effect was a reduction in the number of accidents of approx. 26%. For accidents involving pedestrians and accidents in which pedestrians were victims, the reduction was 27% and 21% respectively. The severity index for pedestrians decreased by about 19%. The area measures in general had a positive effect on the number of injury accidents. The same also applies in the most cases of injury accidents in which pedestrians were involved. The pedestrian severity index also declined, and area measures were mostly cost-effective. This last conclusion is however based on a small quantitative basis.

Apart from the quantitative problems already mentioned, there were also a number of methodological problems with this study. This is why only general conclusions are considered valid. In general, area measures are more effective than location measures. This applies to injury accidents in general as well as injury accidents involving pedestrians. It also applies to the number of pedestrian victims and their severity index. Furthermore, it would appear that the more crossing pedestrians there are, the more effective the area measures are. Their costs, however, are generally higher. The cost-effectiveness index is therefore of a low value. It should also be clear that the amount of data available for this study was too limited to make a differentiate the effects of special measures.

4.1.6. *Sustainably safe traffic; from concept to implementation*

The Dutch Government has set quantitative road safety targets for the years 2000 and 2010. Despite measures in the field of legislation, road construction, passive safety of vehicles, influencing traffic behaviour, and stimulating regions, provinces, municipalities etc. in their activities regarding traffic safety; the number of traffic victims has not markedly diminished.
Therefore the SWOV introduced a new approach: the 'sustainable safe concept'. A long term concept for the implementation of a considerably

safer road traffic system. The vision is that pursuing the till then followed policy, even with greater intensity, does not offer sufficient perspective to achieve the road safety targets of the Government. The new system should drastically reduce the probability of accidents in advance, by means of the structural design. Where accidents still occur, the severity of these accidents should be diminished to such an extent that serious injury is virtually excluded.

In 1996 the SWOV elaborated on the concept of sustainable road traffic safety in a way as to derive operational implementation strategies. In the presented strategy was given attention to

- the relative priority of road design, as compared to the other components of traffic system;
- its translation on various hierarchical levels: local design, specifying categories of roads, structure in road network;
- the position of rules and regulations in road design, taking properties of man and vehicle into account;
- the combination of 'bottom-up' and 'top-down' approaches: local experimental or demonstration projects versus adaptations of the road network on a national scale;
- the importance of phasing and the development of implementation trajectories.

The conclusions led to selected measures and composites of counter-measures as first phase programme or initial version. In the forefront was the combination of feasibility in the short term and stepwise contribution to longer term goals. Low cost effectiveness served as a criterion for inclusion.

The measures should concentrate on redistribution of traffic and redesign of the road network. As first and relatively modest step; uniforming the priority rules, extension to large scale of 30 km/hour zones, a limited set of physical structural road measures.

In order to specify, a phased plan of implementation is needed. This is as follows:

- First, carry out those measures which, as a result of studies carried out, appear to be cost effective.
- Then, set up and distribute temporary guidelines for categorising and design of the road network.
- Make an inventory of experience with, e.g. demonstration projects.
- Adjust guidelines based on experience.
- Introduce Road Safety Effect Reports and AUDITS.
- Then, make decisions based on previous experiences with, among others: categorising, low cost, short term measures, decision making for the middle and long term.
- Finally; plans for monitoring, evaluation, and any necessary adjustment of the implementation plan.

The most effective way is to set out the strategic lines clearly. Diffusion and divergence are practically unavoidable because of the many and variable levels of responsibility and actors, and the extremely complex lines of communication. These can even be unacceptable to the actors involved and society at large. However, too much divergence in the starting points makes the process of implementation uncontrollable.

4.1.7. *Urban network and the role of the infrastructure in residential areas*

To develop a sustainably safe road network, the structure of the network is essential. A sustainably safe structure must address the road safety goals accessibility and quality of life. Investment and upkeep costs must not be ignored.
The complete urban structure is determines to a large extent the accessibility structure of urban residential areas. On the other hand, there is also a relationship between the total urban road network structure and that of the surrounding regional and national networks.

The most usual basic distributor systems are known under the terms: the grid, the tree, and the limited access structures. To determine the road safety, the following indicators play their role: total number of vehicle kilometres travelled, the route speed, traffic volumes, and crossroad density. In general, the grid structure has the shortest journey time, but the most connections with the surrounding road network. The tree or limited access structure have an average journey time 30% less. The tree structure usually has the least number of junctions. T-junctions are generally safer than ordinary crossroads. They are more frequent in limited access and tree structures.

The accessibility is largely determined by the necessary detour distance. A journey along a grid structure is usually longer and a ring road route in a tree structure is often even longer. As far as accessibility is concerned, the grid structure is preferable.

The distribution of the traffic over the area structure depends on the network density and the number of crossroads. The densities per structure do not vary much. The crossroad density also, to a large extent, determines the quality of life. In general, the grid structure has the most crossroads, and the tree structure the least. The grid structure offers the greatest number of possibilities for an equal traffic distribution and therefor relatively the lowest volumes.

