# SAFETY CONCEPTS FOR THE DESIGN OF TRANSPORT AND TRAFFIC FACILITIES FOR PEDESTRIANS, CYCLISTS, CHILDREN AND DISABLED IN URBAN AREAS

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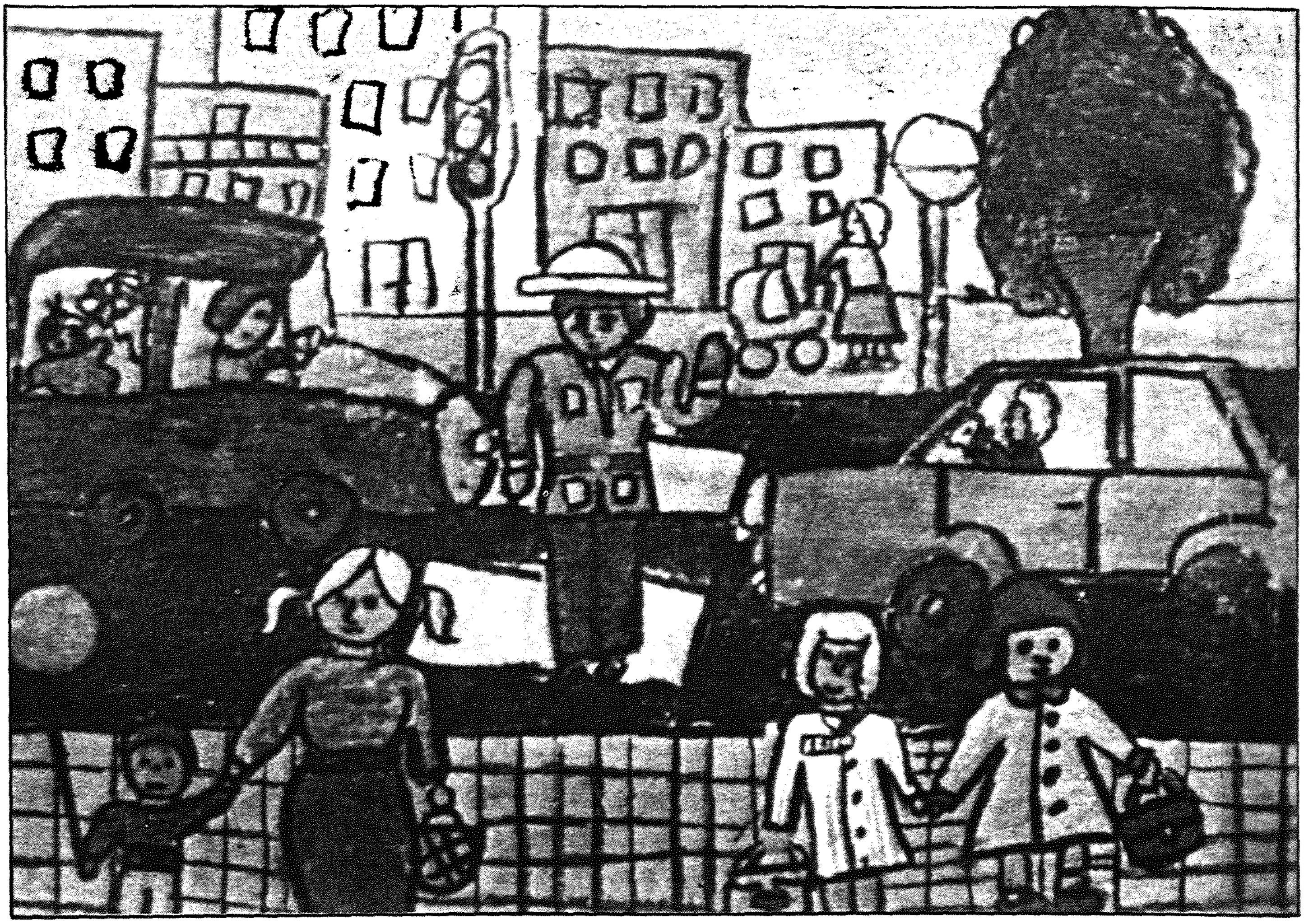
## SUMMARY

Identification of traffic safety problems in urban areas concerns the search for critical combinations of circumstances mainly in the traffic situations, but also in the other phases of the accident process, such as emergency situations and collision situations.
When critical combinations of circumstances occur, mostly the preceding travel and traffic behaviour plays an important role. It may determine the fatality of the accident process.
The "vulnerable" road users, pedestrians, cyclist, children and disabled in urban areas mainly are victims of motorised traffic.
The intensity and speed of this motorised traffic, especially through traffic are the main agents for the unsafety of the "vulnerable" road users.
Safety concepts for urban areas should be directed in the first place on diminishing the intensity and reduction of speed of motorised traffic. This has to be enforced by physical measures and not only by regulations. There are hardly no effective measures or facilities directed to the "vulnerable", conductive to transportation safety, as long as the intensity and speed of the motorised traffic is not reduced.

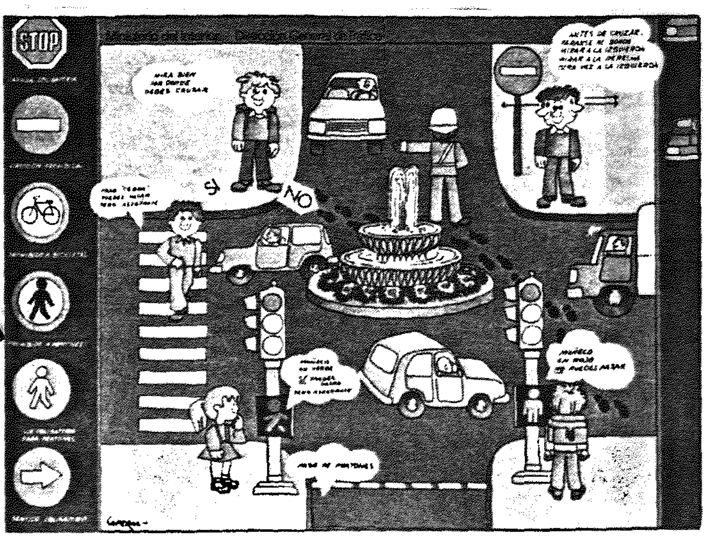
# El tráfico visto por los niños



Este es el dibujo premiado en 1980. La autora ha sido la niña de nueve años María del Carmen Cid, de Tarragona.

## NIÑOS Y PEATONES COMO VICTIMAS

# Indefensos de la circulación




Cartel de la Dirección General de Trafico, orientado a la educación peatonal de los niños.

## 1. INTRODUCTION

While working on this paper, I found in the journal "Autoescuela" (May/ August 1980) two pictures, which characterise the traffic-safety problems in urban areas more strikingly than many words would be able to express. The first picture shows a drawing of the traffic by a nine year old girl as seen by her. The second picture shows all the aspects of traffic, children as young road users have to be familiar with in order to prevent becoming victims of motorised traffic.

