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International Cooperation on Theories and Concepts in Traffic safety

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Abstract

This report summarises the results of ICTCT 's workshop held in Prague in October 1994, dealing with the situation of pedestrians in to-day's traffic. From this huge area, some central topics were chosen and dealt with in working groups: *) Sociological aspects (road user groups and their power, influence on city planning and on all kinds of measures taken or not taken, and "history" of interaction between different road user groups), *) Aspects of problem locations (cities, third world countries, residential areas different types/categories of places and road sections where there are pedestrians), *) Problem types and their appearance (life quality problems including mobility, space consumption, aesthetics, safety; modal choice; individual problems depending on the group one belongs to) and *) Questions connected to problem analysis and evaluation (both "broad evaluation" in the sense of many evaluation types on the micro level, and social and socio-economic evaluation on higher level). All problems and aspects were dealt with from the macro, meso and micro-perspective. All materials and arguments that were in some way connected to countermeasures were to be **marked** and **summarised**. Evaluation methods and recommendations were discussed in the plenum.

As a result, policy goals that are considered as most important by ICTCT were listed (* car speeds have to be controlled better than they are today, it is advisable to improve the quality of life in the society by improving that of pedestrians, * those people who have no other possibilities than to walk should have *sufficient mobility so that they can maintain their social networks*, and participate in their normal activities without any needs for special solutions, * the subjective safety of vulnerable road users should be at least on the same level as that of car drivers and passengers, * it is absolutely necessary to *improve pedestrians' general role in transport policies, planning, engineering, product design, etc.* This would ensure in the long run that the safety and mobility requirements of pedestrians are fulfilled). Recommendations for both future research and evaluation work and aspects to be stressed in future co-operation with practitioners and authorities were formulated.

CONTENTS

1 Introduction	9
1.1 Are solutions considering user interests necessary?	9
1.2 Conflicting interests	10
1.3 What are these proceedings about?	12
2 Identification of pedestrian problems	13
2.1 The situation of pedestrians	13
2.1.1 Pedestrians have no power on a macro level	13
2.1.2 Sometimes pedestrians have (and exert) power on a meso level	14
2.1.3 People who walk have rather limited power on a micro level	14
2.2 Walking	15
2.3 How to improve the preconditions for walking	16
2.4 How to consider interests	18
2.4.1 Intrapersonal conflicts	18
2.4.2 Interpersonal conflicts	19
2.4.3 Conflicts between individuals and the society	20
2.5 How can interest conflicts be solved ⁷	21
3 Problem location	22
3.1 Safety and other important things	22
3.1.1 The safety problem	22
3.1.2 “Other” problems	23
3.2 Possible policy goals	24
3.3 Relations between macro/meso and micro levels	24
3.4 Problem solutions from aspects society man-machine-road	25
3.5 Safety measures	25
4. Problem types and their appearance	28
4.1 Pedestrians and other road-users: who has the power	28
4.1.1 At the macro level	28
4.1.2 At the micro level	28
4.2 Pedestrian mobility and safety and the road infrastructure	29
4.3 Specific pedestrian sub-groups: the elderly, the disabled	29
4.4 Pedestrian safety and other policies	31
4.5 Goals for future action	32
4.6 Research needs identified	33
5. Problem analysis and evaluation	35
5.1 Exposure	36
5.2 Accident Analyses	36
5.3 Traffic conflicts analyses	37
5.4 Behaviour observation	39
5.5 Interviews	40
5.6 Mathematical modelling	41
5.7 Controlled experiments	42
5.8 Activities considered as most important for the (near) future	43
5.8.1 Better use of video-recording	43
5.8.2 Improve task analysis	43
5.8.3 Improve registration of pedestrian conflicts	43

6 Conclusions	44
6.1 Problem identification and definition	44
6.2 Problem location	44
6.3 Policy goals	45
6.4 Recommendations	45
6.4.1 Recommended steps of future action	45
6.4.2 Methodological recommendations	46
APPENDICES	49
<i>MANAGEMENT FOR PEDESTRIANS and COMPLEXITY OF THE URBAN ENVIRONMENT</i> (Dominique Fleury)	51
<i>CRITERIA FOR “GOOD” TRAFFIC</i> (Ralf Risser)	54
<i>PEDESTRIAN SAFETY IN THE FIRST NATIONAL SAFETY PROGRAMME IN CROATIA</i> (Mladen Gledec)	65
<i>TOWN SIZE AND PEDESTRIAN ACCIDENT INJURIES</i> (Brigitte Cambon De Lavalette)	74
<i>PEDESTRIAN SAFETY MEASURES - PAST AND FUTURE</i> (Magda Draskóczy & Christer Hydén)	86
<i>ELDERLY PEOPLE AS PEDESTRIANS</i> (Christine Chaloupka)	97
<i>ELDERLY PEDESTRIANS: A POSITIVE OUTLOOK</i> (Uwe Ewert)	100
<i>THE ACCIDENT IMPENDENCY IN THE MUNICIPAL PUBLIC TRANSPORT SERVICES IN CRACOW</i> (Tadeusz Rotter, Antoni Wontorczyk)	105
<i>CHILDREN’S STREET CROSSING STRATEGIES: AN OBSERVATION TECHNIQUE</i> (Pirkko Rämä)	111
<i>PEDESTRIAN BEHAVIOUR AND PEDESTRIAN SIGNAL DESIGN</i> (Oliver Carsten, Frances Hodgson)	115
<i>THE EFFECT OF DIFFERENT TIMING SCHEMES ON PEDESTRIAN BEHAVIOUR AT SIGNAL CONTROLLED JUNCTIONS</i> (Kirsi Pajunen)	119
<i>TRAFFIC SIMULATION IN PEDESTRIAN SAFETY RESEARCH</i> (Eero Pasanen)	121
<i>BLINKING YELLOW AT SIGNALISED PEDESTRIAN CROSSINGS: AN EVALUATION</i> (Wiel Janssen, Richard van der Horst)	125
BIBLIOGRAPHY	133

1 Introduction

We are in the paradox situation in Europe, that on the one hand car traffic is experienced as a nuisance in many cases - even, and sometimes most of all, by authorities - and, e.g., projects are carried out with the goal to transfer short car trips to walking and cycling¹. On the other hand, the risk of getting involved in an accident as a pedestrian - and to get severely hurt or even killed in such an accident - is considerable.

It is very easy to agree that walking (more) instead of using the car all the time is a goal that should be supported by society, for many reasons: Environmental reasons, economical reasons (e.g., city centres with low car concentration are economically better off), esthetic reasons (lower portions or lack of car traffic allow different architectural solutions), etc. It has to be added that there are many people who have no other possibility to be mobile than by walking. But how should society take the responsibility to convince people to walk (more), if walking is not safe enough.

Moreover, from what is known today it can be stated that not only safety is lacking: From the (potential) user perspective, many other preconditions are not good enough for a clear change of habits towards more walking. Lack of comfort (e.g., high curbs, cars parking at the corners and disturbing the crossing of side roads, narrow pavements), long waiting times (signalised crossings) and unnecessary long distances (feelings that pedestrians in spite of being the most distance-sensitive road users are very often lead long ways), the noise and the bad air produced by the cars have been listed as the most important negative incentives in a study by Praschl et al. (1994) The interesting thing is that safety problems are only felt as being relevant for others: People are afraid for the safety of their beloved ones, their children, etc.. The most important exception, though, are elderly people, many of whom really do reduce their mobility as pedestrians because of feelings of unsafety (Chaloupka et al. 1993). But summarising - and knowing that the average individual feels that he/she has good control of most situations, even as a pedestrian, and thus does not "have to have" unpleasant feelings like that of unsafety - one can say that safety, or the lack of it, certainly is a factor that influences modal choice.

1.1 Are solutions considering user interests necessary?

How would potential users like the situation to be? Too little is known about needs and interests of different road user groups. Authorities tend to talk of "requirements" in an absolute meaning², as if "requirement" could be interpreted in an other way than with respect to certain groups needs

1

In the 4th Framework Program, the EU-DG VII is financing work with the goal to be better able to transfer short car trips to walking and cycling. One of the projects that will be supported is WALKING - Walking and cycling instead of short car trips. This project will be co-ordinated by Christer Hydén, the present chairman of ICTCT

2

E.g., "there are no pedestrians there, anyway, so infrastructures that fit the needs of pedestrians are not required", as if pedestrians would be "there" totally independent from infrastructures

and interests. In reality, different groups' needs and interests, conflicting needs and interests within and between groups, and the way in which interest and needs of different groups are effected when certain measures are introduced - or when they are not - are hardly ever analysed well enough.

Rut when cooperation of people is needed³ - e.g., when one wants more people to walk instead of using the car for short trips - this request will be reacted to in a satisfying way only if walking is considered attractive by the public, i. e., when certain needs and interests of the public (or parts of it) are fulfilled.

In traffic, the traditional way to consider people's (road users') needs is to assume what they want and what they need. One would almost say that authorities take care of the people's interest in the social-democratic style. However, the discussion in the media gives the impression that during the last years more and more people want to express their interests themselves and do not want to be interpreted too much.

Instead of assuming what road users want and what they need, it is suggested that different groups of road users (of people) are dealt with in a psychologically and social-scientifically correct way that makes sure that different groups of people's needs, motives, interests and attitudes are reflected/interpreted more thoroughly. Only then can both technically⁴ and politically⁵ correct decisions be taken.

1.2 Conflicting interests

When trying to resolve the difficult task of considering different road user groups' interests in a satisfying manner, one meets, among other things the two following problems:

more or less legitimate, but conflicting interests of different groups (e.g., traffic calming measures reduce comfort of car drivers, but improve both comfort and safety of elderly road users)

conflicting interests within groups (e.g., people want traffic calming measures where their own children play, but often feel disturbed by them on other sections of the road network)

3

We want to remind the reader that in road traffic there are hardly any measures where the cooperation of road users is not needed at all

4

All measures that rely on or aim at behaviour changes of people (road users) - and virtually all technical measures are of this type - need the cooperation of the people (road users), otherwise they will not work in the wanted way

5

If decisions do not refer clearly to people's or at least to certain groups of people's needs and interests, there will be the suspicion that politicians follow their own interests, or that they support interest of certain subgroups in a hidden way

Political decisions should rely on thorough analyses of different groups needs, motives and interests; then, responsibility has to be taken and conflicting interests have to be weighed against each other clearly and transparently. A public discussion should always be possible; in case such a weighing is difficult, public discussion should even be enhanced, because it would provide more materials for decision taking.

