

The Dutch policy for sustainable road safety

Contribution to the Conference of the Advanced Studies Institute Transport, Environment and Traffic Safety: The role of policies and technologies, April 5-9 1994, Tinbergen Institute, Amsterdam

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1. Introduction

Generally safety policies have been oriented to problem solving instead of to problem prevention. In this respect we have to invest much afterwards. We gave such a high priority to mobility aims in our transport that we have neglected to incorporate safety standards in the transport system. Recently SWOV outlined headlines of a traffic system in which safety demands are integrated in the design of the road network. These safety demands can be applied when roads are reconstructed. Together with integrative aspects regarding the road user and the vehicles, our plan needs about 30 years in order to make our transport system about 90% more safe. Because of the relative great share of cyclists in our mobility patterns and the density of population with its great share of residential pedestrian movements - the Netherlands are at the top of economic developed countries in this respect - the facilities for pedestrian and cyclists need to be an integral part of our road safety plan. This approach has become the basis for the Dutch government in their recent policy on sustainable road safety. This safety policy integrates infrastructural and behavioural measures as well as technological improvements of vehicles in their interactions with roads and the driver. First we explain this by elaborating on the infrastructural influence on road safety and postponing its integration with the behavioural and technological aspects.

2. Infrastructure

Our policy for a sustainable road safety (SWOV, 1992) advocates a reconstruction of the majority of our roads. The safest roads are motorways and residential roads in traffic calming areas. In the Netherlands, a motorway is not accessible for cyclist or mopeds and we surely do not want to change that. These roads make up slightly more than 2,000 km in our small country, but account for about one-third of the motorised mileage. We have many physically separated cycle tracks of over 4,000 km length. Parts of the residential roads in traffic calming areas have a speed limit of 30 km per hour and in parts, the so-called 'woonerfs' and shopping areas only the speed of pedestrians. This affords a mix of cars, cyclist and pedestrian at relative low risks. Between these extremes of freeways and residential roads in traffic calming areas, we have the majority of roads with a mix of slow and fast traffic. We do have side-walks and many bicycle tracks running parallel a carriageway, often physically separated. In built-up areas separated bicycle tracks are found in about 8% of all streets, mainly along the arterial routes and high volume roads. Outside built-up areas bicycle tracks are found alongside 15% of all roads. This kind of separation, however, has not proven to be without safety problems. The problems arise at intersections and the injury risk there is greater than at intersections of roads without separate tracks. It means that what we win in safety on the track by separation, we partly loose at intersections. In built-up areas the main safety problems arise from the fact that some arterials, nearly all arterial intersections and the residential streets are shared by pedestrian, cyclist and cars, while the speed limit 50 km/h is. On not congested arterials in built-up areas the actual motorised vehicle speeds are generally above that speed limit and similar holds for highways in outside built-up areas with a limit of 80 km/h. Moreover, on these arterials and highways there are great speed and mass differences between road users, while opposite and crossing traffic generally are not physically separated. The injury and fatality rates on these arterials and highways are the highest as shown in *Table 1.1*.

Road type	Max. limit km/h	Mix fast slow	Crossing opposite traffic	Injury rate mill.km	Fatality rate 100 mill.km
Calming area	<30	yes	yes	0.20	<0.3
Resid. street	50	yes	yes	0.75	1.2
Urban arterial	50/70	yes/no	yes	1.33	2.5
Rural road	80	yes/no	yes	0.64	4.6
Rural motorway	80	no	yes	0.30	2.1
Rural motorway	100	no	no	0.11	1.7
Motorfreeway	100/120	no	no	0.07	0.5

Table 1.1. *Injury and fatality rates per road type in the Netherlands 1986.*

The differences in risk per type of road hardly can be contributed to differences in behavioural responsibilities of the road users on the different types of roads. We can hardly imagine that the car driver, when leaving the motorfreeway and entering the rural road, becomes suddenly much less

responsible and willingly behaves ten times more risky or suddenly loses the ability of safe driving. The explanation of risk differences lies in the complexity of the traffic tasks, which is structurally different for the types of roads.

