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Workpackage Leader : M.R. Tight

Problems for Vulnerable Road Users in the Netherlands

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DRIVE Project V1031

An Intelligent Traffic System for Vulnerable Road Users

PROBLEMS FOR VULNERABLE ROAD USERS IN THE NETHERLANDS

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1. INTRODUCTION

In the Netherlands pedestrian and pedal cycle travel are important transport modes for the population. However, given the particularly vulnerable nature of these modes of transport, pedestrians and cyclists are involved in a large number of accidents and suffer a particularly high proportion of the fatalities and serious injuries. Technical measures to improve safety and efficiency focus almost exclusively on motorized traffic, disregarding the needs of the non-motorized traffic participants. In order to determine how technical measures, such as Road Traffic Informatics (RTI) applications, can be used to increase the safety and mobility of pedestrians and cyclists, more information is needed about the causes of accidents to these groups. This report deals with a first analysis of the problems of cyclists and pedestrians in the Netherlands. Similar reports are being produced for Britain and Sweden which together will serve as a basic information source from which decisions can be made about which type of measures have potential to improve the situation of vulnerable road users.

This report examines the nature and causes of accidents involving vulnerable road users (VRU's), their mobility patterns and their risk. It is intended to serve as a tool in subsequent stages of this project, and thus is not a general survey of safety and mobility problems for vulnerable road users, but rather a review of those issues that are related to the RTI measures envisaged by the project. The project is aimed at improving VRU safety and mobility both directly, through the enhancement of signalized junctions and pedestrian crossings, and indirectly, through the creation of a model of the traffic system incorporating vulnerable road users. It is intended that this model will permit the routing and guidance of motorized vehicles in such a way as to enhance VRU safety and reduce VRU annoyance and delay from traffic. Both the direct and the indirect measures envisaged will only be relevant to VRU safety and mobility on main roads in urban areas; they are unlikely to be applicable to residential streets or minor roads unless these have substantial VRU flows. The report therefore concentrates (in so far as existing information permits) on VRU safety and mobility on main roads and on VRU use of facilities that are intended to be upgraded through the planned RTI measures.

The report covers both the national level for the Netherlands (about 14.5 million inhabitants) and the local level for the City of Groningen (about 160,000 inhabitants). Section 2 of this report seeks to define a number of the terms which are used throughout, and provides a basis for comparison between the findings from this report and those for Sweden and Britain. Section 3 identifies the sources of information from which the analyses of accident and mobility data have been derived. Sections 4 and 5 identify the safety and mobility situations of vulnerable road users at the national and local levels respectively. Section 6 examines the risk to pedestrians and cyclists, and finally Section 7 provides some conclusions and recommendations for RTI-measures.

2. DEFINITIONS

In this section definitions are presented of the most important concepts used in this report. The definitions that follow are drawn from the Dutch Central Bureau of Statistics (CBS) reports on traffic accidents in the Netherlands and apply to the description of the national situation.

THE NETHERLANDS: This consists of 12 provinces with a total population of about 14.5 million people.

CITY OF GRONINGEN: This is the capital of the province of Groningen in the northern part of the Netherlands. It has a population of about 160,000 people.

TRAFFIC ACCIDENT: An event on the public road, related to traffic, in which at least one moving vehicle is involved and which caused injury and/or death to one or more road users.

FATAL ACCIDENT: A traffic accident with at least one road user dying as a consequence of that accident.

NON-FATAL ACCIDENT: A traffic accident causing only non-fatal injuries to one or more road users.

FATALITIES: Victims who died either in an accident or within 30 days of an accident as a consequence of the injuries sustained in that accident.

INJURED PEOPLE: Victims who sustained non-fatal, severe or minor injuries as a consequence of the accident.

PEDESTRIAN: This includes people using the road environment on foot (excluding people leading or herding cattle held by rope), people pushing a bicycle or moped, and children riding in toy cars or on toy pedal cycles.

PEDAL CYCLIST: A person riding a pedal cycle which is not fitted with a motor. This category also includes passengers on pedal cycles.

BUILT-UP AREA: The area within the boundaries of a municipality, as defined by the provincial authorities.

The CBS data only incorporate accidents that result in personal injury. All property-damage-only accidents are omitted. Due to problems of underreporting the representativeness of the damage-only accidents that are reported must be seriously questioned. Nevertheless it was decided to use all reported accidents, including damage-only, as a source of information in the description of the accidents in Groningen. Excluding the property-damage-only accidents would decrease the database drastically and therefore limit the possible analyses of accident causes and the types of situations that may benefit from RTI applications.

3. SOURCES OF INFORMATION

To provide an overview of the national situation, CBS data were studied. The CBS data give rather general information on road accidents involving different transport modes, different age groups, times of year, days of the week and times of day. Only limited information is given about the accident situation and the manoeuvres of each of the participants at the time of the accident. Accident information is collected through registration forms completed by the governmental, local or military police. These forms are coded and analysed by the Dutch Office for Traffic Accident Registration (Dienst Verkeersongevallenregistratie; VOR).