Conclusion
Generally speaking, the limited access structure is preferable. Up till now, many attempts have been made to build a model, based on which trustworthy prognoses could be made of the number of accidents to be expected in a newly designed residential area. Up till now, however, not one model complies to all operational conditions. In 1988, SWOV (Van Beek, 1988) carried out an accident analysis in 20 residential areas in 6 middle-sized to large (100,000 to 600,000 inhabitants) municipalities. He compared the actual number of accidents with the numbers calculated by what seemed like a very promising model. This comparison showed that a universal, useable, and valid model had not yet been found. What did seem possible, as a byproduct of this study, was to calculate the actual, annual number of accidents per 1,000 inhabitants of that area. For the tree structure this number lay in the range 1.61 - 6.87; for the loop structure 3.22 - 7.63; for the fence structure 4.87 - 8,02; and for the hierarchical structure with long uprights (actually a fence or grid structure with unequal stretches of road) 7.60 - 19.33.

These numbers should only be regarded as indicative. They are based on a rather limited basis of only 20 residential areas; and it is not sure that these were representative for residential areas in Dutch cities in general. At first sight however, they are not contrary to the theoretically assumed results. Integrated research is therefore necessary to form a definite judgement about the influence of the distributor structure on the indicators safety, accessibility, quality of life, and costs. This in relation to the indicators mentioned, aimed at network variables. Simulation techniques can be considered for this, followed up by empirical testing.

4.1.8. *Demonstration and example projects as instrument for the implementation route for the sustainably safe road traffic concept*

In order to allow the implementation process to run smoothly and to increase the experiences and knowledge in the short term, the Dutch government has set up a number of demonstration and example projects in a variety of situations. It also provided support during execution. The projects were distributed around the country. They have to have a good example function, and deliver a contribution to (and extension of) the experience with (and knowledge of) the implementation of the sustainably safe concept. The projects have to illustrate, in the widest possible sense, the positive effects of the new approach. The results have to be recognisable and to be capable of being generalised. If they meet the necessary requirements, the executor (e.g. a provincial or local road authority) can obtain financial assistance, for the execution, from the national government. It is important to choose the right evaluation instruments, whereby attention can be paid to the process as well as the product criteria. The sustainably safety concept was first operationalised to help the planners.
In the first instance, more than 70 projects were announced. Approx. 25 came through the first round of selection. Seven projects were finally accepted. This choice was based on the scores of the process and product criteria which had been previously drawn up, and with the money available as a condition. Monitoring and evaluation have, at this moment in time, not yet been completed and reported. Based on experience up to now, there are preliminary signals which indicate that monitoring and evaluation are not without their problems.
Many municipalities have been stimulated to set up and execute plans for sustainably safe projects. This is due to the publicity for demonstration and example projects. If they are suitable as example projects, they will all be bundled in an idea book for local road authorities, politicians, designers, and executors. This bundle will contain examples referring to:

- Categorising the urban road network to a sustainably safe urban structure.
- A plan in stages for restructuring the road network.
- Through roads with a sustainably safe design in urban (residential) areas.
- Installation of large scale 30 km/hour areas in practice.
- Sustained modelling/designing of distributor roads.
- Design and reconstruction to sustainably safe urban sections of through roads.
- Urban structure oriented towards public transport network.
- Installation of complete satellite cities following the integrated guidelines of the sustainably safe concept.
- Set up and realisation of municipal road safety and mobility plans in the perspective of sustainably safe.

- Integrated public transport systems.
- Public transport bedded in a sustainably safe traffic and transport system.
- Development and execution of bicycle networks, in combination with stimulation of bicycle use
- Restructuring of city centres into areas of limited car access or even carless zones.
- Development and realisation of specific pedestrian areas.
- Tackling aggressive and dangerous traffic behaviour.
- Computerised and intensifying speed control.
- Imbedding of traffic education at school and in the municipal policy.
- Development and stimulation of proficiency training for specific groups of road users.
- Lowering of insurance policies if certain courses have been followed.
- Stimulating joint financing of infrastructural measures with companies.
- Stimulation of local peoples' involvement when restructuring residential areas and their speed limit measures.
- Application of intelligent and flexible telematica for speed control.
- Installation of bus routes through specific residential areas, possibly using telematica.
- Stimulation of cooperation groups between the various local "actors" involved in road safety.

By presenting these examples, the government is trying to promote the exchange of experience and knowledge between the various 'actors' involved, thereby supporting the path of implementation.
Commissioners and executors of the various projects are using this bundle of examples to encourage evaluation in one form or another. Most of the projects are at this moment in time (1997) in the execution phase.

5. Evaluation and monitoring

5.1. Evaluation of the effect of a cycle network; lessons and learning from experiences to apply in integral urban traffic safety policy

'Cycling city, starting today', with this message the final links in the Delft cycleway network were put in place after five years of construction works, costing 29 million guilder (inclusive 14 million of the Ministry of Public Works). Delft is a city in the West of The Netherlands, in the neighbourhood of the Hague and Rotterdam, with a population of over 90.000 inhabitants (14.000 students) and million visitors to its historic centre every year. Cycling was already common practice in Delft, accounting for around forty percent of urban trips. Delft wanted a cycleway network and the transport Ministry hoped to profit from the experiences in Delft. The prime aim was to maximise cycling share in urban travel and to make cycling as safe and pleasant as possible.
The Ministry's involvement reflected the need to test out the new ideas for a full fine-mesh network and not single routes. The Delft networkplan included a wide range of measures designed to create a comprehensive cycleway network. Its structure was to be hierarchical, comprising city, district and neighbourhood sub-networks with distinctive functional and design features.

