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Problems for vulnerable road users in Sweden

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An Intelligent Traffic System for Vulnerable Road Users

PROBLEMS FOR VULNERABLE ROAD USERS IN SWEDEN

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1. INTRODUCTION

In Sweden pedal cycle and pedestrian travel are important transport modes for the population. However, given the vulnerable nature of these modes of transport, the number of accidents involving pedestrians and cyclists is high, and in particular the number of killed and seriously injured victims is high. Technical measures to improve safety and efficiency focus almost exclusively on motorized traffic, disregarding the needs of 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 aims to look at a number of the attributes of accidents which involve vulnerable road users and at the characteristics of their travel, in order to identify areas where safety and mobility improvements may be obtained. 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 is split into two main sections; the first of which will examine safety and mobility problems for vulnerable road users on a national level, and the second will examine safety and mobility problems for vulnerable road users at a more local level, specifically for Växjö. Parallel reports are being produced for Britain and The Netherlands, which will examine the situations regarding the safety and mobility of vulnerable roads users in those countries as a whole, and in one urban area from each (namely Bradford in Britain and the City of Groningen in The Netherlands).

2. DEFINITIONS

TRAFFIC ACCIDENT: an event on the public road in which at least one moving vehicle was involved and which caused injury or death to one or more road users.

FATAL ACCIDENT: traffic accident with at least one road user dying within 30 days as a consequence of that accident.

SERIOUS INJURY: An injury from which a person suffers a fracture, contusion, severe cut, concussion or internal injury. An injury is also defined as serious if a person is detained in hospital as an in-patient.

SLIGHT INJURY: Any injury not in the above two categories.

PEDESTRIAN: Includes people pushing bicycles, pulling other vehicles, operating pedestrian controlled vehicles, leading or herding animals, occupants of prams or wheelchairs, and people who alight safely from vehicles and are subsequently injured.

PEDAL CYCLISTS: Riders of pedal cycles, including any passengers and persons riding cycles on the footway,

BUILT-UP AREAS: Accidents in built-up areas are those which occur on streets with speed limits of 50 km/h or less. Streets with speed limits higher than 50 km/h within cities and where the conditions are similar (e.g. houses on both sides) are also defined as built-up streets. Highways going through built-up areas are not defined as built-up if they are separated from the surroundings by fences or other similar means.

3. SOURCES OF INFORMATION

3.1. MOBILITY DATA BASES

In Sweden there is little information available about pedestrian and cyclist flows. To the extent of the author's knowledge, there are no cities in Sweden which regularly and systematically count the flow of these vulnerable road users. Nor is there any database available at the national level. In the city of Växjö there exists a database which includes information on the numbers of pedestrians and cyclists using different types of locations. This database has been collected by the Department for Traffic Planning and Engineering at the University of Lund.

There is even less information available concerning the route choice criteria of pedestrians and cyclists, although techniques have been developed which will allow the collection of such information.

3.2. SAFETY DATA BASES

Information concerning road traffic accidents are available from at least three sources in Sweden. These are the police, insurance companies, and hospitals. Each of these will be discussed in more detail below.

3.2.1. Police reports. Police reports are the most commonly used source of information on road traffic accidents. The police are obliged to make a report on each accident they attend. However, it is important to note that road users involved in road traffic accidents are not obliged by law to inform the police. One common motive for involving the police is likely to be as arbiters when there is a disagreement about who is to blame. When an ambulance is called to an accident, the police are automatically informed and sent to the scene. This means that the police reports tend to predominantly cover the more serious accidents and those where only motor vehicles are involved. The weaknesses of police reports are well known among both researchers and practitioners, though the limitations of other sources means that most traffic safety research is still based on police reported accidents.

3.2.2. Insurance companies. Most insurance companies collect information on road accidents where claims have been made by or against their policy holders. However, this information mostly concerns motor vehicles, and hence is of limited use in the study of the safety of vulnerable road users.

3.2.3. Hospital registers. Hospital accident databases contain information about accidents which are missing from police reports. In Sweden traffic accidents are not regularly recorded by health authorities. However, some studies have been made of hospital information which have provided some new insights, especially about slight injury accidents. One of the problems with hospital information is that the hospital very often has no interest in distinguishing between information concerning traffic accidents and that concerning other types of accident. At least one Swedish study (Brundell and Ljungberg, 1989) has surmounted this problem by instructing hospital staff to ask all new patients whether or not they had been involved in a traffic accident. Those that said that they had been were asked to complete a questionnaire about the circumstances of their accident. Incomplete or incorrectly filled in forms were, where possible, completed at a later date by telephone interview. The information from this study was extensive in terms of the consequences of each accident, though was of rather less use in terms of explaining the underlying causes of the accidents.