One interesting point is that it is not at all impossible to set priorities between different types of needs and interests: E.g., physical safety of the citizens is placed very prominently in the law texts, while the comfort of people is never named directly and should have lower priority in case of conflicting interests. On the other hand, comfort is strived for by all people and it will play an important role in marketing of, e.g., different ways of transport, which will cause other clashes of interest that have to be solved.

An example: The comfort of car drivers, e.g., on roads in the city where they can proceed quickly and undisturbedly, might be in conflict with the safety of pedestrians (e.g., if there is a certain potential of pedestrians, if the road in question is no motorway, and if some of the people - or what is worse: their children - have to walk along this road or to cross it). Safety should win, in this case. To allow this, a pedestrian bridge over the road is built.

Let us assume that three things happen at the same time, now, as a consequence of this measure: a) the number of pedestrians in total is reduced, b) some pedestrians do not use the bridge and still cross the road on the surface and c) some people write to the authorities complaining that having to cross a bridge is a very uncomfortable thing for them.

Let us assume, moreover, that another possible solution would be, to reduce car speeds instead of building a bridge. Any representative of car drivers could say, in this case: There is the possibility of building a bridge, but pedestrians deny that of comfort reasons. So this is a question of comfort for group A vs. comfort of group B, and not a question of comfort vs. safety.

One can accept this argument. But in this case, authorities have to come back to their original goal: If the increase of car traffic really should decelerate, there have to be more and more cases like the one just exemplified, where it is decided in favour of the pedestrians. **Deciding in favour of the car drivers makes using the car more attractive, deciding in favour of the pedestrians makes walking more attractive.**

Many conclusions can be drawn from this example. The most important ones we like to draw here are the following:

1. Safety influences the attractiveness of walking, but
2. safety is only one of several factors influencing the attractiveness of walking, and
3. safety can be achieved by different means

1.3 What are these proceedings about?

In these proceedings, most weight will be put on pedestrian safety problems. But in all sections we look at safety problems as an integral part of *pedestrian problems in general*, that influence the decision if one should walk or not. It will be discussed where and how they appear (sections 2 and 3), and how they can, or should, be registered and operationalised (section 4). In section four, even some hints on how to solve safety problems will be given. But to start with, we want to discuss and specify a little more where to place “safety” in the frame of all the factors influencing the situation of the pedestrian and the attractiveness of walking (section 1).

2 Identification of pedestrian⁶ problems⁷

The pressure of technology development in transport enhances establishing of dynamical processes of high complexity in the public space, especially in the cities. This would suggest that complex planning structures are developed in order to find solutions that correspond to the situation.

Planning of towns and transport in the traditional way, however, always was characterised by a juxtaposition of monofunctional solutions. At the same time, public space was looked upon as a physical space instead of as a social space. Thus, technical solutions were and are highly estimated. In this frame, the interests and interest groups around “the ear” were most influential.

According to the authors of these proceedings, two problems can be selected that both result from this type of planning and that are relevant in connection with the area we deal with here; the situation of pedestrians. These two problems are that

- a) Safety of pedestrians is not sufficient and
- b) that life quality of inhabitants of towns and cities is not sufficient

These problems are intimately related to each other; (short) walks belong to living in the city. At the same time, we assume that making walking safer would lead to a number of other changes in traffic that improve life quality (less noise due to fewer cars and reduced speed, optical changes due to changed lay-outs of crossings etc., fewer cars parked in the public space, etc.).

2.1 The situation of pedestrians

The situation of people who walk (who want to walk or have to walk) can shortly be characterised as follows:

2.1.1 Pedestrians have no power on a macro level

Many facts and assumptions in the field of transport sciences lead us to this conclusion. The following three aspects reflect the statement in the headline above in a comprehensive way:

1. typical groups are politically inactive (children, youngsters) or active at a reduced level (elderly people)
2. average people with no drivers licence or with no ear are usually socially less powerful (poor, disabled, immigrants, alcoholists)
3. all people who only walk now and then and otherwise have the possibility to use the ear tend to focus on ear drivers’ problems

6

In this connection, the concept of a “pedestrian” is fictitious: It is suggested that a pedestrian is a person who does most of his/her everyday trips by walking, and who uses public transport, or the ear, only for journeys that cannot be done by walking (the limit for which is varying, depending on the person involved, on the circumstances, on the physical and infrastructural preconditions, etc

7

This chapter is based on the summary of the working group on “Identification of pedestrians problems” by R. Risser. Dominique Fleury, Gösta Gynnerstedt, Ralf Risser and Josef Steinbauer took part in this working group

From a sociological perspective it is concluded that these aspects make that not so many efforts are made a priori to help this road user group.

2.1.2 Sometimes pedestrians have (and exert) power on a meso level

Where interests as residents, as parents, as pedestrians on the way to their parking lot, or to the nearest bus station, or to the nearest shop, overlap, you can find pressure groups in the cities and towns, but most of all in the outskirts of the cities who defend “pedestrian rights”. In these cases the “resident” part even of ear drivers becomes so strong that the intrapersonal conflict of interests (between the “ear driver me” and the “resident me” is solved to the advantage of the resident).

This is a very new aspect. Lots of materials on the topic are still to be collected. It will be interesting to see how people fight for certain goals when they will be affected as, e.g., residents themselves, compared to their attitudes towards certain measures they have as ear drivers.

2.1.3 People who walk have rather limited power on a micro level

People who walk have severe disadvantages in their interaction with other road user groups (especially with ear drivers)

- 1 physics would predict that for the case of a collision
- 2 accident analyses give clear hints in this respect (to insist on one’s rights has obviously totally different implications for pedestrians and for ear drivers)
- 3 behaviour/interaction observations show it

Almost naturally, research concentrated on the “risk emanators”, and not so much on those who feel risk most immediately - i.e., unprotected road users. However, interestingly enough, in the few cases when research deals with pedestrian problems, it is more usual to talk about the mistakes of pedestrians than of their needs.

Having said all this, and concentrating on pedestrian problems, especially with respect to safety, one wants to suggest to

- concentrate on pedestrian needs
- define different groups of pedestrians (based on empirical social data; e.g., include the concept of “residents”), in order to be able to discriminate between different types of needs
- define criteria for “good” traffic with thorough consideration of the needs and interests of different road user groups, and give pedestrian and residents’ interests an adequate weight
- define the role of safety in the traffic society, and how it can be achieved, also with respect to the needs of pedestrians (including “residents”)

Those, who concentrate on transport from an economical perspective (underlining how important transport is for an industrial or even post-industrial - society should remember, that walking is transport.

2.2 Walking

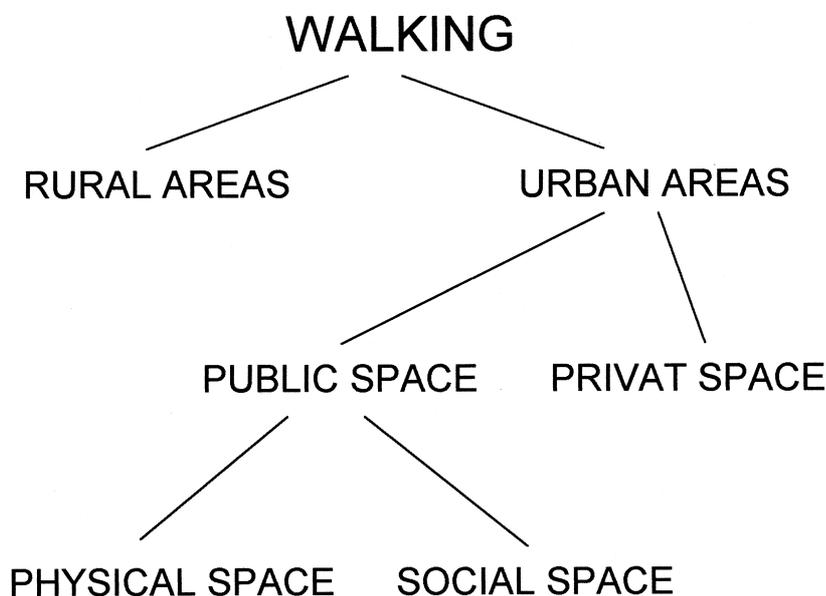
In traffic and transport, research on walking is not very frequent and a rather new topic (although it is the oldest way of transport). Obviously, researchers implicitly did not consider walking as a way of transport. Maybe, unreflectedly, they started from the assumption that “people” make all possible efforts to avoid walking more than necessary, and maybe they forgot other important aspects:

a) only very few people have the possibility to travel all the way in, e.g., their car without having to walk at least for a short period in the public space

b) there always existed and there exist also today people whose only possibility to travel is to walk (References: Garbreht 1981, Olof Gunnarsson, etc.), e.g.

