RECLASSIFICATION AND RECONSTRUCTION OF URBAN ROADS IN THE NETHERLANDS

EFFECTS ON SAFETY, THE ENVIRONMENT AND COMMERCE

INSTITUTE FOR ROAD SAFETY RESEARCH SWOV
ROAD SAFETY DIRECTORATE (DVV)

This report has been compiled by the SWOV Information Department
P.O. Box 170 - 2260 AD Leidschendam - The Netherlands

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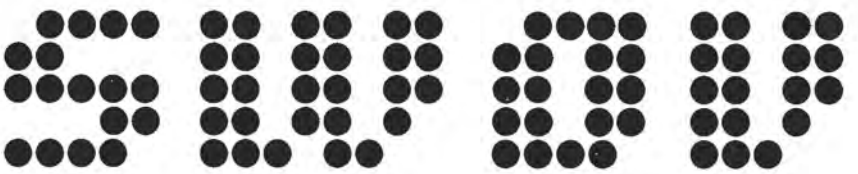

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FOREWORD

Since 1960 Dutch towns have been increasingly confronted with a lack of space, air pollution and road safety problems. The cause of these was the car with its expanding domination of the road traffic scene. During the latter half of the 1970's the realisation grew that car traffic in towns and villages had to be curbed and that pedestrians and cyclists should be allowed more space. Since then, the central government has aimed at excluding motorised traffic as much as possible from residential areas and to concentrate it onto a limited number of designated through-roads. In order to establish how this goal can best be achieved, the government is carrying out a policy of experiments to research the effects of different types of measures.
Under this policy far-reaching infrastructural measures were taken between 1979 and 1981 in the towns of Eindhoven and Rijswijk to improve living conditions and safety in residential streets and at the same time to improve the flow of through-traffic. This pilot scheme was financed by the Ministry of Transport and Public Works and the Ministry of Housing, Physical Planning and Environment. Extensive research was carried out in Eindhoven and Rijswijk, not only into road safety but also into traffic circulation, environmental factors, socio-economic aspects, and use of and feelings about public areas. Each of these five topics was examined by a separate research group, overall responsibility being taken by an interministerial steering group.

Over the years a large number of reports of these various studies have been published, to make the results available to foreign readers, SWOV and DVV have decided to summarise the most important data in this English-language booklet, compiled by SWOV's Information Department. At the back is a list of everything published to date on the pilot scheme in Eindhoven and Rijswijk.

Prof. E. Asmussen, Director, SWOV
Leidschendam, December 1985

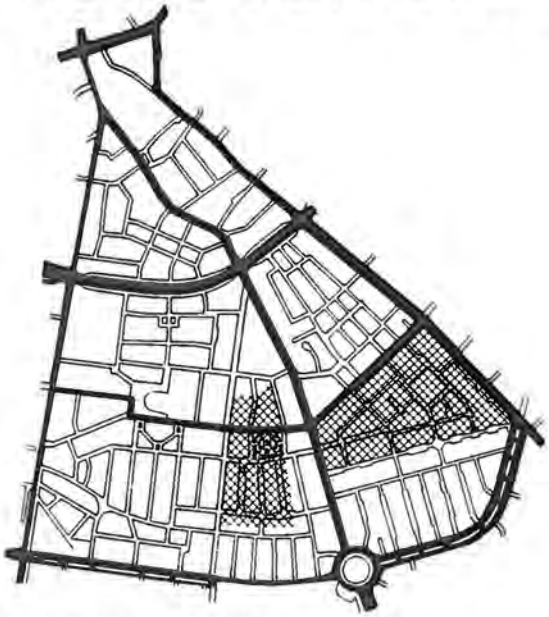
Recommended cycle lane on traffic artery