Interview techniques, such as the one described above, focus only on the points of view of the injured parties in road traffic accidents, and take no account of the views of those who were not injured or of witnesses, who sometimes have information which is vital to the understanding of an accident. It is also important to bear in mind that there can be large time gaps between the occurrence of the accident and when the forms are filled in. This sometimes means that vital information about the accident may be lost.

3.2.4. Comparisons between the sources. None of the sources of accident information described above are entirely satisfactory. It is thought that by comparing information from more than one data source, in particular the police and hospital information (due to their ready availability), a much clearer understanding of accident patterns can be gained.

Using data from both police and hospital sources produces a much larger and more complete accident data set than if only one of these sources is used. A study in the city of Malmo (Brundell and Ljungberg, 1989) compared police and hospital data. The overlap between the police and hospital data, which was only 12%, made it possible to calculate the 'true total number of pedal cycle accidents which should have been classified as injury accidents if the police had received information about all such accidents'. The results showed that the police reports had information on about 21% and hospital data about 29% of all accidents. This means that there is no information on about 65% of accidents which are as serious as the police reported injury accidents.

In this study it was shown that the missing accidents from each of the data sets were not of the same type. Of the pedal cycle accidents reported to the police 31% involved no other participants, compared to 60% of those accidents registered at hospitals. Another difference was that of the accidents registered at the hospital an approximately equal proportion involved males and females, while of those reported to the police about two-thirds involved males. This might indicate differences in willingness to call the police and to visit the hospital. It is not known why such a high proportion of the accidents reported to the police are not recorded by hospitals. One explanation might be that when an accident involves only a pedal cyclist the injured party may not consider it to be a traffic accident, especially as they may blame themselves. Another reason might be that hospital staff are more concerned with medical issues and hence do not put much effort into deciding whether a patient was injured as the result of a traffic accident or by some other means.

It was found that only one third of all pedal cycle accidents were reported to the police even though some of the unreported accidents were so serious that hospital care was required. Pedal cycle accidents involving no other participants were only rarely reported to the police, though they account for about two-thirds of pedal cycle accidents reported to hospitals.

Information on the extent of underreporting has only recently been made available, both in Sweden and in other Nordic countries. It means that a lot more importance is being placed on safety problems concerning VRUs compared to users of motorised transport. Up to now the high priority given to the problems of motorised transport has meant that the problems of VRUs have been disregarded to a large extent.

In addition to the problem of severe underreporting of accidents involving vulnerable road users, there is an additional problem concerning the incomplete nature of accident descriptions. This creates tremendous problems in the interpretation of conclusions from studies of accident causation. One final problem is that while it is true that an understanding of why accidents occur is fundamental to the improvement of road safety, it is also essential to produce theories which seek to explain non-accident causing (safe) behaviour. This is extremely important as it has often been shown that although a certain countermeasure may successfully eliminate an unsafe behaviour, it may also generate new types of unsafe behaviour. Increased speed has often been shown to play an important role in such cases.

Feedback and compensatory behaviour are keywords that are being used more and more often by researchers and practitioners in the field of road safety. There is still, however, a long way to go before our experience and knowledge are sufficient to make possible operationalized theories (i.e. theories that may give reliable and valid contributions to the creation of safe solutions to different safety problems for vulnerable road users).

One major problem is the absence of proven links between theories and reality. There is a lack of tools that can be used to assist in the creation and validation of theories. Traffic Conflicts Techniques (TCT) and other observational methods are tools that are quite promising in this respect. By the observation of near-accidents and road user behaviour in general, it is possible to examine the types of behaviour which may lead to accidents. Such information can be gained from accident descriptions, but for the reasons described above is limited. In Sweden there is a lot of experience with traffic conflict studies and other methods for observing behaviour.

Most of the problems discussed above become even more crucial when comparisons between countries are made as the traditional and cultural differences between them have to be taken into account. The TCT has a potentially useful application in this area, though it will not solve all of the problems.