The VOR records accidents on public roads as far as they are reported to the forementioned authorities. This method of reporting leads to some limitations in the number of recorded accidents. The following estimates were made by the CBS (1988):

1. Accidents resulting in fatalities are reported in virtually all cases.

2. Accidents resulting in non-fatal injuries which require hospitalization are reported in about 70% of the cases. It is unknown whether this 70% is a representative sample of the total number of accidents.

3. Accidents resulting in non-fatal injuries not requiring hospital care are estimated to be reported far less often than the other two categories. A percentage is not provided.

4. For accidents with material damage only, reporting is said to be limited and highly incomplete. These data are omitted from the statistical overview by the CBS.

Hence, due to such underreporting the number of recorded non-fatal accidents is an underestimate of the true number of accidents. A survey of 24,000 households (Van Montfoort et al, 1988) asking respondents about their involvement in road traffic accidents in the preceding 3 months, showed that the number of reported personal injury accidents involving victims who either required or did not require medical care, was nine times the number recorded by the police. It was also shown that the number of personal injury accidents involving victims who needed medical treatment was still four times the number officially recorded.

CBS data only provide very general information about the nature and the causes of road accidents. More detailed information is of vital importance for developing adequate countermeasures. For this reason the more detailed data for the city of Groningen were studied. The City Authority provided access to a copy of the original VOR accident registration forms. For each registered accident, information is given about the accident site, the time and date of the accident, the weather conditions, the persons involved (e.g. their sex, age, mode of transport), the location of each participant just prior to the accident and their intended manoeuvres, and the primary and secondary causes of the accident. This last piece of information is a subjective assessment made by the attending police officers. Such assessments are not included in the national CBS data.

The national figures given in this report are for 1987 (CBS, 1988), the most-recent year available. The local figures for Groningen are for the period October 1987 to September 1988. This is the most recent one year period of data available, and is used so as to take account of the latest infrastructural changes.

4. THE NATIONAL SITUATION

4.1. SAFETY OF VULNERABLE ROAD USERS

In 1987 the total number of traffic accidents was 50,674. Of this total number, 11,613 involved cyclists (22.9%) and 4,203 involved pedestrians (8.3%). 2.7% of the cyclist accidents and 4.1% of the pedestrian accidents were registered as fatal.

The proportion of cyclist and pedestrian accidents varies for different age groups. This is shown in Table 1.

Table 1: Total number of accidents and the proportions of pedestrian and cyclist accidents by age group.

	Total number of accidents		% as pedestrian		% as cyclist	
	Fatal	Non fatal	Fatal	Non fatal	Fatal	Non fatal
0 - 18 yr	227	13,302	18.5%	13.0%	37.9%	34.1%
18 - 25 yr	320	12,579	2.2%	3.3%	8.1%	13.4%
25 - 65 yr	594	18,721	8.9%	6.3%	13.5%	22.5%
65 and over	344	4,057	20.3%	16.6%	34.9%	36.9%

The table shows that approximately half of the accidents involving the 0-18 and the over 65 age groups occur when they are using the roads as pedestrians and cyclists.

Male cyclists and pedestrians are overrepresented in the accidents statistics. In 66.3% of the fatal pedal cycle accidents and in 56.4% of the fatal pedestrian accidents, the victim is male. In the non-fatal pedal cycle and pedestrian accidents, males are involved in 53.4% and 46.6% of the accidents respectively.

Table 2 shows that most of the accidents to VRU's occur in built-up areas as compared to non-built-up areas. This table also shows that despite the smaller proportions of accidents involving VRU's in non-built-up areas, the consequences of such accidents are generally more severe.

Table 2: Percentage of accidents to pedestrians and cyclists by severity and type of area. (Source: CBS, 1988)

	Fatal		Non-fatal	
	Built-up	Non-built-up	Built-up	Non-built-up
Pedestrians	69.2	30.8	89.7	10.3
Cyclists	59.1	40.9	83.9	16.1

Most pedestrian accidents also involve a private car (69%), although appreciable proportions also involve mopeds (13%), and trucks and buses (11%).

Accidents involving pedestrians often occur when a pedestrian suddenly crosses the street (36%), when a pedestrian emerges from behind an object (16%), or on zebra crossings (16%).

Accidents involving pedal cyclists predominantly occur in three types of situations:

1. Where the other participant is on a road which crosses the path of the cyclist (38.7%).

2. Where the other participant is on the same road as the cyclist and one makes a turning manoeuvre across the path of the other (31.7%).

3. Where the other participant is on the same road as the cyclist, but no turning manoeuvre is involved (29.6%).

In the first of these categories a car is involved in 80% of the accidents, a truck or bus in 9.7%, and a moped in 6.5%. In the second category the picture is similar: in 70% a car is involved; in 11.3% a truck or bus; and in 12.7% a moped. In the last category, however, the pattern is very different. Only 38% of category 3 accidents involve a car, 10% involve buses and trucks, while 37% involve mopeds.

The CBS statistics for the year 1983 (cited in Van Schagen et al, 1985) gave a more specific overview of the accident situation and the other vehicles involved in pedal cycle accidents. These show that more than half of the accidents involving pedal cyclists occur in one of the five situations shown in Figure 1.