The duration of the project was 6 years (1981 - 1986). It concerned a network at the level of city, district, and neighbourhood areas. Important starting points were: the routes as short as possible, filling in missing routes, laying out newly desired routes, removing one-way traffic for cyclists, barriers for main arteries, removing railway lines and canals, installing two-way cycle paths here and there, and constructing various short-cuts. For the main road network a mesh width of 400-600 metres, for the district network 200-300 metres, and for the neighbourhood network 100-150 metres. Where necessary, building tunnels, bicycle flyovers and junction reconstructions. Furthermore, designating districts as control areas.

In 1985 (DVK, 1987) the first evaluation study was carried out. This answered the following questions:
- Have the chances for using the bicycle increased considerably?
- Can the approach be described as large scale?
- Have (in the whole of Delft) the facilities for cyclists reached a new level?
- Can the plan serve as a example to be followed by many municipalities?

In the meantime the first study is now several years behind us and the one has got used to the idea. It is of interest to examine to what extent the permanent effects are visible.
In 1993 (Louisse, Ten Grotenhuis & Van Vliet, 1994) a new evaluation study was therefore carried out in order to:
- Establish if there is more and safer use of the bicycle in the long term (instead of car use).
- To get an idea of which permanent effects such large scale, central government investments have. This especially on the way municipalities

structurally shape their cyclist policy and what charismatic influence they have ion other municipalities.
- Find out if the general attitude towards the use of the bicycle has changed.
- Find out which parts of the plans have been realised, what the distribution of costs has been, and which partners have contributed.
- To test the quality of the road network against the criteria which in the meantime had been fixed.

There is no significant effect on bicycle use in comparison with other cities. There has maybe been a positive effect in the study area itself, but not through the whole of Delft. Neither has there been a permanent change in comparison with the control area. The number of trips with the bicycle has remained more or less the same, but the average number of kilometres travelled has increased slightly. The number of trips by car appears to have decreased slightly in Delft, neither could this effect be supported by district data.

There was a slight decrease in the number of bicycle accidents in the study area, compared with the control area; but neither did this effect did not appear to be permanent. However, the number of accidents per distance travelled did decrease, because the average trip distance increased. In contrast with the expectation, the number of bicycle accidents and cyclist victims actually decreased less than in comparable cities, the province of South Holland, and The Netherlands as a whole.

Finally a number of suggestions as to the cause of the disappointing results in Delft.. The subsidy meant an impulse for investments for the bicycle, but after the project had finished, the policy of the municipality reverted back to the old level. It appeared that too little attention had been paid to the facilities at the places of origin and destination (e.g. bicycle racks, security against theft etc.). The quality of the bicycle network seems to be lower than the present day standard, the comfort is inferior, and not clearly visible for the cyclists. There was no consistent choice in favour of the cyclist, as far as right-of-way questions were concerned; on the contrary, the car was often chosen. No structural measures were taken to discourage car usage (the push is missing from the push-and-pull).

Based on both evaluations, the following lessons can be learnt:
- A cyclist policy only aimed at the design of the road network has no long term effect: no significant increase in the use of the bicycle with a decrease in the use of the car. So continue both push and pull.
- Large central government (financial) support does not automatically lead to structural change in the policy and budgeting by municipalities.
- A temporary project does not lead automatically to a greater, long term safety for cyclists, nor better and more conscious choosing for the bicycle.
- The quality of the cycle network needs to be adapted continuously to new insights. Investments are also needed for origin and destination facilities.
- More investment is needed for publicity campaigns, aimed at the public and the road users.

Finally a remark is due that the project did fulfil a pioneering role, abroad as well as in The Netherlands. Delft, however, has only fallen backwards!

In the meantime, other Dutch municipalities have finished bicycle projects. The following examples will illustrate the situation:
Houten is a relatively fast growing municipality near Utrecht (De Jong & Bosch, 1991). Its starting point for shaping the structure was to give priority to the bicycle in combination with public transport (chiefly the train). The structure consists of a number of residential areas around the railway station. These are surrounded by a circular road for motorised traffic. All the necessary facilities for the inhabitants are inside the circular road and are easily accessible by bike. Direct car traffic between the residential areas is not possible; it has to use the circular road. The main road network has a mesh width of 300 x 300 metres. The radially designed secondary network has a mesh width of 150 x 150 metres. An interim evaluation showed that cycling was c. 20% more than the national average. The number of road accident victims among cyclists was clearly below the national figure. Speed measurements in the residential areas showed that 85% of the cars were travelling at 30 km/hour or less.
Another positive example is the municipality of Helmond (population of c. 75,000). The car possession there is higher than the national average. Most of the urban destinations and facilities are within cycling distance (a maximum of 7 kilometres) of one another. Considering this, the municipal government aimed at achieving a cultural change in favour of the bicycle. They therefore assembled a cycle path network, 3.5 metres wide, with non-stop main arteries. On this network, cyclists have right-of-way above the motorised traffic. Wide support for cyclist-friendly policy had grown within the municipality. This resulted in bicycle usage being strongly promoted. This lead to use of the bicycle for travelling to and from work which was above the national average. Furthermore, such a cycle project was highly valued by cyclists.
At this moment in time (1997) a number of Dutch municipalities have developed a positive policy towards the bicycle. The examples dealt with here could be extended with many other cycle projects. Most of the larger municipalities pay explicit attention to the infrastructure for the cyclists in their urban road safety plans.