In The Netherlands 22% of the population is younger than 15 years. They take part in traffic mostly in urban areas and yet I cannot avoid the impression that this age group is hardly taken into consideration (if at all) in the planning of transport and traffic facilities in these areas. It is for this reason that the organising committee of the 5th National Congress on Traffic Safety asked me to elaborate on the safety of pedestrians, cyclists, children and disabled in urban areas.

The number of fatalities for 1980 in The Netherlands give a general indication of the unsafety of these groups: 10% of trafic fatalities occurred in the groups younger than 15 years, about 15% of traffic fatalities occurred among pedestrians and about 21% among cyclists. No data are available as regards disabled killed in traffic. It is well known, however, that one-third of the disabled is older than 65 years and that 23% of traffic fatalities occurred in the 65+ age group.
In 1980 about 2000 fatalities and about 60,000 injured were registered in The Netherlands. Approximately 41% of fatalities and 70% of injuries were registered in urban areas.

Of course, these general indications, like all statistics, give only a rather limited picture of traffic unsafety. Should these percentages being related to the number of persons involved in the group in question and to the traffic performance (travellers kilometers) we would get quite a different picture of the situation.

It also has to be considered that in many cases (slighter) injuries are not registered and that most certainly several hundred thousand accidents occur, involving material damage only. The number of incidents (near-accidents), whereby the involved persons got off by the skin of their teeth, is still higher. Quite often it is thought that the general picture of traffic unsafety is sufficiently characterised by these data. However, a great number of injured people never recovers completely if at all. Each year a considerable number of permanently disabled has to be added to the statistics of the preceding years.

In my present lecture pedestrians, cyclists, children and disabled are in the center of interest. In The Netherlands these groups are indicated by the term:"vulnerable road users". The protection of these vulnerable groups is given high priority in traffic-safety policy, in the first place as regards confrontation with the motorised traffic in urban areas. And yet, the concept "vulnerability" has to be accepted with certain reservation, because the category with the highest number of fatalities might be considered as the "vulnerable" road users.
I come now to the problems involved in the risks of confrontations between different categories of road users on the basis of registered accidents data referring to The Netherlands. The picture in other western countries will not differ very much from this.

## 2. THE RISKS OF CONFRONTATIONS BETWEEN DIFFERENT CATEGORIES OF ROAD USERS

In the first place it should be pointed out that such confrontations result from the present traffic structure. Due to this the traffic risk of one category of the road users depends to a considerable extent on the presence of an other category of road users. As a rule it can be stated that the group of weak or vulnerable road users, who are mainly exposed to the risk of serious accidents, consists of pedestrians, bicyclists and moped riders, while among the pedestrians the children, the young and aged citizens are the most gravely affected.

According to official statements and documents, however, the absolute number of fatalities and injured indicates the car passengers as the most vulnerable road users (see Figure 1). When only age is taken into account we find the highest number of fatalities and injured in the age categories between 15 and 24 years and not among little children or aged citizens. To be more exact: the death rate for the age categories between 0 and 14 years is 8 per 100,000 inhabitants of that group, on an average per year. The death rate for the age categories of 15 to 24 years is about 30 per 100,000 inhabitants; i.e. 30% of the total number of fatalities in traffic concerns these age categories. In view of injuries the percentages are still higher. Traffic causes the highest number of losses of life in the mentioned age groups. Thus, in view of public health traffic takes the heaviest toll with regard to the 15 to 24 years old. Apparently the notion vulnerability is not fully determined by the number of fatalities alone.

Expressing the vulnerability by the number of deaths per $10^9$ travellers kilometer, as per mode of transport for 1978 is represented in Figure 2, the list of the most vulnerables is headed by the motorcyclists, followed by the pedestrians, the moped riders, the bicyclists, while car passengers stand at the end of the list. The special position of the motorcycle requires in my opinion, special measures in traffic safety policy. A campaign focused alone on influencing the traffic behaviour will most certainly not be sufficiently effective.

However, there are so considerable differences in the speeds of the various transport modes, for example between motor cars and pedestrians, that it seems more expedient to base our calculations on the time spent in traffic. Also in this case we will find the motorcycle on the first place, followed by the moped, the pedestrian, the bicycle and finally the car passenger. Figure 2 illustrates that the aggressiveness of passenger cars related to travellers kilometers is not too high. Only the large number of cars in use makes this category so dangerous in absolute sense for other road users.

The aggressiveness of the car seems to be determined, in the first place, by the energy accumulated therein, expressed in mass and speed. This energy is responsible for moving the vehicles, thus it cannot be suppressed completely, although it would be useful to find out to what extent superfluous energy accumulates. In any case it should be investigated in what way the high-energy accumulating vehicles could be isolated from vulnerable structures and pedestrians.

The concept "vulnerability" could also be explained on the basis of collisions with fixed objects. Such objects can be encountered by anybody. The question is which road user category has the greatest chance of being killed in collisions with them (see Figure 3).

The absolute figures referring to fatal accidents caused by collisions with fixed objects again prove the passenger car to be the most vulnerable transport mode. The next category as regards vulnerability is the moped, followed by the motorcycle, lorry (incl. delivery van) and finally the bicycle. In this list we find nothing about pedestrians, because due to the classical definition of traffic accidents assuming the involvement of a riding vehicle, no data referring to pedestrians were available.

In view of passenger cars, motorcycles and lorries (incl. delivery vans) collisions with fixed objects are responsible for about 30% of all fatalities in these categories, mostly occurring outside built-up areas. For mopeds the corresponding figure is 13% and for bicycles 0,2%.

In spite of many countermeasures intended for making vehicles with more than two wheels safer and more collision-resistant, the given figures indicate that there is still much to be done, for example by screening the fixed objects, the obstacles, or by weakening their aggressiveness. For instance, lamp posts might be constructed with a slip or a break-away design.

Statistical data also prove that the number of fatal accidents involving fixed objects shows a declining trend for all categories, with the exception of motorcycles, while the number of motorcyclists on the road steadily grows.

On relating the number of fatal accidents in connection with fixed objects per mode of transport to vehicle kilometers (see Figure 4) the motorcycle will be found as the most vulnerable category, closely followed by the moped. Furthermore, a decrease can be observed for all categories in the period between 1974 and 1978 as compared to preceding years, excepting the moped, the mileage of which, however, is decreasing.

Another possibility of exploring vulnerability more thoroughly consists of establishing the relationship between the number of fatalities in the proper category and the corresponding number in other categories. The final sum is always 100% for all modes of transport (see Figure 5). The graphs in this figure show the pedestrians and bicyclists as the most vulnerable categories, while bus and lorry (incl. delivery van) emerge as the most aggressive modes of transport with the passenger car somewhere in the middle.
Should we apply this form of representations to the different age categories, we would find children and aged persons as the most vulnerable, whereas the 15 to 24 age groups as the most aggressive. This form of graphic representation is in accordance with the general aspects of vulnerability as accepted in policy making and politics but it is unsuitable for characterising traffic unsafety, since it gives hardly any suggestions about the effect of protective and road traffic engineering countermeasures. Only radical countermeasures affecting the traffic structure, like for example the complete prevention of certain type of confrontations, could bring forth improvements with regard to vulnerability as outlined in the foregoing part.