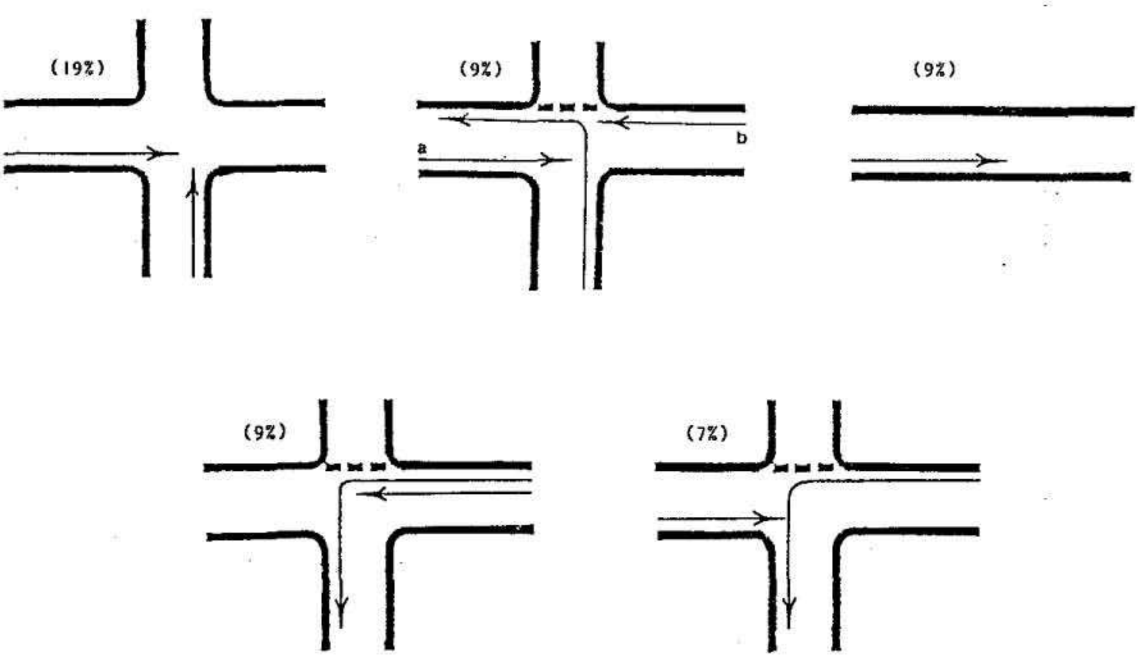

Figure 1: The five most common accident situations for pedal cyclists (figures in parentheses show the proportion of the total number of accidents involving pedal cyclists).

4.2. MOBILITY OF VULNERABLE ROAD USERS

In 1987 more than 5 million cars were registered; about half a million trucks and busses; 130 thousand motor cycles; and 560,000 mopeds. The number of bicycles was estimated to be 11.5 million. In 1985 about 50% of home to work trips within the same municipality were made by bicycle, 30% by car, 10% on foot, 7% by public transport services and 2% by moped. About 66% of home to work trips between different municipalities were made by car, 13% by bicycle, 8.7% by public transport, 2.3% by moped and 1.2% on foot. Reasons for making trips other than to and from work include shopping, visits, sports and other recreational activities.

A study of 1983 data (SWOV, 1987) showed that each person made on average 3.1 trips per day. Table 3 shows the number of trips per person for various age groups and the percentage of these trips made by bicycle or as a pedestrian. As can be seen, the number of trips remains relatively stable over the different age groups apart from the 65 and over age group. Elderly people make appreciably fewer trips than other age groups. Comparing the transport modes, it can be seen that the youngest and oldest age groups make more than half their trips by bicycle or on foot. Even though in general the bicycle is preferred to walking, the relative importance of the bicycle compared to walking decreases with age.

Table 3: Mean number of trips per day per person and the proportion made as pedestrians or pedal cyclists, by age.

	Number of trips	% as pedestrian	% as cyclist
12 - 18 yr	3.36	16.4	59.2
18 - 25 yr	3.53	15.3	28.6
25 - 65 yr	3.24	17.6	24.4
65 and over	1.98	33.8	20.7

Data for 1983 (SWOV, 1987) also show that each person over 12 years covers an average of 26.3 km per day. Table 4 shows that average distances travelled per day vary according to age and mode of transport.

Table 4: Mean distance travelled per day per person, by mode of travel and age. (Source, SWOV, 1987)

	Total	Pedestrians	Cyclists
12 - 18 yr	19.5	0.7	7.1
18 - 25 yr	32.0	1.0	3.6
25 - 65 yr	29.5	0.8	2.2
65 and over	14.3	0.9	1.2

An estimate of the distance walked by children aged between 4 and 12 years (Wolters, 1985) shows that this age groups walks on average 2km per day which is appreciably further than the age groups shown in Table 4. Half of the distance walked by children aged 4 to 12 years is covered on journeys to and from school.

Cycling is less common in the age group 4 to 12 years: they cover only 0.75 km per day, though this ranges from 0.5 km for the 4 to 5 year olds to 1.2 km for the 9 to 11 year olds.

It is commonly supposed that some proportion of VRU trips are suppressed (i.e. not made at all or made on a route which is less than optimal) for reasons of subjective or objective risk. Very few studies have examined this problem, particularly the relationship between objective risk and trip suppression. However, there have been some Dutch studies of subjective risk which will be considered here.