5.2. Monitoring of a large scale demonstration project; a standard for an evaluation plan

The region West Zealand Flanders (part of a province in the south-west of The Netherlands, on the Belgian border) is allocated as a pilot area for a fundamental approach towards road safety problems, also in small urban areas, as part of a plan to stimulate the new 'sustainable safe' approach. The Ministry of Public Works has asked the SWOV to supply a monitor system, together a scenario and time scheme. This monitor plan should serve as a manual with which project offices can set out and supervise the monitoring activities.

The monitoring system consists two main sections: process monitoring and effect measurements. The measurements concern changes to the infra-structure, in traffic behaviour, particularly the speed behaviour and the influences on attitudes in the traffic and the support of information campaigns, education and other communication activities.

In addition, the progress of the activities and implementation of the sub-projects should be determined, so that these can be adjusted in time if necessary. The effect measurements are distinguished into short and long term measurements. The short term measurements are performed periodically and divided into measurements for the entire area and for measurements for sub-projects. The infrastructural measures are tested as supplement to the sustainable safe design principles. This requires a zero measurement before implementation of the measures.
A second measurement is held later, in any case after implementation of the package of measures. The long term effects measurements are distinguished on the basis of design principles relating to functionality, design and recognisability of the road network. In principle the following information for each effect measurement is given: objective, anticipated effects, indicators as measurements variables for the effects, the measurement set-up with measurement instruments, source data and method of analysis, a product description, the planning with efforts involved (time and costs) moments of decision making and relations with other monitoring activities.

5.3. Recent developments in knowledge about cycle measures and infrastructure

With 'Sign up for the bike; design manual for a cycle-friendly infrastructure' (C.R.O.W, 1993), a detailed design guide appeared for the first time. In 1997 this design manual was evaluated regarding aspects such as: topicality, usefulness, and accessibility (for the road authorities). Its most important goal was to find out if topical developments discussed in the manual needed rewriting. Literature and documents of the period 1993-1997 were used. This consisted of: handbooks and guidelines, evaluations of measures and policy, overviews and descriptions, and developed conceptual approaches.

The boom in research and activities in the period before the compilation and publication of the design manual for the bike, is now behind us. The Master Plan Bicycle of the Ministry of Transport (1990) is certainly a result of the stimulating effect of this manual. This Master Plan has, in its turn, resulted in the appearance of many descriptions of practical examples, demonstration projects, and step plans for design and installation of urban network plans. Only a few evaluations have been carried out to give an insight into the cycle policy followed, the implementation path, and the effects on the increase in the (safe) use of the bicycle. Quantitative evaluation studies still appear to be difficult; the necessary data are often absent or not available.

The Netherlands is the classical example of a cycling country. Cyclists often occupy a prominent place in urban traffic. They can also often replace the car in urban areas. That is why the Master Plan Bicycle was compiled in the nineties. Recently (1996) the Project Group Master Plan Bicycle had evaluated the activities in the period 1990-1995. Many pilot projects, demonstration projects and a lot of supporting research has been done and extensive investments have been made. The general tendency, however, is that the use of the bicycle (e.g. as alternative to the car) has not increased much. Use of the car has also not decreased much. There has been a positive change in attitude towards the bicycle. Practically every self-respecting, large municipality has a plan for an urban cycle network, either in the make or already being implemented.

With the concept of a sustainably safe traffic system, attention is still being paid to a safe inclusion of bicycle and pedestrian traffic. An important point of discussion is the design of meeting points with motorised traffic. In the context of C.R.O.W, various options and suggestions are, at this moment in time, being worked out further so that road authorities can be offered guidelines and choice sketches.

A rather depressing final conclusion is that the improvement in knowledge is still insufficient to answer all the questions of the early nineties. There is still a need for schematic models whereby road authorities can choose the safest design. Those already existing leave the road authority with too many questions.