As an illustration we shall investigate which effects have to be taken into account in case of a shift of passenger car traffic towards public (bus) transport. It was found that the bus represents a higher risk per vehicle mileage for other road users than the passenger car (see Figure 6). However, from this it cannot be concluded that a shift of the passenger car transportation towards bus transportation should have a negative effect on traffic safety. From the viewpoint of the traffic system the issue in question is the individual travellers mileage and on interpreting the corresponding number, the number of people travelling in the bus (the occupancy) has to be taken into account as well (see Figure 7). On assuming for a car two passengers on an average and for a bus eighteen, nine cars have to travel instead of one bus in order to attain the same travellers mileage. For the time being we shall neglect the fact that bus passengers quite often have to make detours in order to arrive at the place of their destination, but even in this case the risk the passengers of nine cars are exposed to, is still higher than that for one bus-load. A shift from a car to bus transportation implies that more persons must walk to reach the bus stop, thereby increasing the number of the (more vulnerable) pedestrian kilometers. From the given data it can also be concluded that (large) buses with low occupancy will pose an important risk per vehicle kilometer for other road users. On extending the bus service by running the buses more frequently, the ensuing lower occupancy will cause the deterioration of traffic safety as expressed by the number of fatalities per travellers kilometer. This, of course could be prevented by replacing during non-rush hours, the large buses by smaller ones, which should be less aggressive.

As regards vehicle characteristics buses are more unsafe for other road users than passenger cars or bicycles. Buses display a much greater aggressiviness (mass) and longer braking distance. Neither is the strict time schedule imposed on the bus driver conducive to the safety of other road users. This fact is most certainly not compensated for by the greater driving skill and more thorough training of the bus drivers.

All these problems have been recognised much earlier in connection with railway transport and accordingly a completely seperated track system has been established for the trains, with only few intersections with other traffic routes. As a consequence, railway transport involves no high risk per travellers kilometer for other road users. For the same reason a separate track for bus and tram should for the most part also have to be free from intersections.

In my opinion the promotion of the bicycle is also problematic with regard to traffic safety on account of the high risk the bicyclist is exposed to in confrontations with high-speed motorised traffic. It would be irresponsible to stimulate the use of the bicycle without ensuring adequate protection for the bicyclist beforehand. The first step in this direction should be the creation of protected bicycle routes and lanes. But intersections with high-speed traffic with or without traffic light control would act as hidden pitfalls in the traffic system, both for the bicyclist and the road administration!

In the following I shall examine the possibilities available and in the first place, the best approach to improve the safety of pedestrians, cyclists, children and disabled in urban areas.

## 3. THE MODEL OF THE ACCIDENT PROCESS

Transportation (un)safety is the result of a complex process in the transportation system. A large number of variables (characteristics of the system elements) with many interactions, produce a complex network of relationships expressed in "system behaviour". In this network of relationships, man as an element in the transportation system has the greatest number of degrees of freedom. His behaviour is therefore the most difficult of all to predict. Theories on the overall process in the transportation system are therefore dangerous and misleading. Theories only have predictive force in the relevant sub-processes or process phases. In other words, in order to be able to predict the effects of countermeasures, these process phases must be distinguished within the process as a whole. Countermeasures can have an opposite effect on the different process phases.

Developments in traffic (un)safety, effects of countermeasures implemented for fighting against unsafety, are always the result of changes in the process phases. A speed limit, such as the 30 km/h in urban areas, can have no effect on traffic safety if road users will not drive at lower speed.
Before I present a model of the accident process, in which the relevant process phases are distinguished, I want to mention a description of the phenomenon traffic unsafety:"Traffic unsafety can be regarded as the whole of existing and potential critical combinations of circumstances, incidents (conflicts) and accidents in traffic and the individual and social consequences (damages) caused by them".

In Figure 8 the model of the accident process is shown as a phase system. The main feature of incidents and accidents is that they are always preceded by a critical combination of circumstances in the traffic situation. But there are also critical combinations of circumstances in other phases, such as the collision phase.
A critical combination of circumstances in a traffic situation can be described as a situation where in, with unchanged traffic behaviour or unchanged traffic situation, the interaction between man, vehicle, road, traffic and environment leads to accidents.

The answer of the road user can be "anticipatory" traffic behaviour or, when this is not successful, "emergency" manoeuvre behaviour.
Identification of traffic safety problems especially in urban areas concerns thus the search for potential critical combinations of circumstances in traffic situations, in emergency situations, in collision situations in incident situations and finally in injury situations, that is the general search strategy. In each "critical situation" the previous process phases play an important role.
Example: A child suddenly crossing the road can quite often be avoided by a fast car only through an emergency manoeuvre by the driver. As a rule, there is no time for anticipation in such cases. Unfortunately, even the emergency manoeuvre fails quite often. On account of the high speed of the car, the evading manoevre of the emergency stop do not succeed and it might also happen that the car slips, mainly if the road surface is slippery on that spot.

## 4. SAFETY CONCEPTS FOR THE DESIGN OF URBAN AREAS

Traffic safety policy is certainly not a matter of recipes and most certainly not, if the main issue is the safety of pedestrians, cyclist, children and disabled.
Cars could be designed with a type of cage structure and with a crush zone. This would make cars more compatible to one another. Safety helmets should be made compulsory for moped riders, hereby mitigating in many cases the damaging effect of collisions. Hardly no protective measures can be provided for pedestrians, cyclist, children and disabled, to make them more compatible to other modes of transport.
What yet remains is, on the one hand the ordening or structure of the traffic, i.e. who is confronted by whom? And on the other hand, the control of circumstances, under which the confrontations take place, i.e. which traffc behaviour of motorised road users is compatible with regard to the vulnerable groups? This last point relates especially to speeding behaviour.

Man has to make many decisions in the transportation and traffic system which are of different type according to the phases of the accident process model.
Unfortunately up till now we have to accept the fact that the perception, the information assimilation and the decision making process of the mostly concerned people: the road users, are not sufficiently taken into consideration neither in road planning and traffic control, nor in vehicle design and in legislature, etc., although they have to cope with all the effects and consequences involved in these issues.
The transportation system, in its present form and in its functioning, is in fact the work of monodisciplinarily operating scientists and decision makers.
Town and transportation planners decide which roads should be built and where, traffic-engineering experts decide how the roads should be designed, road builders decide how these roads should be constructed and of which material. Vehicle experts decide how vehicles should be designed and function, behaviour scientists and legal experts decide how the roads and vehicles should be used.
Strictly speaking, everybody operates more or less independently from the

other, more or less without enough knowledge of the others' field of interest. The road user, limited in his possibilities to percieve, decide and act, has to function in a system in which the coherence of the elements (road, vehicle traffic and surroundings) often is not enough taken into consideration.
The lack of coherence of the elements of the transportation system not only influence traffic safety directly, but also indirectly.
The direct influence can be illustrated with the following example. The road user perceives a traffic scene as a whole, also in case of a critical coincidence of circumstances in a traffic situation. Depending on the coherency of the information carriers in this traffic scene, the road user (based on his "information need" and on his general and specific expectations) will anticipate in an adequate or inadequate manner. If information is insufficient or not exact, or if the information is not in accordance with the information need, an emergency manoeuvre will have to decide whether an accident will happen or not.
The lack of coherence has also an indirect effect on unsafety, because it complicates the "learning" process and leads to "incorrect" general and specific expectations.

