Sustainable solutions to improve road safety in The Netherlands

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A 'polder model' for a considerably safer road traffic system

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Summary

The Dutch Government has set the following quantitative targets for road safety: a 25 per cent reduction in the number of road deaths and injuries by the year 2000 (compared with 1985 levels) and a further reduction of 50% and 40% respectively by the year 2010 (compared with 1986 levels). Various indicators suggest that road safety in The Netherlands is not showing enough significant signs of improvement and it is no longer certain that the aforementioned targets will be met, even if the traditional policy continued to be followed.

New, innovative road safety policy is required and in 1990 the SWOV Institute for Road Safety Research was invited by the Dutch Government to develop a scientifically supported, long term concept of a considerably safer road traffic system. The general concept of sustainable development introduced by the UN Brundtland Commission also inspired the new vision for road safety: no longer do we want to hand over a road traffic system to the next generation in which we have to accept that road transport inevitably causes thousands of deaths and ten thousands of injuries, year after year in The Netherlands.
A sustainably safe road traffic system is one in which the road infrastructure has been adapted to the limitations of human capacity through proper road design, in which vehicles are technically equipped to simplify driving and to give all possible protection to vulnerable human beings, and in which road users have been properly educated, informed, and, where necessary, deterred from undesirable or dangerous behaviour. Man should be the reference standard and road safety problems should be tackled at its roots.

Safety principles were identified as keys to arrive at a sustainably safe system (functional use of the road network, homogeneous use en predictable use) and based on these principles as a basically theoretical perspective the concept has been worked out.

Stimulated by a discussion in the Dutch Parliament, the concept of sustainable road safety has been adopted by the Dutch Government as an official part of its policy. Many other stake-holders supported the concept (other governmental levels and the 'road safety community'), although some doubts have been heard about financing the implementation and about possible side-effects. Furthermore, some differences how to translate the vision practically could be detected between road safety professionals.

Two major developments took place since the concept was launched.
A special Steering Committee prepared a so-called Start-up Programme covering the first phase of implementation. This programme will be introduced. Another important step was to implement different large scale demonstration projects in The Netherlands in order to enlarge our practical knowledge and experience on how sustainable road safety may be put into practice. Some information on these projects will be given and on traffic calming in The Netherlands.

Before making concluding remarks, some information will be given about how to finance a sustainably safe road traffic system and how application of new technology might fit in this vision.

Contents

1. Road safety in The Netherlands

Two indicators are regularly used as a yardstick to measure road safety: traffic safety and personal safety (Trinca et al., 1988; Wegman, 1995). Traffic safety - sometimes indicated in terms of fatality rate or casualty rate - is a measure of how safely the road transport system is performed. It is commonly measured in terms of deaths or casualties per 10,000 registered motor vehicles or per 100 million vehicle kilometres travelled. The other - personal safety - indicates the degree to which traffic accidents affect the safety of the population. It could be considered a public health indicator: the number of traffic fatalities or casualties per 100,000 population (mortality).
A third indicator is an estimation of the socio-economic costs of accidents (ETSC, 1997). Attaching monetary values to accidents, environment and travel time allows objectively assessing effects of changes in the road transport system. Socio-economic costs of road accidents comprise both the material (economic) costs and the immaterial costs (value for a lost of human life or injury). The total socio-economic costs of road accidents in the European Union amounted to 162 billion ECU in 1995 according to estimations made by the ETSC. Recent estimations of the total costs of road accidents in The Netherlands (medical costs, potential loss of production, damage to vehicles, administrative costs, costs of traffic jams and immaterial costs) resulted for 1993 in 12,353 million Dutch guilders (Muizelaar, et al., 1995).

	Number of road deaths	Road deaths/100.000 inhabitants	Road deaths/motor vehicle km ($x10^9$)
Australia	2017	11.2	12.1
Belgium	1449	14.3	18.1
Canada	3347	11.3	-
Germany	9454	11.6	15.7
Great Britain	3765	6.4	8.4
Finland	441	8.6	10.5
France	8891	15.3	17.9
Italy	7033	12.3	-
Japan	12670	10.1	17.6
The Netherlands	1334	8.6	12.0
New Zealand	406	16.2	
Portugal	2710	28.8	-
Spain	5751	14.7	-
Sweden	391	6.5	-
United States	41798	15.9	10.7
Total	101457		

Table 1. *Road safety indicators (1995) for different OECD Member States*

Table 1 contains the relevant data for some Member States of the OECD. For The Netherlands the following conclusions could be drawn: without

hesitation we may assess that The Netherlands fits in the group of countries in the North-western part of Europe which has a relatively good safety record. Furthermore, the most recent figures (1180 fatalities in 1996) leading to a mortality rate of 7.6 could partly bridge the gap between The Netherlands and the 'real top'.

