SAFETY; THE CHALLENGE OF TODAY FOR TRANSPORTATION SAFETY IN THE FUTURE

General report on Theme V: Safety, at the 14th International Study Week Traffic Engineering and Safety, Strasbourg, 7-10 September 1982.

by E. Asmussen, Director, Institute for Road Safety Research SWOV,
The Netherlands

R-82-47
Leidschendam, 1982
Institute for Road Safety Research SWOV, The Netherlands

"Both idea and facts are flexible, and verification is the process of mutual adjustment." John Dewey, 1939

1. INTRODUCTION

Traffic or transportation safety is in fact a social problem. The purpose of working on social problems is to solve or to reduce them. There is a need of knowledge to be successful in this work, knowledge about the characteristics of the problem and especially knowledge to control the transportation or traffic system in such a way that the problems are reduced or solved.

Transportation (un)safety is an adverse effect of the traffic process, that arises as a multicausal chance phenomenon. This implies that we can be road users for years without even seeing an accident. There are also no specific places one can never pass through without an accident, no specific vehicles that are always involved in accidents, no persons who always cause accidents, nor are there any weather conditions that always lead to accidents. Yet accidents happen; people are killed and injured. Therefore a coincidence of circumstances, of road, vehicle, traffic and human characteristics is apparently needed to cause an accident. The chance of such a critical coincidence of circumstances is not the same always or everywhere. Nor are the consequences of accidents always the same but depend, among other things, on the type of collision (for instance car versus pedestrian) and the human tolerance of the persons concerned.

Consequently, in my opinion, traffic (un)safety should be regarded as the whole of existing and potential critical coincidences of circumstances, incidents (conflicts) and accidents in the traffic, with all their undesired consequences (fatalities, injuries, material and environmental damage and fright).

Earlier traffic (un)safety was limited to accidents and the outcome thereof. However, such definition evoked contradictions lately. People

are not confronted with accidents daily, only with the threat caused by the critical coincidence of circumstances and incidents (conflicts). Mostly people know about accidents and their serious consequences only by "hearsay". Although accidents leading to damage, injury or death are the most spectacular and emotionally the most impressive events, the individual risk of encountering them (accident risk) is so inconsiderable that the numerical definition of risks has only a vague meaning for road users, if at all.
It is more probable that the undesired consequences of accidents will be associated with more frequently occurring critical coincidences of circumstances and conflicts or near-misses. This could be described as "subjective" traffic (un)safety. I would define traffic risk as the chance of a critical coincidence of circumstances, an incident and/or an accident in the traffic with certain undesired consequences.

If we analyse a traffic (un)safety problem on a statistical level, this implies that we concentrate on averages or central tendencies, mostly concerning accidents or death figures. The question now arises whether or not this gives the relevant information about the real nature of the problems we want to control. Accidents (casualties, death) related to exposure (such as travellers or vehicle kilometer), the so-called accidents rate (casualty or death rate) do not define completely the term "traffic risk". The risks on a trip from A to B for instance are not equally spread over all parts of the trip. We might find that the risk per travellers kilometer of one part is five or ten times higher than that of another part of the trip. The average risk of the total trip per travellers kilometer has no significance at all for control purposes, especially when the low-risk part is rather large.

2. CONTROL OF TRANSPORTATION SAFETY PROBLEMS

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 if all relevant sub-processes are distinguished. In other words, in order to be able to predict the effects of countermeasures, these sub-processes must be distinguished within the process as a whole. Countermeasures can have an opposite effect on the isolated sub-processes.

Controlling a complex, mass system such as the transportation system proceeds in fact very slowly. One can compare control of the transportation-system safety with the steering of a fully loaded mammoth tanker. If the wheel of such a vessel is swung right round, the effect (the output) will not become noticeable for some time. There are two reasons for this:
a. the slow response of the steering system, the causal lag, whereby the reaction of the mammoth tanker will become noticeable only after a certain period of time (cf. the limitations and the response time of statistical registration of developments in the traffic system, like the registration of accidents);
b. the limitation of human perception abilities in noting slow (light) changes (cf. the limitations of statistical-analysis methods for dis closing small changes in the pattern of accidents). The moment the changes in output are observed, it is often too late both on the tanker and in the transportation system to take effective corrective action. Masters of giant tankers therefore do not respond so much to changes in the vessel's course (output variable; cf. accident statistics), but anticipate changes in output by responding to data on input and intermediate processes (input and process indicators), such as position of helm, speed, direction and speed of currents, etc. This is possible because they have sufficient knowledge and comprehension of the rela-

tionship between control variables and process variables, and the influence this has on changes in output. They do not wait, therefore, until the moment the output (changes in course) manifests itself. Ships' captains have acquired this knowledge from real world experience or simulations in which the relationship between control variables (via process variables) and output variables was examined or simulated under different conditions (speed, current, wind). This form of control does also require regular "position-finding" in order to verify and adjust that from "dead reckoning". In terms of the transportation system, this means that output indicators have to be measured in order to verify the predicted relationship between process indicators and output indicators (increase of knowledge). In the same way as described above, control of the transportation system can also be focused on changing the input of the system, for instance on changing the need or demand for journeys in general or for specific modes of transport.

Developments in traffic (un)safety, effects of countermeasures implemented for fighting it, are always the results of changes in "sub-processes". A speed limit, for example, can have no effect on traffic safety if road users will not drive at lower speed.
If we should limit our activities to general statistic accident research only, this would have among other things the consequences:
- that, even after a study period of several years we still have not much knowledge (i.e. about the relationship between speed and unsafety) and that the decrease of the number of fatalities (as possible result of the speed limit) could have been established only in the most favourable case, and interpretation of the result would not be possible; furthermore
- that we would try to explain a multicausal chance phenomenon (involving the coincidence of circumstances) in terms of a monocausal event.

I think you will not be surprised that all the investigations into the effect of speed limits without analysing the sub-process only seldom provided unanimous conclusions.
In addition to accident investigations, as a rule (traffic) behaviour observations and conflict observations of the sub-processes in the traffic and accident process will be necessary as well.

3. THE MODEL OF THE ACCIDENT PROCESS

In order to elucidate the phenomenon of traffic (un)safety, accidents and incidents can be analysed. This, as a rule, takes place by statistical methods and techniques, which are focused to establish relationships between the characteristics of the elements of the transport system (road, vehicle, traffic and man) and the chance of accidents. Such analyses also require an insight into sub-processes. This can be explained by the following example.

The characteristics: wide carriageways and sharp road bends are correlated with a high chance of accidents and injuries of the drivers (passengers) mainly at night on a wet road surface. This correlation, however, gives no indication in view of the required countermeasures, nor in view of a possible success, in the change of the characteristics involved in the relationship.

The intermediary processes mentioned in this example, which also play an important part in general, are shown in ffigure 1, representing the model of an accident process that takes place at manoeuvre level.

The "provoked" traffic behaviour on the road sector preceding the bend, where evidently a critical coincidence of circumstances can occur, concerns in this case the driving on the road at a given speed and the attention level of the driver. On wide roads the driver will be tempted to drive at high speed. On long straight roads the attention level of the driver is, as a rule, rather low. Motivation of the aim of travel, the choice of vehicle, the choice of route and first of all the travel scheme, have also effect on the traffic behaviour of the driver.

The perception of a critical coincidence of circumstances in case of a sharp bend not only depends on various perception factors like visibility, conspicuousness, recognisability and localisability; the general and specific expectation of the driver plays a part here as well. The general expectation in the given example is, whether there will be many sharp bends in the road the driver travels on. The specific expectation, however, is based on characteristics of the preceding road sector, which can give indications as to the further part of the road. On a carriageway in general no sharp bends are expected. One does not expect a bend on a

straight dike road because the major part of the road was straight and not because there are never sharp bends on dike roads.
A critical coincidence of circumstances at a sharp road bend depends on:

- the type of vehicle, the movement characteristics of the vehicle (road holding, braking capacity, steering parameters);
- the characteristics of the road user, such as fatigue, stress, influence of alcohol, sight, age, experience and skill;
- the "provoked" traffic behaviour on the road sector preceding the bend, such as driving speed and alertness of the driver;
- road characteristics at the place of a bend, such as the bend radius, the width of the road, superelevation and the level of illumination;
- road surface characteristics at the place of the bend, such as skidding resistance, trace forming, drainage and dirt;
- the presence of other vehicles;
- behaviour of other road users; etc.

In case the bend is perceived in time or in case road signs sufficiently indicate the (sharpness of) bend, the driver will anticipate accordingly, for example by lowering the speed or by raising his attention level ("anticipatory" traffic behaviour). Whether the driver will anticipate or anticipates to the required extent, depends on the experience about anticipation possibilities with regard to the required behaviour in "negotiating" a sharp bend. These anticipation possibilities depend, in turn, on the information the driver receives from the characteristics of road, road surfaces and traffic in the bend and on the degree to which he can digest this information, among other, in connection with his general and specific expectations.

In case the driver does not anticipate or does not anticipate to the required extent, an emergency manoeuvre will have to be carried out in order not to be "thrown out" from the bend. Such an emergency manoeuvre can be carried out by a slip correction, an extreme steering correction or an emergency braking just before the bend.
The success of the emergency manoeuvre depends on the following factors:

- the steering characteristics of the vehicle, both before negotiating the bend and before the slip correction;
- the road holding and the brake characteristics of the vehicle;

- the reaction capacity and manoeuvring skill of the driver;
- the road and road surface characteristics, such as moisture, skidding resistance, trace forming, superelevation, dirt;
- the presence of sufficient space for the emergency manoeuvre, for example hard shoulder, etc.