As part of a larger study on traffic safety and elderly road users, a non-representative sample of 204 elderly road users between the ages of 60 and 90 years were interviewed to establish their perception of traffic safety (Werkgroep Verkeersproblemen en -deelname van bejarden, 1981). The interview was in three parts: firstly, background questions (on age, lifestyle, transport usage etc.); secondly, questions about how safe respondents felt when using roads and any anxieties they had; and thirdly, questions about their attitudes towards traffic. The results showed that 40% of respondents said that their main mode of transport was on foot, 20% on pedal cycles, and 23% in cars. Almost 70% of the respondents said they were to some degree afraid in traffic, although most of the respondents (82%) felt that they could go where they wanted. For the group of pedestrians this percentage was lower than for the group of cyclists and car drivers, respectively 64%, 92% and 100%. Of the pedestrians, 21% said that they sometimes encountered problems going where they wanted. Care should be taken when interpreting these data because the sample of elderly pedestrians tended to be older and have more physical problems than the sample of cyclists and car drivers. The situations where pedestrians most often felt afraid were when crossing the street and at intersections. For cyclists these situations were cycle paths and intersections. Answers to the question on how the respondent deals with his/her fear showed important differences between the two main transport groups. For pedestrians, the most common solutions to the problem of fear was to stay in their immediate neighbourhood, or to stay at home. For cyclists the most common solution was to walk.

A second small scale study, carried out in a suburb of the city of Groningen, used a questionnaire to ask people aged 55 years and over about their views on traffic safety in the area where they live (Ouderen en Verkeer, 1988). The response rate was very low (92 people or 2%), so the results must be interpreted very carefully. Most responses came from people between 60 and 85 years old. This might reflect the relative disinterest in traffic safety problems by the 55-60 year and over 85 year age groups: the latter group only seldom participating in traffic and the former group not encountering so many problems. Almost three quarters of the respondents mentioned problems with crossing the street as a pedestrian, and a number of common reasons were given:

1. Cars don't stop for pedestrians at zebra crossings without traffic lights;
2. Cars, cyclists and mopeds do not comply with traffic lights at zebra crossings;
3. Sight distance is limited, due to cars parking too close to zebra crossings;
4. Green times for pedestrians are too short;
5. Cars are driven too fast.

Most respondents (81%) reported complaints about the state of the pavements, which are often uneven or blocked by shop stands and bicycles.

As cyclists, the elderly appeared to favour cycle paths along roads where motorized traffic is heavy. They stated that cars drive too fast. About two thirds of the cyclists encountered problems at intersections, in particular when turning left.

A third study was carried out in a part of Arnhem (Bekkers, 1986). About 400 people of 55 years and over were interviewed about their actual mobility and their mobility needs. The results indicated that physical health, car ownership and age were the determinants of actual mobility. About 20% of the healthy and "younger" respondents would have liked to make more trips than they did, compared to 40% of the less able respondents. It is not clear whether this suppressed mobility need is due to traffic safety considerations. There were no indications that obstacles on the pavement or the behaviour of other traffic participants were the causes of decreased mobility, for either able or disabled persons.

In a study of subjective perception of danger in traffic in different living environments (Menkehorst, Miedema and Van der Molen, 1987), 1875 households were sent a questionnaire of which 1224 (65%) were returned. The respondents lived in one of four middle sized cities in the north and east of the Netherlands. Respondents were asked questions about how they rated their environment, their attitudes towards traffic and safety in general, about specific infrastructural and legal measures, and about whether their subjective views on traffic safety affected their behaviour. Four age groups were used: less than 24 years, 25-40 years, 40-60 years and over 60 years. The respondents in the 40-60 years age group had the most negative opinions about the safety of their environment compared to the other three groups. It was also shown that parents with children younger than 10 years old had a more negative opinion about the traffic safety of the street in which they lived than other respondents. There were no differences in appraisal of the traffic situation in the neighbourhood between respondents who travel mainly by car, on pedal cycles or on foot. There was a negative relationship between respondent's subjective views on traffic safety and the amount of behavioural adaptation they reported ($r=-0.61$): the less safe, the more adaptation. Examples of adaptation were that parents accompany their children more often to school and don't let young children play outside. Respondents without children said that they try to avoid specific intersections or would like to see a zebra crossing in their street. The youngest group reports less adaptation, the oldest group the most. No differences in the amount of adaptation between users of different transport modes were found.

From the literature described above, it can be concluded that subjective feelings of danger are explicitly present in elderly road users. Another group of people who report such feelings of risk from traffic are parents with relatively young children. There are some indications that subjective feelings of risk influence mobility. Some elderly pedestrians stay at home or walk only in the immediate area surrounding their home. An appreciable number of people say that on occasions they do not go where they want to go because of the traffic situation. Elderly cyclists seem to be less influenced by their experiences of traffic safety than elderly pedestrians who have to rely on walking as their mode of transport, which might be explained by their on the whole better physical condition. Parents adapt to fears of traffic mainly by imposing limits upon the freedom of movement of their children. The authors have found no Dutch studies which seek to identify children's views on traffic safety and the way to cope with dangerous situations.

