SWOV Fact sheet

Bicycle facilities on road segments and intersections of distributor roads

Summary
Bicycle facilities that separate motorized traffic from relatively vulnerable road users such as cyclists and light-moped riders are necessary in a sustainably safe traffic environment. Research has shown that the road segments of distributor roads with adjacent or separated bicycle paths are safer than road segments without such bicycle facilities. The number of crashes can be reduced by additional measures at intersections: priority regulations, speed bumps, and plateaus. The absolute separation of the various road users is not always feasible, even in a sustainably-safe traffic environment. That is why conflict situations, and the accompanying crashes, can never be completely excluded.

Background
Bicycle facilities in the form of lanes and paths have always been meant to separate bicycle traffic from motorized traffic. This is prescribed for distributor roads in sustainably-safe traffic. Such roads make residential and other areas accessible, and link residential access roads with the through-roads. A physical separation of motor vehicles and other road users is desirable on road segments of distributor roads in order to prevent large speed differences on the same roadway. The speed limit on rural distributor roads is 80 km/h and on urban roads usually 50 km/h, sometimes 70 km/h. This fact sheet will specifically discuss bicycle facilities. More general information about can be found in the fact sheet *Cyclists*.

How safe are bicycle facilities?
The road crash registration in the Netherlands only provides very limited information about the facilities at the crash scene. To obtain insight in the safety of the various types of bicycle facilities, it is almost always necessary to conduct extra crash research.

In *Table 1*, the registered numbers of deaths and in *Table 2*, the registered numbers of in-patients from crashes between cars/delivery vans or lorries with cyclists or (light)-mopedists are given. They are casualty numbers from crashes in which the registered speed limit was 50 km/h or 80 km/h – this means that there were crashes on roads other than distributor roads. The numbers are also given in percentages of the total number of road deaths and in-patients in 2006 (730 and 9,051 respectively.

Vehicle	Crashes against	50 km/h speed limit				80 km/h speed limit				Total	
		Road segment		Intersection		Road segment		Intersection			
		Number	%	Number	%	Number	%	Number	%	Number	%
Car/Van	(Light)-moped	4	0.6	4	0.6	2	0.3	6	0.8	16	2.2
	Bicycle	21	2.8	38	5.2	5	0.7	14	1.9	78	10.7
Lorry	(Light)-moped	2	0.3	2	0.3	1	0.1	7	1.0	12	1.6
	Bicycle	1	0.1	25	3.4	3	0.4	7	1.0	36	4.9
Total		28	3.8	69	9.5	11	1.5	34	4.7	142	19.5

Table 1. *Number of deaths at locations with a 50 km/h and 80 km/h speed limit in crashes between motor vehicles and cyclists or (light)-mopedists: absolute numbers and percentages of the total number of road deaths in 2006 (730).*

Vehicle	Crashes against	50 km/h speed limit				80 km/h speed limit				Total	
		Road segment		Intersection		Road segment		Intersection			
		Number	%	Number	%	Number	%	Number	%	Number	%
Car/Van	(Light-) moped	171	1.9	417	4.6	44	0.5	93	1.0	725	8.0
	Bicycle	251	2.8	756	8.4	56	0.6	106	1.2	1,169	12.9
Lorry	(Light)-moped	10	0.1	12	0.1	2	0.0	3	0.0	27	0.3
	Bicycle	23	0.3	49	0.5	3	0.0	8	0.1	83	0.9
Total		455	5.0	1,234	13.6	105	1.2	210	2.3	2,004	22.1

Table 2. *Number of in-patients at locations with a 50 km/h and 80 km/h speed limit in crashes between motor vehicles and cyclists or (light)-mopedists: absolute numbers and percentages of the total number of road deaths in 2006 (9,051).*

