Towards sustainably safe road transport in The Netherlands

Contribution to the Conference Eurotraffic '95: The development of the traffic sector in a deregulated Europe, 22-24 November 1995, Aalborg, Denmark.

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Fred Wegman
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SWOV Institute for Road Safety Research, The Netherlands

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Author(s):	Fred Wegman
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SWOV Institute for Road Safety Research

Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV

Postbus 1090
2260 BB Leidschendam
Duindoorn 32
telefoon 070-3209323
telefax 070-3201261

Abstract

The recent stagnation in further reduction of road accidents, insufficient results of existing policies to improve road safety and its rather curative nature of these policies induced the wish to renew and to improve road safety policy in the Netherlands. This new approach is called: a sustainably safe road transport system. This system has an infrastructure that is adapted to the limitations of human capacity through proper road design, vehicles fitted with ways to simplify the task 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.

As to the infrastructure, the key to arrive at sustainable safety lies in the systematic and consistent application of three safety principles: functional use of the road network, homogeneous traffic streams and predictability for road users.
Applying all three principles do have an preventative character: to preclude as much as possible the incidence of accidents. A functional use of the road network calls first for establishing the intended function of every road. The present multifunctionality of roads leads to contradictory design requirements. Therefore, in a sustainably safe infrastructure every road is appointed only one specific function.
Three categories of roads have to be created: pure through roads, pure distributor roads and pure access roads. Design principles have been drafted. With financial support of the Dutch Ministry of Transport a few demonstration projects will start in the near future and will learn us about the applicability in practice and the road safety effects of this 'sustainably safe road transport'.

Contents

1. Introduction

The Netherlands is one of the safest, highly motorized countries in the world. The number of road accident fatalities per 100 000 inhabitants (a public health or personal safety indicator) in the Netherlands is 8.5 (1298 road deaths in 1994 and 15.5 million inhabitants) which makes the Netherlands, together with countries as the United Kingdom, Norway and Sweden relatively safe (*Table 1*). This is also the case when we relate the annual number of fatalities to the number of kilometres travelled (a traffic safety indicator), where the Netherlands again scores relatively good.

Since an all time peak in 1972 - the number of road deaths almost 3300 - the annual number of fatalities has been reduced to about 1300 in 1994. However, recent figures indicate that the number of fatalities per year are not diminishing any more.

The Dutch Government has formulated road safety targets in 1987 in their Long Term Policy for Road Safety. This plan formulated a quantitative road safety

Target: 25% fewer road accident casualties in the year 2000 compared to the numbers in 1985.

A plan drafted by the Dutch Government, in which the (political) desired mobility developments in the future and the investments in the infrastructure are broadly outlined, also includes, amongst others, road safety targets for the year 2010: 50% fewer fatalities and 40% fewer hospital admissions resulting from road accidents. Compared with the targets for 2000, meeting these targets implied a greater challenge to policy making, although a controlled and moderate growth in motorized mobility of 35% over the same period was assumed.

1993	road deaths per inhabitants (10^5)	rank order	road deaths per motor vehicles (10^5)	rank order
United Kingdom	6.8	1	13 0	1
Sweden	7.3	2	14.6	2
Norway (92)	7 5	3	14.5	-
Netherlands	8.2	4	18 6	5
Finland	9 6	5	21.1	7
Australia (92)	10 0	6	17 0	3
Switzerland	10 5	7	18.1	4
Japan	10 6	8	19 3	6
Denmark	10 8	9	26 6	12

1993	road deaths per inhabitants (10^5)	rank order	road deaths per motor vehicles (10^5)	rank order
Ireland	12.1	10	37.4	17
Germany	12.3	11	21.9	11
Canada	12.5	12	20.2	9
Italy	12.6	13	20.4	10
USA (92)	15.5	14	20.2	8
Spain	16.3	15	35.8	16
Belgium	16.5	16	33.8	14
France	16.6	17	34.4	15
New Zealand	17.2	18	26.7	13
Greece	20.3	19	65.8	18

Table 1. *Number of road deaths per 100 000 inhabitants and per number of 100 000 motor vehicles in 1993 (source: IRTAD).*

A number of years ago the Dutch road safety policy concentrated only on a number of priorities: alcohol, high and excessive speed, accident black spots, high risk groups, heavy traffic. However it was concluded that the existing policy was not effective enough. Another drawback of that policy is its curative nature: problems are recognized and countermeasures are considered after these problems have manifested themselves. Accident statistics offer the only guideline for this type of approach. In its nature a more preventive approach seems to be more attractive.