- old people who cannot drive a car any longer, and especially so when they have nobody to take them to places
- children and youngsters (only to be outside when one is transported by car by, e.g., the parents, would really mean to be locked in)
- poor people who cannot afford a car (on average, they have to walk for longer ways than car drivers even where they have public transport means they can use)

Graph 1: The walking space



A functional definition of “walking” and the walking space

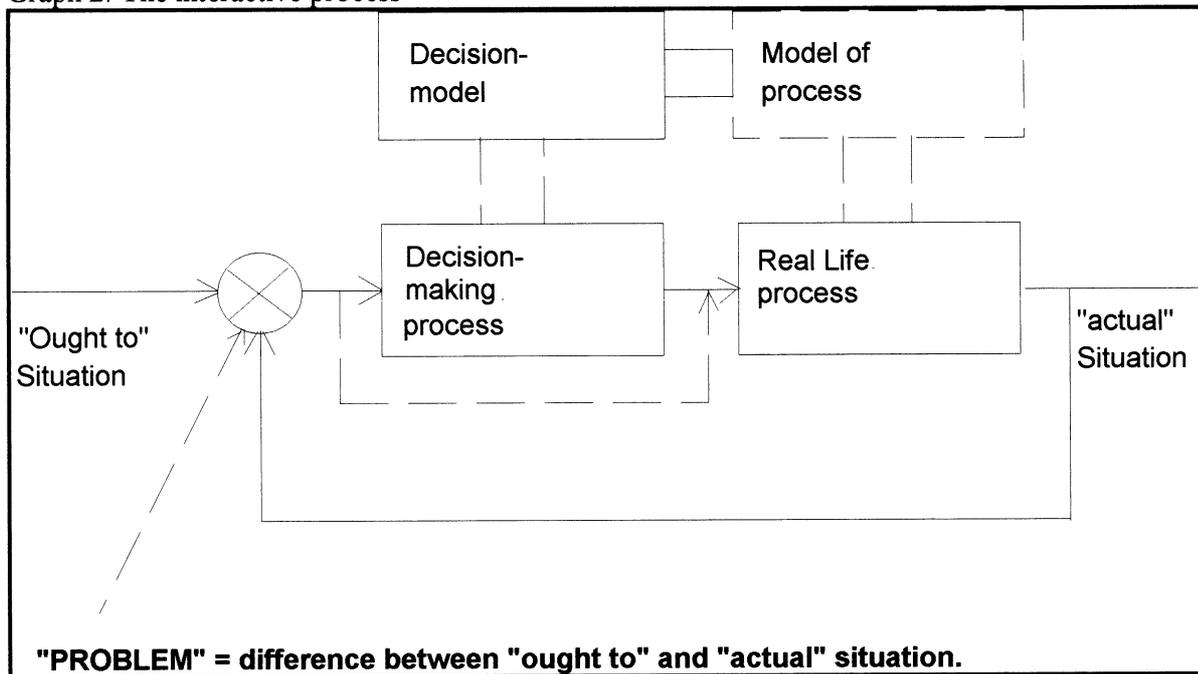
We have decided that we want to look at walking in the public space of urban areas and that we will look upon this public space as a social space (see graph 1). The alternatives that can be derived from graph 1 are either less relevant (like walking in rural areas, which is far from being uninteresting, however), not or only rather marginally belonging to our sector “traffic and transport” (like walking in the private space), or much too restricted in their perspective and thus enhancing monofunctional solutions (like looking upon public space as a physical space).

In the case of playing children, one should have an extra look on what grey zone there is at the border between private and public space.

2.3 How to improve the preconditions for walking

When we say that there are “problems” connected to walking conditions in our present traffic network, we obviously talk about a situation as it ought to be and refer to the difference of this “ought-to-be” situation to the actual situation. Graph 2 displays this.

Graph 2: The interactive process



How should this graph be read? The line followed by G. Gynnerstedt (the author of graph 2), was the following:

- 1 An actual situation is compared to the “ought-to-be” situation and the result of this comparison is “the problem”

- 2 The situation develops further as soon as anybody realises or feels that there is a problem; this can happen on the decision level (including the so called decision makers), but also in more “analogous” ways (meaning that involved people do not treat the problem consciously but adapt on the reflex-level).
- 3 Anyway, the real life processes that result from the stated or experienced differences between an ought-to-be situation and the actual situation, can be different from what they were before any problem-identification process (and they will most probably be different if it is tried explicitly by anybody to improve the actual situation).
- 4 What are needed in order to understand changes, and as a precondition to changing things on purpose, are both models of such decisions (“digital” and “analogous” ones) and models of the real life processes; one needs reliable models of these processes in order to be able to assess and/or influence them.

More concretely, in our case we would take the steps as outlined in graph 3. There the “ought-to-be” situation is defined with reference to the different needs of different (groups of) people who have to or want to walk today, but even the needs and interests of those who would be prepared to walk more under different conditions.

Graph 3 suggests the planning of traffic according to the needs and interests of different groups and subgroups of road-users and residents on all levels⁸. Conflicting needs and interests have to be made transparent. If somebody states that it is a political act to decide which interests are to be respected best, then, we do not discuss this here. All we say in this part of the minutes of a group work is that there are legitimate pedestrian interests that are frequently neglected according to our interpretation. They should be considered in planning, and evaluation processes should build on these considerations.

Steps one to three in graph 3 will provide know-how about different pedestrian groups’ needs and, thus, about the nature of different decision processes (e.g., motivational background for modal choice). This will allow, to make walking “a pleasure”. if anybody wants to do so.

But also, any decision to influence modal choice in the direction of walking will have a better chance to be transformed into successful measures if the background for modal-choice decision is known.

8

See Risser R., “Criteria for ‘good’ traffic”, in the appendix of this report, as well

- 1. GROUPS AND THEIR NEEDS**
- 2. PROCESSES ACCORDING TO THIS
(OUR CRITERIA OF PROBLEM
DESCRIPTION)**
- 3. FOLLOW UP AND EVALUATION**
- 4. IMPROVE KNOW-HOW ABOUT
DECISION PROCESSES
(IN HEADS AND IN GROUPS)**
- 5. INPUT ACCORDING TO DECISION
PROC**

2.4 How to consider interests

It was said above that we do not appreciate monofunctional solutions. Thus, different functions should be considered already in the analytic phase. In this paper, we want to present a model of what should be considered in connection with need analysis (graph 4).

It almost goes without saying that people will have fewer difficulties to agree on values to be respected, on a higher level of the discussion. Everybody agrees on the relevance of the values themselves, and nobody says (loudly) that they should not be considered. However, operationalisation, implementation, and evaluation are increasingly more difficult to be achieved in agreement. Several types of conflicts are to be expected. The graph above symbolises the three most relevant levels of conflicts; intrapersonal ones, interpersonal ones, and conflicts between individuals and the society. These three types of conflicts reflect much of what has been said above already.

2.4.1 Intrapersonal conflicts

We have said above that the role of ear-driver is prioritised by those people who drive a car frequently. Without much reflection, they will vote for the interests of car drivers to be considered firstly. However, marketing measures could make use of the fact that “there is a little pedestrian in every car-driver” (see what has been said about the “meso-level” at the beginning of these minutes)

Graph 4: From values to action

VALUES AGREED UPON

EQUAL RIGHTS
PROTECTION AND INTEGRITY
OF HUMAN LIFE
FREEDOM (OF CHOICE,
OF DECISION)
ENVIRONMENTAL PROTECTION, et.

OPERATIONALISATION

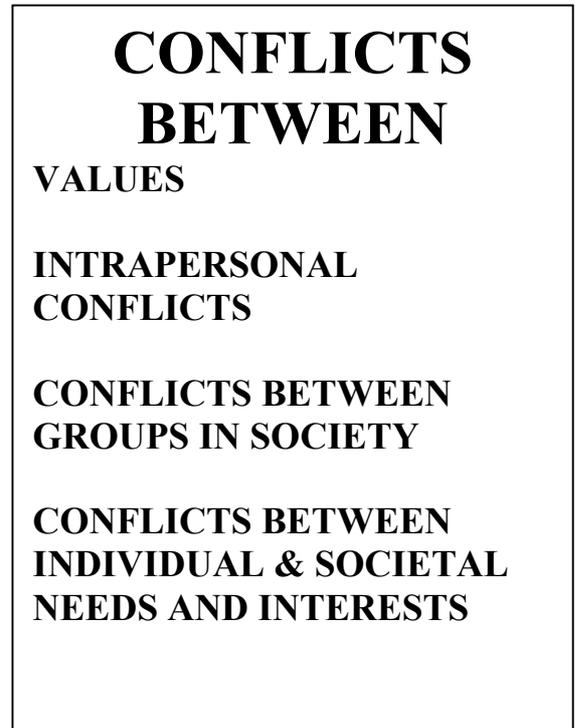
HOW ARE THESE VALUES
REFLECTED AND DEFINED
MORE IN DETAIL?

IMPLEMENTATION

WHAT DO YOU HAVE TO DO?
HOW DO YOU HAVE TO
BEHAVE IN ORDER TO
ACHIEVE THESE VALUES?

EVALUATION

IS VALUE ACHIEVED??



2.4.2 Interpersonal conflicts

Conflicts between (groups of) different individuals in traffic are the most logical outcome of the fact that different (groups of) individuals in traffic (road users and residents) feel different needs and have different interests in several respects. (However, one could also say that they have similar or even the same needs, but the fulfilment of the needs of one group frequently calls for measures that have unwanted consequences for other groups). As a layman in jurisprudence one would say that it should be seen to it on legislation level that the legitimate needs of pedestrians are respected (this becomes most clear when one remembers that there is a considerable number of people who have no other possibility to be mobile than walking).

But even with respect to marketing of walking the argument made in connection with intrapersonal conflicts is valid; ear drivers do know the pedestrian perspective, and it is probably a question of “selling” measures, if better conditions for walking are accepted by the ear driving groups.

In the following, an example for a “typical” conflict between interests of different groups is given (in this case between bus drivers and pedestrians). At the ICTCT workshop in Salzburg 1993, Kirsi Pajunen (1994) showed us, that according to statistics, buses represent a very safe transport mode. However, in the discussion of her presentation colleagues came to the conclusion that there is an interest conflict between buses (or bus drivers) and pedestrians.

Graph 5 (below) reflects this conflict that was felt to be rather typical for cities. Pedestrians in Vienna (Praschl et al. 1994) would state, that bus drivers are the most ruthless people they know. Now, it would be really arrogant to tell pedestrians that buses are safe, objectively, and thus pedestrians have to swallow the behaviour of bus drivers.

There is one more aspect to this that can be mentioned here (as implicitly we have discussed walking as something that should increase compared to ear driving - remember all “marketing” arguments): The comfort felt in connection with a certain modal choice is the product of a large number of factors. Ruthless bus drivers are certainly a strong argument against walking, if a road with bus traffic has to be crossed or if any other interactions with bus drivers become necessary.