The literature about subjective safety and trip suppression is rather scarce and above all rather unsystematic. The studies differ in their aims and in the level of depth of their questions, to the extent that some make global conclusions such as "cars are dangerous" while others make more specific conclusions such as "there is a hole in the pavement just before the entrance of the bakery". Questions about whether or not people change their behaviour as a result of their experiences of traffic safety also deal with different levels of possible adaptation. These differences make comparison of the results of such studies very difficult or even impossible.

Theoretically, feelings of safety can influence mobility in different ways. Michon (1979) distinguishes between different traffic task levels, that can form the framework for a description of possible ways to adapt traffic behaviour. The strategical level is the highest level and covers the field of route planning, choice of transport means and travel time. Below this is the tactical level. Decisions at this level are made during the trip and concern types of manoeuvres (such as turning right and left, or crossing the road), speed, and decisions on where to walk or ride. The last and lowest level is the operational level which covers specific elements of behaviour (e.g. signalling when turning, crossing in between approaching cars, waiting for a red traffic light).

Attempts to simulate the mobility of pedestrians and cyclists concentrate primarily at the strategic level of the traffic task. At this level questions must be answered on the degree to which subjective feelings of danger lead to the following:

1. The cancellation of desired trips;
2. Planning trips at other than the desired time of the day/week;
3. Planning trips along other than the desired route;
4. Choosing another mode of transport than the desired mode;

The tactical level must also be considered when investigating trip suppression, partly because of the effects it might have upon the strategic level, but also because certain types of manoeuvres may be avoided (e.g. turning left or crossing the street at crossings without pedestrian traffic lights).

4.3. PEDESTRIAN AND CYCLIST FACILITIES

The main crossing facilities for pedestrians are as follows:

1. Zebra crossings. Road traffic has to yield for pedestrians who are on the zebra crossing. A traffic sign may be placed near the zebra crossing to indicate its presence. Most zebra crossings are situated near junctions, but some are found midblock.

2. Signalized pedestrian crossings. Signalized pedestrian crossing facilities are commonly found at junctions (although some are situated midblock) with a relatively high volume of motorized or pedestrian traffic. Many pedestrian lights must be activated by push-buttons. Pedestrian lights have three stages: red man, green man and flashing green, the last indicating the end of the green stage. An increasing number of pedestrian lights are equipped with an auditory signal to assist visually-handicapped people. Pedestrians are not allowed to cross during the red stage, but a high level of non-compliance is found (Oude Egberink and Rothengatter, 1984).

   There are two types of signalized crossing: conflict-free and non-conflict-free. Conflict-free crossings imply that all motorised traffic that may cross the pedestrian facility is given red. This is not the case in non-conflict-free crossings, where motorised traffic turning into the path of the pedestrian is given a green light at the same time as pedestrians so that the turning traffic may encounter crossing pedestrians. If this is the case, the motorized traffic has to yield to the pedestrians.

3. Refuges. On wide roads which carry high volumes of motorized traffic, central refuges may be provided, often in combination with zebra crossings or signalized pedestrian crossings.

At all junctions, traffic turning left or right has to yield to pedestrians on the same road, regardless of the crossing facilities provided or the priority regulations that apply.

The main facilities for pedal cyclists (and mopeds) in built-up areas are as follows:

1. Non-compulsory cycle paths. Some cycle paths are non-compulsory, as indicated by a sign. In that case the cycle path is closed to all other traffic, including mopeds. These cycle paths are usually situated on scenic routes outside built-up areas.

2. Compulsory cycle paths. These cycle paths are separated from the main road by a physical division. In built-up areas, they are usually situated on both sides of the road, although configurations with two-directional cycle paths on one side of the road also exist. Both cyclists and moped riders must use cycle paths if these are present. Pedestrians must use cycle paths on roads without footpaths.

3. Cycle lanes. On many roads, cycle lanes are indicated by either a solid or a broken white line. Additional markings are often present, for example a different surface colour or cycle symbols. If a solid line is present, cyclists and moped riders must stay in the cycle lane, and motorized traffic is not allowed to enter the cycle lane. If the cycle lane is marked with a broken white line, motorized traffic can enter it and may stop or park, provided that this does not cause hindrance to cyclists.

4. Pedal cycle signals at signalized junctions. Signalized junctions with separate cycle paths include special signals for pedal cycles, which sometimes have to be activated with a push-button. These signals have three stages: red, yellow and green. A wide variety of signalling cycles is used. In some configurations, bicycles are given green at the same time as the motorized traffic on the same road. In that case the signalling is not conflict-free, and motorized traffic turning left or right has to yield to cyclists. In other configurations, turning traffic on the same road is given a separate green phase, so that no conflicts can occur. Signals in which the bicycle traffic is given a separate phase can also be found.

5. Cycle lanes and bubbles. At some signalized junctions without cycle paths a waiting space (bubble) is provided for cyclists and moped riders in front of the waiting lane for motorized traffic. At other signalized junctions, separate cycle lanes are provided in addition to the lanes for motorized traffic. In such cases, the cyclist has to get in the correct lane.