If the emergency manoeuvre succeeds, i.e. the vehicle does not skid off the road and does not hit an object on or beside the road, we have to do with an incident (near-accident), which gives the driver only a fright. However, in case the vehicle gets into the other half of the road, a chain disturbance can develop if there is oncoming traffic thereon. In this way, a critical coincidence of circumstances occurs for this traffic and the entire process begins anew.

If the emergency manoeuvre did not succeed the vehicle skids off the road or turns over or hits a collision object (obstacles along or on the road, road bank, steep slope or water) and in this case we have to do with an accident (collision).

The outcome of the accident (death, injury, material damage) depends on the following factors:

- the collision characteristics of the vehicle involved (impact safety) and of the obstacle (aggressivity);
- the resilience (human tolerance) of the driver and passenger(s);
- in case of lorries still another factor has to be considered: the "behaviour" of the cargo during the sudden slow-down in the collision; the "tolerance" of the packing of the cargo and the effects caused by the cargo falling off or released from the lorry (environmental damage).

The recovery of the outcome of accidents consists of first aid "in situ", transportation of the injured persons, treatment and cure of injuries, the removal of damaged vehicles and repair of material damages.

A chain disturbance can develop both with oncoming and with following traffic; in both cases a critical coincidence of circumstances will be created.

In this picture the feed-backs between the phases are not taken into consideration. There are also more feed-forwards possible in the model.

The theories concerning the intermediary processes can form a stable background for the statistical relationships established and it will be possible to compare the possible countermeasures on the basis of the expectable effects they will have on the intermediary processes. The analysis of these intermediary processes can also be utilised in case there are no statistical relationships at disposal, for example in the investigation of locations and small residential areas.

In such places there is no sufficient number of fatalities and injured, which would permit assessments based on the usual statistical and technical methods.

In this example of the accident process model only a relatively simple accident is simulated. This is a single vehicle accident wherein the critical coincidence of circumstances is localised. Figures 2 and 3 represent schematically a multiple vehicle accident on an intersection prior to and after the installation of traffic lights. The same model can also be applied to overtaking manoeuvres and in a traffic stream with much too short distances between the following cars. However, in these cases there are no localised critical coincidences of circumstances.

4. DECISION MAKING IN THE TRANSPORTATION SYSTEM

In a system approach to safety problems the main issue is the interaction between the system elements (for example the relation man/vehicle/road/ environment). In spite of this the decision making of road users is often taken into account separately. I shall leave it out of consideration here to what extend this is justified.

In addition to the interaction between man and the functional characteristics of other system elements, the concept "traffic risk" plays also a part in the decision making processes in the transportation and traffic system. The extent of its effects and the mode in which traffic risk influences various decision making processes can be interpreted in various manners. I shall try to build up some structure in the use and operationalisation of the concept "traffic risk".

The experience of traffic unsafety plays an important part in decision making processes of road users (individual decision makers), policy making authorities (collective decision makers) and even inhabitants of residential areas as well.
Statistics concerning traffic unsafety, however, have hardly any influence on the decision making process of road users. In the choice of transport modes for example, benefit is always compared with disadvantages and experience of traffic risk forms only an aspect of the latter. The benefit of car is, as a rule, estimated very high, while the inherent traffic risk is very low. In addition, drivers are convinced of being able to face traffic risks and for this reason prefer to use a car as a transport mode. However, the sitation is different with regard to the critical coincidence of circumstances. In this case the attention level of the driver can be considerably raised by experiencing traffic risks. On account of this coincidences can be perceived better or even earlier, permitting anticipation in good time. In this way experiencing traffic risks contributes positively to (statistically assessed) traffic safety. Consequently, awakening of the traffic risk consciousness as a means of intensifying experiencing it, is used in safety information campaigns.

Inhabitants of residential areas also come to decisions on the basis of traffic risk and feelings about subjective (un)safety. Such experience of the traffic risks in their proper surrounding impedes, on the one hand, the desired development of the children through so-called "residential functions" (such as playing on the streets), while on the other hand this can positively influence safety in case traffic risks make it necessary to escort the children on the street.

The following often quoted slogan shed some light on the mode of decision making of the so-called collective decision makers:

" One accident with one death is a tragedy for those concerned;
" One accident with ten or more deaths is a disaster;
" One million accidents a year with 2,000 deaths and 60,000 injured is
" statistics."

There are many data concerning accidents and their outcome at the disposal of central authorities. So to say, they have a "helicopter view" of the traffic system. To look at events from a great distance has the advantage of being able to use objective data in decision making, free from any emotional involvements. They are also able to compare traffic situations.

Thus, central authorities make observations and decisions on the level of statistics and sometimes on the level of the disaster proper as well. Measures intended after the recent bus accident in France with so many children killed in such a terrible way, are an example of the latter case. Such a disaster quickens decisions and makes decisions possible that otherwise are not considered at all.

Central authorities are able to set up priorities with regard to limiting the total volume of traffic unsafety as indicated by statistical data. This can be attained without hardly any details of factual accidents. Given the great distance to the reality of accidents and the real traffic, it seems inconsistent on the part of the central authorities to fight against subjective unsafety.

As regards collective decision makers in small towns and villages, we can see that the perception range and consequently the amount of data on accidents and the outcome thereof, are more restricted. The distance to the actual accident is here nearly identical for individual and collective decision makers as well.

Each accident will evoke a more or less emotional effect. Also, the confrontation with manifestations about subjective unsafety in certain situations, will compel municipal decision makers to make decisions shortly and on the level of the tragedies.

On the basis of the aforementioned considerations we can conclude that individual decision makers (road users and residents) deal with traffic risks differently from collective decision makers. However, there are differences between collective decision makers as well. These differences mainly depend on the distance off the accidents and the form and content of the information at disposal.

4.1. Differences between collective and individual decision makers with regard to traffic risk

From the aforementioned considerations we can also draw the conclusion that traffic risk is a complex concept and that corresponding decision making is a complex process as well. Complex concepts and complicated processes are grateful subjects of long-term investigations. The question arises how much we actually have to know about them in order to achieve our aim? Collective decision makers aim at managing and controlling the transportation and traffic system in such way that negative effects, like traffic unsafety, could be minimised (while not effecting the primary functions of the system). The aim of the individual decision maker is to arrive at his place of destination quickly, comfortably and safely. The collective and individual decision makers are linked together by the fact that management and control by the collective decision makers affect the "behaviour" of the individual decision maker, while at the same time being determined by it.

Thus the problem is to ensure by adequate management and control, the safe functioning of the transportation and traffic system. In this connection it is important that the collective decision makers have all the knowledge at disposal which is necessary for providing the road users with information they require in order to assume a behaviour as intended by the collective decision makers. Is it for example not necessary to understand and to explain deeply the decision behaviour of the road user?

Is it sufficient to make a model of it, with the aid of which the traffic behaviour can be predicted with satisfactory accuracy? Such a model, of course should have to simulate the interaction between man and his surrounding under certain conditions, and not man in an isolated state.

The concept of risk always comprises a chance component concerning an (undesired) event and a consequence component, in terms of damage, loss or threat. The risk of damage is in relation with events, which occur when a person or a group of persons get involved in certain situations, on carrying out certain actions. Consequently, the concept risk is inseparably linked with the concept exposure. In other words, during any kind of activity one is exposed to certain effects (occurrences) and/or situations which could be dangerous. In the collision phase one is even directly exposed to danger. A dangerous situation only develops in the presence of an agent. Such agent is a necessary but by no means sufficient condition for damages. In the traffic system the agent consists of the accumulated kinetic energy (mass and speed) of the motorised traffic. In case the agent (i.e. the accumulated kinetic energy) is released in an undesired manner and when it gets into contact with objects or other road users, there will be a risk of damages.

In order to make clear the differences between individual and collective decision makers two aspects of the concept traffic risk have to be distinguished:
a. the perception of the risk;
b. the estimation whether the riks is acceptable.
Both these aspects have to be closely examined for individual and collective decision makers and for the various phases of the accident process model.

4.2. The collective decision maker

The perception of risk by the collective decision makers actually implies the determination of the relationship, existing between the type and volume of damage and the extent, time and type of exposure to the agent. In other words, it has to be determined which kind of damage will result for whom or what, from which (degree of) exposure. Although risk is a chance phenomenon, the perception thereof by collective decision makers displays a "measuring" character (calculated risk). Traffic unsafety as a multicausal chance phenomenon can be expressed mathematically by the following formula:

$$y = f(x_1, x_2 \ldots\ldots x_n) + e,$$

wherein y indicates for example the number of accidents, f = the deterministic component, while the variables $x_1 \ldots\ldots x_n$ stand for traffic, road, vehicles, man and environmental characteristics (unfortunately mostly physical characteristics instead of functional ones) and e indicates the stochastic component, a sort of error or noise factor. The deterministic component is endowed with predicting power. By manipulating with some of the variables $x_1 \ldots\ldots x_n$ in relation with one another, it is possible to monitor the system in the desired direction. At the rate at which we get more information, about a sufficient number of the variables $x_1 \ldots\ldots x_n$, while at the same time it is based on a satisfactory amount of accident data, the stochastic component will have a low value.

