

# Stimulation of cycling in a safe way

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*Paper presented to 73rd Annual Meeting Transportation Research Board,  
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## **The design of our transport and traffic system**

Cycling is becoming more and more popular in countries with a high socio-economic standard, like north America and Europe. This asks for a transport and traffic policy in which safety plays an important role. Now we may regret that we designed a transport and traffic system without taking care of the needs of cyclists. We need huge investments to provide afterwards the necessary facilities for bicycles.

Generally safety policy has been problem solving instead of problem prevention. Also in this respect we have to invest much afterwards. We gave such a high priority to mobility aims in our transport and traffic system that we neglected to incorporate safety standards.

SWOV recently outlined headlines of a traffic system in which safety demands are integrated in the design of the Dutch road network. These safety demands can be applied when roads will be restructured. Together with measures regarding the road user and the vehicles, we need about 25 years to make our transport system about 90% more safe. Because of the relative great share of cyclists in our mobility patterns - the Netherlands are at the top of economic developed countries in this respect - the facilities for cyclists are integrated in our plan. This approach is the basis for this contribution to the TRB-meeting.

## **Targets for the bicycle**

In the Netherlands, the bicycle has already been a very common way of transport for many decades. The motorisation caused a drop in cycle use during the fifties and sixties but in the seventies and eighties, after the oil crisis, the popularity has grown again for recreational, fitness and health reasons. Now, about 27% of all trips and about 12% of all vehicle kilometres travelled are covered by bicycle. Moreover, because of growing problems with the environment and congestion, a critical use of the car is needed. That was the basis for the new bicycle policy in the Netherlands.

The cycling policy is outlined in the Bicycle Masterplan, 'Bicycles First'. This policy requires that the major drawbacks of cycling be eliminated as much as possible, to discourage preferential use of the car. Aspects of this policy include:

- measures to improve the infrastructural facilities for bicycle transport;
- measures against bicycle theft and improvement of parking facilities (each year in the Netherlands, with 15 million people and 12 million bicycles, 1 million of bicycles are stolen);
- measures to improve connections with public transport;
- measures to reduce the road hazards associated with cycling.

At the same time, the costs of car use will be enlarged by government measures. Parking facilities for cars are reduced within inner cities. The aim is to expand bicycle use by 30% in 2010, to diminish travel time by bicycle within inner cities by 20%, to make the bicycle the quickest means of transport for trips less than 5 kilometres and to expand trips by bicycles within inner cities by 50%. In addition, the government wants offices and companies with more than 50 employees to have a transport plan that includes bicycle stimulation. Of course it is necessary that the administration and society support each other. The administration can stimulate and provide incentives and will be successful when it takes account of ideas, preferences, needs within society. Perhaps illustrative is the initiative for a bike-lease system, a supplement of existing car-lease systems, nevertheless the fact that 8 out of 10 Dutchman own a bicycle. Together with these transport aims, the government also set safety targets. Using a bicycle is in general more hazardous than using a car. The share of 12% of all vehicle kilometers corresponds with 25% of all serious traffic injuries. In the year 2010 fatalities as a cyclist should be reduced by 50% and hospitalized injuries by 40%. The same targets have been set for other road user categories.

These safety strategies has to integrate infrastructural and educational measures as well as improvements of vehicles. We will explain this now, first by elaborating on infrastructural, educational and vehicle standards.

### Infrastructure

We advocate a restructuring 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 cyclists or mopeds and we do not want to change that. These roads make up slightly more than 2000 km in our small country, but account for about one-third of the motorized mileage. We have many physically separated cycle tracks of over 4000 km length. Parts of the residential roads in traffic calming areas have a speed limit is 30 km per hour and in parts, the so-called 'woonerf's' and shopping areas only the speed of pedestrians. This affords a mix of different transport modes like cars and bicycles with 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 traffic and outside built-up areas with great speed differences. The fatality rates on these highways are the highest as shown in Table 1 where the injury and fatality rates for all road types in the Netherlands are displayed.