Another interesting perspective is the development of the number of fatalities over time. In the long term, the growth of motorisation in many countries is accompanied by an decreasing curve for fatality rates. The percent decline per year differs from one year to the next and per country.

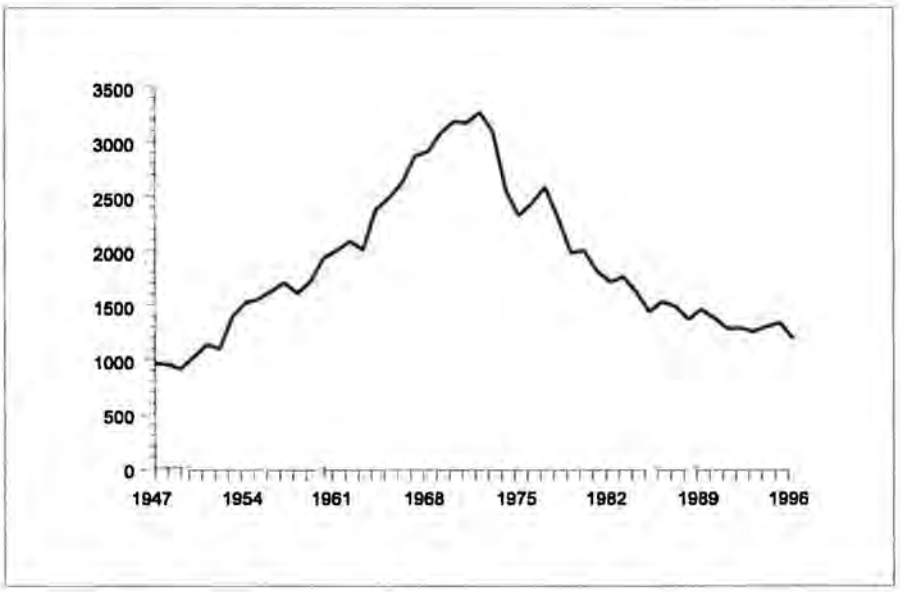

Figure 1. *Development of fatal accident numbers in The Netherlands.*

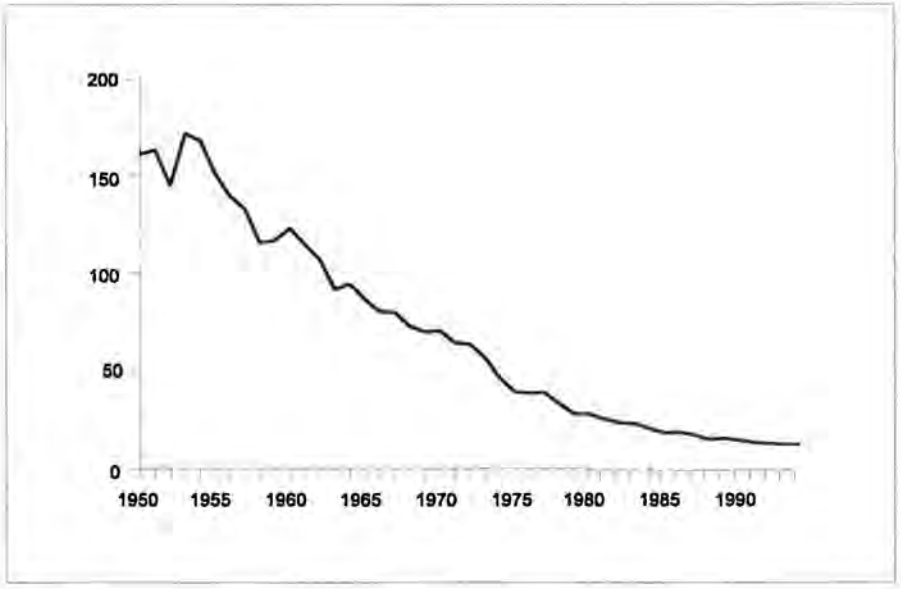

Figure 2 - *Risk development (fatalities/vehicle kilometres) in The Netherlands.*

Figure 1 illustrates the development of the number of fatalities in The Netherlands over the years and *Figure 2* shows the reduction in fatality rates in The Netherlands. We may conclude that from an all-time high in 1972 (3264 fatalities) the numbers reduced to about 1200 fatalities a year. But, we have to conclude that the fatality rate reductions have come down from something like 9% (1973-1985) to 2.5% (1992-1995). Combined with the mobility growth of about 3% makes it understandable that the number of fatalities remained more or less constant in The Netherlands the last few years.

2. Road safety policy in The Netherlands

"The price we pay for our mobility is still much too high." This statement could be found in the most recent formal document from the Dutch Government on road safety (Ministry of Transport, Public Works and Water Management, 1996a). In this document no new vision for road safety policy is developed, but the existing one is pursued to date. To characterise the Dutch road safety policy in a few words, the following one-liners could be given:

- quantitative road safety targets for the year 2000 and 2010;
- a spearhead policy: alcohol, safety devices as seat belts and helmets, speeding, hazardous situations, older and younger road users, heavy traffic);
- emphasis on the importance of involving provinces, municipalities and market parties in road safety policies;
- developing and implementing a sustainably safe road traffic system.