INTRODUCTION

The Minister of Transport and Public Works announced in the 1975 Road Safety Policy Plan that an experiment was to take place involving the reclassification and reconstruction of urban areas, the aim being to restrict as far as possible the strain placed on the residential environment by motorised traffic. Thus through-traffic was to be kept out of the residential zones (networks of residential streets and access roads) and restricted to a limited number of traffic arteries together forming a traffic zone. The locations selected for the experiment were two self-contained urban areas of approx. 100 hectares in Eindhoven and Rijswijk. The roads and streets in these areas were reclassified and reconstructed in accordance with their function.
The measures taken on the traffic arteries were aimed at the smooth flow of traffic, particularly fast traffic, priority being given to trams and buses. Measures were also taken to improve the safety of all categories of road users: clear lane markings, separate cycle paths and recommended cycle lanes, pedestrian crossing facilities and traffic lights.
The packages of measures taken in residential streets were based on three different sets of objectives (options). They ranged from fairly simple in the case of option 1 (one-way traffic and a single ramp) through slightly more complicated in the case of option 2 (one-way traffic in combination with various speed-restricting devices) to far-reaching in the case of option 3 (woonerf or similar scheme). The measures were designed to place slow traffic on an almost equal footing with fast traffic. No explicit objectives were formulated for the access roads, but they were reconstructed in a similar way to residential streets under option 2. Streets under the same option were grouped into 'option zones'.

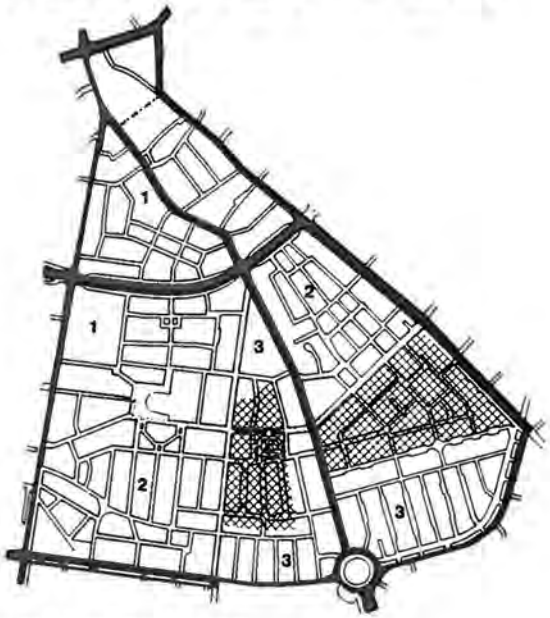
SWOV carried out and/or coordinated various studies to measure the effects on road safety: an accident survey, behavioural surveys and opinion polls. In addition, SWOV carried out some more or less self-contained studies of particular problems which are beyond the scope of this booklet.
The topics dealt with in the chapters that follow are: what measures were taken in Eindhoven and Rijswijk, and what the effects are on road safety; accident rates, behaviour of road users and safety levels as perceived by residents. A brief account is then given of the effects of the measures on the environment and commerce, the research into these two aspects was carried out by the consulting agencies DHV and BGC and the Central Institute for Small and Medium-Sized Business (CIMK) respectively.
The public participation process and its influence on the measures ultimately taken will not be discussed in this condensed report.

EINDHOVEN EXPERIMENTAL AREA



ROAD NETWORK BEFORE

- traffic arteries
- other roads carrying through traffic
- residential streets
- areas already reconstructed



ROAD NETWORK AFTER

- traffic arteries
- access roads
- residential streets
- areas already reconstructed
- 3 option no.

RIJSWIJK EXPERIMENTAL AREA

ROAD NETWORK BEFORE

- traffic arteries
- other roads carrying through traffic
- residential streets

ROAD NETWORK AFTER

- traffic arteries
- access roads
- residential streets
- boundaries of option zones
- 3 option no.

MEASURES

The *reclassification* in the land-use plan of the experimental areas affected the roads carrying through-traffic (totalling 18 kilometres): in Eindhoven 2 km was redesignated as access roads, and in Rijswijk 4.7 km was redesignated as access roads and 1.3 km as residential streets. As a result the residential streets and access roads are grouped together into clearly recognisable residential zones, separated from one another and from the other districts of the town by the traffic arteries. The plans opposite show how the experimental areas in Eindhoven and Rijswijk were reclassified.

The *reconstruction* took the form of the following sets of measures for the various types of road.

Traffic arteries
- construction of separate cycle paths and marking of recommended cycle lanes
- reconstruction of service roads to keep out through-traffic
- improvement of crossing facilities for pedestrians, including the construction of a pedestrian underpass
- construction or repositioning of separate tramway
- clearer carriageway markings
- construction of parking bays
- improvement or installation of traffic lights
- introduction of new traffic regulations to improve flow, with priority for trams and buses.

Access roads
- narrowing of intersections and carriageways
- installation of ramps ('sleeping policemen')
- 'no entry' halfway along roads to keep out through-traffic
- construction of raised intersections
- realignment of road axis.