For the rest of this report, several sources are used in order to make a broad description of the situation for VRUs in Sweden and in the city of Växjö. Further work on this project in Sweden will use the University of Lund's Växjö database, which includes police-reported accidents and conflict studies, and additional behavioural studies and traffic counts.

4. THE NATIONAL SITUATION

4.1. SAFETY OF VULNERABLE ROAD USERS

The population of Sweden in 1987 was 8.4 million people. During this year a total of 21,254 people were reported as being injured or killed in traffic accidents. Of these 2,366 (11.1%) were pedal cyclists and 1,956 (9.2%) were pedestrians. There were 787 reported fatalities, of which 58 (7.4%) were pedal cyclists and 144 (18.3%) were pedestrians. There were 5,423 reported serious injuries, of which 652 (12.0%) were pedal cyclists and 701 (13.0%) were pedestrians. Finally, there were 15,044 reported slight injuries, of which 1,656 (11.0%) were pedal cyclists and 1,111 (7.4%) were pedestrians.

A 1983 survey (Trafikskador, 1987) compared the number of people who were recorded by the police as being seriously injured in a traffic accident with the number of people recorded by the hospitals for the same reason. Results showed that in general 41% of the people recorded by the hospitals were also recorded by the police, but that there were large differences according to road user type. These differences are shown in Table 1.

Table 1: Estimates of the number of people injured as a result of road accidents according to police and hospital information, by road user type.

Road user	Hospital statistics	Police statistics
Car drivers	3060	1915
Car passengers	2250	1344
Mc/Moped riders	2490	1060
Bicyclists	4950	945
Pedestrians	1830	749
Total	14880	6063

This table shows that the number of accidents reported to the police, compared to those reported to the hospitals, is particularly low the pedal cyclists, and for pedestrians and motorcycle/moped riders.

According to a study made by the National Road and Traffic Institute (Thulin, 1987) the number of police-reported accidents need to be multiplied by a conversion factor in order to get some idea of the real number of accidents. Conversion factors for different types of accident are shown in Table 2.

Table 2: Some suggested multiplying factors to convert the police recorded number of accidents into the true number of accidents, by accident type.

Car-car accidents	1.37
Single car accidents	1.57
Car-Two wheeled motor vehicle accidents	1.53
Car-Pedal cycle/pedestrian accidents	4.06
Single pedal cycle accidents	24.30

This table shows that single pedal cycle accidents are grossly underreported to the police, but also that car-pedal cycle and car-pedestrian accidents are also highly underreported compared to other accident types.

Despite the fact that the national accident statistics are far from being perfect, especially as far as the VRUs are concerned, it is still thought worthwhile to make some preliminary breakdowns of the accident statistics. Tables 3 and 4 show the age and sex distributions of pedestrians and pedal cyclists who have been injured or killed in traffic accidents.

Table 3: Total number of road accidents in Sweden and the proportions involving pedestrians and pedal cyclists, by age (1987).

Age	Total		% as Pedestrian		% as cyclist	
	Fatal	Non fatal	Fatal	Non fatal	Fatal	Non fatal
0-17 yrs	94	3196	21%	14%	12%	20%
18-24 yrs	163	5579	5%	4%	1%	6%
25-64 yrs	322	9434	12%	7%	6%	11%
65+ years	208	2121	37%	21%	13%	14%
Total	787	20330	18%	9%	7%	12%

Source: Trafikskador, 1987.

Table 3 shows that the young (<18 years) and the elderly (>64 years) are overrepresented in both pedestrian and pedal cycle accidents compared to other age groups.

Table 4: Total number of road accidents in Sweden and the proportions involving pedestrians and pedal cyclists, by sex (1987).

Sex	Total		% as Pedestrian		% as cyclist	
	Fatal	Non fatal	Fatal	Non fatal	Fatal	Non fatal
Male	545	12445	15%	7%	7%	10%
Female	222	7418	26%	11%	8%	13%
Total	787	19863	18%	9%	7%	12%

Source: Trafikskador, 1987.

Table 4 shows that females are overrepresented in both pedestrian and pedal cycle accidents compared to males.

4.2. MOBILITY OF VULNERABLE ROAD USERS

In 1987 there were 3.4 million passenger cars, 250,000 trucks, 14,000 buses and about 100,000 motorcycles registered in Sweden. Swedish travel patterns are surveyed every few years, the last such surveys being in 1978 and 1984 (RVU, 1978 and 1984). Almost all Swedes own a bicycle. Table 5 shows the total distance travelled in 1984 by certain modes of travel and by sex.