The Dutch Government has set the following quantitative targets for road safety: a 25 per cent reduction in the number of road deaths and injuries by the year 2000 (compared with 1985 levels) and a further reduction of 50% and 40% respectively by the year 2010 (compared with 1986 levels). Recent indications suggest that road safety in The Netherlands is not showing enough significant signs of improvement and it is no longer certain that the aforementioned targets will be met, even if the traditional policy continued to be followed (SWOV, 1996).

In a recent survey (Ministry of Transport, Public Works and Water Management, 1996a) amongst key stakeholders a picture was given how the implementation of policy can be improved and how the partners can contribute to this. The following picture was given:

- increasing mobility demands additional efforts to achieve road safety targets;
- concern exists about deteriorating road user behaviour and reduced levels of traffic law enforcement;
- implementation of sustainably safe road transport ask for more financial means, better understanding of the concept and more integration with environmental planning and general safety policy;
- decentralisation of road safety policies needs to further crystallise and the parties still have to become accustomed to their new role;
- development and dissemination of relevant information on road safety policies need to be improved.

SWOV made an analysis of recent developments in the field of road safety policies as well and came up with some recommendations as to what can be done, now and in the future and how it can be done (SWOV, 1996). 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 sooner tended 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.

SWOV has recommended a strategy to be adopted consisting of three parts:

- 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. 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 (Wegman & Goldenbeld, 1996).
- It should be ensured that road safety considerations are explicitly included and weighed at all levels of the decision making process affecting road safety - national, regional and local - particularly in the field concerning mobility and the infrastructure.
- The results and, hopefully, the successes 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 of time.

3. The concept of sustainable safety

The starting point of the concept of 'sustainable safety' is to drastically reduce the probability of accidents in advance, by means of infrastructure design and, where accidents still occur, the process which determines the severity of these accidents should be influenced so that serious injury is virtually excluded (Koornstra, et al., 1990 and Ministry of Transport, Public Works and Water Management, 1996b).

The concept is based on the principle that man is the reference standard. A sustainably safe traffic system has an infrastructure that is adapted to the limitations of human capacity through proper road design, vehicles fitted with ways to simplify the tasks of man and constructed to protect the vulnerable human being as effectively as possible, and a road user who is adequately educated, informed and, where necessary, controlled.

The key to arrive at a sustainably safe road system lies in the systematic and consistent application of three safety principles:
- functional use of the road network by preventing unintended use of roads;
- homogeneous use by preventing large differences in vehicle speed, mass and direction;
- predictable use, thus preventing uncertainties amongst road users, by enhancing the predictability of the road's course and the behaviour of other road users.

In a sustainably safe road traffic system, the *road user* represents the central element, the reference. He must be prepared to accept an infrastructure, vehicles, rules of behaviour, information and control systems, that may restrict his individual freedom, in return for a higher level of safety. If this willingness is not present, resistance will result. Perhaps by using 'social marketing' the willingness to accept all elements could be achieved. Freedom restrictions without good arguments should not be offered to the road user.

Education could and should play an important role in the transition period from the road traffic system of today to the sustainably safe system. The content of education could concentrate on the whys and wherefores of sustainable safety. Public awareness, public participation and education should create support for implementation and find their place alongside implementation of other key elements of this vision.

With respect to *vehicles*, the diversity of vehicles should be kept to a minimum. Furthermore, the various types should be clearly distinguished. When used in the same traffic area, vehicles should demonstrate the same behaviour as far as possible, or otherwise be provided with separate facilities. In the sphere of passive safety sustainable provisions to be mentioned here are those that work independently of the driver or the passenger: 'built-in' devices like solid passenger compartments of cars combined with crushable zones around and airbags (additional to the compulsory use of seat belts). Improvement of the front-end design of passenger cars to reduce injuries to pedestrians and cyclists are of relevance as well.

In the field of active safety a lot of progress could be expected from devices which provide relevant information to the road users, improve their observation or simplify their tasks (emergency manoeuvres). Emphasis is now being placed on the practical application of electronic equipment. A very interesting development is the so-called Intelligent Speed Adapter (ISA). This device prevents the speed of a vehicle from exceeding a location-specific maximum on the basis of electronic send signals from its surrounding. The technology for the components of this device are available; integration of these components is still needed. Two real problems have to be solved to gain public acceptance and support and to develop an introduction strategy.

The three safety principles (functional use, homogeneous use and predictable use) requires the specification of the intended function of each *road and street*. Roads are built with one major function in mind: to enable people and goods to travel, the so-called traffic function. Three options could be distinguished:

- the flow function: enabling high speeds of long distance traffic and, many times, high volumes;
- the distributor function: serving districts and regions containing scattered destinations;
- the access function: enabling direct access to properties alongside a road or street.