Residential streets (option 1)
- introduction of one-way traffic for cars, reversal of traffic direction in sections of existing one-way streets
- construction of parking bays
- construction of ramps at junctions with traffic zone.

Residential streets (option 2)
- construction of ramps and raised intersections
- realignment of road axis
- construction of parking bays and other measures to control parking
- introduction of one-way traffic for cars, reversal of traffic direction in sections of existing one-way streets
- 'no entry' to motorised traffic halfway along some roads.

Residential streets (option 3)

- construction of woonerf with sign in a small number of streets, in some cases combined with recommended lanes for pedestrians
- introduction of one-way traffic
- construction of ramps and raised intersections
- construction of parking bays
- realignment of road axis
- narrowing of intersection and carriageway
- decorations, e.g. flower tubs
- installation of play facilities, benches etc. for 'residential activities'

Tables 1 and 2 show the main reconstruction measures taken in Eindhoven and Rijswijk.

Table 1. Measures taken in residential streets

	Eindhoven – option:			Rijswijk – option:		
	1	2	3	1	2	3
Length of road (km) with:						
– one-way traffic for all vehicles	1.3	0.4	0.8	1.3	1.1	0.1
– woonerf	0	0	4.1*	0	0	4.9
No. of 'no entries' for motor vehicles	0	2	1	0	3	1
No. of ramps	17	70	85	1	18	43
No. of axis realignments	0	2	26	0	6	90
No. of raised intersections	0	3	10	11	20	6
No. of road & intersection narrowings	3	4	0	4	4	20

*2.2 km was already woonerf

Table 2 Measures taken on main roads

	Eindhoven traffic arteries	access roads*	Rijswijk traffic arteries	access roads
Length of road (km) with:				
– separate cycle path	2.0	0	1.1	0
– (recommended) cycle lane	1.4	0	3.7	0
– separate bus/tram lane	0	0	1.5	9
No. of ramps	0	1	0	14
No. of axis realignments	0	4	0	19
No. of raised intersections	0	0	0	21
No. of road & intersection narrowings	0	25	0	17
No. of pedestrian facilities	16	0	4	0

* inc. 1.3 km of traffic artery changed into residential street

Separate tramway in traffic artery

EFFECTS ON ACCIDENTS

To ascertain whether the measures in the experimental areas of Eindhoven and Rijswijk had a favourable effect on road safety, the numbers of accidents before and after the reconstruction were compared. A six-year 'before' period was taken: 1972-77. Between 1977 and 1981 the measures were devised and implemented: transition period. The 'after' period began in 1982. This needs to be at least three years to indicate the differences in effectiveness between the three packages of measures. To give a rough idea of the overal leffect of the measures as soon as possible, however, the post-test is being carried out in two phases. The first covers a period of fourteen months, i.e. up to and including Februari 1983, the second, which should provide more detailed information, will probably cover the period 1982-85 inclusive.

To ascertain what effect the measures have on road safety, main roads and residential streets were looked at separately in the first phase of the accident survey. Access roads were regarded as main roads, since they do have a certain traffic function, although they form part of the residential zone and smooth flow is not absolutely necessary.

The accident survey was not confined to the experimental areas, but included the adjoining residential areas (influence areas) and the other residential districts of Eindhoven and Rijswijk (control areas). The influence areas were needed to indicate whether the measures did not simply shift the problems from one area to another. The numbers of accidents in the control areas showed to what extent the trend in the experimental areas was due to general factors unrelated to the measures. To enable the accident rates in the different types of area and at different times to be compared it was also necessary to consider the absolute numbers of accidents in relation to the amount of traffic - traffic performance, expressed in vehicle-kilometres. (Various yardsticks of this kind were used in the survey, but since the results differed only slightly, we shall confine ourselves here to vehicle-kilometres).

Table 3 shows the numbers of accidents involving injury in the *residential streets* of the experimental and control areas during the 'before' and 'after' period respectively. Both absolute numbers and figures per million vehicle-kilometres (including cycles and mopeds) are given. The 1.3 km of residential street which, although not designed to do so, carried through-traffic during the 'before' period was included among the main roads during the 'after' period, along with the access roads.