These three reasons *(stagnation in further casualty reduction, insufficient results with existing policy to reach road safety targets and the rather curative nature of this policy)* induced the wish to renew and to improve road safety policy in the Netherlands. This new approach has been named: Towards a sustainably safe traffic system in the Netherlands (SWOV, 1992 and 1993). The need for a new and more effective approach can be further illustrated by the following description of the state of affairs of today.

2. Experiences with traditional measures to improve road safety

Transportation by road arises from people's wish to reach a destination. This sentence defines the two functions of roads and streets: to carry traffic and to reach destinations. The first function is associated with: movement, high speed, a lot of traffic. The second function just indicates that a certain destination has to be reached: accessibility, low speed, low volumes. Besides these functions from a traffic perspective, streets and roads are public spaces where people meet each other: the residential function. In the present situation, most roads are multifunctional, i.e. they perform a mixture of the different traffic functions and the residential function as well. This leads inevitably to a large number of dangerous situations, conflicts and accidents.

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.*

This is demonstrated by the actual accident risks for different types of roads. The number of injury accidents per million motor vehicle kilometres on Dutch roads is relatively high on arterial roads inside built-up areas and on rural roads (*Table 1*).

In general terms: high driving speeds, many inconsistencies in the roads' course, many differences in direction and speed, different types of road users occupying the same space explain the greater risks for these roads.

Multifunctionality leads to contradictory design requirements, poor road design and more human errors. More human errors will lead to more accidents. The proper answer is to define one function of a road explicitly in a traffic plan or in a plan dealing with land use planning or town planning. Then, it is the task of the road designer to design according to the functional requirements.

The idea of traffic free or traffic poor zones in cities and villages is a rather traditional and well-known concept for town planners and traffic engineers in an attempt to solve these problems. In 'Traffic in Towns' (the

so-called Buchanan report from 1964) this idea has been formulated already: create areas where people can live, work, shop, look around, and move in reasonable freedom from the hazards of motor traffic. On the other hand there must be a complementary network of roads - urban corridors - for effecting the primary distribution of traffic. Expansion of urban areas, increase of income, car-ownership and car usage and limitations for expanding the physical space for road traffic have led to enormous traffic problems in cities and villages. During the sixties and seventies the environmental problems related to motorized traffic were added to this and became more prominent.

By expanding the road network, by better urban planning and road design, by improving the efficiency of the existing network, by improving public transport and expanding and improving the facilities for pedestrians and cyclists, traffic problems and the related road safety problems have been tackled successfully. Accident risks have been reduced in many countries; with 6-7% per year in the Netherlands. Of course, these infrastructural measures cannot claim the total of these reductions, it is for sure that they have contributed to a large extent. But other factors have contributed as well: reducing drinking and driving, increased seat belt usage, better assistance given to road accident victims, better vehicle safety, etc. (Wegman, 1995).

Based on their knowledge and experiences planners and designers are quite capable to design relatively safe new areas. Accident research indicate strongly that new and planned areas are more safe than traditional and grown areas. Newer car models are better than older ones. Driving experiences accumulate in traffic and more experienced drivers run a lower risk than inexperienced drivers.

However, to translate research results to full scale implementation of well-known safety principles seem to be very complicated. It looks like we face a Wall preventing us from coming up with a next generation of solutions. With developing the concept of 'sustainably safe transport' an attempt has been launched to tear down this Wall.