It often happens that after the implementation of certain countermeasures, the behaviour of the road users does not correspond with the expectations of the collective decision makers. However, these expectations of the road administrators are not known to the road users proper (no feedback!). Police surveillance and prosecution (followed by penalties) can be regarded as a form of feedback, but the road users will not often recognise them as such. Consequently the final and actual effect of a countermeasure will differ from the expected one.

What can be done in the various process phases with regard to urban areas?
In this connection we have to study the figure of the accident-process model again (Figure 8). With the help of this model we can investigate how to manipulate travel behaviour, traffic behaviour, etc.
In the phase indicated as travel behaviour measures have to be taken to exclude through-going traffic (not local destinations). This means that "sneaking" traffic through residential areas must be made impossible too.

On the other hand, through-going routes must be made attractive for the drivers, with possibilities of continuous unhindered passage and no queue forming, etc.
In this connection selective and rigorous choices must be made: who is allowed to drive where? Which is the primary function of a road: the residential or the transport function.
On the Dutch National Traffic Safety Congress 1982 the following statement was made:
"Since towns and villages have an important residential function, it is an incorrect strategy to indicate special geographically limited residential areas. It is more appropriate to establish on the level of structural plans for such areas a minimum of roads for the transport system. A road can only be regarded as a component of the transport system in case through-going traffic is absolutely unavoidable and the protection of slow traffic is guaranteed."

Yet, even after selective and rigorous choices there will be confrontations between slow traffic and motorised (heavy) traffic. In this case it seems necessary to provoke "mutually compatible" and in the first place "predictable" behaviour. "The provoked" traffic behaviour (for instance: speeding) contributes to circumstances becoming critical in the traffic situation and consequently to the possibilities of anticipatory and emergency behaviour. The main issue in this instance is the speed of motorised traffic. However, the problems must not be tackled with "anti-car" glasses on our eyes. It is possible that bumpy road surfaces will reduce the speed of cars with good springs to some extent, but such surfaces will also hinder the games of children on the road, roller-skating, cycling (with childrens' bikes), the pushing of prams, etc. Neither will older and disabled people move comfortably on streets with columns, botanical boxes, pits and road humps. Even normal bicycle traffic will be hardly possible in such streets.

The provocation of low speed, the provocation of the "right" expectations must be combined with the purposeful elimination of critical traffic situations, which cannot be redressed at all by anticipatory and emergency behaviour. In this connection we think about children suddenly emerging between two parked cars and running across the street; it is clear that the only solution here is to move the cars. We have enough practical knowledge to predict these potential critical situations.

Anticipatory behaviour is a frequently occurring phenomenon in the traffic process in urban areas. It happens all the time that the driver must use the brakes a little, that he must avoid other road users by an evading movement. However, there are critical traffic situations, which hinder adequate anticipations (like insufficient space for evading due to the presence of oncoming traffic). There are also critical circumstances being capable of neutralising the effect of apparently satisfactory anticipation. (For example: a pedestrian crosses the street on a crossing point, the car driver brakes to avoid him, but at the same moment the pedestrian stops; the car driver does not expect this and must make an emergency manoeuvre.) Clearness in traffic situations, space for anticipation, predictable behaviour of the other road users concerned (also provoked by the traffic situation) are the factors necessary for an appropriate anticipatory behaviour.

Screeching tires, a forceful jerk at the steering wheel, a desperate leap back to the kerb, are examples of emergency behaviour, occurring daily in urban areas. Often an emergency manoeuvre results in a side-slip of the vehicle. In many cases sudden, extreme evading manoeuvres or emergency braking will just prevent collisions. In these cases we speak about incidents or conflicts. The involved persons just get off with a fright, but a chain disturbance involving oncoming or following traffic might still happen.

Road surfaces in urban areas are often bumpy and very slippery (cobble stones, etc.). The possibilities for emergency manoeuvres (the evading space, the skidding resistant of the road surface) are usually insufficient in places where, as a rule, such manoeuvres are the most important: for instance, in urban areas with children running across the street, with pedestrians, old people and cyclists.
In the critical emergency situations, there is still sufficient room for improvements such as improving the lack of emergency-skill of the road users of any kind.

In case of a collision there are again critical combinations of circumstances , in the first place those of the collision situation proper. The speed of the colliding objects, the angle of impact, the differences in mass, the characteristics of the collision and the protection of the involved persons, all these factors are of importance with regard to the outcome of the collision. A truck driving at walking-pace can kill a pedestrian or a cyclist. A collision between a passenger car at a speed below 30 km/h and a pedestrian is mostly not fatal.

As examples I shall now present to you some measures to improve the safety in urban areas.

## A rough analysis of measures in urban areas

At present in The Netherlands both policy makers and researchers aim at a distinct separation of traffic spaces and residential areas from one another. This problem, however, has to be approached carefully since there are different types of residential areas and traffic spaces and there is no standard solution for separating them. In case of a very rigorous segregation traffic spaces would act as a kind of barrier between residential areas. Moreover, it seems that residents have, in general, broader ideas about the boundaries of their residential area than policy makers and researchers: quite often they include border line traffic spaces into their habitat. A better approach would be to make distinction between transit traffic and residential traffic and then to make a rigorous choice: who is allowed to go where? This is an important step in solving the problems and it must precede the phase of taking measures. Measures, which quite often are the result of a compromise: in residential areas the habitat function has to prevail, while at the same time (free) access to these areas has to be ensured. This is a point, which has to be made quite clear for the residents and visitors of these areas. But it can not be achieved through information and education only. The complete packet of measures should also contain infrastructural and traffic-engineering measures, which have to be sanctioned by legislation and maintenance. Only such an integrated approach will be effective. Such a packet has to cover the entire residential district and not only special locations. At present, experts are busy to draw up such a comprehensive packet of measures. However, it is rather difficult to set the relevant investigations into motion.

Accident studies in various countries proved irrefutably that reduced intensity and speed of motorised traffic indeed improved traffic safety. All these things can be realised much more easily in new residential areas; the real problems arise in the old ones. However, the necessary steps have to be taken there as well.
From scientific literature the following experiences with various measures can be gleaned.

Residential streets have to be closed when they adjoin the transit road system or access roads.
Only a few residential streets are kept open, thereby creating a system of blind streets. Sometimes it is necessary to provide at the end of such streets turning (reversing) facilities. This measure reduces the risk of accidents both inside of the district and on the adjacent roads as well. This is because there is less transit traffic mixed among residential traffic.

Closure of streets within the residential area
In this way a system of blind streets and looping streets will be created. In some cases the latter are combined with a one-way traffic system. This permits shorter distances in the interior of the area than in case of the former solution, but more crossings (thus increased risk) on circular roads. Blind streets prove safer than looped ones. A combination of these two types of measures can make residential areas extremely unpleasant for the "sneaking" transit traffic provided that car drivers do not get the idea that they will loose too much time on the circular roads.

One-way traffic system
It is rather difficult to assess the effect of such systems. It is much too location-dependent. However, there are indications that in some cases the system brings about favourable results. This depends on the extent in which the number of critical confrontations decreases.