Table 5: Total distance travelled by sex and mode (1984).

	Distance travelled (million kms)		
	Females	Males	Total
Passenger car	25000	45000	70000
Mc/moped	50	600	650
Cycling & walking	2500	2600	5100
Urban public transport	6000	4500	10500
Others(train, plane, etc.)	6000	12500	18500

Figures for 1978 (RVU, 1978) show that the total distance travelled by pedestrians and cyclists was 4,863 million kilometres, which means that there has been little change (+5%) in the amount of travel by vulnerable road users over the period 1978-1984. The increase in travel as a whole was 8% over the six years, with the largest increase being in train and air traffic.

Tables 6 and 7 show some further breakdowns of the distance travelled and trip lengths of certain age groups of road users.

Table 6: The total distance travelled per year in Sweden and the average distance travelled per person per day, by age.

Age	Distance travelled per year (million kms)		Average distance travelled per person per day	
	Pedestrians	Cyclists	Pedestrians	Cyclists
5- 6	37	18	0.4	0.2
7-14	243	299	0.7	0.9
15-17	200	167	1.7	1.4
18-19	99	91	1.3	1.2
20-24	255	162	1.2	0.8
25-34	478	246	1.0	0.5
35-44	377	219	1.1	0.6
45-54	414	278	1.2	0.8
55-64	416	215	1.2	0.6
65-74	379	130	1.3	0.4
75-84	108	32	0.7	0.2

Source: Resvaneundersökning (RVU), 1978.

Table 7: Mean trip lengths for pedestrians and cyclists, by age.

Age	Mean trip lengths (km) Pedestrians	Cyclists
5- 6	0.8	1.3
7-14	1.0	1.8
15-17	1.3	2.0
18-19	1.4	3.8
20-24	1.3	2.4
25-34	1.2	2.1
35-44	1.4	2.0
45-54	1.6	2.8
55-64	1.5	2.4
65-74	1.5	2.2
75-84	1.0	2.5

Source: RVU, 1978

Figure 1 shows the mean trip length for persons aged 5-84 years in Sweden for different travel modes.

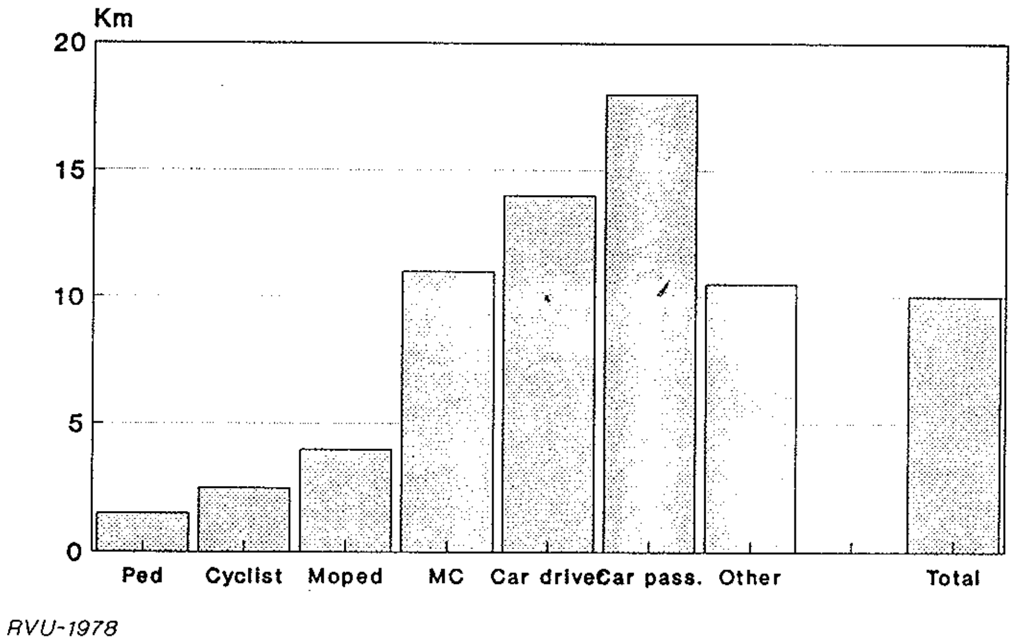


Figure 1: Mean trip length per trip for persons aged 5-84 years.