In case the collective decision makers have sufficient data ("measurings") at their disposal, both as regards damage and exposure, they will be able to make accurate estimations of the traffic risks in the complex of the traffic system. In connection with the present state of the traffic system, it is possible to differentiate between such estimations according to regions, modes of traffic, traffic situations, etc.

The extent of traffic risk acceptable by the collective decision makers is often nearly independent from the total volume of damage. A sudden important increase in the number of accidents during a certain period of time in a certain region is a much more compelling reason for regarding a situation as unacceptable and for proceeding quickly to establish remedial measures.

The estimation of the acceptability of traffic risks is a task of the society and the collective decision makers will have to comply with society's value estimations in view of traffic risks. Social value estimation may change in the course of time, but it can also be different in various countries and various cultures.

Investigations revealed that the following factors play a part in the estimation of traffic risks:

1. The seriousness of the outcome of an accident. An accident with 10 fatalities is regarded more grave than 10 accidents with 1 fatality.
2. The extent of voluntariness, displayed on being exposed to (certain) traffic situations and (undesired) events. An accident involving a child, playing on the street and killed by a car will be judged more severely than an accident, whereby a child is killed as the passenger of a car.
3. The extent to which a road user proper can come into action in order to reduce the risk. The death of a bus passenger will be judged more severly than the death of a car driver.
4. The extent of protection of the road users against the effect of agents. Pedestrians, bicyclists are poorly protected (or not at all) against motorised traffic.
5. The extent to which the agent manifests itself to other road users. In other words: the extent to which a road user (and his transport mode) becomes dangerous for fellow road users.

4.3. The individual decision maker

As the system element of the highest degree of freedom, the behaviour of man is the most flexible and the most unpredictable. Therefore it is not surprising that the decision making process of road users draws so much attention. However, we have to realise that traffic behaviour is developed, "provoked" in interaction with other system elements, i.e. with the characteristics thereof, which are relevant in a given traffic situation. In this connection it is not the physical characteristic of the system element which is of importance, but the functional one. Physical characteristics are only a sort of carriers of the functional characteristics (see Figure 4). The functional characteristics manifest themselves in general as the "behaviour" of the element in interaction with other elements under given conditions (for example the braking capacity of a car under specific conditions of the road surface and use by man).

The functional characteristics have always to be considered in relation to the decisions the road user must take in the traffic. Thus the same physical characteristics will have a different information value for different road users, depending on the task they have to perform, their intimate conditions, their motivations, but also on various other external circumstances.

We shall elucidate this with the following example. The 4 m width of a road (physical characteristic) permits sufficient place for a bicyclist to ride if there is no other traffic on the same road sector. In case of dense lorry traffic on the same road, however, the "available motion space" for the bicyclist (functional characteristic) will be much more limited. Consequently his behaviour will not be affected by the physical characteristic (width of the road) but by the functional characteristic (available motion space) and he will have to make decisions on te basis of the latter.
In addition we have to realise that man, as road user, perceives about 10,000 sense impressions (sensorial memory), but only a very small part of these will penetrate to his momentaneous memory and still less to his semi-permanent and permanent memory. Thus, a very thorough information selection takes place in which memory acts a double part: in the first instance it acts as a sluice system (filter) for selecting relevant information, but it also functions as an instrument which can be called for help from the perceiver to fill up a gap in case a part of the system information is not sufficiently perceptible. The less stimuli are perceived, the more relevant events have to be retrieved from the past.

Due to this selection mechanism in combination with the completion from his own memory content, man does not perceive isolated objects or signs, but only functional relations between the relevant characteristics of objects or signs and the pattern of relations. The characteristics have only then an information value if they have a function in a certain context regarding existing uncertainties in the decision making process. Based on these considerations I would call information a message which removes uncertainties from the decision making process (see Rumar).

Collective decision makers and road administrators not only provide technical facilities for transportation and traffic, but information about the adequate use thereof as well. The information carriers are not only traffic signs, based on regulations, but also functional characteristics of the road, traffic situations, the vehicle, etc. In this way there is a constant information transmission between the road users proper, among other through signs (signals), but also through non-verbal behaviour (traffic behaviour).

There is also a permanent communication between the collective decision makers and road adminstrators on the one hand and the road users on the other hand. Collective decision makers and road administrators act as transmitters and consequently they have to ensure:
- that their signals are tuned to the programme of the receiver (road user);
- that the receiver is tuned to the required programme in the frame of which the road user will get relevant information.

How is it possible to know all this? Effective means for this purpose are behaviour observations from road users. Behaviour is an important form of communication. A communication chain consists of at least three phases:
- the transmission of the message;
- the response on the received message;
- the reinforcement of the response (feedback).

The road user is able to retransmit - through his own behaviour - a reply message to the road adminstrator and to fellow road users. This response has to be confirmed by the original transmitter (reinforcement). Thereby the communication chain is closed, permitting feedback, which leads to behaviour adaptation.
Unfortunately this feedback is in real traffic rather limited (mostly one way communication; a much too small ammount of behaviour and conflict observations) and the circulation time is much too long. It is known that a complex system can be stable only in case of sufficient and fast feedback (short response time). Perhaps this is the crucial point of the entire traffic system safety.

The question now is to what extent the road user's behaviour is affected by the traffic risk; in which manner does he perceive it, and most important of all, in which manner can this be used in influencing the road user's behaviour. The concept traffic risk is, as a rule, based on normative considerations. This is based on the following assumptions:
- there is an optimum communication between road administrator and road user, but also between the fellow road users proper;
- there is a complete feedback;
- there is an optimum risk perception;
- the risk acceptation takes place according to the norms of collectivity.

Under such assumptions there may be a complete communication chain with feedback between transmitter and receiver. The normative concept "risky behaviour" or "unsuitable mentality" looses in this case its significance. In reality the communication of the system does not function properly, there is a rather incomplete communication.

To what extent is it possible to measure risk perception and risk acceptance in real traffic? In the first instance the question arises whether there is actually a seperation in time between risk perception and risk acceptance in the case of decision making of road users? If the answer is positive (what I cannot believe) the question arises whether we have suitable measuring instruments to determine these seperately.
Although up-to-date inquiry methods are highly refined and methods are developed to exclude the influence of the interviewer, questions about feelings of danger will always have a more or less suggestive character. There is as rule a great difference between what people say and what they think or do.
Actually there are three possibilities for the respondent who is questioned as to his experiences:

1. The problems may be so far beyond the consciousness that the questioned person cannot recognise them (for example the traffic risk in a given situation) even if these are correctly formulated (no reply or lip service);
2. In the beginning the questioned person is not conscious of the problems, but through interrogation he will be able to recognise them, in case they are correctly indicated (suggested reply).

Both instances are based on concrete, accurately formulated problems.
If the interviewer poses questions which he did not formulate with sufficient precision, he may get often no response in these cases.

3. The questioned person clearly recognises the problems. In this case any conventional question-reply method can be applied.

Thus in experience questioning the interviewer may choose between a high percentage of non-responses or replies to suggestive questions. In general, I must admit, I have doubts about the very popular experience investigations. As a rule behaviour and conflict observations are likely to provide more correct and objective informations.

5. THE RISKS OF CONFRONTATION BETWEEN DIFFERENT CATEGORIES OF ROAD USERS

I am coming now to the problems involved in the risks of confrontations between different categories of road users, on the basis of registrated accidents data referring to The Netherlands.
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 on 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 and 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 5). 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 on an average per year. The death rate for the age categories of 15 to 24 years is about 30 per 100,000; 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.

Expressing the vulnerability by the number of deaths per 10^9 travellers kilometer, as per mode of transport for 1978 is represented in Figure 6, 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 6 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.

Among the aforementioned data referring to 1978 for the first time has been made use of quite recent ones, selected from the "Displacement Investigation" of the CBS (The Dutch Central Bureau of Statistics). In order to prevent confusions it is important to know that there are considerable differences in vehicle kilometers, travellers kilometers, etc. with regard to earlier data collected in the National Traffic and Transportation Account, which is being used in the following examples. The more recent data reveal among other that the travellers kilometers of motorcycles and those of pedestrians are much lower than assumed up till now. Also the much publicised estimation that road users of various categories spend approximately identical periods of time in traffic seems to be erroneous. The average car passenger spends more time in traffic than other road users. In any case individual scatterings are quite important.

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 users category has the greatest chance of being killed in collisions with them (see Figure 7).
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 8) 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 9). 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 catego-

ries, 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 10). 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 11). 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 also have to be free for the most part 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!

6. CONTROL OF THE TRANSPORTATION SYSTEM SAFETY CONSIDERED FROM THE ACCIDENT PROCESS MODEL

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.

Prior to discussing the decision making processes in the different phases, I shall shortly refer to the submitted papers dealing with this subject.

Barbara Sabey deals in her contribution with the "Perception of risk". She finds that " ... less attention has been paid to the role of human factors in the choice and implementation of countermeasures" and " ... their attitudes to risk are critical in identifying the most effective countermeasures". She maintains that " ... it is the risk as seen by individuals, either actual or perceived, which frequently determines the acceptability or success of countermeasures, particularly in the legislative and behavioural fields".