We are not heading for a completely new and futuristic road transport system. In our concept the challenging task is to find ways to implement our knowledge and expertise to reduce accident rates to a 'sustainably safe level' in a systematic and consistent manner, without too much compromising, instead of in a incidental manner, as we do nowadays.

3. The concept of sustainable safety

Anyone who casts a rational eye over hazards on the road should be surprised about society's attitude towards the road safety problem. In the European Union more than 50,000 people die on the road every year, and over 1.5 million injuries are registered. Road hazard is a major public health issue:

- one in three fatalities in the age group of 5 to 25 is the result of a road accident;
- the figure for the number of years lost as a result of road accidents ranks second to the heart and vascular disease and is greater than the figure for cancer;
- one in ten people involved in a road accident demonstrates more or less severe psycho-traumatic symptoms which continue for a long time afterwards;
- more than half the number of rehabilitated invalids relates to road accident casualties.

Passenger transport by rail or air is 100 to 200 times safer per kilometre travelled than private transport by road. The safety standards applied to the working environment, to technological-energy installations and to protective measures against natural disasters are based on mortality probabilities per time unit that are many times (sometimes thousands of times) smaller than the actual probability of dying in a road accident.

However, the likelihood that an individual road user will be involved in an accident is small. For example, pedestrians must cover 2 million kilometres in traffic before this will result in a fatal accident. On a personal basis, therefore the chance is negligible. But the same individual runs a risk being injured in a road accident of 2 in 3 during a human life. But individual citizens do not allow the probability of road accidents to influence their daily behaviour. However, it can be said that the collective experience of road hazard is increasing: everyone knows somebody...

It is of importance to solve the paradox of a social problem which is not experienced as such by the individual in order to have an acknowledgement of the road safety problem. Again and again, this acknowledgement needs to be gained as a basic step to raise public awareness. *Or, are we beyond the stage of astonishment?* Are we so used to road hazard that we seem to have adopted a somewhat apathic attitude, which permits too much laxity in the approach towards road hazard?

The SWOV Institute for Road Safety Research, in close cooperation with a number of other research institutes, was asked by the Dutch Government to develop a scientifically supported long-term concept of a considerably safer road system. The general concept of 'sustainable development', introduced by the UN Brundtland Commission, also inspired the vision we evolved in the field of road safety: *no longer do we want to hand over a road traffic system to the next generation in which we tolerate that road transport inevitably leads to thousands of killed people and ten thousands of injured people.* Instead, we should try to drastically reduce the probability of accidents occurring in advance; rather preventive than curative: the concept of 'sustainably safe road transport' was born.

The concept of *'sustainable safety'* is based on the principle that man is the reference standard. Human beings are capable of many things, but present-day traffic makes excessive demands on their abilities, causing them to make mistakes, most of the time without any severe consequence but sometimes with serious and even fatal consequences.

The starting point of the concept 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.

A sustainable 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 effective as possible; and
- a road user who is adequately educated, informed and, where necessary, controlled.

In a sustainably safe road transport 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. Perhaps by using the principles of 'social marketing' the willingness to accept all the elements of a sustainably road traffic system could be achieved. On the other hand freedom restrictions without good arguments should not be offered to the road user.

With respect to *vehicles*, it can be stated that in order to harmonize with the aforementioned objectives, the diversity of vehicles should be kept to a minimum. Furthermore, the various types should be clearly distinguishable. 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 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.

Proper *road design* is crucial to prevent human errors in traffic and less human errors will result in less accidents (Ruyters, et al., 1994). To prevent human errors three safety principles have to be applied in a systematic and consistent manner as much as possible:
- preventing unintended use of roads, i.e. use that is appropriate to the function of that road;
- preventing large discrepancies in speed, direction and mass, thus reducing in advance the possibility of encounters with implicit risk;
- preventing uncertainty amongst road users, by enhancing the predictability of the road's course and of the behaviour of other road users.

The first safety principle, preventing unintended use of roads, calls for first establishing the intention of the road: specify the traffic function:

- 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 along 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 three categories of roads: pure through roads, pure distributor roads and pure access roads.