This figure shows that the distance travelled per trip tends to be longer for trips involving the use of motorised transport compared to those trips which do not.

Figure 2 shows the mean trip time for persons aged 15-84 years in Sweden by mode of transport.

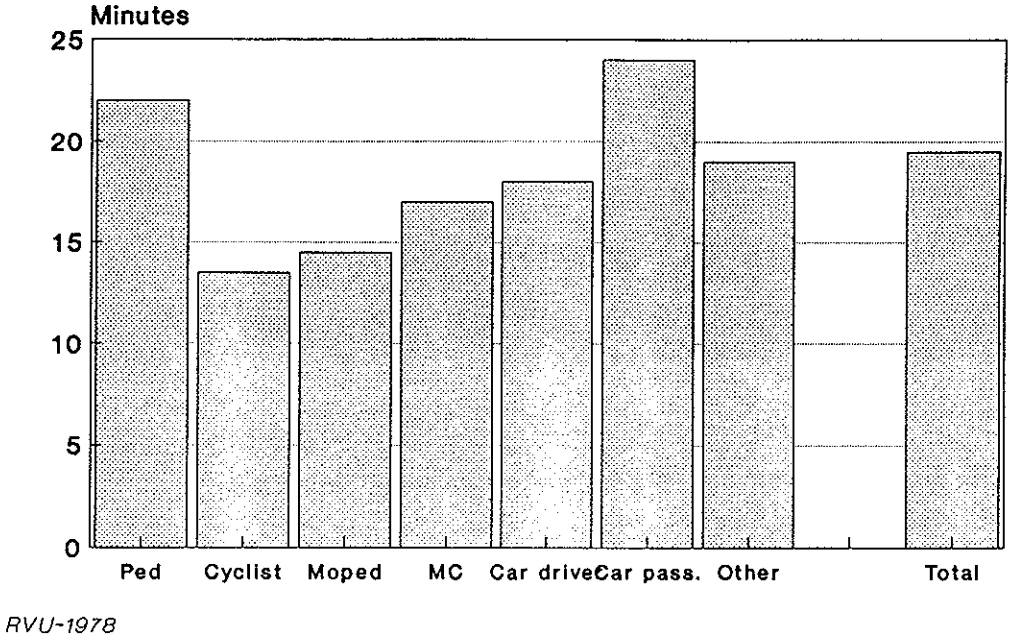


Figure 2: Mean trip time per trip for persons aged 15-84 years.

The pattern shown in this figure is very different from that of Figure 1. The length of trips in terms of time is very much greater for the vulnerable road users relative to other road users, than it is for the length of trips in terms of distance.

4.3. FACILITIES

The standard crossing facilities for pedestrians in Sweden are:

1. Zebras. These consists of white stripes across the road together with a sign and indicate that specific care is to be taken by the motorist, though they do not give the pedestrian priority.

2. Crossings at lights at intersections. All traffic signals in Sweden have specific lights (red and green man) for pedestrians. Exclusive pedestrian phases are rare in Sweden. Pedestrians crossing during the green man phase have legal priority. A flashing green phase at the end of the pedestrian crossing stage is not common; it is used at a few intersections mainly to deter elderly pedestrians from starting to cross at the end of the green man phase.

3. Crossings at mid-block lights. These are very common in Sweden. At these facilities there is a phase when pedestrians have priority. However, such crossings have problems, particularly because many pedestrians and motorists fail to conform to their red lights (Vägverket, 1985).

4. Refuges. Central refuges are commonly provided on wide roads and/or those with heavy traffic. In Sweden they are almost always combined with zebras.

The standard facilities for bicycles are:

1. Totally separated bicycle paths in parks, etc. These are always two-way.

2. Separated bicycle paths along roads. Most of these are two-way.

3. Bicycle lanes on the road separated only by painted lines. These are always one-way.

4. Residential streets signed as part of the bicycle network. Bicycles on these streets have priority although car traffic is not forbidden.

5. Signed bicycle crossings at intersections. On these bicyclists are treated in the same way as pedestrians at zebra crossings.

6. Bicycle traffic signals (small red/yellow/green) at signalised intersections. These are provided if a bicycle path enters such an intersection.

5. THE LOCAL SITUATION

5.1. SAFETY OF VULNERABLE ROAD USERS

Växjö is a mid-sized city in the southern part of Sweden with a total population of approximately 68,000 inhabitants. Over the five-year period 1983-1987 there were a total of 2853 accidents in Växjö. In 767 of these accidents at least one participant was injured. There were 26 fatalities and 1041 other injuries. About 72% of the accidents occurred on main roads. Table 8 shows the number of police reported accidents involving VRUs in Växjö by type of accident and severity.