Rumar deals in his paper with "The role of perceptual psychology in road safety". He claims that "..it is the perceived situation not the physical reality that decides behaviour" and "..many engineers presume intuitively that the same environment is perceived identically by passing road users. This is not the case. Every individual road user selects his own information".

Groot et al. discuss the "Drawbacks of the emphasis on conspicuousness for the natural coherence of the perceived traffic scene". They find that "the traffic scene coherency" is an important quality criterium of the visual process. They also developed a practical model, wherein they designate the "scene-as seen" with the label "model scene". The model scene is an "entity distinct from the physical environment".

These short quotations characterise three opinions about the perception and information assimilation of road users. Unfortunately up till now we have to accept the fact that the perception, information assimilation and 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 transporation 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 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 knowlegde 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. 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 coherency 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 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.

In contrast with the collective decision maker, the individual decision maker has to function in the traffic system without objective data or information.

In addition to that he will not fully be able to perceive and assimilate the information which is inherent in traffic situations. On the one hand this is the result of his limited perception capacity, while on the other hand of his general and specific expectations, on account of which perceived information is not assimilated. The collective decision makers (road planners, road administrators) are able to influence the behaviour of the road user (and also the behaviour of the road users with regard to one another) by providing them with informations.

The aforementioned functional characteristics of the system elements, such as prescriptions, behaviour rules, signals, form together the "carriers" of information for the road user. As indicated earlier, information can be regarded as a sort of message which eliminates decision uncertainty. Collective decision makers will have to find out, on the basis of the traffic situation as suggested by them, the uncertainties the road users have to cope with and to establish which uncertainties have to be eliminated in order to provoke the correct traffic behaviour.

In addition it should be possible to render the incorrect behaviour unattractive or even completely impossible. We shall briefly study the phases of the accident process model, which uncertainties have to be taken into account and which (kind of) information is needed to eliminate them, so as to realise the desired traffic behaviour. In order to simplify matters, we shall start with a situation, in which the road user has already decided to travel from point A to point B. Hereafter he has to make the following decisions:

- which transport mode should he use?
- when will he arrive and when must he depart?
- which route should he choose?

Choice of transport mode

The self-risk of passengers of public transport modes is much lower than that of car passengers. The self-risk of a car passenger is, in turn, lower than that of the bicyclist, moped rider and pedestrian. And yet the aspect of risk is only a negligible factor in the choice of the transport mode. The time of travel, waiting time, walking distance to the mode of transport, comfort, flexibility and expences: these are the most important factors in choosing a certain mode of transport. In addition, an accident with a public transport mode, with many casualities (disaster) makes a much deeper impression than accidents with a dozen cars, bikes and mopeds.

Public transportation has its advantages for the road user in some cases of commuter traffic, whereas it is much less popular and attractive as regards other travel motivations. The increased use of public transportation in the Netherlands (a.o. on account of high fuel costs) is for this reason mostly limited to the rush hours. The slight increase of cycle traffic is more a phenomenon of social character (fashion). It is healthy and sportive.

Choice of travel scheme

The major part of traffic takes place in day-time. The accident risk is much higher during the night than at day-time. This may be an indication that risk has some influence on the decision making process of people. However, the investigations of Giscard (1966) do not support this. 59% of regular night drivers found night driving safer than day-time driving. They know from experience that motorised traffic is less intensive during the night, i.e. that less "agents" are present. 57% of drivers who never drive during the night, found night driving more dangerous than day-time driving. However, this was not the reason that detained them form night driving.

Choice of route

The threat of (motorised) traffic plays decidedly a role in the choice of route, mainly for older bicyclists. However, it often happens, that the routes found dangerous by some people or traffic situations they encounter, are really not dangerous from the objective point of view. In any case, the avoided routes or traffic situations involve relatively intensive motorised traffic.

The choice of route is furthermore influenced by being acquainted with it (or not) and by the possibility of waiting time (traffic lights, traffic jams, etc.). Routes with many traffic light installations or congestions are avoided and routes leading through calm residential areas are given preference. Other factors affecting the choice of route are the road length and the amount of the probably necessary manoeuvres in the traffic situations which might occur on it.

Provoked traffic behaviour

One of the most important features of provoked traffic behaviour is the fact that it is created in a marginally conscious state, through nearly "automated" paths. This is in contrast with the aforementioned phases, which take place on a cognitive, conscious level.

Behaviour manifests itself in speed, acceleration and deceleration and lateral displacements. This behaviour is mainly determinded by the effort one has to summon up in order to follow consistently a given course on the road. This is the reason why wide, well paved and correctly marked routes prompt to high speed.

Another motive determining the behaviour of the driver is the global assessment of the possibility that in a critical (expected) coincidence of circumstances he still will be capable of anticipation or, if necessary, even of carrying out a successful emergency manoeuvre (his assessment of coping with risky situations). Perception conditions play a role in this instance.

In the investigation of Watts & Quimby (1980) speeds on road sectors under restricted perception conditions are used as indicators of risk taking. From the objective point of view this is correct: higher speeds reduce the chance of timely anticipation in a critical coincidence of circumstances, while at the same time also limiting the possibility of a succesful emergency manoeuvre.

The Swedish psychologist Ola Svenson reveals in her survey: " When a man gets behind the wheel he becomes deprived of some of the normal behaviour feedback which he was biologically and psychologically designed for. The most fundamental change in this respect may be the improper or complete lack of feedback for adequate regulation of movement. When a person walks, runs, cycles, falls or rides a horse, he gets direct feedback in terms of perception of muscular tension, balance, respiration, pain and so forth. But, when travelling in a car many "natural" cues do not have the proper meaning and this leads, among other things, to speed adaptation, inaccurate estimates of the speeds of oncoming cars, unawareness of

the relation between speed and severity of an accident (should it happen), and unrealistic ideas about the time which can be saved by increasing speed.
In general the estimated time saved by increasing the speed over a given distance is overestimated for speeds higher than about 60 km/h (Svenson, 1970, 1973, 1976). This implies that the incentives for speeding up when in a hurry are greater than they should be. People tend to believe that they can save more time than they actually can."

From the point of view of objective risk, an inexperienced driver should drive more slowly than an experienced one. However, it is quite often difficult to realise this, just because inexperience manifests itself in the overestimation of capabilities. This feeling will be intensified by the example of other high-speed drivers. "What he can, I can too."

A traffic sign acts on a cognitive, conscious level, while speed adaptation by the driver takes place in such an automatic manner, that the message issued by the sign, has hardly any influence.
In order to exert a successful effect on the speed behaviour of the car driver, actual behaviour determinants have to be mobilised. Information about objective risk will prove insufficient.

The "provoked" behaviour of the road user can also be regarded as a multicausal chance phenomenon in the following form:

$$g = f\ (p_1,\ p_2,\ \ldots\ldots\ p_n) + e$$

where g is the ultimately measurable behaviour, $p_1 \ldots\ldots\ p_n$ indicate characteristics of the road, the vehicle, the environment and in the first place the human being and e is the error component (stochastic).
The primary characteristics of man are the following: his experience, knowledge, memory content, motives, and in addition the information he receives and assimilates.
In case the driver has sufficient knowledge (experience) and does not receive much relevant information i.e. not the information he needs and which is in accordance with his knowledge, the deterministic component will be low, whereas the stochastic component rather high, thus involving a considerable decision uncertainty. Also here feedback plays an important part.

With regard to the risk, for example the chance of encountering critical coincidences of circumstances, the driver will receive hardly any information (if at all) as long as he does not perceive them. Consequently he must turn to his memory. What he actually perceives is the accompanying motorised traffic, in the first place the vehicles which are heavier than his car, or massive potential stationary collision objects.
Such objects which he regards as threat since he associates them with the possible release of energy in case of an eventual collision, act for him as information carriers, which may influence his behaviour. In the presence of any information carriers (intensive motorised traffic) he will duly adapt his speed behaviour. Here we have the case of compensating through feedback, because information about a possible effect from his memory or his mental representation will be feedback to the perceiver.

The reinforcement of feedback is an effective countermeasure for improving traffic safety. In view of the present high energy costs, it would be advantageous if for example at a given speed behaviour fuel consumption could be adjusted by instant feedback e.g. through a display on the dashboard.
It would be possible to inform the road user about his incorrect behaviour in road-bound systems as well.
The speed behaviour of the driver could also be influenced by making the manoeuvering effort in following the course, much too heavy in case of excessive speed. This could be achieved by creating narrow lanes, but also through a not too complete monitoring or visual guidance on the straight sectors of the road.
There is a trend to intensify the visual guidance function of public lighting at the expense of the luminance or illumination on the road surface. In my opinion this is not right as regards straight road sectors, because this would incite to high speeds while reducing the possibility of perceiving collision objects in time.
Imposing speed limits in some road sectors, (other than imposed by the road proper) through traffic signs does not have in general too much effect.

The perception of the critical coincidence of circumstances

Whether a critical coincidence of circumstances (CCOC) can be perceived (or not) and anticipated, depends on the following factors:

1. The provoked traffic behaviour in advance. During high-speed driving perception is mainly focused on following the road ("tunnel look"). In addition, the required space for anticipating is considerably larger and less accurately predictable by the road user.
2. The attention level of the driver.
3. The visibility, conspicuity, recognisability, but also the localisability of functional characteristics of CCOC, in other words, the intensity and relevance of the information provided by the CCOC (see Groot).
4. The extent to which the road user expects a CCOC in a given road sector.