6. Bicycle crossings. At those places where a two-directional cycle path starts or ends, pedal cyclists and moped riders may have to cross the main road. These places are marked with traffic signs and block

markings on the road. Crossing cyclists and moped riders have to yield to motorized traffic.

At unsignalized junctions which do not have a specific priority regulation, motorized traffic has priority over cyclists and moped riders except that all turning traffic has to yield to oncoming traffic on the same road. This also applies when separate cycle paths are present unless specific priority regulations are indicated.

5. THE LOCAL SITUATION

Between October 1987 and October 1988, there were 406 accidents involving cyclists and 77 accidents involving pedestrians reported to the local police in Groningen. About half of the cyclist accidents and a fifth of the pedestrian accidents resulted in material damage only. Of the cyclists involved there was 1 fatality and 51% were injured. Of the injured cyclists 35.6% received treatment in hospital and of these three quarters were hospitalized. Of the pedestrians involved there were 3 fatalities and 73% were injured. Of the injured, 39% received treatment in hospital, and just over three-quarters of these were hospitalized.

Peaks in cyclist accidents can be found in the months of May, September, October and November (together accounting for 43% of the total number of accidents) and peaks in pedestrian accidents in the months of December, January, April and September (together accounting for 53% of the total number of accidents). More accidents to pedestrians and cyclists occur on Thursdays and Fridays than on other days. Most accidents occur in the afternoon between 2pm and 5 or 6pm. Another peak occurs between 8 and 9am for cyclists and between 11 and 12am for pedestrians.

The distribution of accidents between age groups is shown in Table 5. There are some major differences between the national data (Table 1) and the data for Groningen. This is particularly the case for the two youngest age groups. The 0-18 year age group in Groningen have a much lower proportion of accidents as pedal cyclists than the same age group nationally. This may be because the Groningen data represent accidents occurring in built-up areas only, whilst youngsters in the 12-18 year age group make many pedal cycle trips outside of built-up areas particularly when travelling to and from school. For the 18-25 year age group there are a substantially higher proportion of accidents to both pedestrians and pedal cyclists in Groningen than there are for the country as a whole. This may be because, being a university city, Groningen has a higher proportion of people between the ages of 18 and 24 than the national average.

Table 5: Proportion of accidents involving pedestrians and cyclists by age for Groningen.

	Pedestrians	Cyclists
0 - 18 yr	26.7	21.7
18 - 25 yr	18.9	24.3
25 - 65 yr	32.4	44.8
65 and over	21.9	9.1

VOR data not only enable the other participants involved in accidents to be identified but also the participants considered to be responsible for the accident. It can be shown that the pedestrians and cyclists who belong to the youngest age group are in most cases considered responsible for the accident. For cyclists in the 25 to 65 years age group the opposite is the case, whereas in the other two age groups of cyclists about half are held responsible for the accident and half not.

Pedestrians of 65 years and over are more often considered as not responsible or only partly responsible for the accident. In the age groups 25-65 and under 25 years no major differences are found.

More male cyclists (60%) are involved in accidents than female (40%). Pedestrian accidents are almost equally distributed between the sexes. There is a tendency that males are more often primarily responsible for an accident than females.

Private cars are involved in more than half of both pedestrian accidents (52%) and pedal cycle accidents (59%). The other main participants in pedestrian accidents are cyclists (20%), mopeds (17%) and busses and trucks (6.5%). The other main participants in pedal cycle accidents are other cyclists (11%), mopeds (9%), busses and trucks (5%), pedestrians (4%) and motor cycles (3%).

Almost two thirds of the pedestrian accidents occur not at junctions, the remainder occurring at junctions. Most pedestrian accidents (95%) involve a pedestrian attempting to cross the road: 42% occur at zebra crossings; 27% when the pedestrian "suddenly" crosses; and 13% when the pedestrian moves into the road from behind an object. In 36% of the accidents no blame is attributed to the pedestrian at all. In accidents where the pedestrian is considered to be primarily responsible for the accident, the most common reasons are "incautious crossing" (56%) and crossing from behind an object (27%). Red light violation by a pedestrian is classified as the primary cause in 7% of pedestrian accidents. When the pedestrian is not responsible or only partly responsible for the accident, the most important cause is a vehicle not yielding to the crossing pedestrian (60%).

62% of pedal cycle accidents occur at junctions and the remainder not at junctions. About half (51%) of the accidents at junctions were where the junction was regulated by signs, in 30% of these accidents the general priority rules had to be applied, in 16% traffic lights regulated the throughfare, and in 3% specific rules were relevant (e.g. in case of residential areas, exits and entrances).

In 64% of pedal cycle accidents the cyclist was on the right hand side of the road. In 21% of the cases the cyclist was on a cycle path which in 16% of the cases was a so-called free cycle path (divided from the road by, for example, trees, bushes or parking places).

Most cyclists (65%) involved in an accident at a junction intended to go straight on; 20% wanted to turn left and only 5% wanted to turn right. However, if only those accidents where the cyclist was primarily responsible are considered then 49% intended to go straight on, 33% wanted to turn left and 9% wanted to turn right. When the cyclist is not primarily responsible the percentages are as follows: 81% intending to go straight on, 7% turning left, 15% turning right.