There are about twice as many fatalities or in-patients on the intersections of the selected roads/streets as on road segments. This illustrates the fact that many more potential conflicts occur on those locations.
There are over five times more in-patients on road segments and intersections with a 50 km/h speed limit than on those with an 80 km/h speed limit. This is mainly caused by the larger numbers of cyclists and mopedists in urban areas. The fact that, there are relatively more fatalities on 80 km/h roads than 50 km/h roads is due to the larger speed differences and the resulting greater crash severity.
Relatively little is known about the characteristics of the locations on which the crashes occur. It is, however, registered whether a cyclist, mopedist or light-mopedist came off a bicycle path or lane. On 50 km/h road sections, 13 out of 33 (39%) of the fatalities among cyclists came off a bicycle path or lane; this was 18 out of 31 (58%) for 80 km/h road sections. For in-patients this was the case for 171 out of 419 (41%) on 50 km/h road sections and 125 out of 288 (43%) on 80 km/h road sections. The percentages for (light-)moped riders are almost identical, except that for fatalities on 80 km/h road sections, which is as low as 13% (1 fatality on a total of 8). A bicycle facility alongside a road section seems the ideal separation between slow and fast traffic, but these figures show that such a facility apparently does not eliminate all crashes by far. For more information see under *How large are the effects*.

What are the measures for cyclists?
The main types of bicycle facilities that are meant to separate them from motorized traffic are (in sequence of increasing 'separation grade'): recommended bicycle lane, bicycle lane, adjoining bicycle path or separate bicycle path. It is desirable that parking lots are not adjacent to bicycle facilities in order to avoid conflicts between parking vehicles (manoeuvres and occupants getting in and out) and passing cyclists.
It is preferable that intersections of two distributor roads should be shaped like a roundabout. However, there are also level junctions, with or without traffic lights. The driving speeds at an intersection should be slower than on the adjacent road segments. Driving speeds on roundabouts are slower anyway. Speed inhibitors, such as speed bumps just before an intersection area or a raised intersection area (plateau), are sometimes used at other types of intersection. Whether or not these intersections have special bicycle facilities, streaming lane, streamed bicycle path, recessed bicycle path, turning right at a red traffic light, or 'triangular channelizing island', mainly depends on the volume of passing traffic (motor vehicles and bicycles) and on the presence of (bicycle) facilities on the adjacent road segments.
A residential access road should meet a distributor road in a three-branch intersection. The bicycle path runs right through the adjacent residential access road, preferably at a greater height than the roadway of the adjacent residential access road.

Many roads and streets have not yet been laid out according to the Sustainably-Safe approach. The safety of cyclists will gradually improve while this redesign takes place during the coming years. A complete separation of motorized traffic and cyclists is only possible if there are separate paths along road segments and (only in special situations) grade separation at intersections. Mixture is unavoidable in other situations, especially at intersections and bicycle lanes. That is why conflict

situations will always remain and, even with Sustainably-Safe, crashes between motor vehicles and bicycles will not be excluded.

How large are the effects?
SWOV research in the 1980s (Welleman & Dijkstra, 1988) showed that bicycle paths along urban through-roads were safer for cyclists than bicycle lanes, and that bicycle lanes were less safe than no bicycle facilities (i.e. cyclists on the roadway). 50% less injury crashes per cycle kilometre were found on road segments with bicycle paths than on bicycle lanes. 50% less injury crashes per cycle kilometre were also found on road segments without bicycle facilities than on bicycle lanes. The group of bicycle lanes in this study was rather diverse anyway: narrow and broad bicycle lanes and recommended bicycle lanes, with or without parking along the side of the road had all been added up together. In the same report it was also found that on through-roads intersections, paths were less safe for cyclists than separate lanes (50% more injury crashes per passing cyclist) or no facilities (32% more injury crashes per passing cyclist). This led to the recommendation to terminate ('truncate') bicycle paths some distance from an intersection. These results were completely different for mopedists, and this was reason enough to recommend the Moped on the Roadway measure.

In the 1990s, Louisse et al. (1994) reported the (second) evaluation of the Delft Bicycle Route Network. This city introduced many bicycle facilities in the 1980s. In 1994 the situation in Delft was again studied, and compared with the evaluation that took place a short time after introduction. There is more bicycle use in Delft than in other medium-sized towns, but this was also the case before the introduction of the bicycle route network. The conclusions in the evaluation study were not very positive: bicycle use had not increased, neither had the road safety. A route network of bicycle facilities apparently has no added value for bicycle use or road safety.

The introduction of 60 km/h speed limit for rural access roads went together with the introduction of (non-compulsory) bicycle lanes. A pre and post test on roads that did not have such a lane at first, but on which one was constructed later (Van der Kooi & Dijkstra, 2003) showed that this results in modest positive effects on the behaviour of cyclists and car drivers. For more information see also the fact sheet *New type of layout for 60 km/h rural roads*.