Besides a traffic function, streets and roads in built-up areas should allow people to stay in the vicinity of their house safely and comfortably. We call this function residential function and this function could well be combined with the access function.

The concept of sustainably safe road transport comes down to the removal of all function combinations by making the road monofunctional, i.e. by creating categories of roads: pure through roads, pure distributor roads and pure access roads. Multi-functionality leads to contradictory design requirements and also to higher risks. *Table 2* indicates the risk levels of different road types and from this we can learn that applying the safety principles, as has been done on motorways and in 30 km/h-zones, lead to relatively low risks.

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

Table 2. *Injury rates in The Netherlands (1986) on different road types*.

The differences between the existing approach to categorise a road network and the sustainably safe approach are depicted in *Table 3.*

Common practice of today		Sustainably safe practice	
Existing types of roads	Traffic function	Traffic function	Sustainably safe types of roads
Motorway	↑ increasing through and decreasing access	Through	Ia. Motorway
Motor road			Ib. Motor road
Main distributor		or	IIa. Distributor road (rural)
Local distributor		Distributor or	IIb. Distributor road (semi-urban)
District artery	↓ decreasing through and increasing access	Access	IIIa. Access road (rural)
Neighbourhood artery			
Residential street			IIIb. Access road (urban)
Woonerf			
	Residential function	Residential function	

Table 3. *Common practice and sustainably safe practice of categorising roads and streets.*

Based on our existing knowledge functional requirements for design criteria have been developed for a sustainably safe traffic system (Van Minnen & Slop, 1994):

- create residential areas as large as possible;
- every trip as long as possible over the safest type of roads;
- make trips as short as possible;
- combine short and safe;
- prevent search behaviour for destinations;
- make road types recognisable;
- reduce and uniform design characteristics;
- prevent conflicts between on-coming traffic;
- prevent conflicts between crossing traffic;
- separate different transport modes;
- reduce speed where conflicts could occur;
- prevent obstacles alongside a road.

Recently, these functional requirements have been made operational in 'draft guidelines' by a C.R.O.W-working committee (C.R.O.W., 1997). An example of these guidelines for roads outside urban areas are presented in *Table 4*.

Design criteria	ROADS OUTSIDE Built-up AREAS		
	Through road	Distributor road	Access road
Speed limit	120/100	80	60
Longitudinal marking	complete	partly	no
Cross section	2x1 (or more)	2x1 (or more)	1
Road surface	closed	closed	open
Access control	yes	yes	no
Carriageway separation	yes, physical	yes, visual, to be crossed over	no
Crossing between junctions	at grade	at grade	grade
Parking facilities	no	no	parking space or on the carriageway
Stops for public transport	no	outside the carriageway	on carriageway
Emergency facilities	emergency lane	in verge or on hard shoulder	no
Obstacle free zone	large	medium	small
Cyclists	separated	separated	depending
Mopeds	separated	separated	on carriageway
Slow motorised traffic	separated	separated	on carriageway
Speed reducing measures	no	appropriate measures	yes

Table 4. *Design criteria for road sections outside built-up areas (C.R.O.W, 1997)*

The policy on implementation of sustainable safety follows three lines: to develop the concept into more practical terms, to implement a so-called 'Start-up programme' and to carry out different demonstration projects.

4. Start-up programme on sustainable safety

To pay lip service to the concept of sustainable safety is one point, to put this concept into practice is another. The concept cannot be handed over to just those who are interested in the concept and rely on their individual willingness to come to implementation and leaving those who are not interested aside. The concept requires an active participation of all road authorities in the country and of the whole road safety community as well. The culture in Dutch public administration requires dialogue and consultation to meet this aim. A special Steering Committee, with representatives from the central, provincial and local government and from the water board, has been set up to guide this process. After broad consultation this Steering Committee came to the conclusion that the vision of sustainable safety received broad support. However, different opinions were heard about how to implement the concept and how to finance it. The Steering Committee made an integrated Start-up programme, covering the first phase of implementation of sustainable safety (Stuurgroep Duurzaam Veilig, 1997).
This Start-up programme comprises a package of measures which forms essential conditions to fulfil firstly before investments in a sustainably safe road transport system could be made. Secondly, all measures in this start-up programme are relatively cost-effective and could be implemented in a rather short time (three year period) and got support from a wide majority of those who were consulted. It is to be expected that an agreement will be reached in a rather short term.

July the first 1997 a letter of intent had been signed by the central government, provincial and local governments, and by the water-board. This letter of intent comprises the real implementation of the Start-up programme. If all the contracting parties will give their consent, which w expect to be the case by the end of this year, the programme will be realised in the period between 1998 and 2000. The total costs of implementation are estimated to be some 200 million dollars. The central government will provide half of the financial means required, and the other partners will contribute the other 100 million dollars.