Table 3. Effects on the safety of residential streets

	accidents inv. injury		traffic performance*		accident rate**	
	exp. areas	control areas	exp areas	control areas	exp areas	control areas
'before'	109	879	48 2	1462.2	2 26	0 60
'after'	8	152	7 7	269.0	1 04	0.57

* in millions of vehicles
** accidents involving injury per million vehicle-kilometres

Road safety did improve in the residential streets in the experimental areas, whereas it did not in those in the control areas. Statistical checks carried out on the results indicate that this effect is 90% certain to be a result of the measures and not of contingency. It is a striking fact, incidentally, that the residential streets in the experimental areas were still almost twice as unsafe as those in the control areas, even during the 'after' period.

Analyses reveal that the improvement in road safety in the residential streets in the experimental areas has been due solely to a reduction in the number of collisions involving motor vehicles. The number involving only slow traffic has not decreased. Mopeds play a strikingly large part in this, being involved in four out of eight accidents during the 'after' period. This may be because the measures brought about only a slight reduction in the speed of mopeds (see report of speed checks in next chapter).

Table 4 shows accidents involving injury on *main roads* of the experimental and control areas during the 'before' and 'after' period respectively.

Table 4. Effects on the safety of main roads

	accidents inv. injury		traffic performance*		accident rate**	
	exp. areas	control areas	exp areas	control areas	exp areas	control areas
before	814	3574	407 2	1984 7	2 00	1 80
after	101	533	78 2	384 2	1 29	1 39

* in millions of vehicles
** accidents involving injury per million vehicle-km

The improvement in road safety was also greater on main roads in the experimental areas than on those in the control areas. Statistical checks, however, indicate that this effects cannot be ascribed with sufficient certainty to the measures (under 90% certainty).

The accident survey further revealed that the measures in the experimental areas have not had a negative effect on road safety in the influence areas, where the residential streets even seem to have become safer. The measures in the experimental areas have not therefore shifted the problem to other parts of the town.

'Bisected' access road with 'sleeping policemen'

EFFECTS ON BEHAVIOUR AND PUBLIC OPINION

In addition to the accident survey, various studies of behaviour and public opinion were carried out: traffic censuses, speed checks, observations of behaviour and conflicts, polls of residents. The main purpose of all these studies was to establish what changes in the traffic process enable the measures to have an effect on road safety.

TRAFFIC CENSUSES

The traffic censuses were carried out first of all to enable the accident rates to be considered in relation to traffic performance and thus to permit comparisons between the 'before' and 'after' period. The results of the censuses are also valuable in themselves, however: they indicate what changes the measures have brought about in the amount of traffic and the traffic mix.
One of the major objectives of the experimental scheme was to keep through-traffic out of the residential zones. Table 5 shows that this was reasonably well achieved: motorised traffic in the residential streets in the experimental areas dropped by 12%, whereas it rose slightly in the control areas.

Table 5. Average daily traffic flow in residential streets

	experimental areas			control areas		
	'77-8	'82	diff	'77-8	'82	diff.
bicycles	227	208	- 8%	907	908	0%
mopeds	37	24	-35%	184	96	-48%
motor vehicles	378	331	-12%	1149	1167	+2%
total	642	563	-12%	2240	2171	- 3%

SPEED CHECKS

The objectives for most of the residential streets included not only keeping out through-traffic but also reducing the speed of other traffic. No speed checks were carried out during the 'before' period as part of the road safety study; all that could be done during the 'after' period, therefore, was to ascertain which package of measures for residential streets resulted in the lowest speeds. Accordingly, 25 sections of road were selected among the residential streets in the experimental areas. The advisory agency Advisie monitored the speeds of passing traffic at three points on these sections (start, middle and end). Table 6 shows the highest and lowest average speeds at particular monitoring points.

Table 6 Speeds in areas with the three options (kmph)

	option 1 (8 streets*)	option 2 (8 streets)	option 3 (9 streets**)
cars			
highest average speed	38.6	36.1	21.8
lowest average speed	13.1	14.3	11.7
mopeds			
highest average speed	32.1	34.3	27.5
lowest average speed	14.8	11.3	12.0

* inc. one access road
** excl. woonerf streets

Strikingly, the speeds of cars and mopeds in option 2 streets seem to be only slightly lower than in option 1 streets, despite the fact that speed-restricting devices were installed on a large scale in option 2 streets. This is because, to have sufficient traffic to monitor, sections of road were selected which all joined up with main roads (traffic arteries and access roads). Among the option 2 streets these are precisely the sections of road with very few speed-restricting devices. The knock-on effect of the measures carried out further down the street seems, judging by the results of the speed checks, to have been very slight.
The woonerf layout does have a clear speed-restricting effect, at least on cars. It is evidently much more difficult to bring the speed of mopeds down to an acceptable level: in woonerf streets their speeds are even higher than those of cars. This may be the reason that the measures have not had a favourable effect on the safety of moped-riders in residential streets.