Allocation of access roads in residential areas

This is mainly important for extended districts. Such roads belong to the "lowest" category of transit road, where transit traffic and residential traffic have often to be combined. Consequently, such streets must meet rather complicated traffic-engineering requirements. In new areas or in older, but expansively built districts, these aims can be realised quite easily, thereby reducing accidents in such places.

As a rule, the aforementioned measures are applied in some sort of combination. Studies carried out in this respect prove that such combined measures lead to a reduction of accidents in the investigated area without increasing in the influence area.

Speed reducing measures

There are reliable indications that collision speeds under 30 km/h do not involve danger to life. The problem is, how can we achieve such speed limitation. To set up a traffic sign is certainly not enough. The first condition of effectively reducing speeding is to keep short the straight-lined street sectors. In West-Germany and Sweden a straight-lined street sector cannot be longer than 200 meters. In The Netherlands, according to the "woonerf" system, some kind of speed limiting provision must be created at intervals of 50 meters, which makes speeding impossible. The width of the street has also some influence on speeding. Local narrowing (with a minimum width of 2.75 m) of the street will certainly reinforce this influence.
Road humps are created in several countries (e.g. Denmark and The Netherlands. Such humps are able to reduce speeding in case they are suitably constructed and arranged on the right places. English investigations prove that a certain type of humps is rather effective. The problem where to place them, however, is not yet solved completely. The intervals between humps vary from 50 to 130 meter. The first hump of a series (in a street) must certainly be built on a place where speed has to be reduced anyhow, for example right after a crossing. The assumption that purposely laid out humps will distract the attention of the drivers is not proved by experiments. Another mode of reducing speeding consists of shifting the road axis ("chicane"). However, in order to be effective, such shiftings of the axis must be rather abrupt.

(Re)structuring "woonerven"

The "woonerf" (residential yard) is conceived in order to enhance the amenity (quality of life) in residential districts. It is put into effect by a series of legal measures, road construction and traffic management measures, planning measures and social measures. The basic idea is that the houses and the open space between the houses together should form "homes" for the residents to live in, not only to find shelter. The "woonerf" therefore is primarily aimed at improving the quality of life, the amenity.

There is not much known about the effects of the "woonerf", neither as regards its influence on traffic safety, nor as regards social activities.

Cars are driven only seldom at the required "walking-pace", is was found. However, it is not sure, whether this is really necessary.

The consensus of opinion of people living in a "woonerf" is in general positive. But this may be inspired more by the sphere in and possibilities offered by the "woonerf", than on traffic-safety considerations.

## 5. FINAL REMARKS

Most of the discussed measures of urban areas are not specially directed on pedestrians, cyclists, children or disabled, but on their opponents: the motorised traffic.
It is highly problematic whether traffic situations can be related specifically to children. It is just not possible to translate them in terms of "adults on their knees".

In The Netherlands a survey was made on infrastructural and traffic engineering measures for disabled in urban areas (see Appendix 1). In this connection we have to realise that measures for a certain category of road users can conflict with aims and measures for other categories. For example, some categories of disabled need a flat continuous road surface, and roads without sharp bends. This, however, evokes high speeds from the drivers.
Due to the lowering of the kerbs and the creation of inclined ramps for the wheel chairs of the disabled, the guide dogs of blind people cannot orient themselves anymore and it may happen that the blind will suddenly be shocked to realise that instead of being on the pavement, he is in the middle of the traffic stream.

Conflicting interests and paradoxes are rather characteristic for traffic-safety problems. This means that we always must make choices and assessments. These assessments are of high importance with regard to human life. Right assessments can save many lives, many handicaps, disabilities, injuries and many sufferings and tears. For these reasons it is necessary to integrate traffic-safety concepts into the traffic and transport system in urban areas, thereby improving unsafe traffic conditions.

FIGURES 1 - 8

Figure 1. Number of deaths per mode of transport (The Netherlands, 1978)

Figure 2. Number of deaths per mode of transport per $10^9$ travellers kilometers (The Netherlands, 1978)

Figure 3. Number of fatal accidents with fixed objects per mode of transport (The Netherlands, 1969-1973 and 1974-1978)

Figure 4. Number of fatal accidents with fixid objects per mode of transport per $10^9$ vehicle kilometers (The Netherlands, 1969-1973 and 1974-1978)

Figure 5. Ratio "self-risk and "others risk" per mode of transport (The Netherlands, 1969-1973 and 1974-1978)

Figure 6. Number of deaths per mode of transport per $10^9$ vehicle kilometers, divided in "self-risk" and "others risk" (The Netherlands, 1969-1973 and 1974-1978)

Figure 7. Number of deaths per mode of transport per $10^9$ travellers kilometers, divided in "self-risk" and "others risk" (The Netherlands, 1969-1973 and 1974-1978)

Figure 8. Model of the accident process.

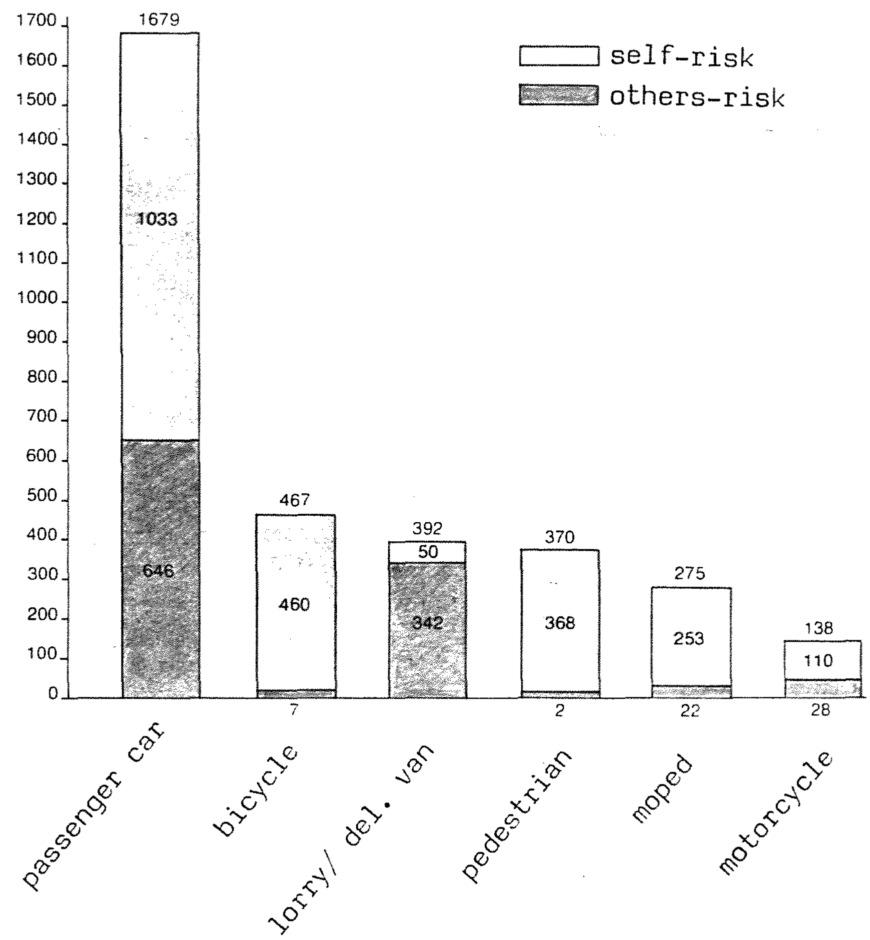



Figure 1. Number of deaths per mode of transport (The Netherlands, 1978)