The number of actions which a road user has to perform per unit of time differs with the complexity of the road, the traffic situation and the level and variance in speed of traffic, but in the mean one can distinguish about 25 generally more or less automatic actions per minute. In the Netherlands nowadays a road user needs about 20 000 hours in traffic before he or she is involved in a severe road accident. Combining both facts it means that a road user only once per 30 million actions errors in such a way that a severe accident occurs. Since man is not infallible and not indestructible, the safety gains from further behaviour improvement of road users, apart from those who are not yet or no longer able to participate in road traffic, is questionable. Complexity of roads and traffic situations and the level and variation of speed determine the number of needed actions per unit of time, which in its turn determines the chance of errors and thus the level of risk. In traffic calming areas the level and variation in speed are low and, despite the road and traffic complexity, the number of needed actions per time unit is low, while on motorfreeways the complexity of the road and the traffic situations and relative variation in speed is low and, despite the high level of speed, the number of needed actions is also low. No surprise that we observe low risk on these road types. On the other types of roads, where level and variation of speed are relative high as well as where roads and traffic situations are relatively complex, the observed risks are much higher. The main conclusion, therefore, is that the infrastructure determines the differences in task complexity and that structural reduction of high task complexities by infrastructural road and traffic measures can reduce the risks on these other road types.

A sustainable road safety is only possible if we structurally adjust the task complexity to the non-infallible abilities of road users. For this purpose we have, either to separate slow and fast transport modes on roads and intersections where a moderate or high speed for motorised traffic is accepted or to reduce the speed of motorised traffic (for example by enlarged traffic calming areas or by changing intersections to roundabouts).

3. Human factor and infrastructure

The sustainable road safety policy is based on the necessity to segregate traffic by its function. In principle we only have to differentiate between three types of functions: the flow function, distribution and access function and the residential function. Safety asks for an allocation of traffic with different functions to different road types and the design per road type has to optimise its function. This also implies that the design has to be adapted to the needs and behavioural characteristics of the road users.

Roads with a flow function are designed for relative high speeds with minimal discontinuities. Safety on these roads is only guaranteed if cars and bicycles as well as pedestrians are separated absolutely and if speed variation is minimised. The design is that of dual two or multiple lane motorfreeways or for lower intensities the design is a separated single lane motorway without emergency shoulder. Many rural highways have to be upgraded to the latter type of road with complete separation for cyclists and pedestrians. The need of cyclists for roads that facilitate an efficient and safe stream is also enhanced by cycle tracks which are separated from the upgraded rural highways.

On roads with a distribution and access function we are forced to use different measures, because of the functionally required density of intersections and functional penetration in urban areas. Still separated tracks are important, but additional measures are needed at the many intersections without a physical separation. In built-up areas the intersections can be designed by traffic calming measures. In the Netherlands we have good results with roundabouts in the residential street network, also for cyclists. Changing signalised and non-signalised intersections into roundabouts resulted in about an overall 70% less casualties, but also 30% less injured cyclists (Schoon & Van Minnen, 1992). The strategy is that all residential roads should be upgraded or downgraded to either urban arterials or streets with a traffic calming area design.

The residential function and safety in built-up areas ask for enlarged traffic calming areas with diameter of about 4 km, which are then divided by urban arterials with a distribution and access function. On the streets of calming areas the speed of cars is reduced to a maximum of 30 km per hour, which is sustained by the layout of the streets and traffic facilities. Only this affords a safe mix of cars, bicycles and pedestrians.

The design of the three types of roads is totally different in order to serve its different functions and to evoke the behaviour that fits with that function. The design and safety devices for these types of roads must be exclusive and permanently visible, possibly without local traffic signs. The road user must easily recognize the desired behavioural options that are left. These designs lead to reliable expectations and predictable behaviour for all road users.