Graph 5: A conflict between the interests of ear drivers and those of pedestrians

	SAFETY		EQUAL RIGHTS	
	BUS +DRIVER	PEDESTRI-ANS	BUS +DRIVER	PEDESTRI-ANS
VALUES	OK	OK	OK	OK
DEFINITION/ OPERATIONALISATION	NO ACCI-DENTS	NO ACCI-DENTS	AGREEABLE MOBILITY	AGREEABLE MOBILITY
IMPLEMENTATION (OR JUST “AS THINGS HAVE DEVELOPED”)	= STATUS QUO IN THIS CASE			
EVALUTION (ACHIEVED?)	YES	YES	YES	NO

Risser (in ICTCT 1994) has discussed extensively, how this interest conflict should be tackled, namely mainly by reducing the speed of buses in a smooth way, in areas where they have to interact with pedestrians. As long as speed remains constant, passengers in buses do not react strongly against reduced bus speeds.

2.4.3 Conflicts between individuals and the society

Very often road users want to behave in a way that is detrimental for safety in a statistical sense. Obviously, they do not feel any risk (or feel that risk is under control) when they do so. However, countrywide, this behaviour leads to considerable safety problems. A risk of this type is very

abstract and not felt. Consequences are not anticipated by the individuals. (Psychology tells us that such consequences are no good reinforcements).

Behaviour of ear drivers when turning left or right in the cities, and by that crossing the ways of pedestrians who walk straight on, can be seen under this perspective (and a lot of other types of behaviour, as well): It is obviously dangerous to force one's way through groups of walking pedestrians in such situations, or to turn left or right without considerable deceleration (e.g., if one does not see any pedestrians as a driver), as accident statistics from big cities show. And, obviously as well, ear drivers do not feel such danger. (Of course, this conflict can also be seen as a conflict between (groups of) individuals, as pedestrians heavily criticise the behaviour of ear drivers in such situations, see, e.g., Garbrecht 1981).

2.5 How can interest conflicts be solved?

The working group came to the following conclusions that refer more to the methods of data collection and interpretation than to giving advice for conflict-solution processes from the shelf

1 Prepare better materials, especially with respect to establishment of groups and subgroups who are affected by different situations (to be evaluated) or by different measures (e.g., elderly, children, parents, "average" ear drivers, professional drivers, cyclists). Produce thorough description and specification of their needs and interests, in order to provide for a good basis for problem solutions (so that, e.g., "political" statements like "ear drivers never would accept such a solution", become obsolete).

2 Even, if this is not the case for the recommendations you are reading here, it has to be remembered that recommendations have to be operational in the sense of **what should be done** and **why should it be done**, where one again should refer to all relevant groups and subgroups. E.g., to recommend road-narrowings at crossroads in the city so that crossing distances for pedestrians become shorter, is not enough; it has to be added that these measures are most often implemented in a way - together with other measures - that they also lead to lower ear speeds, that they prevent cars from parking at the corners, etc.. Thus, the measure has more advantages for one group, and more disadvantages for the other group. Suddenly it becomes clear that one has to look at the character of advantages and disadvantages: For pedestrians it seems to be a matter of safety if their crossing distance becomes shorter and if ears drive slower, for the ear drivers it is more a matter of comfort and not so much of vital needs.

3 Thus, it has to be seen to it that one gets data from different disciplines, or that one gets allies from different disciplines: If the task to "make walking in the cities more worthwhile" has to be fulfilled, a large number of experts from different disciplines should be involved in such a task architects, psychologists, road construction engineers, sociologists, town planners, traffic engineers, and others.

3 Problem location⁹

3.1 Safety and other important things

Pedestrian safety and especially child pedestrian safety has improved in France, Japan, and the Nordic countries considerably since the early 1970's. Pedestrians still have, however, numerous safety problems in the transport system of today.

3.1.1 The safety problem

We discussed and identified several different **problems** related to pedestrian safety. *The first* is related to measuring pedestrian *safety* i.e. what is the right indicator for that purpose? Several different ratios have been used, e.g.

1 number of accidents resulting in pedestrian injuries / exposure

2 number of accidents resulting in pedestrian fatality / exposure

3 number of pedestrian fatalities/number of pedestrian injuries

The number of fatalities has the advantage of almost 100 % reporting by the police, and a very common definition of the person dying within 30 days of the accidents (although e.g. in France the time limit is 6 days, and in Japan as short as 24 hours). The disadvantage of fatalities is their large random variation due to the small numbers. The number of injuries is much higher and therefore it has much smaller random variation, but their underreporting is a considerable problem. The reporting varies very much between countries and also within countries, in addition to the fact that the definition of injury differs quite much. Hence, both have their advantages. It is also evident that the choice between fatalities and injuries affects safety analysis with regard to results. The paper presented by B. Cambon De Lavalette (appendix) showed that in terms of child pedestrian injuries/child population, the safety of child pedestrian becomes worse with increasing town size.

Town size and pedestrian accident injuries¹⁰

General aim of the paper is to identify the specific groups of young pedestrians that are at high risk to be involved in traffic accidents. The paper explores especially the relationship between young pedestrians' accident occurrence and severity and urban density (rural communities; < 5000 inh., 5000 to 20000 inh., 20000 to 50000 inh., 50000 to 100000 inh. and > 100000 inh.). Child pedestrian accident rates appear to be proportional to urbanisation density, whereas accident severity is negatively related to conurbation size: The higher the conurbation size, the lower the accident severity rate. Speed seems to be an important underlying factor. The city of Paris has an extreme position on both scales (accident and severity rate). To reduce the numbers of child accidents, the large towns need countermeasures. First fatality rates should be reduced, and then rural and semi-rural areas should be treated more in detail.

9

This chapter is based on the summary of the working group on "Problem location" by R. Kulmala. Mladen Gledec, Christer Hydén, Masaki Koshi, Risto Kulmala, Brigitte Cambon de Lavalette took part in this working group

10

See B. Cambon de Lavalette, "Town size and pedestrian injury accidents", In the appendix of this report

When the indicator is the number of child pedestrian fatalities/child population, the safety seems to improve with increasing town size.

The *definition of exposure* is the other aspect of the indicator problem. The ideal measure for exposure would perhaps be the number of encounters between a pedestrian and a motor vehicle, where an encounter is a situation where both participants have crossing paths, and there is a risk of their collision unless at least one of them changes his course or speed to avoid it. The number of encounters is unavailable at any statistics, and therefore a number of other exposure measures have been used, e.g., pedestrians' distance travelled, time spent in traffic, population. Some exposure measures get near to the idea of encounters by using the product of *vehicle x pedestrian* flows.

Conflict studies and other behavioural studies offer the possibility to actually count the number of encounters, and the number of conflicts, and then have the number of conflicts/ the number of encounters as the indicator of pedestrian risk.

3.1.2 "Other" problems

The *second problem* is related to **the other pedestrian problems in traffic**. The whole community and urban structure is very much based on the use of motor vehicles, and the use of cars in particular. This has a negative effect on the mobility of pedestrians and other vulnerable road users in general. Whereas pedestrians are often children, or elderly, these mobility impacts focus on these demographic groups especially. All of this has a negative effect on the quality of life in today's society, and especially in the urban areas.

The *third problem* that we discussed was related to the **poor adaptation of humans to new traffic systems**. One example were the safety problems encountered by the Bosnian refugees in Croatia. The people from the rural areas of Bosnia have had high accident risks in the urban areas of Zagreb. Many of the safety problems of children can be explained by their difficulties in learning to adapt to the traffic system designed to work under the conditions set by car traffic. The elderly, who have adapted their behaviour to the particular traffic system in their daily living environment, have sometimes tremendous difficulties in adapting to new traffic systems (e.g. traffic signals) in that environment. One part of the high accident risks in developing countries might also reflect this difficulty of adaptation to new transport systems.

The problems in developing countries, however, are also linked to other factors. One is the fact that the transport **mode is connected to the social position** of the person. Car owners and drivers in the developing countries have a high position in the social hierarchy, and the pedestrians lie very low in the hierarchy. This social structure is also reflected in the traffic system, in official and unofficial traffic rules, and in the outcomes of interactive situations in traffic. The pedestrians should always give way to car traffic, and the car drivers rarely pay any special attention to pedestrians.

The overall problem is the fact that car drivers set the scene for other road users. This applies to all levels, macro, meso, and micro. Above, we have mentioned some macro level examples. One example from the micro level is a highly over-speeding driver. As the car moves along the street network other drivers and especially vulnerable road users immediately have to react defensively in order to maintain their safety and health. The car drivers can force the situation in their favour by various means, and one of them is speed.

On the macro and/or meso level. the pedestrian *safety problem areas* are:

- developing countries
- big cities (accidents)
- rural communities (fatalities) low income families

On the micro level. the problem areas are:

- high-speed drivers and motor vehicle speeds in general
- central business districts of the cities
- residential streets (children)
- junctions and intersections

3.2 Possible policy goals

The **primary goal is to improve the quality of life** in the society by improving that of pedestrians. This means that we should aim for improving the pedestrians'

- mobility
- safety
- feeling of safety

Pedestrians should have sufficient mobility so that they can maintain their social networks, and participate in their normal activities without any needs for special solutions. The safety of pedestrians and other vulnerable road users should be at least on the same level as car drivers and passengers. On the macro and meso level, the feeling of safety should be so low that it does not affect the pedestrians' mobility nor cause any anxiety in their part. On the micro level, a certain feeling of unsafety might be beneficial to the objective safety of pedestrians, by making them wary and attentive in risky road and street environments.

The **second goal is to improve pedestrian's general role** in transport policies, planning, engineering, product design, etc. This would ensure in the long run that the safety and mobility requirements of pedestrians are fulfilled.

3.3 Relations between macro meso and micro levels

In our discussion, we reached the conclusion that micro level measures also affect the macro/meso level in general. We also found out that these effects are not always necessarily in the same direction. One example is the implementation of physical speed restriction measures on just one road section. This might result in car drivers choosing to use an alternative and even longer route to avoid the improved section, which in turn could affect an increase in the number of accidents in the whole network, while the accident number on the improved section might be dramatically reduced.