We mentioned earlier, that the risk of a potential CCOC only weakly affects the provoked traffic behaviour in advance. Various investigations prove that a rather high percentage of car drivers classify themselves into a group which drives better than average (for example by overestimating the anticipating possibility). Thus high-speed driving is assumed to be risky only for other drivers but not for oneself! In addition some investigations (Portfolio theory of Coombs and Huang) found that one is ready to accept higher risks if only the benefits are adequate (benefits in form of shorter travel time, more driving comfort, etc. at higher speed). People are not willing to give up benefits in exchange for reduced risk.

Investigations also revealed that police surveillance, safety information campaigns and education, have not much effect.
In order to influence the provoked traffic behaviour in advance on certain places (for example road intersections, potential CCOC), it would be more promising to attack the "benefits", i.e. to make high-speed driving less attractive. On combining such efforts with preliminary signals indicating a potential CCOC, it is possible to raise the attention level of the driver at the same time. This implies that information about the possible effects or consequences of the momentary speed behaviour should be made known to the driver at the place in question proper. On perceiving such information the road user will, as a rule, react positively (the modal driver does not enjoy collisions!).

The aggressiveness (in case of eventual collisions) of objects on and along the road is, as functional behaviour charateristic, also an information carrier for the driver, who will react thereto adequately (feedback).

Such feedback mechanism has introduced in our present traffic system an internal monitoring function, through the "hierarchy of threat". This means that vulnerable pedestrians, bicyclists, aged citizens, give priority to or recoil from the aggressive (motorised) traffic. This hierarchy of threat and the natural classification resulting from it made our present traffic system considerably safer. The internal monitoring (hierarchy of threat) could be eliminated for example locally, only by rather selective and at the same time rigorous measures, such as elimination of confrontations between incompatible transport modes.

In this connection we should realise that each message (information) always displays a content component and a reference component. The latter indicates the hierarchical relationships between man and the other system elements and classifies the content and the relevance of the message. The threat emanating from the motorised traffic (accumulated energy and mass) functions in the traffic as a reference component.

On providing information about potential CCOC,it has to be taken into consideration, that the signal/noise relationship is usually very low for the receiver (road user). This means that some messages can be missed or not interpreted correctly (i.e. the message actually does not reach the receiver). Therefore it is always necessary to provide redundant information, i.e. repeated information which can corroborate perception and increase the veracity content of the information for the receiver.

Emergency manoeuvre and incidents (conflicts)

Many near-accidents (near-misses) cause not all too serious consequences because a more or less successful emergency manoeuvre could be carried out in time.

Yet, still much more could be achieved in this phase, for example through emergency training, through improving emergency chances on the road (in view of space mainly in cross-direction) through local skidding resistance and emergency provisions in the car etc. Moreau de St. Martin &

Adam describe in their report modes of improving emergency manoeuvres of lorries on steep and long slopes with the brakes out of order.

The conflict occurring in consequence of an emergency manoeuvre plays a double role in the process, in the first place as process indicator. Thanks to the activities of an international working group, Calibration of Conflict Observation Techniques, sponsored by the OECD, conflict observation technique approaches a phase whereby it can be made available for use, as a reliable instrument for road administration, traffic engineering, etc.

Incidents (conflicts) are also important for the training of the road user. In any kind of training repeating patterns (redundancy) are of great importance. At the rate at which the repeating frequency of certain pattern increases, knowledge becomes richer too. Accidents are for every road user a rather seldom occurring event. In addition, in case of an accident any trace of the pattern will be blocked out from the memory of the involved person shortly before the crash. The frequency of near-misses (conflicts) is much higher, while the inherent fright is less menacing. So conflicts stimulate learning in the traffic.

The collision phase

Measures implemented for diminishing the consequences of collisions, such as improvement of crashworthiness of cars, piles (masts) with slip or break away design, seat belts, crash helmets, have proved to be quite successful up till now.
This can be explained by the fact that the possible feedback in this instance led only to limited changes in the phase of provoked traffic behaviour or the anticipating phase. In spite of this there is still much scope for improvement, mainly as regards collisions between motorised traffic and low-speed traffic in built-up areas.
Risk acceptance plays in this phase hardly any role (if at all), perhaps with the exception of the voluntary wearing of the seat belt. However, the decision on this does not belong to the collision phase, but to a much earlier phase, i.e. to the choice of transport mode and the use of active safety measures. Important improvements can be realised in the recovery phase as well. I shall not discuss this matter, because no related reports have been submitted.

7. FINAL CONCLUSIONS

The problems around the traffic safety are mainly characterised by complicated relations between causes and consequences.
It is a well known fact that in controlling such phenomena, there is a great chance of making decisions which will be regretted later on. The "do" people set processes into motion without consulting the "thinkers" beforehand. Meditating, devising and acting, i.e. theory and practice form an indivisible whole.
Practice is founded on theory (knowledge), in other words each solution provided by the "do" people originates from a theory. Such theoretical knowledge results from and is improved by practical experience. The "thinkers" and "do" people of today should, in my opinion, realise that the problems of the future may differ from the problems of the past.

The worldwide economic decline and rising energy costs have already in our days an evident influence on travel customs, the choice of transport mode, the choice of route and even on traffic behaviour. Governing policy must be adapted to changing circumstances. Novel possibilities must be found and applied in order to influence human behaviour for the sake of a safer use of public spaces. In this connection I would like to mention the stormy development of the microprocessor. With rational actions and correct adaptations of the human decision making process it can be hoped that new ways will be discovered for a better control of traffic circulation and road users behaviour. With "better" I mean: without imposing any limitations on other functions of public spaces, as it unfortunately all too often happens at present, through speed limiting and traffic engineering countermeasures. In my opinion "better" also implies a correct feedback, i.e. that bottlenecks in the system manifest themselves as fast as possible, and in the right manner, both as regards the individual road user and the collective decision maker.

Systems involving human elements, must, in the first place, be considered as goal-oriented, which means that the goals to be achieved must be clearly understood and accepted by everybody.
In such systems the communication aspects play a primary role. Communication has to ensure that faults in the system are detected thereby permit-

ting improvement completion and correction of the process. Only under such circumstances a stable process in the system can be realised.

You have certainly observed that I repeated myself quite often. I started from the conviction that the signal/noise relationship is not optimal in our commmunication.
Sometimes your attention has been perhaps distracted, sometimes you have received other signals or you did not understand everything. Redundancy of information is a "must". Too much redundancy makes a speech tedious, but I hope I found the right balance.

I gave you both ideas and facts in this lecture. In the discussion and later in your daily work, I hope you can contribute to the verification of them in the process of mutual adjustment.

CONSULTED LITERATURE

- Asmussen, E. (1980). Ongelijkheid en ongelijkwaardigheid in het verkeer; de risico's van confrontaties tussen verkeersdeelnemers van verschillende categorie. Probleemstelling congresthema van het Nationaal Verkeersveiligheidscongres 1980. R-80-43. SWOV, 1980.
Bijdrage Congresverslag Nationaal Verkeersveiligheidscongres 1980, Internationaal Congrescentrum RAI, Amsterdam, 21, 22 en 24 april 1980, blz. 4-9. ANWB, 's-Gravenhage, 1980.
- Asmussen, E. (1980). System safety as a starting point for education and training of engineers. Contribution to Sociêtê Europiênne pour la Formation des Ingenieurs SEFI Conference 1980: The education of the engineer in, and for his society, Unesco Headquarters, Paris, September 10-12, 1980. R-80-50. SWOV, 1980.
- Asmussen, E. (1981). A model of the accident process as a tool to develop indicators for transportation system safety and traffic risks. Contribution to the International Symposium on Surface Transportation System Performance, Washington, D.C., May 11-13, 1981. R-81-38. SWOV, 1981.
- Boulding, K.E. (1956). General systems theory - The skeleton of science: General systems I. 1956.
- Ferry, T.S. & Weaver, D.A. (eds) (1976). Directions in safety; A selection of safety readings for the student and the practitioner and for the teacher and the safety professional. Charles C. Thomas, Springfield, Ill., 1976.
- Lowrance, W.W. (1976). Of acceptable risk, science and the determination of safety. Harvard University, Los Altos, Calif., 1976.
- Michon, J.A. (1980). Beïnvloeding van mobiliteit; Nieuwe impulsen voor een sturend beleid (Influencing mobility). Serie Verkeerskunde en Verkeerstechniek, nr. 15. ANWB, 's-Gravenhage, 1980.
- OECD (Special Research Group on Pedestrian Safety) (1978). Chairman's report and report of Sub-group III Mass media communications for pedestrian safety. TRRL, Crowthorne, 1978.
- OECD (Research Group UT3) (1980). Urban public transport: Evaluation of performance. OECD, Paris, 1980.
- OECD (Research Group TS4) (1980). Methods for evaluating road safety measures. OECD, Paris, 1980.