Before sustainable road safety was thought of, the application of the safety principles had, to a large extent, already been successful on motorways and in 30 km/h zone streets. If properly implemented, each of these two types of road perform virtually one function: motorways realize a through function, and 30 km/h streets an access function/ residential function. As a consequence of this, they show a relatively low accident risk (see *Table* 2). In contrast, arterial urban roads and non motorway rural roads, mostly multifunctional in their usual present appearance, demonstrate high risks.

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

<table>
<tr><th colspan="2">Common practice of today</th><th colspan="2">Sustainably safe practice</th></tr>
<tr><td>Exististing types of roads</td><td>Traffic function</td><td>Traffic function</td><td>Sustainably safe types of roads</td></tr>
<tr><td>Motorway</td><td rowspan="9">↑ increasing through and decreasing access

↓ decreasing through and increasing access</td><td rowspan="2">Through</td><td>Ia. Motorway</td></tr>
<tr><td>Motorroad</td><td>Ib. Motorroad</td></tr>
<tr><td>Main distributor</td><td rowspan="3">or

Distributor

or</td><td>IIa. Distributor road (rural)</td></tr>
<tr><td>Local distributor</td><td>IIb. Distributor road (semi-urban)</td></tr>
<tr><td>District artery</td><td rowspan="3">Access</td><td rowspan="2">IIIa. Access road (rural)</td></tr>
<tr><td>Neighbourhood artery</td></tr>
<tr><td>Residential street</td><td>IIIb. Access road (urban)</td></tr>
<tr><td>Woonerf</td><td colspan="3"></td></tr>
<tr><td colspan="2">Residential function</td><td colspan="2">Residential function</td></tr>
</table>

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

Based on our knowledge draft design criteria have been developed (van Minnen & Slop, 1994):

- every trip as long as possible over the safest type of road;
- combine short and safe;
- prevent search behaviour for destinations;
- make road types recognizable;
- 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.

Several theoretical and practical exercises have been made to test these criteria, with satisfying results.
In *Table 4* a first indication can be found of a road network outside built up areas and some characteristics per road type.

Class	**I Through roads**	**II Distributor roads**	**III Access roads**
Types	Ia. motorway Ib. express road	IIa. rural, less turning traffic IIb. semi-urban, much turning	IIIa. rural
Actual function	connecting	distributing and collecting	offering access and opportunity for parking, serving properties
Bicycle/moped traffic	not on carriageway	not on carriageway	on carriageway
Agricultural vehicles	not on carriageway	IIa: not on carriage- way IIb. allowed on carriage way (?)	on carriageway
Number of carriage ways	2	IIa. 2 IIb. 1	1
Volumes [veh/day] (approximate)	Ia: >20,000 Ib: <20,000	4,000 - 15,000	<3,000
Speed level [km/h]	Ia: 100-120 Ib: 80-100	IIa: 80 IIb: 60	40
Parking	no	no	yes
Access to properties	no	no	yes
Trip time criterion	none	3-5 minutes (?)	3 minutes (?)

Intersection design:

Ia mutually:	interchanges
Ia with Ib:	fully, grade separated
Ib mutually:	(large) roundabout; cyclists preferably grade separated
I with II:	grade separated
II mutually:	roundabout
II with III:	major/minor junction; roundabout or signal control when many bicycles
III mutually:	uncontrolled junction

Grade separated crossings preferably with 4 legs
Major/minor junctions preferably with 3 legs (T junction)
Uncontrolled junctions preferably with 3 legs
Smaller roundabouts with 4 legs ($4x90^{o}$) or 3 legs ($180^{o} + 2x90^{o}$)
Larger roundabouts may also have 5 or 6 legs

Table 4. *Summary of warrants for the various road types outside urban areas (van Minnen & Slop, 1994).*

4. Some first experiences

It is obvious that sustainably safe road transport will remain something from Utopia when not enough societal and political support can be obtained. The Dutch Government (the National Government and the Association of Provinces) and the Dutch Parliament have declared their support. All important road safety organizations and peer groups did the same. Now, other actors have to act: road authorities, municipalities, provinces, road safety organisations and the private sector. In the culture of the Dutch political system almost no procedures are available to force their co-operation for example with procedural, legal or financial means. This leaves the way of convincing and making the concept attractive for all relevant actors.