This interaction between the different levels call for a strategy of implementation. In a good strategy, the safety measures form an important link in the communication between safety experts, decision makers, traffic planners, and the road users or citizens in general. Hydén gave an illustrative example of this in the case of the Swedish town of Växjö, where mini-roundabouts were implemented as an area-wide measure.

3.4 Problem solutions from aspects society – man – machine - road

We structured the solutions in a hierarchical manner, by starting from the most general goal on the macro level, and then going down onto the micro level solutions. The solutions were based on the problem areas described above. We had four main solutions to the pedestrians problems related to safety and other aspects of the quality of life:

- reduction of motorised traffic
- planning in order to reduce encounters
- pedestrian-friendly design for encounter locations
- redistribution of responsibility so that car drivers get more responsibility and do not just set the scene for vulnerable road users
- reduction of vehicle speeds

3.5 Safety measures

On the macro level, one important measure would be to take care that the costs **of car traffic should include all external costs** caused by it i.e. also accident and environmental costs etc. Today, car traffic's attraction in relation to e.g. public transport is at least partly based on the fact that the costs of car traffic are much cheaper than those of public transport. The situation would be much more evenly balanced, if all transport modes would carry also the external costs caused by them.

Long-term investment in public transport is another measure that would help in the realisation of the solution of less motorised traffic.

Measures related to planning in order to minimise encounters could be **pedestrians-only areas in central business districts** and other **restrictions of car use**. These measures are best suited in areas with high pedestrian flows or where the number of child or elderly pedestrians are high, as in residential areas.

In order to improve the quality of life in urban areas, the planning should perhaps start by first planning the pedestrian path networks, and after that planning the motor vehicle road networks and separating that from pedestrians with the help of motor traffic tunnels and bridges instead of doing the opposite, which is the conventional manner. One way of saying this is to aim for **separation of cars from pedestrians and not the other way round**.

However, it should be noted that **good integration is often better than separation**. This is especially true in residential areas, where quite good results have been obtained through traffic calming, Woonerfs, and physical speed measures. When car drivers operate with the same speeds and prerequisites as vulnerable road users, the result can be improved quality of life for all.

Telematics applications can improve pedestrian safety, but only if they are designed in a very careful manner. If this is not the case, the car drivers will probably misuse the applications to increase only their own mobility and comfort, and neglect the needs of vulnerable road users. The telematics applications should enhance the interaction between car drivers and pedestrians, and make drivers act in a more attentive manner.

Pedestrian-friendly design in encounter locations means primarily improved **visibility of pedestrians**, increased **attention of car drivers and pedestrians** by various means, and **signal control also considering pedestrians** and their mobility needs on an equal base as the car drivers'.

At the macro as well as micro level, the most effective measures deal with speed control in various manners. The choice of the actual measure depends mainly on the implementation environment and its size. One promising feature would be a **speed limiter on vehicles**. It should be a dynamic one i.e. adapting itself to the surroundings (e.g. 30 kmph on residential streets, 50 kmph on urban main roads, 80 kmph on highways, etc.). Due to the foreseen resistance of car drivers towards such a device, it requires integration with some more “attractive” functions in order to make it acceptable. Such attractive functions could be e.g. intelligent cruise control, automatic lane keeping, etc.

The good safety effects obtained by **physical speed reduction measures and traffic calming** make them recommendable, although good detailed design is of utmost importance in their case. Good examples of this were presented by Miaden Gledec and Christer Hydén (see appendix). Among suitable measures are mini-roundabouts, humps, and rumble strips.

Signal control design can also affect driving speeds, and should not be forgotten in this context. The actuation of the signals and the green wave formation are two examples of signal control features influencing speeds. These micro level measures gain the most effective results when implemented according to a macro level strategy, which serves the purpose of comprehensive, area-wide improvement of pedestrian safety as well as road safety in general.

Pedestrian Safety in Croatia¹¹

In Croatia 800 people are killed in traffic every year (a rather high number for a rather small country (4.1 mio inhabitants). Therefore, a national program was established to improve traffic safety. This should be achieved by *) reducing speeds (+ obedience of the speed limits), *) improving pedestrian safety (e.g., obedience of red lights to 100% by car drivers, obedience at critical sites by pedestrians), *) black spot treatment (30% of the most critical spots should be eliminated), *) and improvement of the accident information system.

Especially for the pedestrians the situation should be improved by implementing a series of specific measures like *) pedestrian information campaigns, *) better traffic engineering measures (e.g., reduced waiting times at traffic lights, reduced vehicle speeds), *) changes in town planning and land use strategies, *) and traffic calming measures (that in many cases are the only possibility to improve the safety situation of pedestrians).

Some of these measures were tested in the field (2,7 km test route). Some rather positive results were achieved speed reductions

- o more homogeneous speeds
- o reduction in accidents
- o 200000 DM savings, while the costs of the measures (humps and other traffic calming activities) were only 14000 DM

Pedestrian safety measures - past and future¹²

After a review of effects of existing pedestrian safety measures such as zebra crossings, refuges, traffic signals at intersections, mid-block signalisation, and speed reduction at intersections, the paper identifies road transport telematics (RTI) that may have the potential of improving pedestrian safety, viz. intelligent traffic signals, local speed reduction where and when needed, both warning and tutoring functions. RTI can help to warn drivers of pedestrians only in the actual situation when the presence of e.g. school children is really likely.

11

See also M. Gledec, "Pedestrian safety in the first national safety programme in Croatia", in the appendix of this report

12

See also M. Draskoczy & Ch. Hydén, "Pedestrian safety measures - past and future", in the appendix of this report

4. Problem types and their appearance³

4.1 Pedestrians and other road-users: who has the power?

4.1.1 At the macro level

There is often a discrimination against pedestrians on social grounds, especially in the less motorised countries. It is, at least partly, a problem of social hierarchy as pedestrians include both the poorer part of the population and the most vulnerable one (children, the elderly, the disabled).

Even in Europe, there are still obvious traces of such discrimination in the traffic environment generated by road engineers up to the early 80's. In general, low attention has been paid by engineers to pedestrians in road design and facilities (narrowed pavements, scarcity of pedestrian crossings, introduction of pedestrian facilities as a last resort after all other goals have been taken care of, or other such shortcomings), which reinforces the attitude of drivers that pedestrians are negligible quantities with no particular rights.

The power game between the different road-users is also, to some extent, determined by the law. In general, traffic laws are meant primarily to keep vehicle traffic flowing smoothly, rather than to protect the walking population from such traffic (a pedestrian is not as dangerous as a car driver!). In actual facts, the law provides legal power to drivers. In such context, stronger regulations to protect pedestrians (as, for instance, in Great Britain) may not always have the expected effect, unless compliance by pedestrians is very high (the risk for offenders seems to be all the more severe that the regulations are strict).

In recent years, new local regulations applying to parts of urban areas have reversed the priorities, providing pedestrians with increased powers on limited territories (30 km zones, urban yards, mixed traffic streets, etc.). But the situation has not changed on rural roads and through villages or small towns, where the most serious accidents occur.

Pedestrians are not an organised force. In the less motorised countries, although pedestrians are the larger group of road users, they are particularly powerless to claim protection.

4.1.2 At the micro level

In a traffic interaction between a pedestrian and a driver, there is a conflict of will. Who has more power? Some of the answer is in the traffic environment, some in the attitude of the driver. Are drivers particularly influenced by the volume of the pedestrian flow or by the category of pedestrian encountered (for example, are they more careful with a child pedestrian)? There are

13

This chapter is based on the summary of the working group on "Problem types and their appearance" by N. Muhrad. Christine Chaloupka, Nicole Muhrad, Uwe Ewert, Tadeusz Rotter and Antoni Wontorczyk took part in this working group

some indications that being in a group confers some power to pedestrians. In individual situations, the drivers' feelings may be more diverse.

Drivers are not always aware of the risk they can generate to unprotected road-users, and of the amount of reaction they can expect from the latter in an emergency situation. This often contributes to delayed evasive action in a critical interaction.

The balance of power is particularly tilted in interactions involving a pedestrian and a heavy vehicle (bus, lorry). The consequences of a critical situation of this type are also particularly serious for the unprotected road-user.

4.2 Pedestrian mobility and safety and the road infrastructure

In general, little attention has been paid to the comfort of pedestrians when planning or improving roads and streets. Who is ever concerned with the fluidity of pedestrian flows? There have been very few studies of pedestrian needs in urban areas, although information could be gained by interviewing people. At the micro-level, pedestrians tend to be accounted for by engineers and planners through a simplified (and little explicit) model of the "standard walker" that crosses a street at 1.2 m/s, walks up steps of an overpass or underpass, and patiently waits at the kerb for the green sign. This takes into account neither the actual preoccupations and habits of pedestrians nor the variations of abilities and behaviour of a whole population. The pedestrians deviant from the model are usually the most vulnerable ones and the less able to cope with a critical interaction.

We still do not know much about pedestrian risk production. If, in urban areas, planners have brought some solutions to the pedestrian safety problem, it has been more through eliminating exposure than through decreasing risk (segregation schemes, re-routing vehicle traffic, etc.). Only the recent plans to reduce speeds have had that effect, as well as some traffic calming measures (see the French experimental programme "Safer cities with accident-less neighbourhoods") which work on the assumption that interactions between pedestrians and vehicles are made safer when the level of awareness of drivers can be raised through visible signals in the traffic environment.

It is to be noted that the intentions behind the implementation of measures apparently addressing pedestrian protection are not always as stated. For example, crossing facilities may be installed more to restrain pedestrian movements and limit the time when they may cross the street, thus facilitating vehicle traffic management, than to actually decrease their risk; some of the earlier pedestrian streets were implemented for economic reasons (the city centres had to become more attractive to potential shoppers) and not really for safety; etc.