Table 8: The number of road accidents reported to the police in Växjö which involved vulnerable road users, by type of accident (1983-1987).

	Fatal	Serious	Slight	Total
Car-Pedal cycle/moped	5	47	83	135
Car-Pedestrian	5	25	41	71
Single pedal cycle	0	8	16	24
Pedal cycle-pedal cycle	0	7	20	27
Total	10	87	160	257

Source: Carlquist and Persson, 1988.

Computer programmes are not readily available to produce further breakdowns of the accident data for Växjö. The data does exist to make further breakdowns, but due to the small number of accidents involved, these would have limited statistical reliability.

5.2. MOBILITY OF VULNERABLE ROAD USERS

No regular surveys of the mobility of VRUs are carried out in Växjö. The only data available on VRU mobility are calculations from normal traffic counts and lengths of road, which provide a rough guide to exposure (Carlquist, 1988). These show that the average distance travelled by bicycle per day in Växjö is 55,088 km, which gives an average distance per person per day of 1.1 km (the population of the central area of Växjö is 50,506). This is similar to the figure for Sweden as a whole.

6. SAFETY AND RISK OF PEDESTRIANS AND CYCLISTS

Accident risk, the ratio of the number of accidents to the relevant exposure or the opportunity for such accidents, can be calculated using the different indices of mobility/exposure mentioned above.

The risk to different road user groups using different measures of exposure is shown in Table 9.

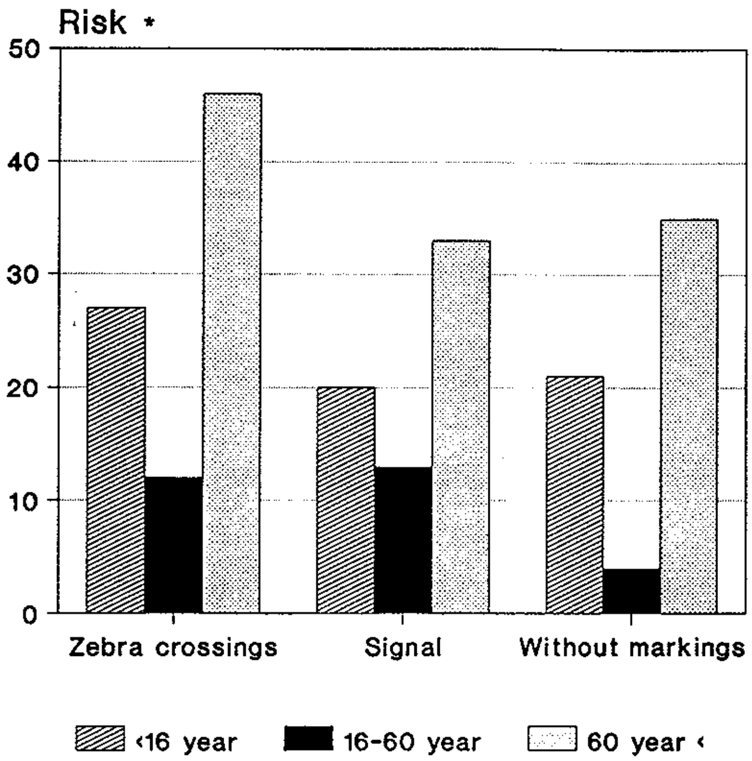
Table 9: Three measures of the risk of an injury by road user group.

	No. of injuries		
	Per million trips	Per million passenger kms	Per million hours in traffic
Pedestrians	0.9	0.7	2.3
Pedal cyclists	2.4	1.1	10.3
Moped riders	13.9	3.4	57.5
Motorcyclists	95.0	8.5	334.0
Car drivers	2.2	0.2	7.4
Car passengers	3.5	0.2	9.4
Total	2.4	0.2	8.0

Source: Thulin, 1981.