Estimations are made about the costs of changing the complete Dutch road transport system in a sustainable safe system: for 100 000 kilometre of road the costs will be approximately 60 billion Dutch guilders (1 US$ = 1.70 HFL). Road authorities are looking for possibilities to combine the introduction of sustainable safety with periodical maintenance of the roads. Under Dutch circumstances maintenance will take place every 20 - 30 years; per year 2 - 3 billion Dutch guilders. This big amount of money have to be placed against two other figures. First of all the Dutch Nation invests year after year 5 billion Dutch guilders to expand, renew and maintain its road infrastructure. The second figure to be mentioned here is 9 billion Dutch guilders which are the economical costs of road accidents. Nevertheless, until now no solution has been found for this financial problem.

In the meantime, first attempts are made to introduce the concept of this sustainably safe transport system. The Dutch Ministry of Transport launched a programme to stimulate road authorities and other interested parties to implement this concept. Four carefully selected demonstration projects will start soon and will be subsidized with about one hundred million Dutch guilders for a four year period.

One of the projects is situated in the south of the Netherlands. Due to high accident figures societal and political support was growing to improve road safety in the region of West Zeeuwsch-Vlaanderen and by preparing a road safety plan with traditional countermeasures. The result was considered as insufficient, also compared with the necessary budget. Another approach based on 'sustainable safety principles' resulted in a more cost-effective approach. Estimations are made that by applying the principles in a consistent and systematic manner, and even when a sober alternative will be implemented, a reduction in the number of casualties may be expected in between 50 and 80% (*Figure 1*).

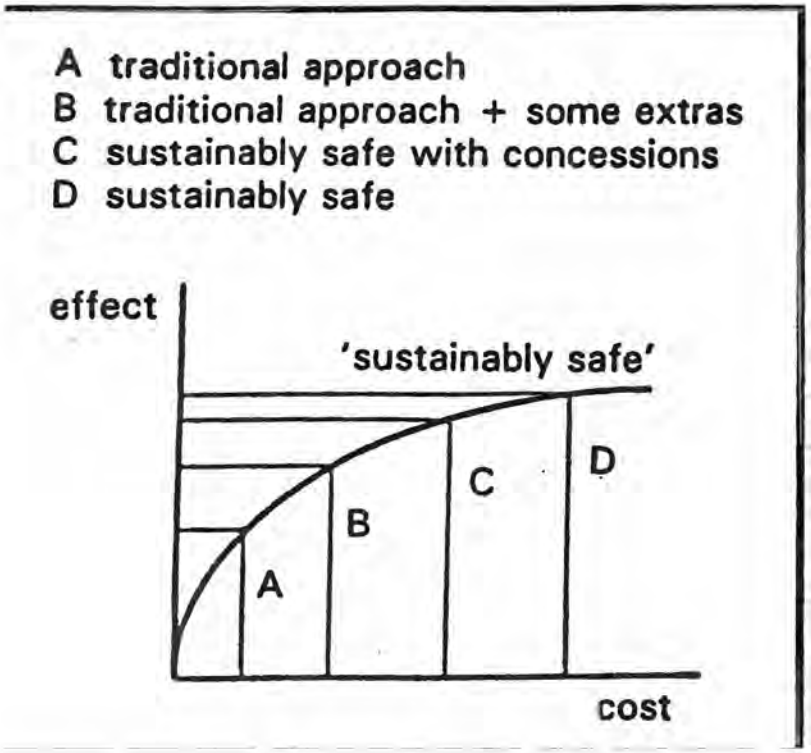

Figure 1. *Comparisons of effects and costs of different approaches.*

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