5.4. Effects of an Intensive Scheme: Campaign -25%.

The campaign started in 1987, with the objective of involving municipalities in counteracting road hazard and to encouraging them to develop more traffic safety activities. An initial evaluation led in 1990 to continuation in a modified form. Also this amended plan is now evaluated by the SWOV.
The principle of the campaign was that, in response, municipalities would formulate more and better policy in the field of road safety and realise better implementation. The question was if the campaign and the associated project subsidies led to more and better road safety policy, and would that policy ultimately be expressed in terms of a reduction in the number of road accident victims. It was also queried whether such a reduction could be demonstrated through an accidents study.
The governmental policy makers assumed that the campaign envisaged an enhancement and improvement of municipal road safety policy with respect to: the amount of administrative and political attention devoted to road safety, the level of knowledge related to road safety, the level of thoroughness of road hazard analysis performed, the concrete application of locally specified objectives in the field of road safety, the quantity and quality of plans, the policy performance delivered in the field of information campaigns and education, the level of financial support and finally, the degree of cooperation with external influencing factors.

The knowledge relating to road safety as utilised in the process of policy preparation has certainly improved. The campaign has offered favourable results for the quantity and thoroughness of local road hazard analyses, where in general an improvement can be noted. Also the evaluation shows that the municipal road safety objectives have hardly undergone any change. They have not been formulated in a concrete fashion in most cases. Also with respect to an increase in the number of road safety plans, only a limited number of objectives have been achieved. Insofar plans were made, an improvement in quality was noted. Also a growth was noted in the number of policy achievements in the field of education and information supplied. The anticipation that the campaign would lead to municipal budgets setting aside more funding for road safety was not realised fully. In particular, the cooperation with regional authorities increased.
The financial instruments of the campaign, start-up funding, achievement premiums and project subsidies, did not all prove equally successful. A change in application of this instrument may have a greater effect.

The supply of information can be considered successful, and can even gain in value by also focusing on specific target groups.

In the accident study three groups of municipalities are compared: most active, average active and not active municipalities. The analysed period was 1987-1992. The study was not able to offer if there is a clear relation between the development in the number of road accidents victims and the level of activity of the municipalities. It is possible that this can also attributed to the approach selected and the method of analysis in the explorative part of the study. Nevertheless it can not exactly what the effect of the campaign is on the degree of road hazard in the involved municipalities.

6. Summarising conclusions

6.1. The road hazard problem in The Netherlands

In order to be able to study road safety, and to keep a finger on the pulse, it is of the utmost importance to have a valid registration of (the relevant variables of) road accidents, those involved, and the victims. This registration must be as complete as possible but, above all, representative and reliable. In The Netherlands, as in other western countries, the registration level has declined a lot. The regularly available data from the registration by the police is no longer considered sufficient for scientific research needs. The combination of linkage en/or matching of the accident data to other databases, together with periodic additional research, our insight into the real size of the road safety problem has lately increased. It is now clear that the regular registration in the form of police data is but a fraction of the reality, expressed in accidents and victims. Plans to improve the police data have existed for some time.

During the last 10 years, a combination of an increasing mobility and increasing road safety has lead to see it differently. This tendency could already be seen, among other, in the form of a rather constant reduction of the total number of road accident victims. This lead to a reduction in the risk; measured as the number of deaths per kilometre travelled (the so-called Death Rate). The reduction in the number of victims seems to have come to a halt. The ministry's quantitative goals (expressed as a certain reduction in the numbers of deaths and injured) have become difficult or impossible to achieve. Maybe it is now too early to speak of an actual break in the trend; from a decrease to an increase. However, all those involved in achieving these goals should look at this seriously. The development gives us every reason to adjust or change the policy.

Car occupants, seen in absolute numbers, are still the largest group of road deaths and in-patients. Cyclists occupy the second place. Lorries etc. are a 'bad' collision partner; they have c. 6% of the total number of kilometres travelled, but 15% of fatalities had a heavy motor vehicle as collision partner. Mopedists have the highest traffic risk; followed by motorcyclists, cyclists, and pedestrians. A large share of the accidents of the above mentioned groups occur inside the built-up area; in urban areas.

Nearly 70% of all injury accidents occur inside the built-up area. Victims of accidents outside the built-up area are mainly from cars, delivery vans, and lorries. The greatest numbers of the following groups are victims of accidents inside the built-up area: motorcyclists, mopedists and light mopedists, cyclists, and pedestrians. Their shares are 57%, 81%, 84%, and 90% respectively. The urban road safety problem is thus concentrated on these groups of road users. They are generally referred to as 'vulnerable road users'.

Finally, it would seem that the cost of road safety in The Netherlands can be estimated at Dfl. 8,000 million; this is approx. 2% of the Gross National Product (GNP). Apart from the unspeakable suffering that road accidents

bring, it would seem that their costs are also increasing. This is also therefore a strong argument for intensifying the efforts to improve road safety.

6.2 The changing policy in The Netherlands

During the last few years a number of different developments in road safety policy have been signalled.
In the first place, most of those professionally involved are now convinced that road safety is not exclusively the responsibility of the government, nor that of just one ministry. For years, traffic and everything to do with it, has been considered to be the business of the Ministry of Transport. It is nevertheless abundantly clear that road safety has many overlaps and is strongly related to the policy areas of other ministries. During every decision making process which can influence road safety, this last aspect should be made visible and be explicitly addressed and considered. Road safety should not only be a matter of sectoral policy, but should also play its role in facet policy. This should make itself visible in the policy goals of the various ministries where road safety one of the aspects is. For example, the Town & Country Planning policy and the environment.
The basis for a sustainably safe traffic and transport system is already being laid during the phase of Town & Country Planning. This presents an excellent integral framework. The two policy areas are closely linked. The relationship between mobility policy, localisation policy, and road safety are to a large extent already determined at the structural level.