Research abroad
International research mainly dates back to the 1990s.

In the 1990s Denmark paid a lot of attention h to research into the effects of various sorts of bicycle facilities. Herrstedt et al. (1994) carried out experiments with the layout of bicycle paths and lanes, just before and at intersection areas. They mainly used drastic marking. Experiments were also carried out with the layout of bus stops that are right next to bicycle paths. They also studied the safety differences of road segments with or without bicycle facilities. They carried out a before-and-after study of the construction of (real) bicycle lanes on 37 road segments. Taking into account the volumes of car and bicycle/moped traffic, the number of crashes with cyclists and mopedists declined with 35% and 52% respectively after construction of the lanes. It is not known whether these bicycle lanes are safer or less safe than bicycle paths. It is also not known what the trend in crashes was on roads without facilities, because there was no control group. In a comparative study, they found that narrower bicycle lanes (less than 1.2 metres wide) were three to four times less safe (crashes per cycle kilometre) than wider bicycle lanes.

In Germany, Angenendt et al. (1993) and Schnüll et al. (1992) carried out studies of the effects of facilities on road segments and intersections. With regard to the road segments they, just as in Denmark, compared differences between those with or without bicycle facilities. It comes as no surprise that, also in Germany, bicycle paths are safer than road segments without bicycle paths. What was a surprise, however, was that no bicycle facilities are needed to increase safety on road segments with less than 10,000 motor vehicles per 24 hours and driving speeds not exceeding 50 km/h. They even dared to extend this to 15,000 motor vehicles per 24 hours and driving speeds with a 85^{th} percentile of 45 km/h. This deviates considerably from the Netherlands recommendations (CROW, 2006; figure 19 on p. 112). The study of intersections is aimed at the differences between the layout of bicycle facilities just before and at intersection areas with or without traffic lights, and on the consequences for cyclists continuing straight on ahead of motor vehicles ' turning right at a red traffic light' and on large roundabouts (i.e. with more than one lane for car traffic). Research indicates that it is preferable to mix cyclists with motorized traffic just before and at the intersection areas. If that is

neither possible nor desirable, the bicycle path should not be too far from the roadway (i.e. no more than 2 metres). This is also preferable in the case of 'turning right at a red traffic light'. The recommendation for large roundabouts is to allow cyclists on the roadway; there they are (taking the traffic volume into account) less involved in crashes than on bicycle lanes and bicycle paths.

In Switzerland, Bürgler & Lindenmann (1994) carried out observations on a number of *expanded bicycle streaming lanes (EBSL)*. In most cases, cyclists and motorists behaved as intended. They recommend the use of the EBSL especially in situations where the share of bicycle and moped traffic is at least 30% of the total. Proportionally, the period of a red light for cyclists at traffic lights should last at least as long as the green period.

Sweden
In a Swedish study of with pedestrians and cyclists at intersections, Brüde & Larsson (1993) used a simple *model* was used to calculate the number of crashes with pedestrians and cyclists. The model only contains the combination of the number of passing motor vehicles and the numbers of passing cyclists and pedestrians. The crash level can be calculated accurately with just these two variables.

How much do they cost?
Wesemann (2000) reported an amount of €130,000 per kilometre for constructing a bicycle path. This amount is exclusive of VAT, land purchase, and maintenance costs. A parallel road costs €308,000 per kilometre. According to his calculation method, the cost-effectiveness of a bicycle path along an urban distributor road is € 4.66 million per casualty saved (fatality or in-patient). A parallel road beside a rural distributor road has a cost-effectiveness of € 18.18 million per casualty saved. The Contribution Regulation for Road Traffic Facilities, and after 1994 the Infrafund, made it possible that 737 projects were partially financed by the state during the 1990-1997 period. The total subsidy was € 91 million. € 56 million of this was used for a total length of about 700 kilometres of bicycle paths and lanes. 332 bicycle paths were built along roads, as were 86 bicycle lanes and 69 bicycle paths with their own route.

Conclusions
In a sustainably safe road traffic it is essential to have adjoining or separate bicycle paths alongside distributor roads in order to have a proper separation between motor vehicles and other traffic. Additional facilities are necessary at intersections in order to reduce the speed differences between cyclists and other traffic as much as possible. Priority regulations, speed bumps, and plateaus are suitable to achieve this.

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(Most sources are not in English; SWOV reports have an English summary)

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