In the Netherlands we are experimenting now to work this out, especially on roads with a distribution and access function and on intersections between roads with a distribution function and between these roads and access streets to residential calming areas within urban areas. The problems for a road user in a traffic situation are set by the amount and directions of the traffic flows,

the traffic rules, the angle between roads, speed, mix of traffic modes and obstruction of view. Reduction of complexity and enhancing predictability determine the control of the situation. We have to be aware that the needs and abilities of cyclists and pedestrians are different. We have to offer more than one behavioural option, taking into account the different needs of children, adults and elderly people. Children and elderly people need more time for decisions. One solution can be to have a safe place to stop before a next decision will be made, another solution can be a division of the crossing task by making it possible to cross a road in more than one stage by the adjustments of roundabouts especially for these road users.

The required behaviour must correspond with the characteristics of road user behaviour. Road users learn to act automatically. Their behaviour is not only elicited by a given traffic situation, but also based on the experiences on similar situations before and previous information on their route. A main route with alternating design elements, such as separated and non-separated cycle tracks, alternating rules for right of way and alternating parking facilities, creates false expectations. It is important that road users can rely on continuity and uniformity. Moreover, when a road user enters another type of road the road design must attract the attention of the road user to the most salient information and provide anticipatory clues and signals. Moreover, the desired behaviour also has to correspond with the logic and preferences of the road user. A safe but inefficient way of crossing will only be used by cyclists and pedestrians when the traffic situation seems not to be safe. Otherwise, many cyclists and pedestrians tend to look for a more efficient way of crossing. This counteracts the predictability of behaviour. It is better to make safety devices and designs attractive in many respects: safe, efficient and comfortable. Potential risky alternatives should not only be forbidden, but also be very unattractive. Recently a design manual for a cycle-friendly infrastructure, 'Sign up for the bike', has been published (CROW, 1993). It contains the Dutch expertise on the infrastructure that cyclists need and is based on the above mentioned principles. Five criteria were used for the design of the cycle infrastructure: traffic safety, directness of connection, aesthetic, comfort and social safety.

4. Human factor and vehicles

Active vehicle safety is partially sustained by modern technology with in-car devices, but these devices tend to induce more and higher risk taking under the assumption that the driver can control the danger by the enhanced devices (for example ABS leads to shorter car gaps in car following behaviour). Up to now telematics have not shown to contribute very much to road safety (OECD, 1992), but undoubtedly there are great potentials. Probably the adaptive maximum speed control to variable speed limits which vary by area, road type and also by traffic, light and weather conditions, will guarantee a tremendous decrease in risk. For the moment we do not expect telematics to take over safely the task of the driver (the complexity of the relevant input signals for the correct speed and direction prohibit such), but adaptive electronics can help to keep the driver within the limits, wherein a driver generally on its own can solve the conflicts safely. In the Netherlands the possible application of variable maximum speed control by telematics has now gained political attention, but its social acceptance is still low. Anyhow it is foreseen that interactive man-car-road electronics will be an integrative part of the sustainable safe traffic system of the future.

Passive safety of cars and road equipment is mainly sustained by mechanical devices for energy absorption and protective measures like seat belts. They undoubtedly have contributed much to road safety and will contribute even more in the future. In the concept of sustainable road safety passive safety and applications of telematics have to guarantee the preconditions which eliminate nearly all harmful outcomes of the always remaining, but much reduced number of accidents. Especially the effects of improved energy absorbing constructions for side impacts and enhanced protective devices are promising in the near future. Many passive safety requirements are legally obliged for the car manufacturing and import.

A contribution to the safety of bicyclists and pedestrians is found in the requirements for the car front. The European Commission considers to improve the level of safety for pedestrians (which also is to the benefit of bicyclists) by a directive requiring 'softer' bumpers and engine hoods.