The causes of the pedal cycle accidents are far more diverse than those of the pedestrian accidents. In 40% of pedal cycle accidents no blame is attributed to the cyclist. If the cyclist is thought to be the person primarily responsible for the accident, this is mostly because he/she did not give way (28%) or did not yield (21%). Other important faults of cyclists are riding too far to the right (7%) or riding insufficiently to the right (8%). Red light violation by the cyclist is the main cause in 5% of the accidents. If other traffic participants are primarily responsible, priority and failure to give way are the main causes in about 50% of the cases. The most important other causes are driving too much to the right (8%); following too close to the bicycle in front (5%); overtaking on the left (5%) and errors in turning such as taking the turn too wide (5%). Red light violation is a primary cause in

only 0.5% of the accidents in which pedal cyclists are not considered to be primarily responsible.

6. RISK TO VULNERABLE ROAD USERS

6.1. ACCIDENTS IN RELATION TO FLOW

The Dutch national accident data cannot be linked to specific flow data. However, the facts that markedly more accidents take place in built-up area's, that relatively few accidents occur during the weekend and that there is a peak in accident numbers during rush hours lead to the not very surprising conclusion that there is a positive relationship between flow and accidents. The local accident data for Groningen revealed a number of clusters of 3 or more pedal cycle accidents in a year. A total of 14 such clusters at intersections could be identified, all of which were outside the inner city centre. Nine are located on the major entrance or exit roads of the inner city centre. Vehicle flow is high on these roads (4,800-30,100 vehicles per 24 hours). One accident cluster is located on a minor city entrance/exit road. The other four clusters can be found on roads leading to and from residential estates. The flow of cyclists at these locations is not known, though it might be expected that flow is relatively high on the major roads heading towards and out from the city centre.

No such clusters were identified for pedestrians, possibly because they can move more freely through the network. However, most pedestrian accidents happen on the major inner city centre entrance and exit roads. Unlike the pedal cycle accidents many of the pedestrian accidents take place in the inner city centre itself, in particular in shopping streets. Residential estates and conglomerates of shops in or near major entrance/exit roads are other important sites for pedestrian accidents. Apart from the residential estates, all of the types of areas where pedestrian accidents are common have moderate to high motorized flow as was indicated before. Pedestrian flow data are not available, but particularly in shopping centres, pedestrian flow is probably high as well.

6.2. RISK SITUATIONS

The fact that situations with high flows tend to have high numbers of accidents was to be expected. However, this does not tell us anything about the risk of being involved in an accident. To identify relative risk requires specific and detailed knowledge on exposure, including usage of certain types of infrastructural layouts, frequency of making various types of manoeuvres and the number of encounters with other traffic. This type of information is lacking for all types of road users, but most particularly in the case of pedestrians and cyclists. The conclusions presented below concerning risk situations for pedestrians and cyclists are based upon general prescientific "knowledge" about the Dutch and, more specifically, the Groningen traffic situation, and therefore must be considered as highly tentative.

More than 40% of the pedestrian accidents in Groningen occur at zebra crossings compared to only 15.5% in the Netherlands as a whole. This is partly explained by the high number of zebra crossings in Groningen compared to many smaller towns, villages and non built-up areas. Nevertheless it does not seem very likely that a zebra crossing is used in as many as 40% of the total number of crossings in Groningen. If this is true then pedestrian accidents are overrepresented at zebra crossings compared to other locations and hence zebra crossings may not be having quite the safety effect which was intended.

One fifth of the pedal cycle accidents in Groningen occur on cycle paths, mostly in a situation where a car and the cyclist go in the same or opposite direction and the car, when turning left or right, has to cross the cycle path. Many of the main entrance/exit roads to and from the city centre have a free cycle path. However, it is thought unlikely that one fifth of the pedal cycle mileage takes place on cycle paths, and it is almost certainly not the case that one fifth of the encounters between cars and cyclists occur on cycle paths.

The above description of the risk situations for pedestrians and cyclists is based upon highly incomplete empirical data. In order to test the validity of the conclusions more empirical data must be collected, in particular for the hypothesized high risk situations outlined above: cycle paths and zebra crossings. It is also important to determine why these situations are dangerous. In order to be able to forecast, even to a limited extent, the effects of RTI-measures such as "intelligent" traffic signals or warning systems in cars, a more detailed appraisal of these situations is needed. If, for example, car drivers do not notice cyclists and mopeds on cycle paths or forget to look, a kind of intelligent warning system in those situations might have a positive effect. If, on the other hand, car drivers misjudge the speed and distance of the approaching bicycles and mopeds or overestimate the accelerating capacity of their car, the benefits of RTI-measures must be doubted. The same kind of reasoning can be applied to the situation of pedestrians at zebra crossings: if car drivers fail to yield to crossing pedestrians primarily because they want to avoid any delay and/or because they misinterpret the possibility of passing just in front or behind a pedestrian on the zebra crossing, a general solution to the problem will be difficult. Attitudes and beliefs of the pedestrians and the cyclists can be another explanation for the problem situation. They may be have an unjustified feeling of safety when using special facilities such as zebra crossings and cycle paths, which will lead to a lower level of attention and insufficient preparedness to react to unexpected encounters. If this is the case then RTI-measures must also be directed at vulnerable road users as well as motorized traffic.