Instruments for a mobility policy at the urban level are, among others: the development of a quick and reliable public transport, combatting (unnecessary) car traffic, and stimulating the use of public transport and other alternatives for the car, such as the bicycle. It is possible that the nature and volume of motorised traffic can be influenced by location policy (removing or moving objects attracting traffic), parking policy (making parking more expensive, reducing the number of available parking spaces), stimulating company transport management plans, and alternative goods transport.

The situation in The Netherlands is that regional and structural plans are legally set down. The general lines of areal policy are formulated, the choice for the various functions is set down, and the main structure for traffic is indicated. A separate road safety paragraph should not be absent! A checklist has been developed for integrating road safety at the structural level. This can be used during the planning process at moments when the functional choices for designing a particular area have to be made. These choices refer to: determination of various facilities, the road network and access structure for the various types of traffic, built-up area standards and densities, and similar aspects. The central government has commissioned several checklists, phase plans, and module books to be compiled and distributed to municipal decision makers and executers, in order to support them.

An integrated and effective road safety policy that is anchored in the policy plans of the various ministries involved requires interdepartmental consultation and coordination. This coordination often takes on the nature

of carelessness and a lack of commitment. We get the impression that hindrances are found more often at the organisational level than being a question of contents. The results of such consultations should be anchored in legal rules in order to reduce this lack of commitment. Controllable procedures for execution should be developed and agreements made should be formalised in, for example, contracts. The interdepartmental consultation concerning an integrated road safety policy, until recently, was the initiative of the Minister of Transport as the coordinating minister for road safety. Now it is carried out by the consultation bodies ISCRC (Interdepartmental Steering Committee Road Safety) and CCRS (Coordination Committee Road Safety). In spite of there being ever more structured interdepartmental consultation, it would seem that integration of road safety at the relevant policy areas presents a considerable difficulty. Seeing the large number of actors involved with the execution of the road safety policy, and the great variety of goals and vested interests, it is by no means simple to get all social and private organisations 'on one line'. Its implementation requires a steering/guiding hand and support by the central government; maybe even at Cabinet level!

Up to now, especially the horizontal level has been in focus. In recent years the aspect of vertical coordination has shown considerable shifts in outlook. In many policy areas (without exception of road safety policy) the impulse of decentralisation process has continued. The responsibility of organisation, implementation, and execution of road safety policy lies much more at the level of local government and/or road authorities. Good communication between central and local government is essential for the successful implementation at the national level.
This has been particularly clear during the recent introduction of the new vision for the approach to road safety; the sustainably safe concept should certainly be mentioned here. A faulty of fragmentary spread of knowledge can result in a divergence at the application level. In its turn, this could lead to differences of interpretation and a lack of uniformity in design and ways of application. The ultimate result, as is rightly assumed, could negatively influence road safety. Therefore, the central government has initiated a number of activities in the direction of local governments and private organisations. These activities are meant to improve the spread of knowledge and the exchange of experiences.
Examples of these activities are: recommendations, supporting stimulation actions using subsidies, compiling and distributing helping hands, manuals, design guides, checklists, phase plans for specific subjects, getting a policy information system developed, and many other stimulating and supportive activities, mainly aimed at local road safety decision makers and executers. In the near future, there will also be an INFO-point sustainably safe. This will fulfil the role of a central, national point for questions and exchange of knowledge and experience.
In order to strengthen the general support for the concept of sustainably safe, and to stimulate its correct implementation on a large scale, the central government has compiled and distributed a start document. This explains how the sustainably safe concept could be implemented step by step, which measures need priority to achieve this, and which effects can be realistically expected. This is all meant to achieve the policy goals for the years 2000 and 2010 which the ministry had already made known. In order to be able to keep the finger on the pulse, various sorts of policy effect reports have been

developed for road safety, the environment, and Town & Country Planning In order to prevent such report having a lack of commitment, they should preferably be given a legal status. The idea is to test various infrastructural designs by using the road safety criteria. This is based on the starting points of the sustainably safe concept (so-called Safety Audits), and is finding more and more support. If this type of road safety research be introduced, then there is also a legal basis for preventing the judgement that it is not obligatory.

6.3. Design and implementation of traffic safety measures and other traffic safety activities in urban areas

The lay out and street patterns of many Dutch cities and towns has a historical background. Whenever extension and restructuring of the built-up area and the urban road network are being considered, the protection of statues, streets, and buildings with cultural and historical value is taken strictly into account. It is clear that the enormous growth in mobility, and especially that of motorised traffic, has lead to many problems in many cities. The city centre has in many cases lost its original (and for the inhabitants attractive) functions. The accessibility of a large number of these facilities came under threat. Shopping centres appeared on the out skirts of cities because of parking problems. This created new car kilometres. The quality of life in residential areas threatened to become unacceptable because of the increase in traffic, their emission, and noise. The public opinion realised that the price paid for motorised traffic, in the form of annoyance and less safety, was too high. This meant that it was high time that national and local governments had to take action.