Compared to legal safety requirements for cars, there are only a few such requirements for bicycles, even though the number of bicycles in the Netherlands is somewhat less than three times the number of passenger cars. The Dutch law demands only one well functioning brake, a well functioning steering system, a simple warning system that should be heard over a distance of at least 15 m and a series of lighting and reflection requirements (only when light conditions are bad). In this respect the Netherlands is far behind other countries (Kostense, 1992). There is also no Dutch bicycle safety standard in contrast to other countries. The Ministry of Transport is considering to upgrade the level of legal requirements with respect to lighting systems, brakes and frame. SWOV recently started a study to establish quality and safety aspects of bicycles-in-use. Especially the quality of light systems and reflection appeared to be very poor. It already was established that a vast amount of Dutch bicyclist do not use their lighting systems at night, even if it is available and in good condition. Though obligatory reflecting wheel circles and rear reflection have shown to decrease the number of casualties with 5% (Blokpoel, 1990), lighting

systems are as well considered to be of great importance. Finally the use of helmets will greatly contribute to the safety of bicyclists, since head and brain injury is by far the biggest injury-threat to this group of road users. However no obligation is considered by the government, while stimulation of the voluntary use is studied. Promotion of helmet use will almost certainly be a very difficult matter in the Netherlands. Nearly everyone regards helmets for cyclists as silly.

5. Human factor and education

Education is a prerequisite for a safe participation in traffic. In accordance to infrastructural reconstruction, we have to adjust our educational programmes. In the Netherlands we have nowadays different programmes for children from 6 till 16 years, for the obtainment of driver licenses, for elderly people and for adults who have not been grown up in the Netherlands. Road users must learn how to behave safely, they must be able to perform this behaviour and they must be willing to take safety demands into account. The needs for education differ according to developmental stages of experience and abilities and to the main use of the infrastructure type during the enlarging action radius of pupils. The traffic education of children can be divided into three such developmental stages (Wittink et al. 1992). A fourth stage begins with the lessons for a driver license.

First we have to learn very young children basic skills and elementary defensive behaviour and elementary rules. Of main importance is instruction in practice. It is very important that experienced people - in the Netherlands most parents are experienced cyclists - accompany children and give advice and provide model behaviour that fit with the abilities of them. Practice has to start in traffic situations around the house, the playground and kindergarten in the residential area. Explanations serve to learn from experiences. Already here the education is more than learning to control the vehicle and to apply traffic rules.

In a second stage we must accompany children in the new situations with roads for the distribution function and help them find more efficient but still safe behaviours. From about 8 years, the intake of knowledge and understanding grows rapidly. The children can take also more and more a social perspective now. The focus on behavioural prescriptions can change, children can explore and analyse behavioural alternatives. This is a good starting point to make them aware of the social consequences of their road conduct and the ways in which the infrastructure and regulations are meant to manage the traffic process. The need for defensive behaviour is not completely over. Even most twelve year-old children are unable to apply priority rules quickly enough in complex traffic situations, and cannot adequately assess risks. For children from 12 years onwards the action radius on the bicycle is enlarged by routes to secondary schools and remote living friends. From that age on the norms of the peer group become to get big importance. The bicycle can become an important means of presenting an attitude and competence. Control by parents and police remains important but it is also very important to communicate with them about ways to behave 'independently' without taking risks. Understanding of the consequences of behaviour, understanding of the position of other road users and obvious reactions to their behaviour is important to help these young people take smart decisions. Within educational programmes, teaching this understanding ought to be a goal. For children we have school education programmes. In primary schools they are obligatory, but for secondary schools the opportunities for their use have to be taken. Because of the intensive programmes of teachers, we have to look for integration of traffic safety subjects in other programmes. Most important is that the teaching is related to the experiences of pupils. We have to enrich them with feedback on their own behaviour. In order to promote the right kind of road conduct,

we should take greater account of their preferences and problems experienced by them. This is all the more important when a greater use of bicycles is asked for. A predictable and efficient cycle infrastructure, as well as responsible behaviour of other road users are important preconditions for making education effective.