Road type	Max. km/h	Mixing fast slow	Crossing opposite traffic	Injury rate km*10 <sup>6</sup>	Fatality rate km*10 <sup>8</sup>
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 motorroad	80	no	yes	0.30	2.1
Rural motorroad	100	no	no	0.11	1.7
Motorfreeway	100/120	no	no	0.07	0.5

Table 1. Injury and fatality rates for road types in the Netherlands 1986.

We do have many bicycle tracks running parallel a carriageway, physically separated. In built-up areas these 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 problems from a safety point of view. The problems arise at intersections and the injury risk there is greater than at intersections of roads without separate tracks. That means that what we win in safety terms on the track by separation, we partly lose at intersections. Therefore, we must either also separate the slow and fast transport modes at these intersections or we have to reduce the speed of motorised traffic, for example by roundabouts.

### **Human factor and infrastructure**

However, stimulating bicycle use and safety is not simply building more bicycle tracks. We need more understanding of the problems of road users, of their capacities, their interests, their needs. Most road safety research has been carried on the basis of accident analyses. There are however restrictions of accident analyses. It is not always certain to which precise elements of the situation the hazard can be attributed and traffic situations often differ significantly. So it is often difficult to apply the findings for a particular situation to other locations. Another restriction of accident analyses is that the degree of hazard of entirely new design concepts cannot be determined at forehand. We do not want to determine the hazard of a situation only in retrospect. We must analyze the interaction of design and road user behaviour and predict under which circumstances accidents may occur and avoid designs which for the road user contain such circumstances. This is the way to integrate safety standards in the design of the road network.

We think it is necessary to segregate traffic on the basis of its function. In principle we only have to differentiate between three types of functions: the flow function, distribution function and the residential or living area function. We must allocate traffic with different functions to different road types and the design per type of a road has to optimize its function. This also implies that the design has to be adapted to the capacities and needs of the road users.

On roads with a flow function the design must allow for relative high speeds with minimal discontinuities. Therefore, on these roads cars and bicycles should be separated absolutely. Cyclists also need roads that facilitate an efficient stream. As much as possible, these roads should not be connected to car streams.

On roads with a distribution function we can use different measures. Still separated tracks are important, but additional measures are needed at intersections. In built-up areas 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 signalized and non-signalized intersections into roundabouts resulted in 30% less injured cyclists. Our philosophy is that all residential roads should be upgraded or down graded to either urban arterials or streets with a traffic calming area design. On the latter roads the speed of cars are 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 and bicycles.

The design of the three types of roads will be completely different, to evoke the behaviour that fits with the function. The design and safety devices for these types of roads must be exclusive and permanently visible, if possible without local traffic signs. The road user must easily recognize the desired behavioral options that are left. These options must lead to predictable behaviour for all users of the road.

We are experimenting now to work this out, especially on roads with a distribution function and on intersections between roads with a flow function and a distribution function 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 abilities of cyclists differ. 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 decision will be made, another can be a division of the crossing task by making it possible to cross a road in two stages.

The desired behaviour must also correspond with the logic and utility of the road user. Road users learn to act automatically. Their behaviour is not only elicited by a given traffic location but mainly based on the experiences they had on similar trips before and the previous information they got on their route. A main route with alternating design elements, cycle tracks and no separated 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. They generalise the most pronounced information and derive from this expectations. The road designer must attract the attention of the road user to the most saillant information and provide anticipatory clues and signals when a road user enters another type of road.

Moreover, the desired behaviour must also correspond with preferences of the road user. A safe but inefficient way of crossing will only be used by cyclists when the traffic situation seems not to be safe. Otherwise, many cyclists 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 dangerous alternatives should not only be forbidden, but also be made very unattractive.

Recently the design manual for a cycle-friendly infrastructure, 'Sign up for the bike', has been published in the Netherlands. It contains the Dutch expertise on the infrastructure that cyclists need. Five criteria were used for the design of infrastructural measures: traffic safety, directness of connection, aesthetic, comfort and social safety. Several institutes, among others SWOV, contributed to it in cooperation with the Ministry of Transport that published it and translated it into English.