The mix of urban functions was no longer adequate. The first important distinction that was made was the division into traffic and residential functions. This approach can be traced back to the often quoted and applied SCAFT guidelines and Radburn principles.
After originally being successful, it appeared that this rather strict, functional way of dividing also had disadvantages. In The Netherlands, a reaction for typical residential areas came in the form of a development concept that, when applied, involved an integration of traffic sorts: the 'woonerf'. Because there were a number of objections during a relatively short blooming season, the 30 km/hour concept became an alternative to the 'woonerf'.
This concept has been introduced in various countries, in various forms, and with various names (traffic calming, tempo 30, etc.). Because of its success (an additional reduction in the number of road accident victims) this 30 km/hour model was applied in The Netherlands on a large scale.
After this, plans were made in which the whole built-up area, excluding the distributor road network, would become a 30 km/hour area. The following was therefore proposed: 1) not 50 km/hour inside the built-up area, unless otherwise indicated, 2) but 30 km/hour inside the built-up area, with as exception, 50 km/hour (or an occasional 70 km/hour) where that is indicated.
An important contribution to the road safety and the quality of life in residential areas is expected from this approach, which departs from the principle of existing traffic laws. The view is that this measure is relatively 'low cost' to implement; calculations which support this have been made

It is also expected to be cost-effective, and suitable for the step-by-step introduction. Achievement and maintenance of the speed limits mentioned should be guaranteed by the design of the road network or by introducing infrastructural facilities. A large number of design elements have been worked out in detail in the ASVV (C.R.O.W, 1996) mentioned in § 3.2.4.1.

In the future, in urban speed control, it would seem that there is a role for intelligent and flexible speed regulators. A number of experiments have already started. Evaluation has not yet taken place. Furthermore, the experiments are of a limited size. Experiments are being carried out using various enforcement systems. Computerised systems play an important part. Speed control facilities of an infrastructural nature are being developed for that part of the urban road network which has been designated as through road. Various forms have also been adopted in the ASVV. Specific recommendations have been made for traverses through (a number of consecutive) city/town cores. These are roads partly with motorised through traffic.
These recommendations can be achieved by following a step-by-step plan. The roundabout using a modern shape is a successful solution to crossroads. This construction appears to be advantageous for the traffic flow as well as the road safety.

The most recent visionary approach to road safety in The Netherlands was introduced under the concept 'sustainably safe road transport system'. This has been explained in many places in this report; in the appendices the background of this concept are explained and the essentials discussed! Implementation of the concept is taking place at the national level as well as the city and town level. An essential part of the concept (for urban application) is to categorise the whole urban road network in a limited number of mono-functional road categories. In the meantime, a guide book for categorising the road network in a sustainably safe way has been published. The method described in this guide book is based on consensus and broad support from traffic experts (C.R.O.W, 1997). The initial note discussed in § 4.1.6. was the starting point for the first step on the road to larger scale implementation of the new vision in practice.
It is expected that this will start a further decrease in the number of accidents.

6.4. Evaluation and monitoring

Large scale evaluation studies, in which the effects of measures are expressed in terms of reductions in the numbers of accidents, fatalities, and injured, are rare. This is especially true if the measures are in largely residential area. Here there are relatively few accidents with relatively few victims. Such studies are also hindered by the general problems of evaluation research. These are:
- a lack of sufficient measurable and quantifiable data concerning the before-period as well as the after-period;
- a lack of data concerning comparable control areas, for excluding autonomous effects;
- a lack of insight into relevant area characteristics.

In the meantime, in The Netherlands, there are a large number of 'traffic calming' measures that have been put into practice. Examples of these are 'woonerfs', 30 km/hour areas, infrastructural road stretch measures, and roundabouts in urban through-roads. The number of 'woonerfs' is now about 6,600 having a total road length of more than 2,000 kilometres. Furthermore, there are more than 1,300 30 km/hour areas having a total area of 20,000 hectares and total road length of 5,000 kilometres.
Also, several hundreds of new-style roundabouts have been constructed. The total number of road accidents occurring on all these infrastructural changes, is regarded as sufficiently representative to justify a statement concerning the average effect in terms of the reduction of accidents and victims.

The average reduction of the number of accidents in the 30 km/hour areas is 10 to 20% of all accidents. The reduction of injury accidents is about twice this, and there are indications that the reduction is even higher for the seriously injured. There is however a large variation in the effects between the various areas. The reduction in the number of accidents and victims can vary from a few percent to 80%. The effects seem to be dependant on the extent in which the through traffic has been successfully removed and the originally high speeds driven have been lowered.
It is logical that in an area where a high level of safety already existed and where accidents hardly happened, introduction of a 30 km/hour area will not have a measurable effect in terms of an accident reduction. In fact, infrastructural intervention in such an area is not strictly necessary. Furthermore, it seems that various area variables in combination with the internal structure of an area influence the nature and size of the effect. These relationships need more research done.
Furthermore, it seems that area-wide infrastructural measures have in general a stronger effect than isolated interventions at separate locations. This last type of measure is often seen as 'low cost', but this is not the same as cost-effective! In the Dutch situation preference is often given to an area-wide approach. In special cases the rearrangement of complete routes has occurred. The choice in general has been for area-wide combinations of infrastructural facilities. This is why it has been difficult to reliably measure the effects of individual measures.