As part of the study of traffic circulation, additional speed checks were carried out during the 'before' and 'after' periods on two access roads. One of them was made 'no entry' halfway along as part of the reclassification, checks were carried out on both halves. The results of the checks, carried out by the Transportation Research Laboratory of Delft University of Technology, are given in Table 7. On the two parts of the 'bisected' access road in particular there was a substantial drop in vehicle speeds as a result of the measures.

Table 7. Speeds of motor vehicles on access roads (kmph)

	'before' mean speed	85%-value	'after' mean speed	85%-value
access road a	37.5	46.0	35 3	42.4
access road b, monitor point 1	45.5	52.5	35.8	42.9
access road b, monitor point 2	42 4	48.5	35.8	42.9

BEHAVIOURAL OBSERVATIONS

Special facilities were introduced on the traffic arteries in the experimental areas to improve the safety and comfort of pedestrians, cyclists and moped-riders. The Institute for Perception TNO (IZF-TNO) and the consulting agency DHV carried out behavioural surveys to gain an indication of how these facilities are working. IZF-TNO made video recordings at a number of locations during the 'before' and 'after' periods to analyse the effects of the facilities on cyclists and moped-riders. The analyses show that continuing the cycle-path paving across a junction with a side road raises the attention of car drivers crossing it: they approach at a lower speed. Narrower carriageways and islands enable cyclists and moped-riders to cross a traffic artery more quickly, but they do not make crossing any safer. Facilities were introduced on three traffic arteries to allow cycles and mopeds going straight ahead to weave with cars turning right at a light-controlled intersection. At one location this causes nuisance to the cycles and mopeds since the cycle lane for those going straight ahead is repeatedly obstructed by stationary cars waiting to move into the right-hand lane. Nevertheless the weaving system seems to have a small favourable effect on the safety of cyclists and moped-riders.

DHV examined the crossing behaviour of pedestrians at a small number of locations. Measures such as narrowing of the carriageway, application of wide central markings and installation of central refuges evidently make it easier for pedestrians to cross traffic arteries. The narrower carriageways in particular produce much shorter waiting times. The central refuges, incidentally, were found to have very little effect on the route taken by pedestrians, who generally take the shortest.

CONFLICT OBSERVATIONS

To gain an idea of the changes in the traffic process resulting from the measures, traffic conflicts were observed in the residential streets in the experimental areas. Since no conflict studies were carried out during the 'before' period, a comparison between the residential streets with the various options and a control area was carried out in the 'after' were those where Advisie carried out speed checks. Two

Woonerf exit

types of conflict observation were carried out: Lund Institute of Technology (Sweden) observed conflicts at the intersections of residential streets with the surrounding main roads (traffic arteries and access roads), and Advisie carried out 'shadow observations' on the sections of road which joined up with main roads.

Fixed-location observations

The Lund Institute of Technology study showed that conflicts at the exits from the reconstructed streets were no less numerous or serious than those at the exits from the residential streets in the control area. (The numbers of conflicts were in every case considered in relation to the amount of traffic: the figures were weighted to enable a clean comparison to be made). Nor were there any differences in conflicts between the reconstructed streets with the various options. There are two explanations for these findings. The first is that it was at the exits of streets with options 1 and 2 that no measures were taken; in this respect they did not differ from each other or from the exits of residential streets in the control area. The second explanation has to do with shortcomings in the design of the woonerf exits (option 3), which caused specific conflicts: the raised section of many of these exits is too close to the junction with the main road, and cars sometimes roll off these sections and can then come into conflict with passing traffic if the main road is narrow. Also, the exits are often so narrow that cars entering and leaving can easily come into conflict.

On the basis of the conflicts observed, the researchers calculated what the risk of an accident involving injury was to car drivers and cyclists in various situations. They came to the conclusion that cyclists travelling along the main road ran the greatest risk. Pedestrians were not included in the calculations because the number of conflicts observed involving them was too small statistically.