4.3 Specific pedestrian sub-groups: the elderly, the disabled

There are specific safety problems with the elderly pedestrians: why are they more involved in accidents than the younger ones? Because of exposure? Observance of traffic regulations? Low motorization? Handicaps or disabilities? We have only scarce knowledge on most of these questions. Some investigations carried out in Switzerland show that exposure as pedestrians increase with age. From literature, it appears that compliance with regulations is no worse for the

elderly than for the younger pedestrians. Although driving practice of elderly pedestrians used to be low (for example, in 1978 in Switzerland, only 25 % of pedestrians over 65 involved in accidents had a driving license), it is now increasing: More and more elderly pedestrians have had some experience as a driver. Some disabilities do appear with age; in particular, decision time becomes longer. Also, attention is divided between surrounding traffic and other problems to be dealt with (stepping down from a kerb, etc.).

Road users tend to choose their traffic situations in relation to what they feel they can cope with. However, some aging pedestrians have not realised their loss of abilities and thus fail to adapt their behaviour. In addition, social disengagement of the elderly causes them to lose some of their aptitudes to communicate, which can be dangerous in traffic (when they are unable to interpret what other people will do). Improving the environment to make it easier to cope with for persons with decreased abilities should be one way to decrease risk.

Elderly pedestrians¹⁴

This paper indicates that one fourth of injured pedestrians and 60% of all fatalities involve persons of 65 years of age or older. With a 15% part in the total population in Switzerland, the 65 and older age group is well over-represented in the accident statistics. Possible causes may be

- a higher exposure for this group as pedestrians,
- a lower obedience to traffic regulations,
- less experience with motorised traffic,
- or psychological/physical handicaps that hinder effective participation in road traffic.

* Exposure has an influence; whereas people up to the age of 50 participate in traffic as pedestrians for 20 to 30 minutes, elderly spend about 40 minutes per day.

Obedience to traffic regulations does not appear to be an explaining factor, elderly even comply better than other groups.

* Elderly with a driving licence behaved more appropriately when crossing the street than those that never possessed one. Since the proportion of elderly with a licence is expected to increase steadily over time, a certain autonomous reduction in the number of pedestrian accidents can be expected without any additional efforts.

* Literature gives a lot of evidence that the psychological and physical functioning of elderly deteriorates and puts elderly at risk in complex traffic situations. Behavioural observations of 880 elderly people crossing a two-lane road and interviews afterwards indicated that sixty per cent failed to look at all although a car was approaching. The crossing of the second lane appears to be more dangerous than the first one. After crossing the first lane elderly seem to keep going in accordance with Swiss traffic regulations. *Driving too fast by car drivers and high traffic volumes were most frequently mentioned by elderly as main problems as a pedestrian.*

Elderly road users are particularly sensitive to some life quality problems. For example, walking (or driving) at night in an environment with insufficient lighting will be particularly repulsive to them, on account of both feelings of insecurity and difficulties to cope with traffic. This means decreased mobility and social life.

Elderly pedestrians¹⁵

Many studies have shown clearly that, when it comes to needs and interest that steer behaviour, all other data sets are more important than accident data. Especially the needs of elderly - as expressed by themselves - have to be analysed thoroughly in order to take decisions that really meet their needs (instead of just assuming that one does things that meet their needs, as is often the case).

It is to be noted that some disabilities start early in life or may be temporarily experienced by younger road users. Focussing on particularly vulnerable groups such as children or the elderly should not hide the fact that everybody may at some time become handicapped. Planning for the elderly and the handicapped should thus benefit everybody. Decision makers should be more aware of this!

One of the sources of temporary disability is alcohol. In some countries there is evidence that drunken pedestrians are a real safety problem, particularly on rural roads.

4.4 Pedestrian safety and other policies

Pedestrian safety is to some extent a political decision, on the grounds that “it costs”. No strong stand can be expected when there are no pedestrian pressure groups. Traffic safety is not the main care of decision-makers. For example, air pollution has been a better argument for reducing car traffic in urban areas than pedestrian safety; similarly, the traffic calming measures which have been implemented in European cities usually had multiple aims: improving safety, but also urban life (better access, less air pollution, less noise, greater quality of public spaces).

While traffic safety may benefit from policies aiming at other goals, it may also be in contradiction with some of these other goals, especially at the micro-level. For example, while public lighting tends to improve both personal security and traffic safety, underpasses under busy streets, meant to prevent accidents, are ill-used by pedestrians, partly for security reasons. While plantations may be used both to enhance aesthetics and to attract drivers’ attention to the urban quality of the area they are going through, ill-designed plantations may be a screen to visibility and generate accidents.

There is a trade-off between accidents and mobility. Accidents are not sufficient to represent the whole safety problem of pedestrians. In some particular areas, apparent safety (a low number of recorded accidents) may hide an actual loss of mobility: some walking trips are abandoned from fear of danger. The same is valid for public transport (that is often combined to walking): It may not be used if a risk of accidents is perceived by the potential users, as, e.g., may be the case for public transport (which often has to function as a complement to walking).

15

See also Ch. Chaloupka, “Elderly people as pedestrians”, in the appendix of this report

Accidents in municipal public transport⁶

In Poland, the number of people that make use of public transport is still more than three times as high as the number of people that drive their own car. The condition of public transport vehicles, however, is relatively poor, resulting in break-downs, disturbance in transport service and even safety problems. An inquiry of 203 passengers revealed that 23% indicated to be at risk in a public transport vehicle due to driver's behaviour such as careless driving, sudden braking, and speeding in curves or while overtaking. Other issues related to dangerous design elements of the vehicles such as sharp edges, lack of handgrips, and even defective doors (3%) that open during the ride at unexpected moments. 18% indicates that automatic door control would increase safety. 62% of all accidents with public transport involvement occur at bus/tramway stops. ...% on straight road sections, and ...% accidents within the public transport vehicle (right numbers in figure 1, not included). The latter group consists of jamming in the door, by falling inside of the vehicle or even by falling out of the vehicle. Passengers indicate that a better organisation and several improvements in the ergonomics and maintenance of the vehicle could help considerably to bring the public transport at a higher level of service.

The mobility system is autoregulative: people tend, as much as they can, to avoid situations they feel they cannot handle. Decreased mobility subsequently causes some loss of social life.

4.5 Goals for future action

The following goals for future action were discussed in the working group and presented to the plenum, which approved:

1 Formulate a philosophy

There is a need to formulate a philosophy under which the role and social place of pedestrians is rehabilitated. The point is to make pedestrians partners with equal rights on the roads. Principles should be specified for different social and traffic conditions (Western and Eastern European countries, less motorised countries).

2 Generate a professional culture

The main actors in road safety policies are decision-makers (administrators at the national and the local levels), engineers and planners who are responsible for creating and managing the road and traffic environment, and educators that teach or train road-users (or train future decision-makers). Their specialisation in road safety is often minimal. There is a need to generate a professional culture, based on an acceptable philosophy and therefore focussing in part on pedestrian needs, abilities and specific problems.

16

See also Rotter R. & Wontorczyk A.. "Accident impendency in the public transport system in Cracow", in the appendix of this report

3. Improve mobility and safety to improve social life

Mobility is a condition of social communication and of the fulfilment of everyday needs in our modern society. The road and traffic system is meant to provide such mobility for all road users. For equity purposes, particular attention must thus be paid to the needs of pedestrians.

4. Focus on the weakest elements of the traffic system

Improve the road and traffic system in order to facilitate the movements of the most vulnerable road-users (the elderly, the disabled) and make them safer. Such policies should not only decrease the risk of these particular groups, but also benefit all the road-users as their task will be easier and their temporary impairments better accounted for.

5. Avoid measures that stigmatise particular groups of pedestrians

Although some care has to be systematically be taken that measures aimed at other road-users should not penalise the most vulnerable groups, safety improvements for the elderly or the disabled should not result in visibly setting them apart from the rest of the population. The point is to integrate, not segregate.

6. Improve driver training

Introduce in driver training programmes more elements about interactions with pedestrians: where and when to expect them, how to manage them. Stress the role and rights of pedestrians, as well as their fragility as unprotected road-users.

7. Encourage the development of speed reducing measures in urban areas

There is a need to radically change drivers' attitudes and behaviour through all means possible. In addition to reducing accident risk, lowering speeds (and raising drivers' awareness of other road users) through environmental measures in urban areas creates driving situations which are totally different from those encountered in more classical systems providing full priority to motorised vehicles. Such policies particularly address city centres, (mainly) residential areas, and transition zones between rural and urban situations (entry to towns, city suburbs).

8. Change people's behaviour primarily through situational change

Given minimum standards of traffic education, road-users behave as well as possible. They react to situations and adapt in consequence. In spite of economic problems, changing the road and traffic system to provide road-users with adequate clues and encourage adequate behavioural changes may be the best chance of progress in traffic safety.

4.6 Research needs identified

Although "future research" is part of "future action", this area is considered as so important that it has been discussed separately and is displayed as an extra point, below.

1. Accident factors

As most of the past effort in pedestrian safety has been to reduce interactions between pedestrians and vehicles, little has been learned on how and why pedestrian accidents actually happen. Such knowledge should be necessary for further progress, particularly with regards to pedestrian accidents in rural areas or small towns.

2. Detailed exposure data

Little is known of pedestrian risk because of lack of exposure data. Some research is needed on the selection of risk indicators and their measurement according to situations and groups of road-users.

3. Pedestrian needs and requirement

More knowledge is needed on the role and importance of walking in everyday life and on the mobility requirements of pedestrians, in order to improve infrastructure and traffic planning and management.

4. International comparison

Much can be learned through internationally co-ordinated research studies on specific social and safety aspects of the pedestrian safety problems, particularly as regards the most vulnerable groups.

5. Behaviour changes

That pedestrians, particularly the elderly, adapt their behaviour to compensate for loss of abilities or difficulties to cope with complex traffic situations has been widely acknowledged, but research is needed on the phenomenon to size it and understand it better.

6. Pedestrians and the law

The legal rights of pedestrians vary from country to country and also tend to change in time (see new local regulations). To some extent, they are reflected in road planning and safety facilities. An international comparative study of the rights and role of pedestrians in traffic through laws and regulations should provide a valuable background to the study of behaviour and of the effects of safety measures.