Maybe optimal solutions for facilities will not always be the same in every country, because we may have a too different traffic history and a different role of the bicycle. But the principles for the design can not be different, although these have to be adapted to the conditions in a country or region.

## **Vehicle**

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 nearly three times the number of cars. The Dutch law demands at least 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 to be met when light conditions are bad). In this respect the Netherlands are far behind other countries (Kostense, 1992). There is also no Dutch bicycle (safety) standard such as ISO, BSI, DIN or AFNOR safety standards from other countries. The Ministry of Transport is considering to upgrade the level of legal requirements with respect to lighting systems, brakes and frame. But first they demand proof that such quality improvements also improve traffic safety. This proof appears very hard, since the type of accident data needed for this purpose is not readily available.

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 bicycle riders 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 devices have shown to contribute to the improvement of traffic safety by decreasing the number of injury accidents with some 5% (Blokpoel, 1990), the normal lighting systems are still considered to be of importance too.

Another contribution to the traffic safety of bicyclists is found in the field of requirements for the car front. The EC is considering to improve the level of safety for pedestrians (which will also benefit bicyclists) by a directive requiring 'softer' bumpers and engine hoods. A cost-effectiveness study is carried out by SWOV to evaluate the potential benefits of this measure.

Finally it is thought that the use of helmets will greatly benefit bicyclists in all kinds of collisions, 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. Dutch people do not take the burden of their use as worthwhile. They never have used them and nearly everyone regards the obligation of helmets for cyclists as a silly measure. The Dutch cyclist organisation advocate accident prevention measures.

## **Education**

In accordance to infrastructural measures we will improve our educational programmes. In that respect we speak of 'permanent education'. Road users must know 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. In the Netherlands we have different programmes for children from 6 till 16 years, for elderly people and for adults who have not been grown up in the Netherlands. Further we have information



programmes to stimulate the use of the bicycle. We need still more target group segmentation. Besides there is a need to pay more attention within driver training to prevent accidents with cyclists. The drivers have to learn how to cope with cyclists on roads and intersections and to anticipate on their behaviour. The effectiveness of traffic education will be multiplied when both conflict partners are taught how to prevent accidents.

Permanent education can be divided into three stages.

First we have to learn very young children basic skills and elementary defensive behavior 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 that are rather simple. 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 cyclists in more complex situations and help them find more efficient but still safe behaviors. 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-olds are unable to apply priority regulations (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 too many 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 can be one of the goals.

In the third stage, when the cyclist has reached his top of expertise, we must consolidate. Traffic situations may change, behavioural patterns may change and people may change. For example, people may use the bicycle in new situations and other purposes or people may loose some practice, when they get older it becomes necessary to compensate for declining capacities. So there are several reasons to support them with education. Even before people are 50 years old, they are confronted with some loss of functions with consequences for their abilities as a road user. It is easy to find solutions for that, at most by taking a little bit more time for perception and decision taking. Of course, these problems increase, for some more quickly than for others. Figure 1 shows the amount of fatalities of cyclists per 100 000 inhabitants, in three periods of three years.