The researchers commented that it was not so much the construction of the streets that determined the numbers and seriousness of conflicts at exits as the design of the junction, the amount of traffic and the traffic mix. They concluded, among other things, that intersections between a residential street and an access road were safer than those between a residential street and a traffic artery. Lastly, they made a large number of suggestions, based on the conflicts observed, on how to improve safety at exits from residential streets.

Shadow observations

Advisie followed pedestrians on the sections of road which joined up with main roads and observed their conflicts with moving vehicles. Observers followed a total of 1 051 children and 530 adults. Remarkably, it was found that it was the children who were least involved in serious conflicts (per unit of time) and the adults the most. Given the small numbers of serious conflicts, however, no general conclusions can be drawn from this. It was possible, though, to identify the cause of serious conflicts involving pedestrians in a number of woonerf streets: certain obstacles forced adult pedestrians to zigzag across the street, as a result of which they had to cross passing traffic at points with restricted visibility.

Pedestrian underpass under main road

POLLS OF RESIDENTS

Polls were conducted among the residents of the experimental areas both before and after the reconstruction. The polls in the 'before' period were carried out by the consulting agency DHV and those in the 'after' period by the Institute for Applied Sociology (ITS).

The main purpose of the polls in the 'before' period was to identify dangerous locations in the experimental areas and to establish to whom they were dangerous and why. The question of the kind of measures needed was then examined. About two-thirds of the respondents were able to name one or more dangerous locations in their neighbourhoods, these were particularly dangerous, they said, to slow traffic. Most of these dangerous locations were sections of road and intersections on main roads. The main causes of danger mentioned were busy traffic, cars travelling at high speeds, poor visibility at intersections and absence of good crossing facilities.
After the reconstruction the residents were again questioned on this point. The measures taken - which many did not know about, as it transpired - had influenced their opinions very little. Again, two-thirds said that there were dangerous locations in their neighbourhoods and again they mentioned more or less the same causes (the only improvements they noticed were in the crossing facilities). Incidentally, the opinions of residents on hazards by no means tallied with the results of accident surveys. An example is given in Table 8, which classifies the locations identified in Eindhoven as dangerous before the reconstruction according to the number of times they were mentioned in the poll, and according to the number of accidents which occurred there. Comparison of the two columns clearly shows that polls are not a straightforward substitute for accident surveys.

Table 8. Locations classified by hazard level

location	order* on basis of poll	order* on basis of accidents
A	1	6
B	2	3
C	3	2
D	4	5
E	5	4
F	6	9
G	7	1
H	8	7
I	9	8

* the lower the figure, the greater the danger

Despite the fact that the same number of residents said that there were dangerous locations in their neighbourhoods before and after the reconstruction, in general they nevertheless took the view that safety had been improved in their streets and neighbourhoods. A notable exception were the residents of the only woonerf included in the poll, who said that the area had become more dangerous rather than less after the reconstruction, especially for children, old people and other pedestrians. It may be that their opinions were unfavourably influenced by problems associated with the public participation process. It is also possible that more children and old people go out on the streets now that they have been reconstructed, as a logical result of which these categories are more likely to be involved in traffic conflicts and accidents. Lastly, the obligatory zigzagging by pedestrians discussed above in connection with the conflict observations (shadow observations) may have had a negative influence on the opinions of residents. The most favourable opinion on the effect of the measures on safety was held by residents of option 2 streets, where numerous speed-restricting measures were taken.

Lastly, the polls conducted after the reconstruction examined to what extent the various packages of measures (options 1, 2 and 3) met their primary objectives according to the residents. The results are summarised in Table 9.

Table 9. Opinions on success in relation to primary objectives in experimental areas

opinion of residents	Eindhoven - option:			Rijswijk - option		
	1	2	3	1	2	3
through-traffic reduced/ eliminated after reconst	59%	51%	84%	76%	82%	92%
cars drive slower after reconstruction		64%	62%	59%		78%
neighbourhood pleasant to walk in:						
- before reconstruction			67%			87%
- after reconstruction			50%			54%

All three packages were designed to keep *through-traffic* out of residential streets. According to the residents the measures were particularly effective in option 3 streets. Residents of option 1 and 2 streets in Eindhoven were the most dissatisfied in this respect: only a small majority said that through-traffic had disappeared wholly or partly from their neighbourhoods.
In the option 2 and 3 streets the measures were also designed to reduce the

speed of motorised traffic. This objective was achieved most effectively, according to the residents, in the option 3 streets in Rijswijk, but in the other residential streets in Rijswijk and Eindhoven about 60% of residents also said that cars were now driving more slowly.
The measures in option 3 streets, lastly, were also designed to make the streets an *attractive* place to walk and talk in. To find out whether this objective was achieved, residents were asked before and after the reconstruction whether they found the neighbourhood pleasant to walk in: both in Eindhoven and in Rijswijk they found it less pleasant after the reconstruction.