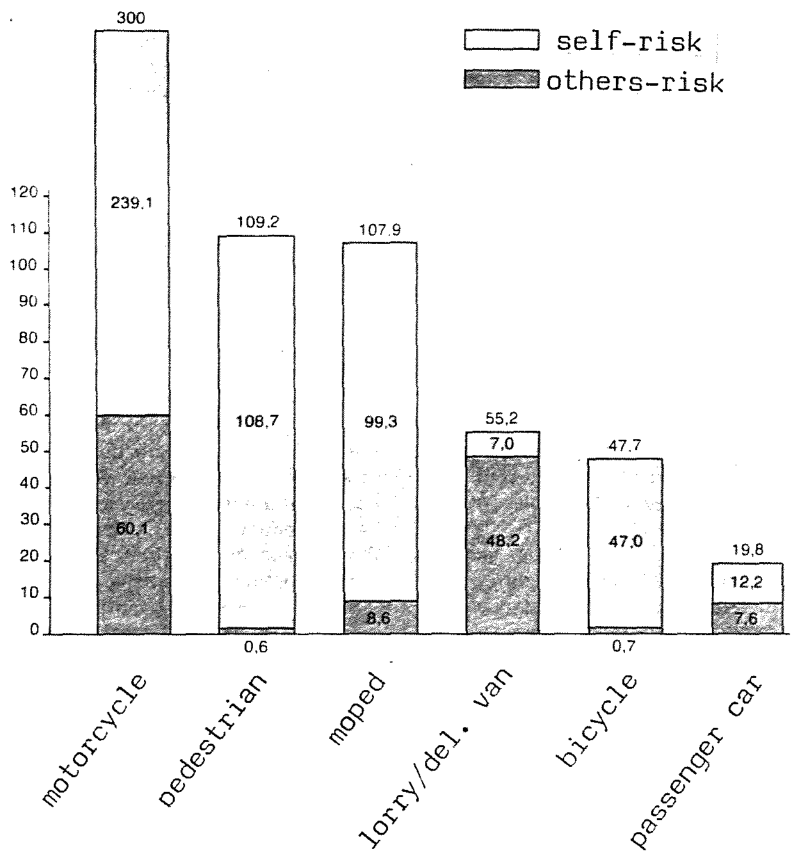



Figure 2. Number of deaths per mode of transport per $10^9$ travellers kilometers (The Netherlands, 1978)

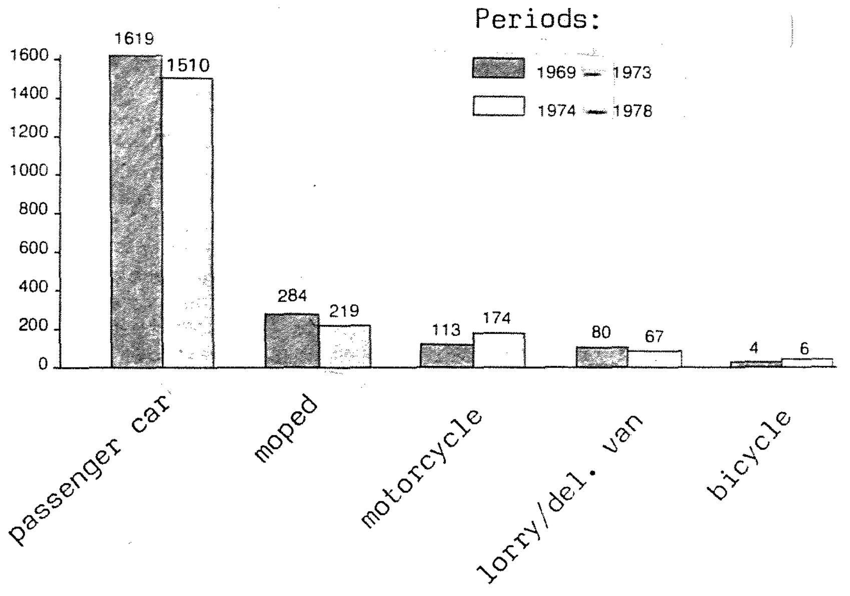



Figure 3. Number of fatal accidents with fixed objects per mode of transport (The Netherlands, 1969-1973 and 1974-1978)

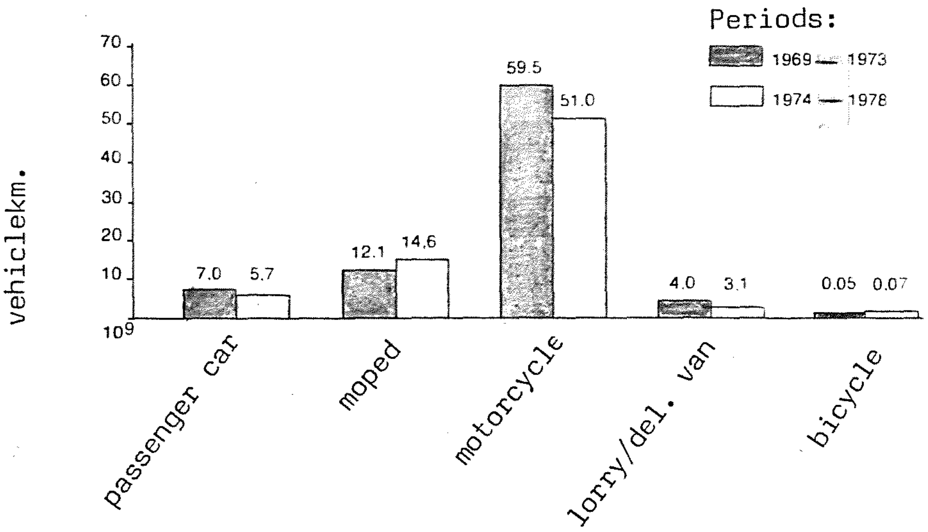
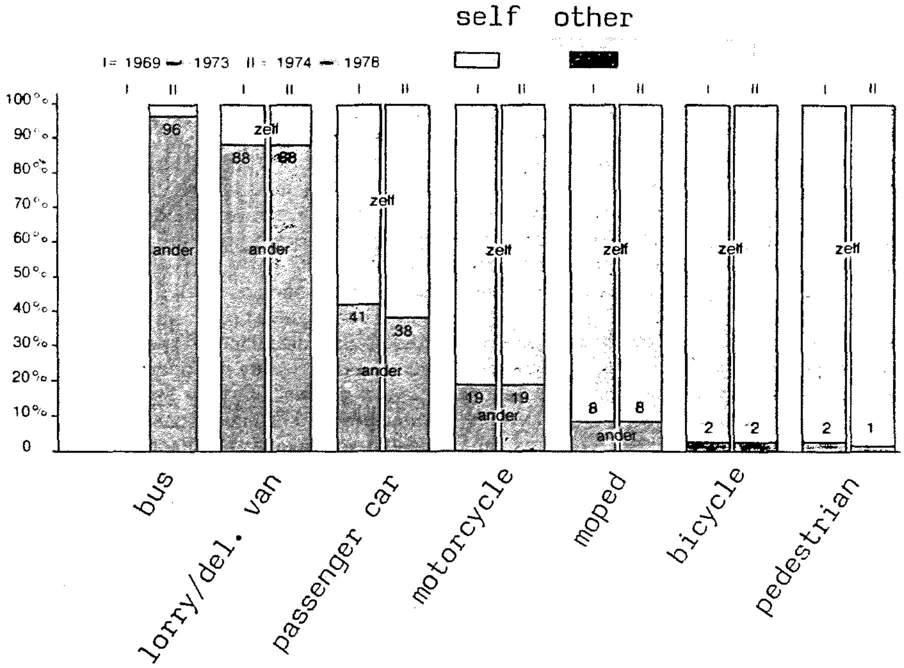