- Svenson, O. (1978). Risks of road transportation in a psychological perspective. Accid. Anal & Prev. 10 (1978) : 267-288
- Vester, F. (1976). Hoe wij denken, leren en vergeten. (How we think, learn and forget). Baarn, 1976.
- Visser, J.P. (1979). Kwantificering van risico's. (Quantificating risks). De Ingenieur 91 (1979) 48: 835-848.
- Vlek, C.A.J. & Stallen, P.J.M. (1979). Persoonlijke beoordeling van risico's; Over risico's voordeligheid en aanvaardbaarheid van individuele, maatschappelijke en industriële activiteiten. (Personal estimation of risks). Instituut voor Experimentele psychologie, Rijksuniversiteit Groningen, 1979.
- Wagenaar, W.A. (1979). Door ons beperkte denkvermogen leren we weinig van onze fouten. (Due to our limited intellectual capacity we only learn little from our mistakes). TNO-Project (1979) 6: 221-223.
- Watts, G.R. & Quimby, A.R. (1980). Aspects of road layout that affect driver's perception and risk taking. TRRL Report LR 920. TRRL, Crowthorne, 1980.
- Watzlawick, P.; Helmick-Beavin, J. & Jackson, D.D. (1974). Progmatics of human communications. Van Loghum Slaterus, Deventer, 1974.

Reports Theme V: Road Safety

- Groot, R.E.; Ebell, R.J.E.V. & Theewis, S.R. Drawbacks of the emphasis on conspicuousness for the natural coherence of the perceived traffic scene (The Netherlands).
- Moreau de St. Martin, J. & Adam, S. Road safety; road accident study methods-France; research into ways of stopping heavy vehicles if the brakes fail (France).
- Podesta, Prof. C. & Vella, M. Road safety-reflections on a policy of driver information; Statistical analysis of traffic accidents (Italy).
- Rumar, Prof. K. The role of perceptual psychology in road safety (Sweden).
- Sabey, B.E. Perception of risk (Great Britain).
- Walthert, R. & Sehlen, P. Roadway lighting as a means of preventing accidents: criteria for its optimal application (Switserland).

FIGURES 1 - 11

Figure 1. Model of the accident process.

Figure 2. Accident process before installing traffic lights.

Figure 3. Accident process after installing traffic lights.

Figure 4. Relations between men and (characteristics of) system elements.

Figure 5. Number of deaths per mode of transport (The Netherlands, 1978).

Figure 6. Number of deaths per mode of transport per 10^9 travellers kilometers (The Netherlands, 1978).

Figure 7. Number of fatal accidents with fixed objects per mode of transport (The Netherlands, 1969-1973 and 1974-1978).

Figure 8. Number of fatal accidents with fixed objects per mode of transport per 10^9 vehicle kilometers (The Netherlands, 1969-1973 and 1974-1978).

Figure 9. Ratio "self-risk" and "others-risk" per mode of transport (The Netherlands, 1969-1973 and 1974-1978).

Figure 10. 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 11. 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).

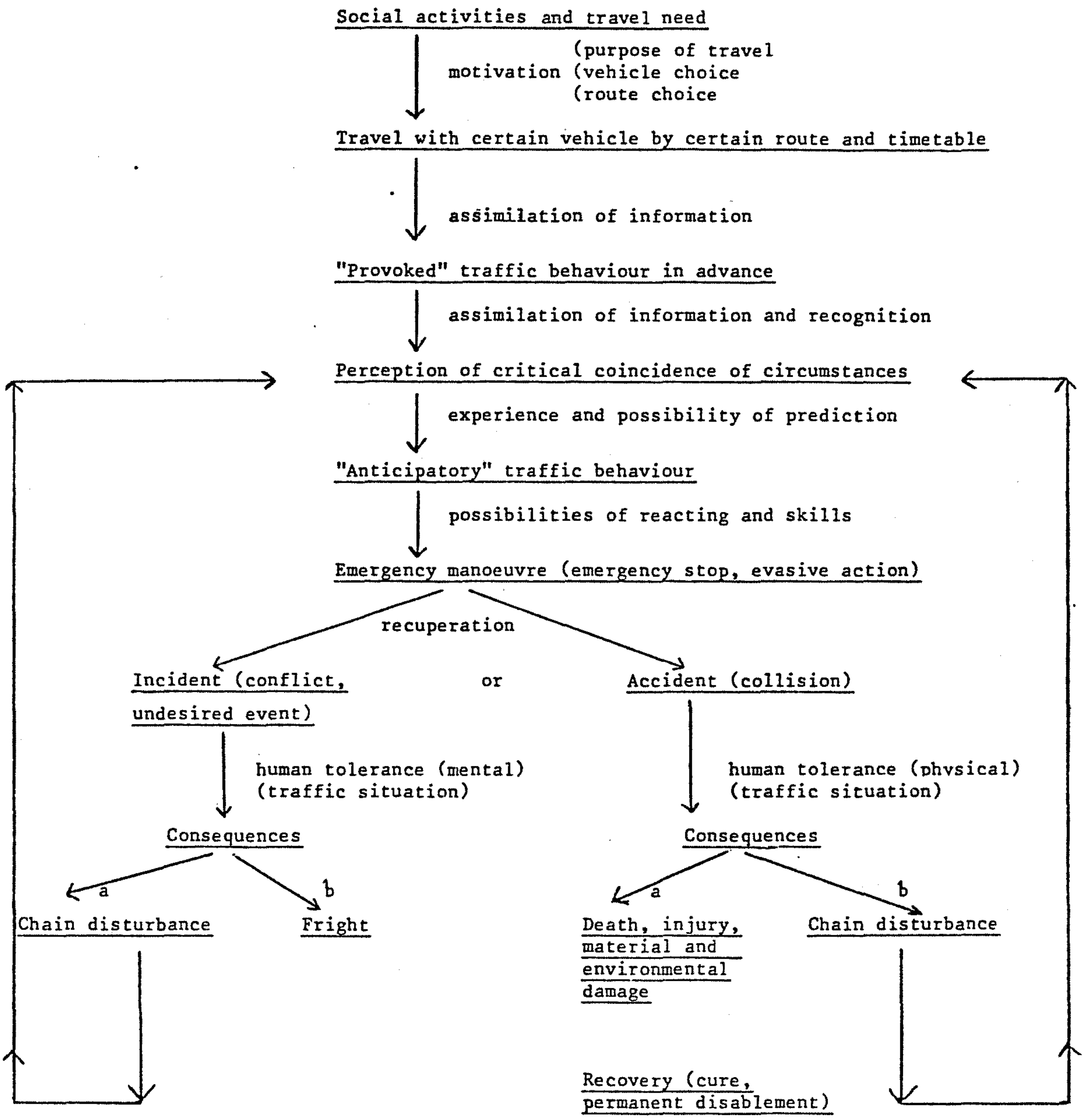


Figure 1. Model of the accident process.

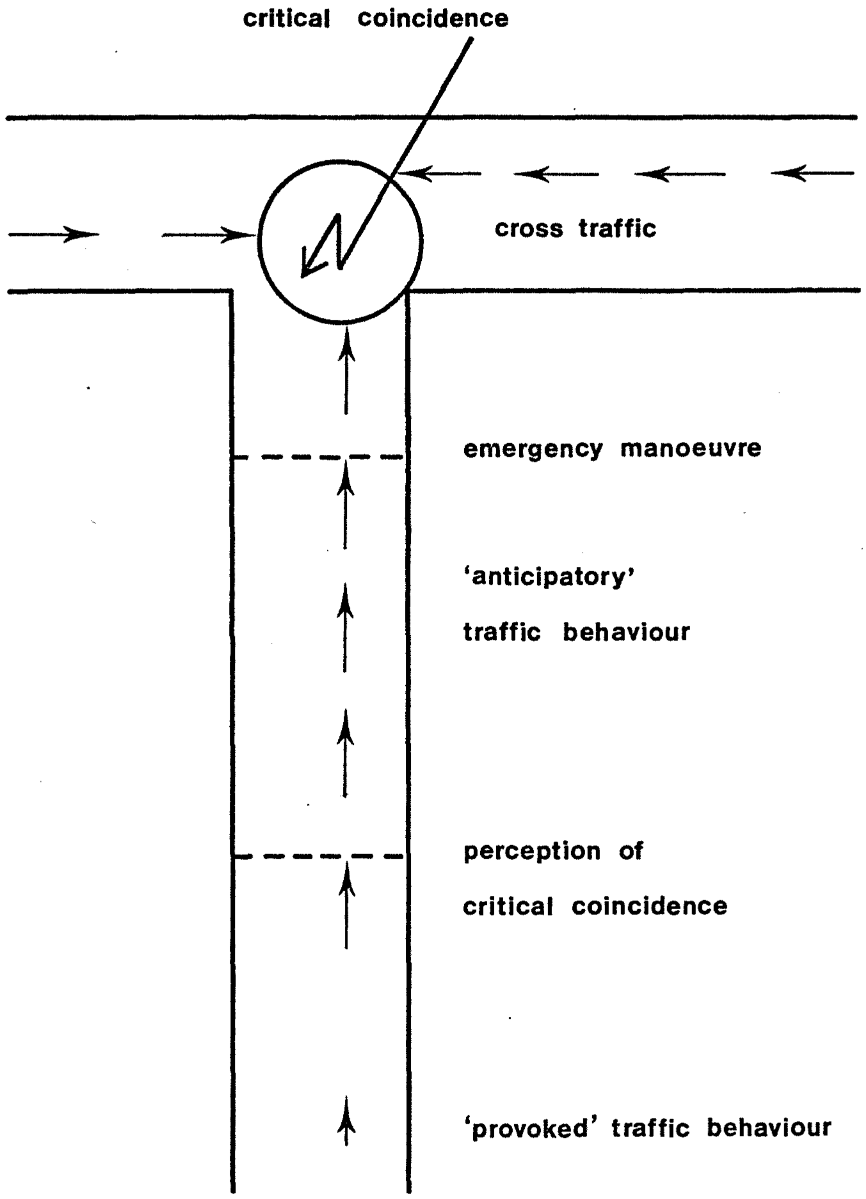


Figure 2. Accident process before installing traffic lights.