Raised intersection

EFFECTS ON THE ENVIRONMENT AND COMMERCE

THE ENVIRONMENT

To ascertain the effects on the environment, measurements of noise, vibration and air pollution caused by traffic were carried out before and after the measures were taken.

Measurements of noise showed a decrease in all three types of residential street (options 1, 2 and 3) in the experimental areas. In residential streets which had suffered a good deal from through-traffic before the reconstruction, the equivalent daytime noise level dropped by as much as 6-10 dB(A). Also illustrative of the improvement in the situation is the decrease in the number of dwellings with a noise level of over 60 dB(A); under the Noise Nuisance Act insulation measures must be taken on any dwelling with this level of noise. Table 10 shows the percentages of dwellings requiring insulation before and after the reconstruction

Table 10 Percentages of dwellings requiring insulation

	Eindhoven - option:			Rijswijk - option		
	1	2	3	1	2	3
'before'	13	19	15	33	31	18
'after'	9	7	1	10	5	7

There was very little increase in noise along the traffic arteries since their traffic density rose only slightly in relative terms. The equivalent noise level along one traffic artery even dropped by 5 dB(A) because the distance between the carriageway and the houses was increased and the carriageway was asphalted. The measures in Eindhoven and Rijswijk had very little effect on vibration. The levels measured remained below the ISO standard for vibration in the residential environment, both before and after the reconstruction. This means that the vibration is not perceptible to humans.

The effects of the measures on air pollution were ascertained by measuring exhaust gas emissions on a number of test trips. The measurements showed that emissions of carbon monoxide per kilometre travelled rose fractionally in option 2 streets, those of nitrogen oxides dropped somewhat and those of hydrocarbons remained virtually the same. In option 3 streets emissions of carbon monoxide and hydrocarbons per kilometre rose noticeably, whereas those of nitrogen oxides fell. The rise in carbon monoxide emissions in option 3 streets is due to the numerous bends made in the road, which cause drivers to release and then depress the accelerator frequently. Because of the halving of motorised traffic in option 3 streets, however, total emissions of exhaust gases there dropped to some extent.

Cars and cycles weaving on traffic artery

COMMERCE

The whishes of local businesses were taken into consideration as far as possible when drafting the plans, as long as this did not affect the nature of the project. Attempts were made to gain an idea of the effects on commerce with the aid of a survey of businesses and a consumer survey.
The measures had no effect on the amount and composition of commerce, investment, closing-down or relocation of businesses. In the public service sector, especially the retail trade, a large section of businesses took the view that their turnover dropped as a result of the measures. It was not possible to establish to any great extent how true this claim was in terms of actual turnover figures, since businesses were very reluctant to cooperate in providing them. On the basis of the material available it is possible only to draw a few general conclusions regarding the experimental areas as a whole. In the consumer goods and durables sector the trend in the experimental areas was in line with the national trend. In the food and drink sector turnover lagged behind somewhat: this is surprising, since this sector depends mainly on local residents, who shop mainly on foot or by bicycle. The consumer survey showed that the residents of the experimental areas visited their local shops at least as often as they used to before the measures were taken.

Partial one-way traffic in option 1 street

SUMMARY AND CONCLUSIONS

ACCIDENTS

The initial results of accident surveys indicate that a clear division of urban areas into traffic zones and residential zones can have a favourable effect on road safety in urban districts. The number of accidents involving injury per vehicle-kilometre in residential streets in the experimental areas has been halved, on traffic arteries and access roads it has dropped by about 15%. The overall drop on all types of road and street in the experimental areas was about 20%.

Some caution is however called for in relation to these conclusions, given the very short 'after' period (14 months) on which they are based. Because of the relatively small numbers of accidents that took place during the period, the effect on traffic arteries and access roads in particular cannot yet be ascribed with sufficient certainty to the measures. These small numbers are also the reason that the effects of the various packages of measures for residential streets cannot yet be ascertained.