Figure 4. Number of fatal accidents with fixid objects per mode of transport per $10^9$ vehicle kilometers (The Netherlands, 1969-1973 and 1974-1978)




Note: 1974/1978 lorry=96% "others-risk"
delivery van=81% "others-risk" } =88% "others-risk"

Figure 5. Ratio "self-risk and "others risk" per mode of transport (The Netherlands, 1969-1973 and 1974-1978)

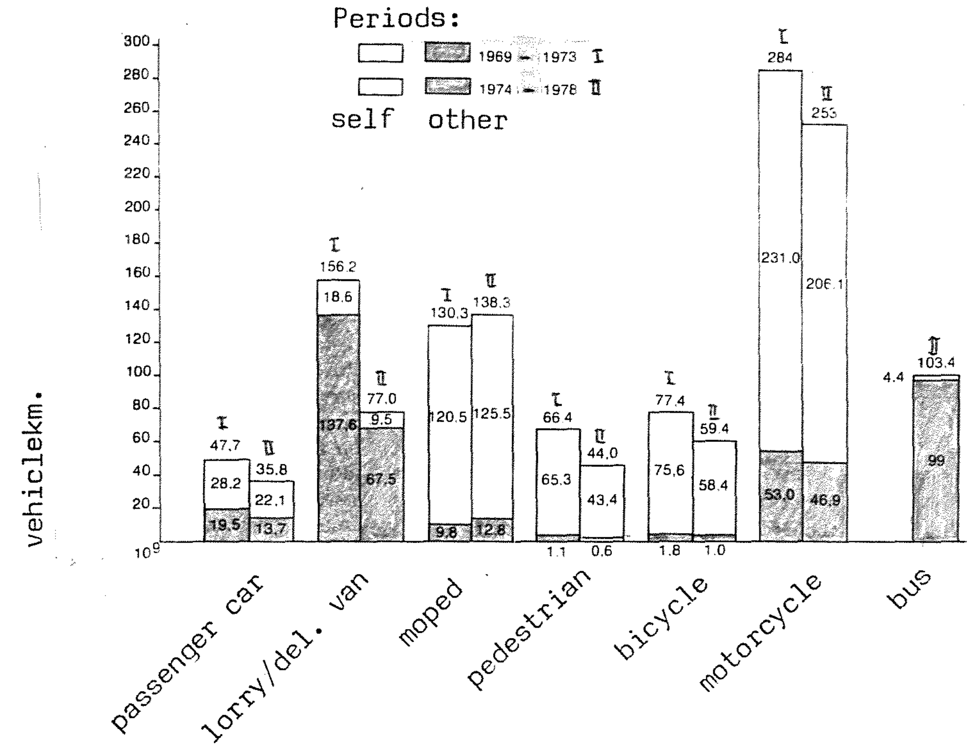
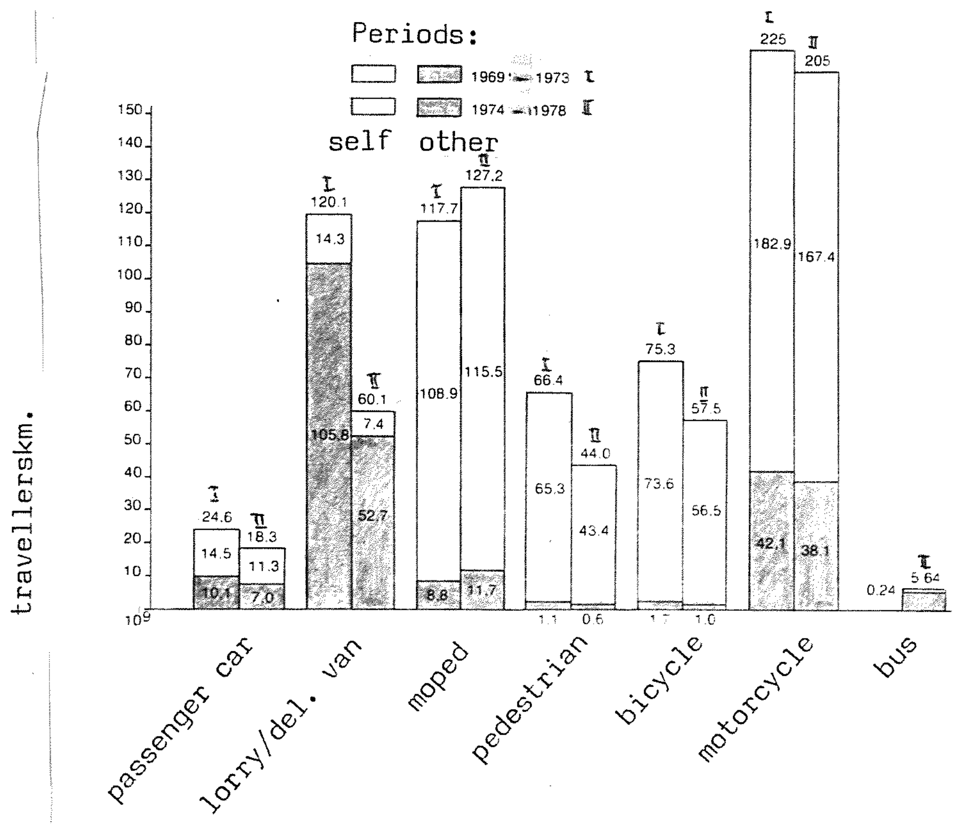



Figure 6. Number of deaths per mode of transport per $10^9$ vehicle kilometers, divided in "self-risk" and "others risk" (The Netherlands, 1969-1973 and 1974-1978)




<u>Figure 7</u>. Number of deaths per mode of transport per $10^9$ travellers kilometers, divided in "self-risk" and "others risk" (The Netherlands, 1969-1973 and 1974-1978)