The following measures are part of this Start-up programme:
- road classification programme *(for the complete Dutch road network of more than 100,000 km. road length)*, which enables the roads to fulfil their functions satisfactorily and forms a basis to solve the problems of contradictory design requirements;
- stimulate a low-cost introduction of 30 km/h-zones inside built-up areas (excl. roads with a flow function and with a distributor function); an extension is agreed upon of the number of 30 km/h-zones from 10% of the possible zones (as is the case now) up to 50% by the year 2000;
- introducing with simple means a concept of 60 km/h-zones for minor rural roads; some 3,000 km of road length is aimed for to be realized by the year 2,000;
- if needed and possible infrastructural measures like cycle facilities, roundabouts, small-scale measures to support 30 km/h-zones and 60 km/h-zones;

- inside urban areas mopeds on the carriageway instead of on cycle tracks or cycle paths in 1999;
- indication of priority at every junction (outside the 30 km/h-zones); the same priority rules for cyclists and mopeds as for motorised traffic will be introduced;
- public information campaign to support the introduction of sustainable safety; a better police enforcement and education programmes;
- the introduction of a road safety audit in 1998.

Based on the implementation of this Start-up programme further steps will be defined for the implementation of a sustainable safe road network in The Netherlands in the years to come. This Start-up programme is, after all, only the beginning. Implementation of the Start-up programme could be considered as a major step to reach the road safety targets set for the year 2000.

5. Demonstration projects

Large-scale demonstration projects are implemented to gather practical experiences when applying the sustainable safety principles. Four of them are co-financed by the Dutch Ministry of Transport (West-Zeeuwsch-Vlaanderen, Oosterbeek, Grubbenvorst and a project in the northwestern part of the Province of Overijssel). Other plans are developed without such financial support: Westland, West-Friesland, and others. Two of these projects are introduced here.

5.1. West-Zeeuwsch-Vlaanderen

The concept of sustainable safety is realised through different demonstration projects throughout the country with the support of the central government. Other projects are carried out as well besides these more formal projects. From these projects we hope to learn how to implement sustainable safety in practice. For this reason the variety of starting conditions was an important selection criterion. All demonstration projects will be monitored carefully. From this monitoring and assessment it should become evident that road safety improvements are the result from the sustainable safety approach and that the gains in this respect are more than could be expected from the more traditional approach. Gaining practical experience and transferring the knowledge are key elements for these demonstration projects.

One of the demonstration projects is carried out in the very south-west of The Netherlands, close to the Belgian border: the western part of Zeeuwsch-Vlaanderen. This area is a rather rural one with many visiting tourists during the summer season. The road network is without a clear hierarchy of mainly low volume roads. Enormous differences could be observed in usage of this network: a mix of different types of vehicles (fast moving passenger cars together with agricultural vehicles and biking school children using the same physical space).
It is not surprising that the road safety record of this area is rather poor. Compared to The Netherlands as a whole, with 7.6 fatalities per 100.000 inhabitants (1996), West-Zeeuwsch-Vlaanderen had a mortality rate of more than 20 in the beginning of the nineties. The high number of severe accidents in the last few years created a strong support in this region for remedial actions and the concept of sustainable safety was adopted as the leading philosophy behind these remedial actions. This choice was made based on cost-effectiveness comparisons of different approaches. Estimations were made on three alternatives: by applying traditional countermeasures, by using sustainably safe principles in a very consistent and systematic manner and the third alternative was a sober variant of the second alternative (DHV, 1994).

In *Figure 3* the results of these three packages are presented. The region has chosen for the 'sober sustainable safety alternative'. It is estimated that this alternative will result in a 60% reduction of the number of road accident casualties and the costs will amount 200 million Dutch guilders.