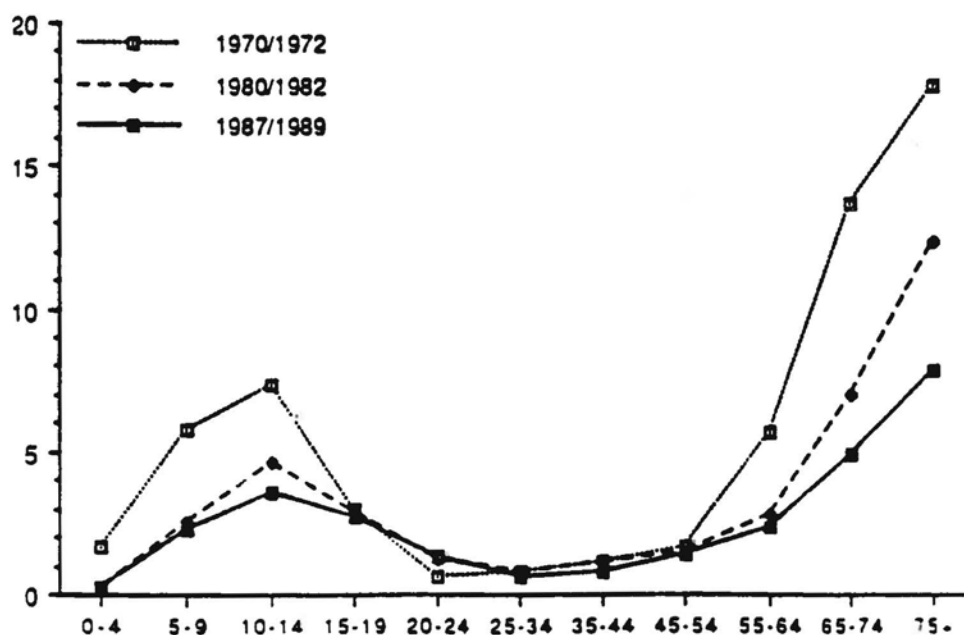


Figure 1. Fatality rates (per 100.000 inh.) for cyclists in the Netherlands.

It is evident that children and elderly people are more involved in serious accidents. It is also evident that in general safety problems of cyclists have been reduced since 1970.

When people are - let us say - 70 years old, it is becoming more and more important that they do exercise to remain fit. The bicycle is an excellent way of keeping fit. But then the routine in traffic must necessarily be maintained on a sufficient level. Advice on how to cope with traffic, especially in complex situations, are helpful. For most of the problems, there are possibilities to find behavioural alternatives that compensate for the loss of function. Not only elderly people show that it is often efficient to combine safety instruction and stimulation of bicycle use in education programmes.

The emphasis may differ by age group. At a certain age communication about bicycle use is most important. From about 15 years 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 can help them to evaluate different traffic modes. For young adults circumstances in life 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.

For children we have school education programmes. In primary schools they are obligatory and for secondary schools the opportunities for their use have to be taken. Because of the very intensive programmes of teachers, we have to look for integration of traffic safety subjects in their programmes. Most important is however that the lessons are related to the experiences of pupils. We have to enrich them with feedback on their own behavior. For training in practice we can use parents. In the US you use community based programmes. We use these kind of programmes too, for adults who come out of another country and for elderly people. Information programmes can be very helpful too, especially when they provide concrete behavioural recommendations. Attention for mass media information will only be attracted when solutions are provided for problems people really have. In order to promote the right kind of road conduct, we should take greater account of the preferences of cyclists and the problems experienced by them. This is all the more important when a greater use of bicycles is asked for. Facilities for cyclists, e.g. a predictable and efficient cycle infrastructure, as well as responsible behaviour of other road users are important preconditions for making education of cyclists effective.

### **Integration**

Police enforcement regarding bicyclists is relatively rare in the Netherlands. There is increasing cooperation between the police and schools to enforce the most important traffic rules in combination with teaching understanding of the traffic process. Another interesting development is the integrative approach with several enforcement and other traffic measures. In Amsterdam the police enforces bicycle lighting and red light discipline of cyclists, together with speed and red light discipline of motorists. Also cycle tracks are constructed, cars that are blocking cycle tracks are towed away with priority and traffic lights have been adapted to make cycling more efficient. This is really an integrated approach.

### **Conclusions**

To conclude, the promotion of bicycle use and safety is dependent on:

- a transport policy for the use of bicycles on short and recreational trips;
- efficient bicycle tracks between living, working and recreation areas;
- separated bicycle tracks on roads with a distribution function;
- traffic calming measures in residential areas;
- safety requirements for the bicycle;
- an education scheme for different target groups;

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