In the third stage, when the cyclist has reached his top of expertise, we must consolidate. The emphasis may differ by age group. At a certain age communication about bicycle use is most important. From about 15 years onwards young people focus more and more on their future, on society, on independence. Mobility plays a very important role in this context. From one of our surveys it is obvious that young people see the car as a prominent way of going to particular destinations. But that does not mean that the bicycle is neglected, the appeal of environmental reasons the popularity of cycling even may increase. We may learn them to evaluate different traffic modes. For teenagers circumstances in life may change a lot. Many of them move house several times in a short period. Mobility patterns change as a consequence. Decisions about transport mode can be fixed for a long period. Information about a critical use of the car and the possibilities of using a bike - in combination with public transport - remains important. When people after a long period are used to drive a car for all their transport needs, it is far more difficult to promote the use of a bike. For adults, cycling gets importance as a way of relaxation and of compensating for sedentary work. In the Netherlands, programmes have been developed in cooperation with companies and offices to make more use of bicycles for home-work trips and for short trips as part of work. About 12% of the total mileage in the Netherlands is due to the bicycle.

The fourth stage is the education for a license to drive a car or motorcycle from 18 years onwards. Nowadays we have a theoretical (traffic rules) and practical part in the examination for a driver license, which examination generally asks for a minimum of 20 driving lessons from a private driving school. The fact that a license is not a guarantee for the mastering of the road and traffic complexity of the present-day infrastructure, is illustrated by research which shows that those who pass the examination in the familiar traffic area of the driving lessons fail to pass an examination in an other not familiar traffic area (Vissers, 1990). The unpredictability of the infrastructure is an additional difficulty which apparently interferes so much with the driving skill that safe driving is insufficiently learned. The young driver needs now about 50,000 to 100,000 km of experience in order to reach the four times lower risk level of the experienced 30 to 40 years old driver. Therefore, we have to consider a graded licensing or provisional license system, wherein initial curfew laws holds for difficult situations (night driving, high speed driving, motorfreeways) and wherein accompanied driving may bring more experience in the perception of dangers and a responsible driving attitude, as experiments in France (Twisk, 1991) have shown. It is conjectured that the uniformity of a restructured infrastructure in the future of a sustainable road safety will shorten the learning period to a full experienced driver and, thereby, will also lower the risk of young drivers considerable.

6. Integrative effects, costs and benefits

The reconstruction of our infrastructure in the Dutch policy for a sustainable road safety will provide gradually lower mean risk levels. Since risk judgement is relative to the mean experienced risk (Koornstra, 1990) a lower mean risk level will also result in less risky behaviour of individual road users. In this way the risk norms of individuals are gradually lowered. It not only will bring an additional collective risk reduction, but it also forms a force in itself for the social pressure for the restructuring to an infrastructure with a sustainable road safety.

Based on the reduction of the possible conflicts between slow and fast traffic and of possible conflicts between motorised vehicles as well as on the reduced severity outcomes of remaining accidents in the restructured infrastructure, the calculations show that an overall risk reduction to about 10% to 20% of the present-day risk level is very well possible. These calculations do not contain the additional effects of lowered risks for newly licensed drivers and lowered risks norms in the risk taking behaviour of all road users. All together we estimate that the integrative effect of the Dutch policy for a sustainable road safety will be expressed as an actual continuation of the risk adaptation (Koornstra, 1992) of the past 40 years by a 50% risk reduction in every ten year.

Nowadays the lack of road safety amounts to a macro-economic cost of about 9 billion guilders per year in the Netherlands. The yearly expenditure for maintenance and enlargement of the road infrastructure in the Netherlands are about 5 billion guilders. The calculated total costs of the reconstruction of the infrastructure for a sustainable road safety are estimated to be at least 60 billion guilders. It is judged to be feasible that 2 billion guilders from the usual expenditures for infrastructure can be employed for the reconstruction of the infrastructure. In that case it will take at least 30 years before the task is completed. In these 30 years the savings from the increasing road safety, however, are cumulating in the macro-economic sense to about 120 billion guilders. In the end the savings are at least 8 billion guilders per year compared with the present-day costs. Hence, viewed over a longer period the economic benefits are estimated to be much higher than the costs. So we conclude that, apart from the improved quality of life and a major reduction of the uncountable sorrows over lost and injured life, the Dutch policy for a sustainable road safety pays off and let the nation profit.

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