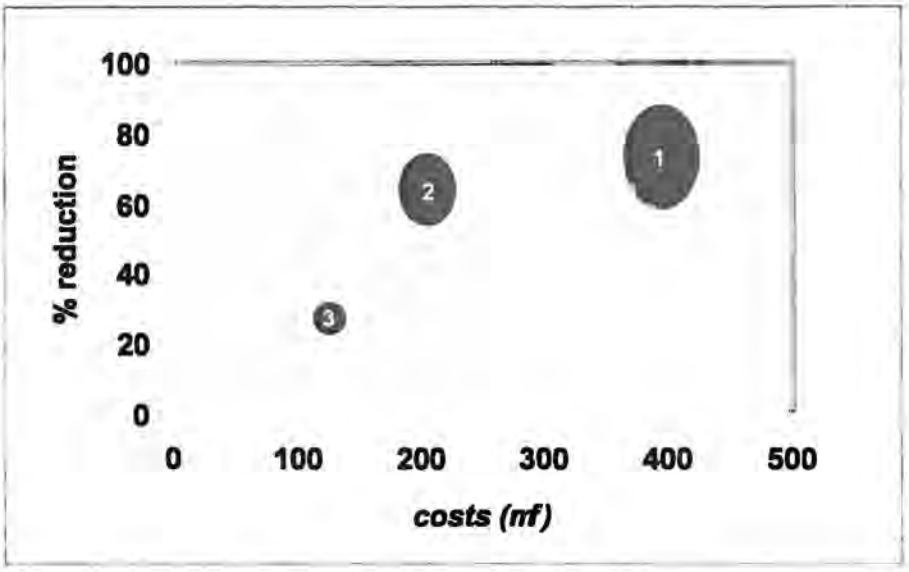

Figure 3. *Results of the three 'packages'.*

The key elements of this project is the restructuring of the road network in the region according to the principles of sustainable safety. The road network will be divided into four categories and the total operation involves 1,000 km of roads, mainly the upgrading of roads. Intersections between the highest and lowest categories of roads will be eliminated and many intersections will be transformed into roundabouts.
It is important to know that all four road authorities in the region (central, provincial, local and the district water board) are co-operating and are co-financing the implementation of this major restructuring of the road network. Based on the agreements reached so far, it is estimated that all construction work will be finished in the year 2000. It is important to know that public participation is considered as an essential step in this process. Furthermore, activities in the field of publicity, education and enforcement will support the changes to the infrastructure.

5.2. West-Friesland

West-Friesland is a region of 350 square kilometres, 180,000 inhabitants, in the Northwestern part of the country, with relatively high accident figures. About 50% of the population lives in villages of less than 5,000 inhabitants. The number of casualties in this region has been increased with 14% since 1986 and in the same period of time a reduction of casualties has been registered in the surrounding regions. A large proportion of the accidents occurs on rural roads on or in the direct vicinity of junctions.
Two major causes of accidents are reported: high driving speeds and road situations which are unclear for road users.
A road safety plan has been developed in the region based on the principles of sustainable safety. Implementation of this plan could reduce the number of casualties with 60%, if all road authorities in the region cooperate, if the implementation will be prepared carefully and if the measures are taken quickly.
Two ideas are leading in this plan: to categorise functionally the road system and to design the different types of roads (flow, distributor, access)

in order to meet the corresponding functional requirements as indicated before. This leads to roads with a flow function with access control, with separated carriageways and at-grade crossings. Design of distributor roads will depend on the traffic volumes: 6000 vehicles/day has been chosen a criterion. Large areas (1000 - 5000 ha.) will be considered as 60 km/h-zones, where through traffic will be prevented and the 60 km/h speed limit will be enforced. These so-called '60-zones' form the backbone of this plan.

The following criteria are used when designing these 60-zones:
- size of the villages inside the 60-zone: villages with more than 5000 inhabitants are connected with through roads by distributor roads;
- a maximum driving time on 60-roads will be three minutes, which means a maximum of 3000 m road length and a maximum size of 5000 ha.
- a time factor of 2 is considered as acceptable detour distance for through traffic.

These three criteria are preliminary when detailing the plan and will be made final after communication with the population.

Some interesting consequences of this design philosophy are:
- the introduction of gates when approaching the boundaries of 60-zones;
- a maximum road width of 3,50m (< 2000 vehicles/ day) and 5,00 m (> 2000 vehicles/day) and so-called grass-cobblestones in the verge to allow for passing;
- to prevent through traffic by Automated Physical Closures, allowing destination traffic to pass;
- no direct connection from these 60-zones with through roads;
- speed reducing measures mainly in the vicinity of junctions and, if needed, also in between junctions;
- junctions between 60-zones and distributor roads will be designed by roundabouts, T-junction or, when the other solutions are not possible, by priority-junction.

The costs of the implementation are estimated to be 240 million Dutch guilders and the time needed for implementation will be some 10-15 years. A reduction in the number of casualties of 300 (60%) is expected.

6. Traffic calming

The Netherlands has a long history in the field of improvements with regard to environmental and road safety measures in (existing) residential areas. As in other countries, the massive growth in car-ownership and use meant that motorized traffic in The Netherlands took an increasingly dominant position. Activities typical to residential areas were crowded out while the urban dweller felt increasingly threatened by motorized traffic and by high speeds.

In newly designed areas the design principles based on the separation of different types of traffic (such as the American Radburn-principle and the Swedish SCAFT-guidelines) were in The Netherlands only used on a rather limited scale.

During the seventies an entirely different principle to that of separation was developed for residential areas in The Netherlands: total integration of the different transport modes. The concept has also become internationally known by the Dutch word 'woonerf'. Motorized traffic - excluding through traffic - is accepted but is subordinate to the other 'woonerf'-users. In a woonerf motorized traffic is permitted to drive at walking pace (5-8 km/h). Separate provisions for pedestrians (such as sidewalks) are absent. In 1976 the 'woonerf' achieved legal status.