Studies of risk are a useful means of identifying safety problems related to different types of facilities for pedestrians and pedal cyclists. A study was made at the University of Lund (Ekman, 1988) to calculate risk using police reported injury accidents and manual pedestrian counts along a large number or urban streets with a total length of 56 km. The results showed that 2/3 of all pedestrian accidents on urban streets are to be found at or near to intersections. Children and elderly people had much higher risks than other age groups. It was also shown that crossing the road at pedestrian crossing facilities, such as zebras and signals, was associated with a much higher level of risk than crossing the road at similar places without any facilities. This may be explained by such crossing facilities giving a false feeling of safety to pedestrians who cross there. However, the Lund study was not able to test this hypothesis.

Figure 3 shows the risk of an accident to different age groups of pedestrian at certain types of crossing location.



* Risk = (6 years of accidents/number of crossing pedestrians during 12 minutes)*1000

Figure 3: Number of pedestrian accidents per road crossing (within 18 metres of an intersection). Source: Ekman, 1988.

7. CONCLUSIONS

The aim of this report has been to focus on the most important issues for vulnerable road users both from a safety and a mobility point of view. It is thought that the places with the greatest potential for improvement for VRUs, both from a safety and mobility point of view, are the central parts of urban areas. Given the effects that improvements for VRUs may have upon other road users in these areas, it is felt essential to develop an effective model of the traffic system, which not only takes account of motorised transport (as most existing models already do), but which also takes account of the needs of VRUs and hence will aid the development of a truly integrated transport system.

7.1. SAFETY

Two types of locations are of great importance from the point of view of safety. Firstly, places where there are many accidents involving VRUs and secondly places where accident risk for VRUs is high.

From a pedestrian's or a cyclist's point of view the most important safety issue is "where is it safest to cross". Hence, they are primarily interested in the risk of an accident per road crossing or per kilometre cycled. A government may look at the question of safety slightly differently, and be more interested in sites which have a high absolute number of accidents, regardless of how many pedestrians and cyclists use that piece of road. Accident risk of vulnerable road users is difficult to estimate because of the difficulties of obtaining accurate and reliable exposure data.

There are a number of basic problems concerning attempts to improve the traffic safety of VRUs. These are:

1. Most of the safety measures which aim to reduce the number of accidents to VRUs result in a higher degree of separation usually resulting in longer delays and more inconvenience for VRUs.

2. Safety measures aimed at pedestrians often result in situations where car drivers no longer need to take account of pedestrians.

3. Studies on the influence of different safety measures show that in order to avoid conflicts and accidents, car drivers and VRUs need to be aware of each others' presence. This means that VRUs should be clearly visible and in the line of sight when they approach each other.

4. There are certain widely used facilities which can create a false sense of safety for either the driver or the VRU.

Zebra crossings have for a long time been the most common type of countermeasures used to protect pedestrians when they cross busy streets, especially in urban areas. A study made in Sweden (Ekman, 1988) proved that the safety effect of zebra crossings was questionable. The results of the study showed that the pedestrians experienced approximately twice the risk of being injured when crossing on a zebra crossing compared to a crossing location without any signs or road markings (traffic flows at the zebra crossings were equal to or lower than the flows at the other locations). Similar studies in England and Norway have shown that the zebra crossings seemed to have a much more positive safety effect in those countries. Hence, a proven safety measure in one country need not necessarily work in another country, and the possible effects of cultural differences should be taken into account before introducing new measures. These studies of the safety of zebra crossings show that analyses of accident risk are just as important for pedestrians as for other road user groups if a true feel for the problems faced by this group is to be gained.

In addition to analyses of risk it is also important to identify the underlying processes which determine the different levels of risk. The Lund studies show that pedestrians seemed to rely more on the expected safety effect of zebra crossings than they had reason to do, as the car drivers did not markedly reduce their speed when approaching the crossing even if a pedestrian was on the crossing or was just about to step onto it. Behaviour and conflict studies may be the tools for proving the truth of hypotheses about the underlying processes.

7.2. MOBILITY

For pedestrians and cyclists mobility is a very broad field. The fact that pedestrians and cyclists are able to change direction very quickly and easily and are capable of climbing has enabled planners to send them down into tunnels and up stairways. VRUs have shown such a good talent to adapt to new and often hard situations, that it is sometimes thought that mobility can never be a problem for them. In reality pedestrians and bicyclists are the most environmentally sensitive road users. It is known that they create their own paths if the official one is not convenient enough. They are sensitive even in terms of social communication and architectural values. For VRUs, it is very much the case that the system defines their level of comfort, whilst other road users can compensate for a lack of comfort in the environment by shutting themselves into a vehicle. One other important element which VRUs must bear in mind when using the road system, perhaps more than other road users, is the risk of attack by other people.