The accident surveys have shown that the measures in the experimental areas have not had a negative effect on road safety in the influence areas, where the residential streets even seem to have become safer. Thus the measures in the experimental areas have not shifted the problems to other parts of the town.

Lastly, it should be noted that the improvement in safety in residential streets in the experimental areas definitely does not apply to moped-riders, who have become less safe in relative terms.

BEHAVIOUR AND PUBLIC OPINION

The polls carried out after the reconstruction asked the residents of the various types of residential street whether they believed that safety had improved in their streets and neighbourhoods. In general their reactions were fairly positive, but not in the woonerf streets. The most favourable opinions were held by residents of option 2 streets, where numerous speed-restricting measures were taken.

Whether the measures in the experimental areas achieved their primary objectives was examined both in behavioural studies and in polls.

Traffic censuses showed that they were successful in *keeping out through-traffic* from residential streets. Motorised traffic dropped by 12% in residential streets in the experimental areas, whereas it rose slightly in residential streets in the control areas. The polls also indicate that there was less unwanted through-traffic after the reconstruction. Such traffic virtually disappeared from woonerf streets and other option 3 streets, according to the residents. Many took the view, however, that there was still too much in the other streets.

Reducing traffic speed was a major objective of the measures for option 2 and 3 streets. About two-thirds of the residents of these streets took the view that car speeds did indeed drop. Speed checks have shown that car speeds are lowest in woonerf streets. They also showed, however, that it is difficult to curb the speed of mopeds in residential streets; in woonerf streets they even reach higher speeds than cars in many cases. This may explain why their safety did not improve after the reconstruction.

A woonerf is designed not only to keep out through traffic and restrict the speed of other traffic but also to create an *attractive environment* where residents can

spend their time pleasantly. To find out whether this objective was achieved, residents were asked before and after the reconstruction whether they found the neighbourhood pleasant to walk in.
It may be that their answers to this question – as well as their unfavourable opinion of safety, mentioned above – were influenced by problems associated with the public participation process. In addition, however, conflict observations revealed some shortcomings in the design: obstacles placed on alternate sides more or less forced pedestrians to zigzag across the street, crossing passing traffic at places with poor visibility. Some shortcomings were also noted at places where woonerf streets joined up with main roads, causing particular problems for cars: many of the exits have a raised section from which cars can easily roll onto the main road, where they can come into conflict with passing traffic, particularly if the main road is narrow. Also, many of the exits are so narrow that cars entering and leaving have difficulty in passing each other.

The provisions made on traffic arteries in the experimental areas included crossing facilities for pedestrians, cycles and mopeds. Behavioural observations showed that these categories of road users were able to cross more quickly thanks to central islands and narrower carriageways. These facilities did not however seem to have any effect on safety.

THE ENVIRONMENT AND COMMERCE

The drop in traffic density in the residential streets in the experimental areas resulted in particular in a drop in daytime noise levels, and emissions of exhaust gases also decreased to some extent. The reconstruction had no effect on the extent and composition of commerce in the experimental areas, although a large proportion of retailers took the view that it had had a bad influence on their turnover. If this assessment is tested against actual trends in turnover, however, it may be concluded that only in the food and drink sector did turnover lag behind the national trend somewhat.

FINAL COMMENTS

In the experimental areas some of the unwanted through-traffic disappeared from residential streets and the speed of other traffic dropped. The number of accidents involving injury fell, both in the residential streets and on main roads. At this stage it is not yet possible to say which package of measures for residential streets has the greatest favourable effect on safety, as the results of the behavioural studies and opinion polls do not provide an adequate basis. Accident surveys will presumably enable a conclusion to be drawn, but not until accident data are available for a longer 'after' period.

It may be noted already, incidentally, that 80-90% of accidents involving injury in urban districts occur on main roads. Purely from the point of view of road safety, then, it is here that measures can be expected to have the greatest effect. It would seem, therefore, that relatively simple measures to keep out through-traffic and restrict the speed of other traffic are more appropriate for residential streets than complex and expensive measures such as the construction of woonerf areas. Moreover, Dutch municipal authorities have recently been given the power (under certain conditions) to establish 30 kmph zones in built-up areas, which is a major addition to the measures available to compel drivers to adapt their style of driving to the needs of residential streets.

'Sleeping policeman', realignment of road
axis and parking bays in option 2 residential street

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