The 'woonerf' concept has greatly influenced thinking on the improvement of road safety and environmental aspects in The Netherlands. The 'woonerf ' led indeed to a substantial reduction in the number of injury accidents. In some projects some 70% reduction of injury accidents were reported. However, the application of the 'woonerf' often remained restricted to only a limited amount of and relatively small areas. As reasons for this the following was given: very strict legal design requirements, the high construction costs and the extra physical space needed for realisation.

From these first experiences we learned two features were essential: reducing driving speeds and reducing through traffic. From accident studies it turned out that the collision speed should remain below 30 km/h, because then the probability of a serious injury will be minimal. Since 1983, Dutch road authorities can get a legal limit of 30 km/h on roads or in zones within built-up areas. Based on a recent survey it could be concluded that 300 out of 700 Dutch municipalities have realised one or more '30 km/h-zone'. To guide Dutch municipalities to design effective speed restricting and through traffic preventing measures, a handbook was developed. Recently the effect on the number of injury accidents was studied and it was determined that the number of serious injury accidents had dropped by more than 30% (although a wide dispersion of effects was observed from almost no effect to more than 50% reduction).
A rough estimate at this moment is that 10% of the network of roads in the built-up areas has the status of 30 km/h areas. Opinion is that within the built-up areas approximately 80% of the road network could be given the status of 30 km/h-streets.

Two recent developments also deserve attention. Firstly that due to the high costs streets which qualify for a 30 km/h status do not receive it and for the same reason those areas which have the 30 km/h status are relatively not extensive. In The Netherlands there is therefore reason to investigate to what extent a more low-cost construction demand for 30 km/h-areas would lead to large-scale implementation and in addition to determine if a low-cost construction is equally effective and thus more efficient.

Intensive stimulation to foster implementation of large-sized '30 km/h-zones' is recommended. This stimulation should probably fit in a more integral approach and the 'sustainable-concept' could possibly act as a framework.

7. Financing a sustainably safe road transport system

Estimates have been made to investigate what the introduction of a sustainably safe traffic system would cost. The first SWOV-estimations resulted in 60 billion Dutch guilders; a major proportion of this money should be invested in adapting the existing road infrastructure according to the principles of sustainable safety. Based on different recent and more detailed estimations, especially based on the demonstration project in West-Zeeuwsch-Vlaanderen, a more sober implementation would cost 30 billion Dutch guilders. SWOV has suggested to spread these investments over a period of 30 years in order to run these investments in parallel with the standard maintenance of the road infrastructure; a period of 30 years is a reasonable one for the Dutch circumstances.

The Dutch government annually spends about 6.8 billion guilders on the road infrastructure. Just over half of this is invested in (major and minor) maintenance work, while the rest represents investments, excluding the (no longer freely disposable) capital costs of earlier investments (Poppe & Muizelaar, 1996). In view of both the size of this sum and the number of kilometres of road annually renewed or newly constructed, this offers sufficient space to realise a sustainably safe system within a period of thirty years. Firstly, a political discussion is needed in order to redirect already existing budgets instead of asking for additional budgets.

It is interesting to learn whether these investments offer enough economic returns and are cost-effective. So, estimations have to be made of the costs of road hazard and the reduction of these costs due to the investments to implement in a sustainably safe traffic system. The material costs of road hazard in 1993 amounted to 9.53 billion Dutch guilders a year. Material costs are assumed to mean the medical costs, potential loss of production, damage to vehicles and the like, administrative costs and the costs of traffic jams. Road hazard also leads to immaterial costs. These tend to be included in the social costs (e.g. environmental pollution). The immaterial costs relate to the suffering, loss of enjoyment of life for the victim and their social environment, etc. When the immaterial costs are also included in the calculation, the total costs come to 12.35 billion Dutch guilders a year.

If we invest 30 billion Dutch guilders over a period of 30 years, we estimate a reduction of 60% of the number of road accident casualties. Even if we use a conservative basis for cost-effectiveness estimations, SWOV concludes a cost-effectiveness of 9%, which is considerably higher than the customary government standard of a 4% return on investment for infrastructure projects. The next question is why such cost-effective investments have not yet been made.

A part of the answer might be that the benefits of a sustainably safe traffic system do not come to those who have to invest. The benefits of a sustainably safe traffic system can be divided into effect for various groups: government, private individuals, employers. The group of private persons and the group of employers would benefit most, such that a proportionate investment would be profitable in this case. However, this

leads to a kind of paradoxical obstruction: if only the odd individual invests, no gains are made; if many invest the benefits are also shared by those who do not contribute. In order to still encourage individuals or companies to invest, therefore, government intervention is likely to be necessary. Insurance companies (both motor vehicle, life and health cost insurers) who would also profit from the steady drop in claims - and hence in payments - could be employed as intermediary for this purpose. But from this perspective it might become clear that the key stakeholder to realise a sustainably safe road traffic system is the government, either directly as investor or indirectly as 'broker'.