Pedestrians and cyclists are traditionally subjected to greater delay than other road users. It is a perverse fact that time for a person sitting in a car is considered to have a positive value, while for the same person or another person walking, their time is considered to have no value. The reasons for this strange way of treating delay for VRUs may be twofold: firstly, there is a lack of a good model to estimate delay; and secondly, transport planners consciously put a low value on VRUs time. From research in the public transport area it is known that people put different values on different types of delay, for instance waiting time is valued several times higher than running time. It is also known that pedestrians and cyclists are very keen on using the shortest route. Information on the route choice criteria of VRUs is essential, if some account is to be taken in transport models of the delays they suffer. At present information of this type is virtually non-existent. This may be because the preferences of VRUs are very complex, and in order to be able to use such information efficiently it needs to describe behaviour both on the macro and micro levels.

One other important and difficult issue to bear in mind when examining the mobility of VRUs is the extent of "trip suppression". This is where adjustments are made to the routes taken, or in extreme cases journeys are not made at all, due to fears for safety. Such behaviour is particularly common for elderly and disabled people, where fear of crossing certain roads can be a major influence on daily life.

Sometimes only essential trips are made, and others, such as to and from social activities, are forfeited.

A survey in Sweden (Ståhl, 1986) showed that almost 35% of the elderly (above 65 years) said that they had problems when walking. These problems could be divided into three main groups:

1. Individual physical capacity.

2. The physical surroundings.

3. Interaction with other road users: due to the quick, complex and rapidly changing nature of traffic flow, the task of processing all of the available information when one is about to cross the street is very complicated.

This study concluded that it is not impossible to solve these problems. It was indicated that unfulfilled travel needs could be fulfilled with only minor changes in the physical surroundings or in public transport.

Even if pedestrians are able to cross the street, doing so often causes them great delay. If society wants to incorporate vulnerable road users into the traffic system and not treat them as second class citizens, their delays have to be treated the same way as that of users of motorised vehicles. Trip suppression may mean in the case of vulnerable road users that they change their mode of transportation because of the inconveniences of walking or cycling. Such a change may not be in the best interests of society as modes of travel such as on foot or bicycle are environmentally friendly. An improvement in the situation for VRUs may encourage more people to travel by these modes, and hence result in a cleaner and more pleasant place to live.

8. REFERENCES

BRUNDELL-FREIJ, K. AND LJUNGBERG, C. (1989) Bicycle accidents reported by the police and by the hospitals in the city of Malmö (Manuscript).

CARLQUIST, T. (1988) Interna arbetshandlingar. Växjöprojektet Sarskilda undersokningar. (Different surveys in Växjö.) Department of Traffic Planning and Engineering, Lund.

CARLQUIST, T. AND PERSSON, H. (1988) Polisrapporterade trafikolyckor 1983-86. Växjöprojektet rapport 3. (Police-reported accidents in Växjö 1983-86.) Department of Traffic Planning and Engineering, Lund.

EKMAN, L. (1988) Fotgangares risker pa markerat overgangsstalle jamfort med andra korsningspunkter. (Pedestrians' risks at zebra crossings compared to other crossing places.) Department of Traffic Planning and Engineering, Lund, Bulletin 76.

RESVANEUNDERSOKNING (Travel habit surveys) (1978) SOS.

RESVANEUNDERSOKNING (Travel habit surveys) (1984) SOS.

STÅHL, A. (1986) Att vara äldre i traffiken. (Traffic and the older person.) Department of Traffic Planning and Engineering, Lund, Bulletin 67.

THULIN, H. (1981) Risker i trafiken for olika aldersgrupper och fardsatt. (Traffic risks for different age groups and modes of transport - based on information from traffic accidents reported to the police and from results of a study of travel patterns in Sweden made by National Central Bureau of Statistics in 1978.) VTI Rapport 209. Linkoping.

THULIN, H. (1987) Trafikolyckor och trafikskadade enligt polis, sjukvard och forsakringsbolag. (Traffic accidents and traffic injuries according to the police, the hospitals and insurance companies.) VTI Meddelande 547. Linkoping.

TRAFIKSKADOR (Traffic Injuries Official Statistics of Sweden) (1987) Stockholm.

VÄGVERKET (1985) Frilig gande gång- och cykelsignaler. (Midblock pedestrian and bicycle signals.) Tu 160.