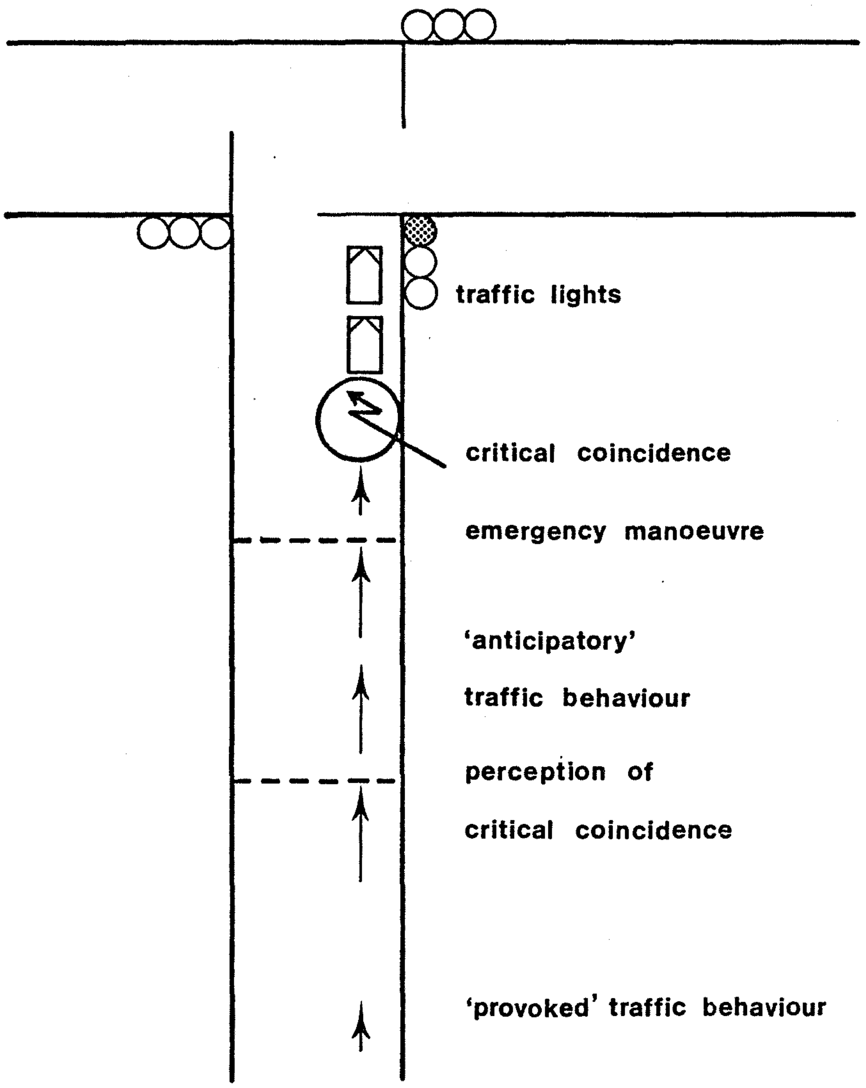


Figure 3. Accident process after installing traffic lights.

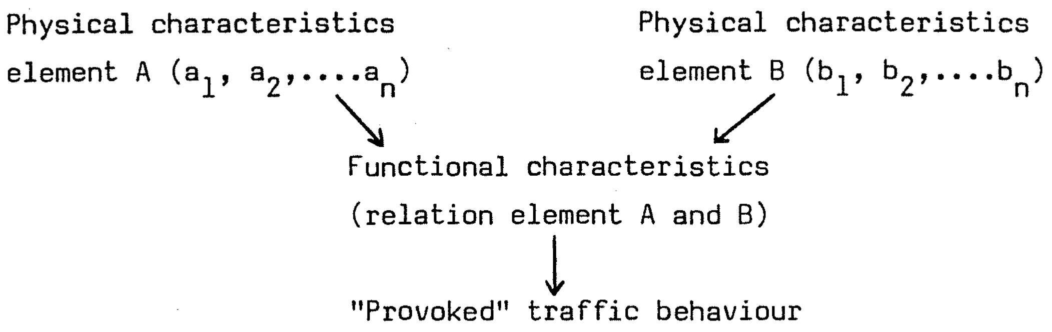


Figure 4. Relations between men and (characteristics of) system elements.

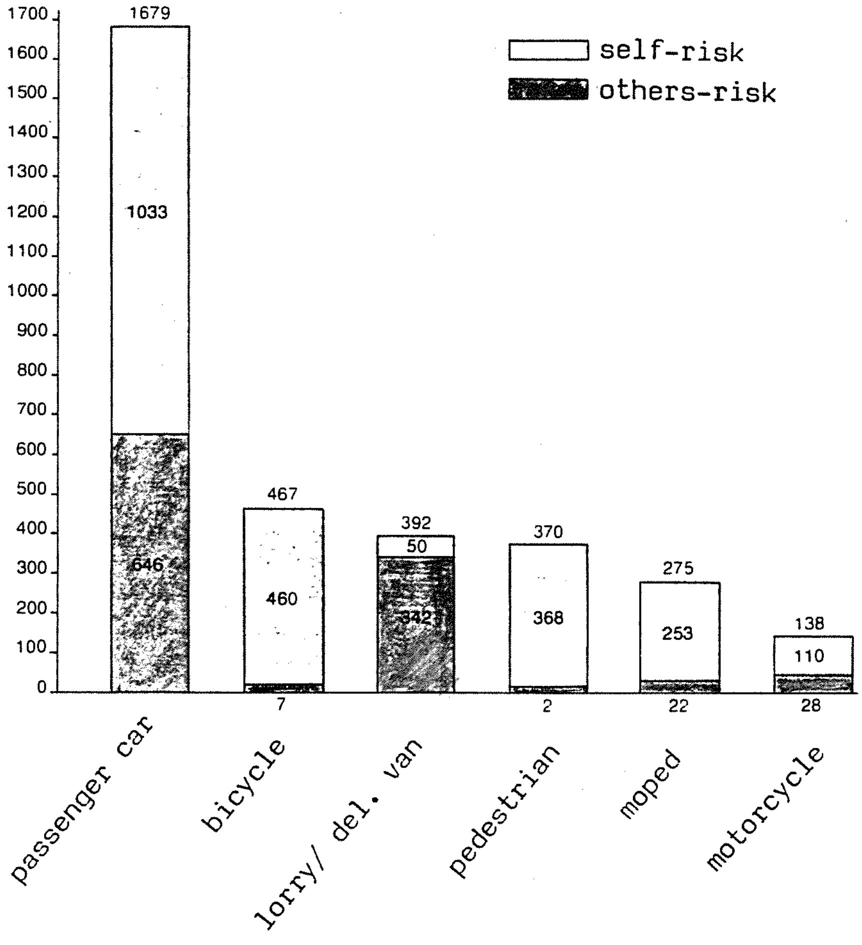


Figure 5. Number of deaths per mode of transport (The Netherlands, 1978).

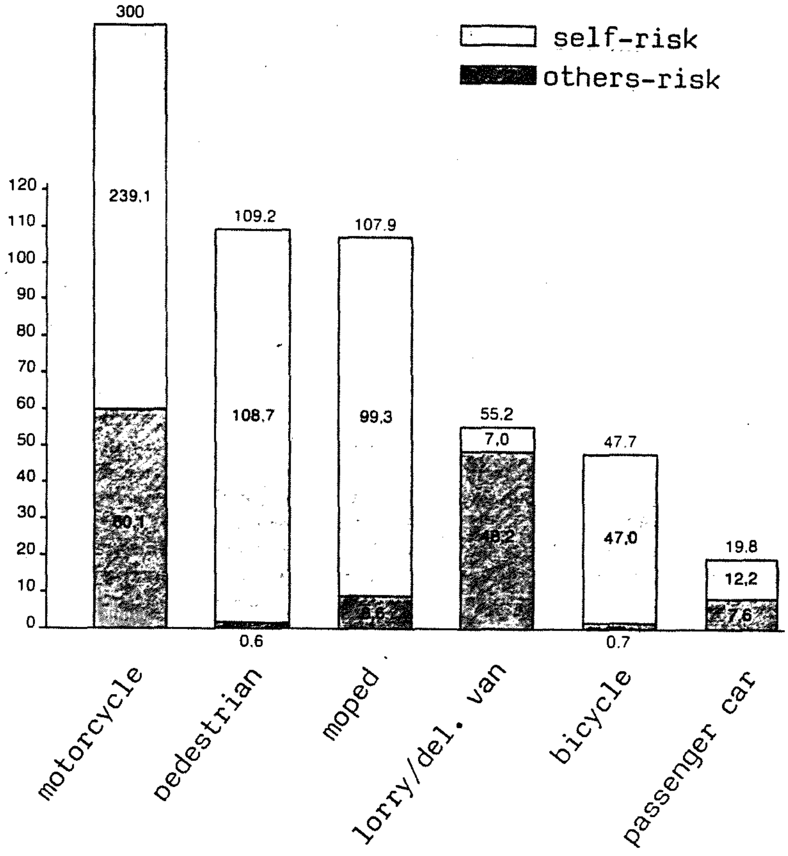


Figure 6. Number of deaths per mode of transport per 10^9 travellers kilometers (The Netherlands, 1978).