7. Specific pedestrian facilities and how they work

There are often discrepancies between what pedestrian facilities are explicitly meant to achieve and why they have actually been implemented; also between how facilities are supposed to be used and how they actually work. More research is needed on a number of sites (pavements, crossing areas) in different traffic and legal conditions.

8. Influence of modal split and the provision of public transport on pedestrian facilities

Research is needed on global safety issues related to transport planning. How does any change in modal split influence exposure and risk to pedestrians? What about the risk in trips to or from buses or other public transport vehicles? etc.

5. Problem analysis and evaluation⁷

In the group that dealt with this topic, work focussed on three aspects that are relevant especially in connection with work in the field:

- Problem analysis (Which are the pedestrian related problems and how do we detect them?)
- Countermeasures (How do we solve these problems?)
- Evaluation (How do we find out if a specific countermeasure is the proper solution to the problem?)

The relationship between these three aspects might be displayed as follows:

A->	B->	C->
Problem analyses	Solution/Countermeasure	Evaluation

It was decided to concentrate on different methods/techniques and discuss how appropriate they are in order to understand the underlying process. By this we mean the whole traffic process. An accident does not for instance just occur for no reason at all. By studying the processes in traffic it is possible to understand why and how certain characteristics in the process can develop into and create risky situations.

It also was found necessary to discuss the methods/techniques on two different levels

- pedestrian safety
- pedestrian efficiency/comfort

We discussed the methods/techniques one by one and filled in a table like the one below for each method. The signs in the table implies how good we thought the method was to

- A) detect and analyse safety and efficiency/comfort problems
- B) suggest safety and efficiency/comfort solutions/countermeasures
- C) evaluate the safety and efficiency/comfort solution/countermeasure

++	Very good
+	Good
?	Questionable
-	Inadequate
X	Irrelevant

17

chapter is based on the summary of the working group on “Problem analyses and evaluation” by Å. Svensson. Marie-Berthe Biecheler-Fretel, Oliver Carsten, Magda Draskóczy, Herbert Gstalter, Richard van der Horst, Kirsi Pajunen, Irén Papp, Miklós Papp, Eero Pasanen, Pirkko Rämä, Arndt Schwab, Tamás Siska and Åse Svensson took part in this working group

5.1 Exposure

The question of exposure is relevant at many levels of problem analysis (accidents, conflicts, behaviour. In many traffic safety analyses it is convenient to find a risk ratio to enable the comparison between

- * different types of road users
- * different locations
- * the before and after situation of an introduced countermeasure, etc.

This is however a complex task. We do still not fully understand the relationship between risk and flow. Recent research shows that it is not as simple as assuming a linear relationship. The conflict/encounter ratio is feasible to use both on a overall level but also to differentiate between age groups like children and elderly.

The “best” parameter to reflect exposure cannot easily be decided upon. Different measures of exposure could be

- * number of encounters, e.g., in an intersection
- * time spent in traffic e.g. for certain categories of road users
- * total distance/time walking a year

Exposure data for the meso and macro level could be achieved from household interviews. The members of the household could for instance be asked about distance travelled and time spent in traffic. It could also be possible to let the members draw their route on a map for a specific trip in order to get an estimate of number of crossings. Counts are also necessary on the micro level.

5.2 Accident Analyses

Different use can be made of accident analyses, and in the group different usefulness was attributed to this type of data.

A) *For detecting and analysing safety problems, accident data analysis is often needed but insufficient.* The most appropriate way to use accident data is to use it for detecting problems on a macro level. On this level the number of accidents are usually high enough to point out problematic sections. In the table for accident analysis there is a small plus sign for detecting and defining safety problems.

B) *For the (ask of suggesting solutions (here could be situations when accident analyses is a usable tool, but perhaps not the most appropriate tool.*

C) *Very often it is necessary to wait several years before it is statistically correct to make a judgement based only on accident data.* So besides being a slow evaluation tool the time span also indicates that we do not always evaluate comparable situations, many dependent factors may have changed over the years.

It also was felt that accident analysis is not the method to use when it comes to efficiency/comfort problems, solutions, evaluation, although, being afraid of accidents influences comfort considerably. This, however, may be almost independent from “objective” accident data.

	Safety	Efficiency/comfort
A	+*	X
B	?	X
C	-	X

*) needed but not sufficient

Accident analysis can be carried out on different levels, using different methods, some of which are displayed in the table before:

macro level:	E.g., surveys
meso level:	In-depth analysis with interviews with the road users involved, Interviews, e.g., to learn about the influence of alcohol and driving; to find out what makes drivers fail to perceive pedestrians, especially children. It can very well be the case that there is a pedestrian overload, that makes it a heavy task to be a pedestrian in urban areas.
micro level:	On line observation .continuous video recording at different locations (an example of this is the study Eero Pasanen showed in his presentation); this a roach would make it possible to put accidents in relation to other variables.

Then the question was raised about accident and exposure. Is the task to treat risk or what? If we are going to reduce risk in traffic then we must agree upon a common understanding of the phenomenon risk.

5.3 Traffic conflicts analyses

The use of traffic conflicts analysis has a lot of its justification in the drawbacks of accident analysis

- Conflicts are far more frequent than accidents
- Conflict analysis is a quick tool, very useful in before/after studies
- With conflict analysis it is possible to study the whole process preceding the conflict. There is a bigger opportunity to find causal relationships between factors in the traffic process and risk.

Conflict studies in connection with the pedestrian safety problem can be performed in mainly two different ways

- Follow pedestrians in order to detect conflict points.
- Observation at specific sites.

In the discussion regarding the potential of using conflict studies the following conclusions were drawn:

- A) In the phase of detecting and analysing problems, conflicts studies are very useful
- B) Conflict studies are also useful for suggesting solutions/countermeasures
- C) There is a big potential in using conflict studies for evaluating solutions/countermeasures

However, conflict studies have no relevance when it comes to efficiency/comfort problems (although higher risks to get involved in conflicts might influence both efficiency and comfort for pedestrians).

	Safety	Efficiency/comfort
A	++	X
B	+	X
C	++	X

Pedestrian behaviour and pedestrian signal design⁸

The EU DRIVE II project VRU-TOO is targeted to the specific problem of pedestrians crossing arterial roads, since arterials account for about half of the number of all pedestrian casualties and some two-thirds of pedestrian fatalities in urban areas. The project tries to separate cars and pedestrians through the use of intelligent traffic signals. Approach is to improve understanding of the behaviour of crossing pedestrians, to identify pedestrian problems, and to produce signal schemes that are better tailored to pedestrian needs. The potential benefit of detection of pedestrians that already use crossing facilities has been examined. A greater safety benefit will be obtained by providing immediate green on arrival than by reducing waiting times for those who have already stopped. Conflicts are mainly associated with those who do not stop. Signalisation on its own does not lead to safe conditions for pedestrians.

Blinking yellow and signalised pedestrian crossings¹⁹

45% of pedestrians in the Netherlands cross against red. To introduce blinking yellow lights and to let the pedestrians decide themselves if they should walk or not means that crossing will be a legal decision instead of a law infringement in many cases. The question is, how risky such a measure is. The authors have evaluated effects of blinking yellow light at 6 intersections in Delft with the help of

Video analysis

traffic conflicts observation accident analysis

The results indicate

- that the inclination to cross outside green has been doubled
- that there has been a considerable reduction in waiting times
- that there are longer initial gaps in average, but the acceptance of short gaps remains unchanged
- that there is a reduction in serious and slight conflicts

18

See also “Pedestrian behaviour and pedestrian signal design” by Oliver Carsten and Frances Hodgson, in the appendix of this report

19

See also “Blinking yellow at signalised pedestrian crossings. An evaluation” by Wiel Janssen & Richard van der Horst, in the appendix of this report

5.4 Behaviour observation

There are a number of different behaviour studies to be carried out when it comes to pedestrian safety. Pedestrian safety is for instance dependent on

- * motor-vehicle speed
- * gap acceptance
- * where in the intersection the pedestrians cross
- * number of encounters or interactions and 50 on.

It was concluded that there should be a clear distinction between the observation of behaviour and the interpretation of behaviour. There is also a distinction between different levels of decision, namely the overall long-term strategic process and the decision taken in a single specific situation. This is important since the use of information differs between people, or between groups of people. In order to learn about the internal decision processes a more experimental method must be used.

The question of exposure is of course interesting in connection with behaviour observations, as well. Behaviour observation can be related to more micro level exposure measures than can be observed on the spot. Such an exposure measure may be encounters: An encounter is an interaction between road users when at least one of the road users adapts his behaviour because of the presence of the other. This adaptation is often mutual and includes a sequence of interactive behaviours. Behaviour observation studies usually concentrate on the behaviour of one of the partners because of the difficulties in describing mutual interactions.

The table below reflects the fact that behaviour studies can be found where this method allows a good or even a very good approach. According to such findings,

- A) behaviour observations support the detection and analysis of both safety and efficiency/comfort problems
- B) that they help to develop suggestions for solutions/countermeasures both for safety and efficiency/comfort problems
- C) that they are necessary for a sense-full evaluation of solutions/countermeasures both for safety and efficiency/comfort

Studies for detecting and measuring efficiency are for instance waiting time studies, delay time studies and route choice studies.

	Safety	Efficiency/comfort
A	+	+
B	++	++
C	+	++

The effect of different timing schemes on pedestrian behaviour at signal controlled junctions²⁰

In a field study three different signal timing schemes were compared, a conventional traffic actuated scheme, a fast mode traffic actuated scheme (pedestrians got faster green), and a fixed-time control. Based on six hours observations of conflicts no safety difference was observed among the schemes. Waiting times for pedestrians were longest for the fixed time control as expected. The fast control scheme reduced the waiting time for pedestrians at two of the three locations, whereas the number of pedestrians crossing against red increased. Signal control schemes tailored to each individual intersection function best with respect to pedestrian comfort than just simply making the control faster.