8. Further innovations

To reach the Dutch targets for road safety, we cannot and will not rely only on existing knowledge and technologies. Innovation is, as ever, a necessity. The safe design of a sustainably safe traffic system needs further exploration, and especially the design of urban arteries and rural roads requires special attention, as applying low-cost measures. Moreover, we are of course very interested in possibilities of new technologies.

A wide range of Transport Telematics devices could possibly solve current transport problems and the road safety problems. Technological developments are going very fast and one could have some concern whether these developments will show positive net effects on road safety. A recent report from TRL (Perrett & Stevens, 1996) gives a review of potential benefits of road transport telematics for road safety. Using suitable scenarios for several (36) applications the UK researchers came to a conclusion that some applications show a positive (e.g. incident detection, speed control, speeding detection, area traffic control) and others not a positive benefit (e.g. anti-collision systems, autonomous intelligent cruise control, dynamic route guidance). Of course, these results are based on a large number of assumptions and we are still lacking knowledge of the behavioural impacts for example. These results are not presented here to be the last word on it, but as a starting point of a necessary discussion on how to proceed from here. In this discussion the role of the public sector is likely to be very critical. Four policy options for a role of the public sector are described in the TRL-report (from no specific intervention to making binding choices by the public sector) and the recommendation is a rather active role of the public sector to choose a particular Transport Telematics architecture and to ensure that the chosen architecture could be implemented with commercial involvement of the private sector.

We have to be careful that new telematic devices, which are meant to support the driver, do not overload or underload the individual driver or will result in counterproductive adaptation. A project instigated by the Transport Research Centre (AVV) of the Dutch Ministry of Transport aimed at investigating the effects on road safety of various applications of telematics to support the driver. Three Dutch research institutes carry out this project (the TNO Human Factors Research Institute, the Traffic Research Centre of the University of Groningen TRC and the Institute for Road Safety Research SWOV). A summary of the interim-results of this project have been reported recently (Heijer, 1997).The overall aim of this research is to provide policy-makers with a well-based tool to assess the safety effects of existing and new transport telematics applications in road vehicles. The project must result in a set of guidelines and methods to identify potential safety hazards that single or multiple applications of these Transport Telematics may produce.

The Dutch Government and the transport research sector work together with the industry and with transport organisations in order to optimise road safety aspects of new technology. Of course, the international arena is of major importance. The Dutch are actively involved in a number of

European projects and observe with special interest the activities in the United States and Japan.

From a road safety point of view perhaps three observations are of importance. First of all, the introduction of some means of speed management seems to be very significant to improve road safety. Secondly, telematics applications should specifically deal with protecting vulnerable road users (pedestrians, cyclists, the elderly and the young). Finally, a large proportion of our road safety problems exists on urban traffic arteries and on rural roads. It is to be recommended to put special emphasis to these types of roads when further developing transport telematics.

9. Concluding remarks

A new vision on how to improve road safety considerably, like the Dutch concept of sustainably safe road transport, will only get support from key stakeholders (politicians, government, road safety community) if a need for a new vision is broadly considered as inevitable.

Furthermore, such a new vision has to be seen as attractive by those stakeholders. In the Dutch situation members of parliament played a key role by expressing their support on a conceptual level at the right moment. The positive attitude of private organisations in the field of road safety turned out to be very valuable. The Dutch Ministry of Transport embraced the concept without many hesitations and their 'policy craftsmanship' resulted in support from the organisations of municipalities and provinces and the water-boards, although it has to be admitted that their support could be seen as somewhat hesitant. Nevertheless, it looks like that a very positive point will be reached when the just signed letter of intent will result in a formal agreement on the so-called Start-up programme. *This ambitious approach would not have been possible without using a so-called 'polder model' of creating awareness, support and commitment of all key stakeholders in The Netherlands.*

An explanation for this positive development could be the following. Quantitative road safety targets, as we have in The Netherlands, result in quality-improvement of the road safety policy. Targets lead to targeted programmes. Targeted road safety programmes create pressure to monitor and assess recent developments and road safety programmes and, therefore, to continue effective programmes and stop ineffective ones. Having set road safety targets and observing trends that these targets would not be reached by continuing existing policies, created a sound breeding ground for developing a new vision on road safety policy in The Netherlands (towards a sustainably safe road traffic system) and encouraged support from key stakeholders. Otherwise, most probably 'the-muddling-on-approach' instead of this 'new vision' would now have been dominant in The Netherlands.

It is without doubt that in the period between launching the concept (1991) and 1997 sustainable safety induced new energy in the road safety community. Many stakeholders and road safety professionals asked themselves which contribution could be made to elaborate the concept and to contribute to implementation. The debate, which is still going on, on sustainable safety has enriched and improved the concept.

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