Because of the rapidly growing popularity of the roundabout (within a short space of time several hundreds were installed) it has been possible to conduct reliable effect research for this measure. In those situations where a crossroad was replaced by a roundabout, there was a reduction in the number of accidents, in comparison with the original situation, of approx. 50%. The reduction in the number of victims was even higher, viz. circa 70%. It made little difference if the roundabout replaced a regulated or unregulated crossroads.
A problem that has not yet been solved is the right-of-way question for bicycles and (light) mopeds on roundabouts. In any case, uniformity in the regulation is an important factor. If the bicycles and (light) mopeds have to share the right-of-way on the roundabout or not is still a point of discussion among traffic experts. Up till now the accident data points in the direction that it is more sensible not to give them right-of-way. Much depends on the design of the facilities to be introduced for cyclists and (light) mopeds.
The final word in the discussion of this question does not yet seem to have

been said. Further research can maybe convince all those involved. In this research, the various designs for the facilities for cyclists and (light) mopeds are the variables.

Furthermore, research has been conducted in The Netherlands as to the position of the mopedist on the road inside the built-up area. The results of the research that has been conducted up to now (1997) show that on roads inside the built-up area with a separate cycle lane, the mopedist can best be directed to use the road. It is in the interest of the safety of the mopedist (less conflicts with motor vehicles) as well as the safety of the cyclist (less conflicts with mopedists). This measure will maybe already introduced inside the built-up area in The Netherlands in 1997.

6.5. Final Remarks

The Dutch government has outlined the road safety policy for the future in which the realisation of a sustainably safe is aimed at. Within the framework of the implementation process strategic decisions must now be taken. The "Steering Committee Sustainably safe" plays a leading and stimulating role in this process. This steering committee, supported by research institutes such as SWOV, will take the lead, as far as contents are concerned as well as organiser.
Realising the above-mentioned sustainably safe traffic system is strongly intertwined with, and is more or less dependant on, achieving a consistent and systematically designed infrastructure.
It is also clear that the positive effects on the road safety of a thus categorised road network can only be completely generated when a large amount of the national road network is adapted in the spirit of the new vision. It is reasonable to expect that a smooth, step-by-step implementation at a national level will be more effective than a very intensive and complete implementation at the local level. The chance of large differences in experience between users of the local infrastructure meant and the other road users in The Netherlands, would only be detrimental to the aimed at clarity and recognisability of how a road looks to all road users.
For a well registered, consistent, and systematic implementation programme, the following is essential: there must be consensus and a wide acceptance by all actors of design guidelines which will serve as a starting point when categorising local infrastructures. Under the strongly decentralised road safety policy, the central government must continue to direct the main lines. This in order to prevent divergencies at a local level which are against the conceptual starting points of the sustainably safe concept, or could be disadvantageous for the road safety.
However, a one-sided direction process must not be created, because the momentary views about decentralisation could be damaged. This in its turn could have a negative effect on the support and enthusiasm at the local level. Local initiatives must stay, within certain margins, providing that the central level carries out tests referring to the starting points. Of utmost importance is (the organisation of) an effective dissemination of knowledge, offering the possibilities of exchanges of experiences (also at the local level), and availability of a clear testing framework.
From the previous considerations it would seem that a sustainable traffic system leans strongly on the shape of the infrastructure. It is also not so strange that, while carrying out the activities and example projects, the

accent was strongly laid on the infrastructural projects. This has also had its repercussion on possibilities for evaluation studies. These were also mainly (apart from the policy evaluations) concerned with projects with an infrastructural nature. The essence of the sustainably safe approach is however its integrated nature. Sustainably safe is not exclusively an infrastructural matter, although those projects that have been started until now, may give this impression. An urban road network, categorised according to sustainably safe ways and norms, should be supported by: 1) sufficient laws (for example a new Highway Code), 2) effective maintenance strategies, 3) designs for safer vehicles, and 4) application (and frequent use) of more and better safety devices (such as helmets, seatbelts, airbags etc.). Improvement of driving lessons, public safety campaigns, and education should also be part of the activities based on the starting points of the sustainably safe concept. Possibly in the not too distant future, electronic devices, in the vehicle and/or as part of the infrastructure, will contribute to the desired sustainably safe traffic system.

At this moment in time, the central government has developed the most essential instruments for allowing the local governments and road authorities responsible to carry on. The outlines for a strategy for a national implementation of the aimed-at sustainably safe transport and traffic system have been expressed. Priorities have been indicated for those activities and measures which are considered to be the most effective in the short term. The local governments, road authorities, town planners, and traffic engineers (in harmony after consultation) must now go to work!

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