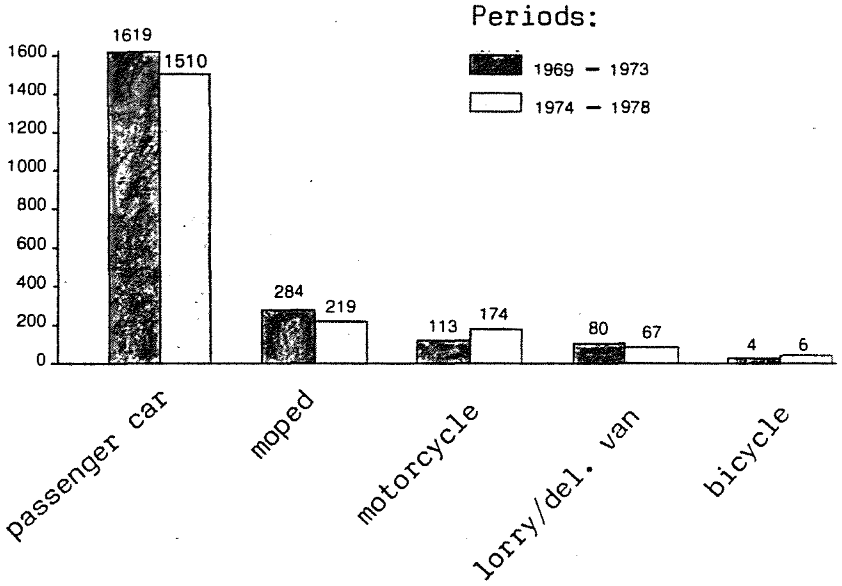


Figure 7. Number of fatal accidents with fixed objects per mode of transport (The Netherlands, 1969-1973 and 1974-1978).

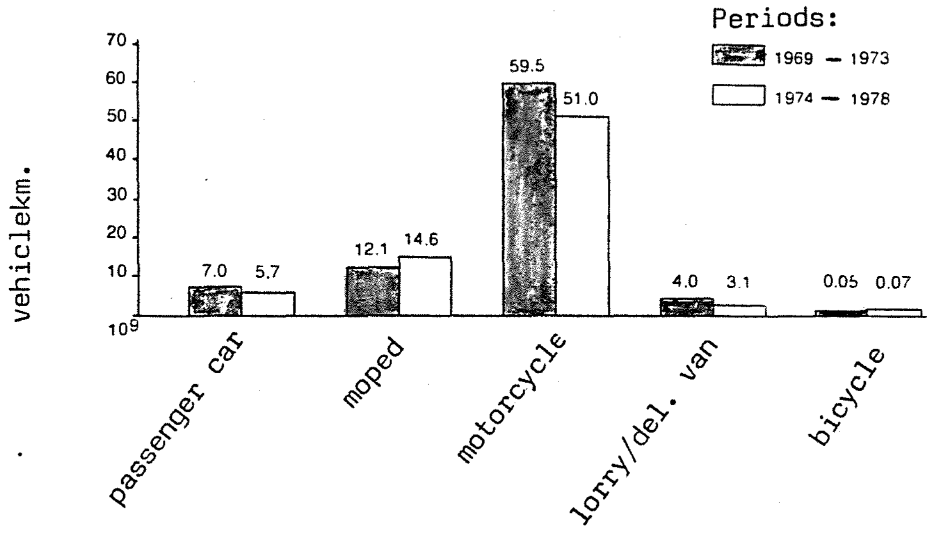
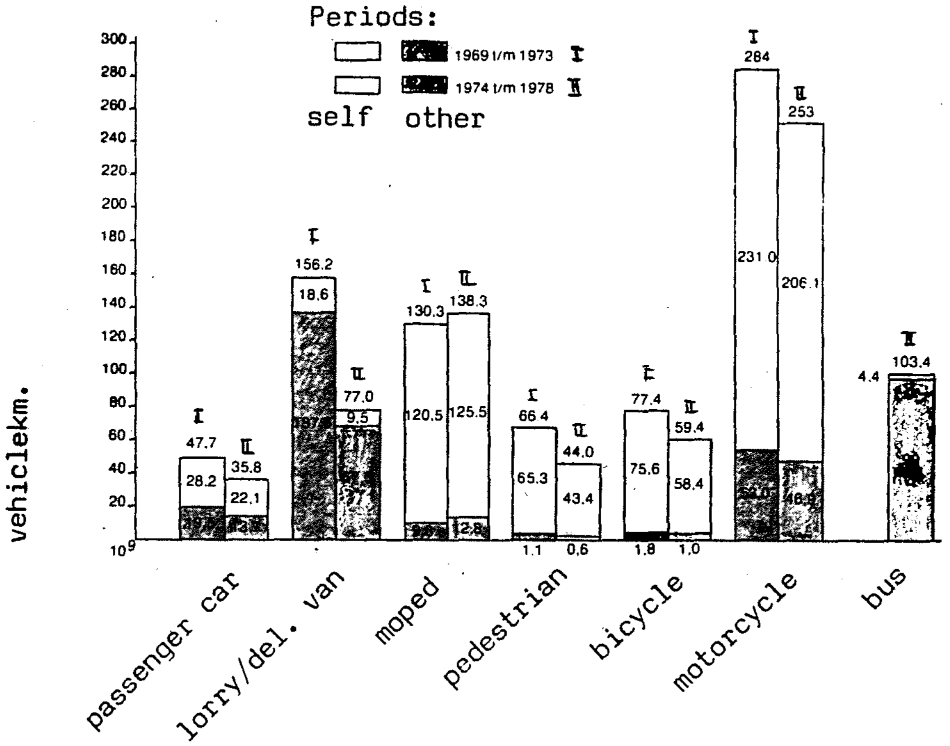


Figure 8. Number of fatal accidents with fixed objects per mode of transport per 10^9 vehicle kilometers (The Netherlands, 1969-1973 and 1974-1978).

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

Figure 9. Ratio "self-risk" and "others-risk" per mode of transport (The Netherlands, 1969-1973 and 1974-1978).



<u>Figure 10</u>. 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).

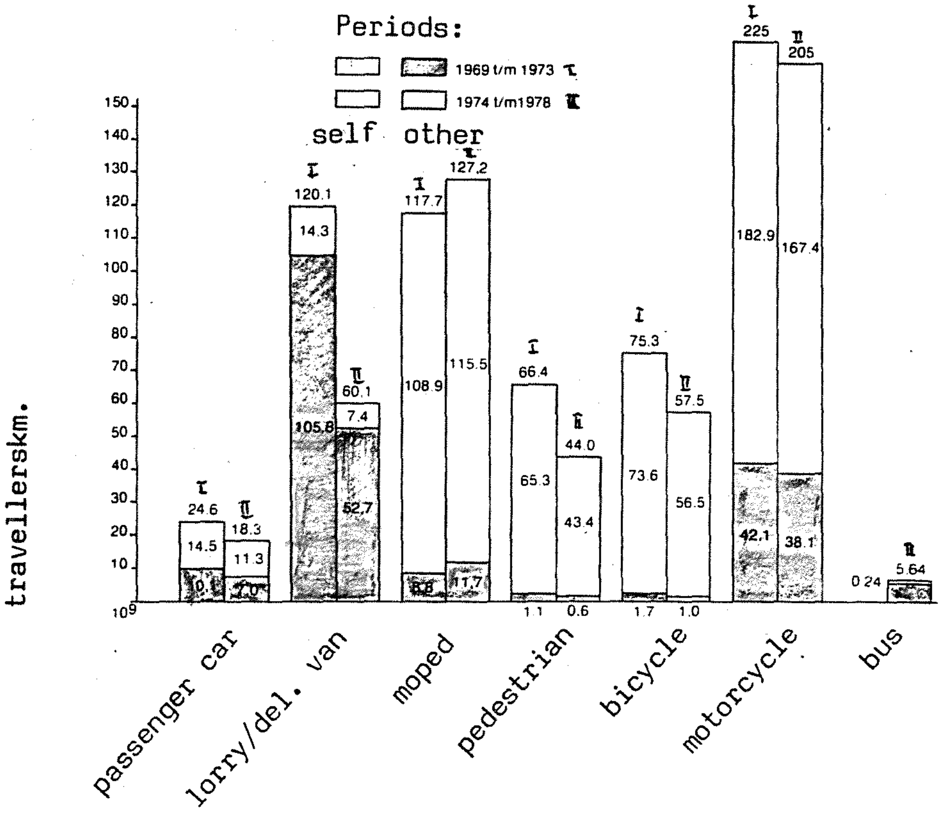


Figure 11. Number of deaths per mode of transport per 10^9 travellers kilometers, divided in "self-risk" and "others-risk" (The Netherlands, 1969-1973 and 1974-1978).