7. CONCLUSIONS

7.1. SAFETY, RISK AND MOBILITY OF PEDESTRIANS

It has been shown, using national accident and mobility data, that pedestrians are particularly vulnerable road users: 3.6% of the total distance travelled is covered on foot, whilst 8.3% of the total number of accidents involve pedestrians. It is not known for certain whether the actual accident involvement of pedestrians really is higher than that of other road users, or whether because the consequences of pedestrian accidents are very often more serious than other types of accidents, they tend to be recorded more often. Most pedestrian accidents occur in built-up area's, though the consequences are more severe in non built-up area's. Most pedestrian victims fall into two age groups: the under 18 years and the over 65 years. Their high accident involvement cannot be explained by exposure alone for either age group. Per kilometre both elderly and young pedestrians have markedly higher accident risk than other age groups.

In most pedestrian accidents the other vehicle involved is a car, though in 13% of pedestrian accidents a moped is involved. Bearing in mind that there are almost ten times more cars than mopeds in the Netherlands, the moped must also be considered as an important participant in pedestrian accidents.

Most accidents to pedestrians happen when they try to cross the street. The number of accidents at zebra crossings seems to be unduly high compared to other locations given the relative number of crossings. Pedestrian accidents on zebra crossings mostly involve a vehicle which fails to yield. Whether this is due to inattention or impatience of the drivers and/or to inattention or unwarranted feelings of safety on the part of the pedestrians is not known.

Feelings of danger due to traffic are present in all adult age groups, but most pronounced in the elderly and parents with (young) children. To the knowledge of the authors no studies have questioned children about their feelings of danger. There are some indications that subjective feelings of risk result in trip suppression or avoidance of specific traffic situations, in particular for the elderly. Parents have been shown to restrict their children's spheres of activity due to their perception of danger. On the basis of the available literature it is not possible to give general conclusions about the actual amount of trip suppression nor about the situations where trip suppression is most pronounced.

7.2. SAFETY, RISK AND MOBILITY OF CYCLISTS

14.7% of the total distance travelled is by bicycle, whilst cyclists are involved in 22.9% of the accidents. As with pedestrians, cyclists are overrepresented in the accident statistics and hence are truly vulnerable road users. Most pedal cycle accidents occur in built-up area's, though the consequences are far more serious in non built-up area's. The age groups 0-18 and over 65 years are involved in a substantial number of accidents as cyclists, and even taking account of relative exposure compared to other age groups, are still high risk groups. The overrepresentation of men in the accident statistics can probably be ascribed to the higher exposure rate of men compared to women.

Most pedal cycle accidents involve a car, though collisions between a pedal cycle and a moped are also rather common, particularly when account is taken of the relative numbers of mopeds and cars on the roads.

Most pedal cycle accidents occur at intersections with the colliding vehicles on crossing roads, and are largely due to one vehicle failing to give way. More accidents happen on intersections where priority is regulated by signs than where other types of regulation are in force. It cannot be concluded that regulated intersections are more dangerous, because roads with high vehicle and bicycle flow are for the most part regulated. Cycle paths seem not have the expected safety effect. Many accidents to cyclists happen when they are on a cycle path, in particular collisions with a turning vehicle which did not have right of way.

Studies of the perception of the traffic environment by elderly road users do not show major differences between pedestrians and cyclists. Like pedestrians, cyclists report general and more specific problems in traffic. In coping with the subjective feelings of risk, cyclists report that they sometimes avoid specific situations. They report less often than elderly pedestrians that they cancel a trip, but more often that they change their mode of travel to walking or public transport. Literature on this topic is scarce and unsystematic and few definite conclusions can be made.

7.3. SITUATIONS SUITABLE FOR RTI-MEASURES

There are three types of situations where RTI measures might have a positive effect upon safety and/or mobility of vulnerable road users:

1. Situations where pedestrian or bicycle flow is high and many accidents occur;

2. Situations where pedestrian or bicycle flow is high and the accident risk is high;

3. Situations where pedestrian or bicycle flow is low and trip suppression is high because of high vehicle flow.

Existing data upon the amount of trip suppression and the exact situations that are avoided by vulnerable road users are insufficient to identify locations for RTI-measures. More systematic research is needed to obtain an insight into this problem.

Many pedestrian accidents occur in shopping streets in the city centre and in shopping area's with high vehicle flow outside the city centre. In both cases, pedestrian flow can be expected to be high, though empirical data are lacking on this point. Situations with many pedal cycle accidents are found on the major city centre entrance and exit roads and not in the city centre itself. These accidents are mostly at intersections where vehicle flow is known to be relatively high and it is thought likely that bicycle flow is also high.

The last type of situation suitable for RTI-measures are those with high flow and high risk; that is situations where the number of accidents exceeds the number that could be expected on the basis of exposure. Unfortunately, existing exposure data for pedestrians and cyclists is limited and cannot be used to identify risk situations in a specific town or city. At this moment it must be considered as a hypothesis that zebra crossings and cycle paths are high risk situations for pedestrians and cyclists respectively.

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