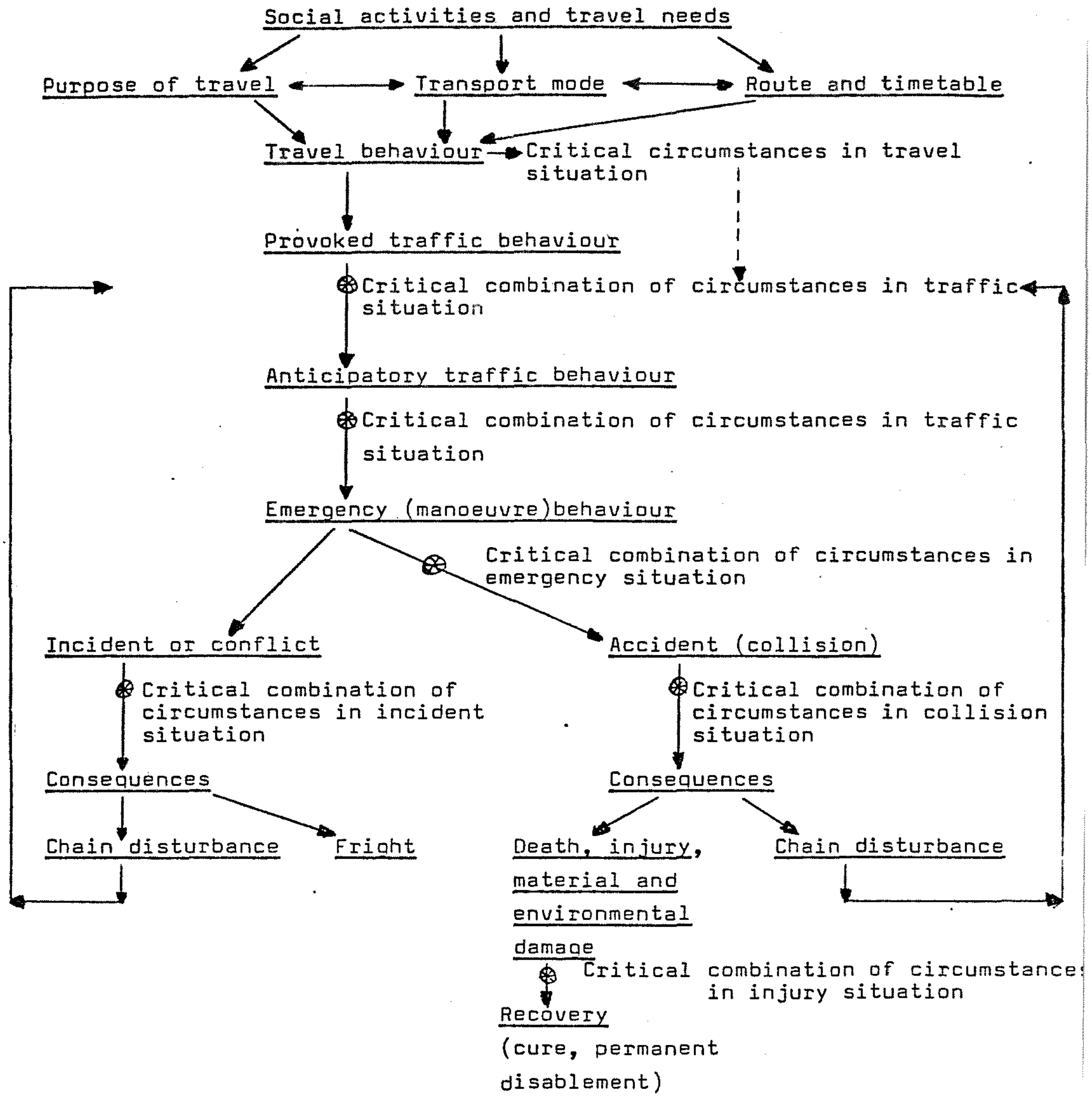



Figure 8. Model of the accident process.

## APPENDIX 1. TRAFFIC INFRASTRUCTURE AND FACILITIES FOR DISABLED ROAD USERS

| Problems | Possible solutions/proposals | wd | wc | ls | ed | ld | bl | pv |
|---|---|---|---|---|---|---|---|---|
| Road surface | 1. Flat, slip-free, continuous | x | x | | x | x | x | x |
| Level differences | 2. Lowered kerbs, levelling to a height difference of 0.02 m | | x | | | | | |
| Passage space | 3. Maximum gradient towards the kerb 1:100 | x | x | | x | | | |
| | 4. Width of pavement/bicycle lanes, minimum 2.00 m | | x | | | | | |
| | 5. Opening in the closure of pavements/bicycle lanes, minimum 1.00 m | | x | | | | | |
| | 6. Traversable traffic guide, width 1.50 m, depth 1.20 to 1.80 m | | x | | | | | |
| Obstacles | 7. Obstacle-free strip on pavement of at least 1.20 m | | x | | | | x | x |
| | 8. Mesh-size in the grates and well or channel covers 0.02 x 0.02 m | x | | | | | x | x |
| | 9. Warning marks on/ahead of fixed obstacles, contrasting colour/material | | | | | | x | x |
| | 10. Height obstacles at least 0.60 m, free; free height at least 2.00 m | | | | | | x | x |
| | 11. Delimiting of building sides and broken up roads | | | | | | x | x |
| | 12. Straight-lined road edges/planting on shoulders | | | | | | x | x |
| Crossing points | 13. Push-button on traffic light, columns at a height of 1.00 to 1.30 m | | x | | | | x | x |
| | 14. Pull-bars on traffic light columns | | | | | x | x | x |
| | 15. Extended green light phase/clearing time at traffic lights (base 0.5/1 m/s) | x | | x | | | x | x |
| | 16. Warning marks on crossing points in contrasting colour/material | | | | | | x | x |
| | 17. Guiding marks towards crossing points in contrasting colour/material | | | | | | x | x |
| | 18. Acoustic signals at the traffic lights | | | | | | x | x |
| Dips/slopes | 19. Slope-tracks: maximum gradient 1:12; height difference 1.50 m; width minimum 1.20 m; turning platforms at 6.00 to 9.00 m | | x | | | | | |
| | 20. Stairs along the slope-tracks with gradients above 1:20 | x | | x | x | | | |
| | 21. Providing lifts at heigh differences above 1.50 m; push buttons 1.00/1.30 m | x | x | x | x | | | |
| Stairs | 22. Providing rails at the stairs, easily gripped, coloured, no abrupt ending | x | | x | x | x | x | x |
| | 23. Design stairs: wide tread (at least 0.32 m), steps maximum 0.14 m; no overlapping stair edge, no open stairs; no sharp edges | x | | x | x | | x | x |
| | 24. Contrasting colours at the tread edge, for example alternating white/yellow | | | | | | | x |
| | 25. Warning marks at the beginning and the end of stairs | | | | | | x | x |
| Resting facilities | 26. Providing resting facilities (banks, etc) at pavements, stops of public transport and shopping centres | x | | x | x | | | |
| Parking | 27. Providing sufficient parking slots for disabled, 3.00 x 5.00 m, obstacle-free | x | x | x | x | x | | |
| Road/route markings | 28. Clearly legible streetnames, route markings, house numbers, traffic signs | | | | | | | x |

wd = walking disorder; ed = equilibrium disorder; bl = blind
wc = wheel-chairs; ld = limb-function disorder; pv = poor vision
ls = low stamina