5.5 Interviews

This method can be used sensefully both on the micro-, meso- and macro level of both problem definition, development of countermeasures/solutions, and their evaluation.

micro level: A controlled way of getting to know details in different situations. Both in-depth accident analyses and conflict analyses could benefit from interviews with the road users involved. In combination with accidents it is however clear that factors like blame and fault can play an important role in the way people answer. This is however not a problem when interviews are made with road users involved in a conflict. Field studies indicate the opposite, it can put valuable information to the understanding of how and why risky situations occur.

meso and macro level: For the overall planning, for the analysis of mode and route choice of different groups. More favourable for efficiency studies than for safety studies.

The following scheme reflects the efficiency of interviews as a method in connection with our problem area on all levels:

	Safety	Efficiency/comfort
A	?*	+
B	?	+
C	?	+

*) in combination with other methods

20

See also “The effects of different timing schemes on pedestrian behaviour at signal controlled junctions” by Kirsi Pajunen. in the appendix of this report²⁰

Children's street crossing strategies - an observation technique²¹

In this part of the project, the goal was to find out which are the most relevant behaviour variables of children in traffic. In studying essential variables there were two important points of view:

* Children's behaviour should not be examined in isolation from its environment. This means both the traffic and the social situation of the children.

* Increasing attention should be paid to the children's own thoughts and rationality.

A new method for investigating children's behaviour when they are crossing a street was developed in the study. The method involves making video-recordings of children and traffic situations and two interviews with the children. The first interview took place immediately after a child had been filmed crossing the street, the other on the following day in school. Each child could then first watch his/her behaviour when crossing the street the previous day on the video. The child was encouraged to freely comment on his/her own behaviour and thoughts. After that, a more structured set of questions was presented.

5.6 Mathematical modelling

A mathematical model is useful as a prediction tool. Different situations can be simulated and the result is an estimate of the accident outcome. On a micro level specific interactions could be interesting to simulate. The problem is that the outcome of such a model would be very general. It would not be possible to predict individual behaviour. These models work with aggregated data

To be able to set up a satisfying model, the variables that influence the accident outcome must be known. Is there a common understanding of which these relevant variables are? There are a number of questions to be answered. Do we for instance model the pedestrians to arrive randomly and cross randomly? Speed influences accident rates and injury rates. To what extent? What speed? The average speed or the 85 percentage? Analyses of the video recorded accidents shown at Eero Pasanens presentation suggests that the most interesting speed is the speed of free flow vehicles (that are not part of a queue and the speed of which is not directly influenced by other vehicles, thus). These were the vehicles most often involved in accidents with pedestrians.

A) Could a model be helpful in the analysis of a problem? The question is; where do we have a problem? A more thorough screening should take place at sites where we have a higher accident rate than could be expected from the model.

B) Solution: What can we expect in terms of accidents/conflicts/behaviour if we change the geometric design (if a zebra crossing is introduced for instance)?. Gradually different solutions can be "tested" systematically with the help of mathematical models.

Oliver Carsten told us about a model developed in a DRIVE project called VULCAN. This model is route-choice based and the choice of route depends on delay which for instance depends on the signal timing, layout and S0 on. Then there are different safety aspects for different routes.

21

See also "Children's street crossing strategies - an observation technique" by Pirkko Rämä, in the appendix of this report

Miklós Papp suggested a mathematical model that expressed safety in terms of number of accidents, conflicts, encounters, complaints with number of pedestrians as the denominator.

In the group discussion it was pointed out that the number of pedestrians can not be the best denominator in a safety equation. That should instead be some measure of safe interaction between cars and pedestrians, e.g. “encounters”. It was also agreed that this certainly needs more discussion in the future.

	Safety	Efficiency/comfort
A	+	+
B	++	++
C	?	?

Traffic simulation in pedestrian safety research²²

Keeping speed limits of 40km/h in the city centres leads to reductions in death toll of up to 1/3. At the same times, travel times increase only to a very low percentage. Such speed changes can be illustrated nicely with the help of simulations (HUTSIM). Analyses of accidents on video show that the main problems “construction” consists of free vehicles (= single vehicles that are not in queue) driving fast combined with pedestrians who make errors, though, not consciously. Pedestrians in most of the accident cases in Helsinki behaved headlessly. Especially in connection with children it can be said that not bad assessment of vehicle speeds is the problem but their impulsiveness. Drivers do not feel any risks, biologically, when confronted with pedestrians and when driving at their own chosen speed. Thus, they have difficulties to reduce speeds consciously by themselves. This means that speeds must be reduced by force. What can be done to console car drivers is, however, to make speed reducing measures less painful for car drivers.

5.7 Controlled experiments

Here it was agreed that controlled experiments could be very useful for understanding the process and defining the problem to be analysed. It could be possible to define hypothesis from data in real traffic. One could test these hypothesis in a controlled experiment and then return to real traffic in order to implement a tested countermeasure in order to see how it turned out.

Controlled experiments can be carried out

- in the laboratory
- in the field

Both kinds of experiments can be of different level of depth (from observing behaviour to measuring physiological indicators)

²²

See also “Traffic simulation in pedestrian safety research” by Eero Pasanen, in the appendix of this report

	Safety	Efficiency/comfort
A	++	++
B	+	+
C	?*	?

*) the question-mark is regarding the validity of controlled experiments

5.8 Activities considered as most important for the (near) future

The working group identified several activity areas that should be dealt with (more) in the future, and the ideas were presented to the plenum

5.8.1 Better use of video-recording

Projects with the aim to combine the different safety evaluation methods should be carried out. With the help of video recordings, possibly including image processing, it would be possible to do a joint data collection. Then, each and every partner involved in the project would be able to carry out his/her own analysis. At the end results of all the different types of analyses involved could be integrated.

5.8.2 Improve task analysis

It is necessary to further elaborate on how pedestrian traffic and pedestrian interaction with other road users and with the environment should work.. The goals to be achieved by better planning should be related to safety, comfort, and efficiency. Critical elements of behaviour; international communication (or encounters, as they have been called before), errors and violations have to be defined or operationalised with these goals in mind.

5.8.3 Improve registration of pedestrian conflicts

Further studies have to be carried out to learn more about the relationship between conflicts with pedestrians involved, and the “real” risk they reflect.

6 Conclusions

This report summarises the discussions and presentations of the ICTCT workshop held in Prague in October 1994. There, it has been tried to discuss the situation the “pedestrian” is in in today’s road traffic.

6.1 Problem identification and definition

The analysis of this situation aimed at identifying problems connected to walking. It was generally agreed upon that there have to be certain preconditions in order for people to be prepared to walk to a larger extent. *Among others, this is an important point because in many countries and cities - at least in Europe - efforts are made to reduce the speed with which car traffic increases. To achieve this, people have to be prepared to accept alternatives, and, e.g., walking could replace short car trips, or, in connection with public transport, even longer ones.*

However, in order for people to accept it as an alternative to car use, the preconditions for walking have to be attractive enough. It has not been studied in detail, yet, what preconditions have to be fulfilled so that walking is really experienced as an attractive option by different groups and people in society. *But generally, one can assume that it should be safe, comfortable (i.e., not more difficult than absolutely necessary in a physical sense), and not too time consuming, and the people who walk should be led through an esthetically attractive environment.*

As life and traffic in the cities consist of a large number of different activities, including traffic participation in different forms, monofunctional solutions do not work. When analysing the situation of the pedestrians, identifying problems, and looking for solutions, therefore, one has the difficult task, to consider different people, groups, needs, interests, functions of structures (e.g., laws, regulations and habits) and infrastructures, etc.

Clashes of interests are to be expected and a general way to solve problems will be to find compromises. This is a very complicated task, and this means that the basis for decisions has to be sound. *I.e., what different people and groups want and need in order to co-operate to a satisfying degree - so that traffic planning becomes more than just a hazard game - has to be studied thoroughly.*

6.2 Problem location

The working group that dealt with the problem-location question listed *) *developing countries, *) big cities (accidents), *) rural communities (fatalities) and *) low income of families as main locations or contributing factors on the macro and or meso level.*

On the micro level *) *high-speed drivers and *) motor vehicle speeds in general, *) central business districts of the cities, *,) residential streets (children) and *,) junctions and intersections* were named.

A very interesting conclusion was that ***the overall problem is the fact that car drivers set the scene for other road users.*** One example from the micro level (see above) is a highly overspeeding driver: As the car moves along the street network other drivers and especially vulnerable road users immediately have to react defensively in order to maintain their safety and health. *The car drivers can force the situation in their favour by various means, and one of them is speed.*

6.3 Policy goals

The working groups and the plenum implicitly agreed upon the goals for further work, both scientific and practical, in connection with walking:

- One conclusion of all the arguments listed above is ***that car speeds have to be controlled better than they are today.***
- A more generally formulated goal is *to improve the quality of life in the society by improving that of pedestrians.* This means that we should aim for improving the pedestrians'*) mobility, *) safety, *) feeling of safety.
- Those people who have no other possibilities than to walk (many elderly, children, youngsters) should have *sufficient mobility so that they can maintain their social networks*, and participate in their normal activities without any needs for special solutions.
- The subjective safety of pedestrians (and of course that of other vulnerable road users) should be at least on the same level as that of car drivers and passengers. *) On the macro and meso level, *the feeling of unsafety should be so low that it does not affect the pedestrians' mobility nor cause any anxiety on their part.* *) On the micro level, *a certain feeling of unsafety might be beneficial to the objective safety of pedestrians, by making them attentive in risky road and street environments.* (This means of course, on the other hand, that streets and environment have to be designed in the objectively safest way).
- Last but not least, a goal is *to improve pedestrians' general role in transport policies, planning, engineering, product design, etc.* This would ensure in the long run that the safety and mobility requirements of pedestrians are fulfilled.

6.4 Recommendations

6.4.1 Recommended steps of future action

The working group dealing with problem types and their appearance arrived at some conclusions that are actually a continuation of what has been reported so far. The following *steps of future action* were listed:

- 1 ***Formulate a philosophy*** (There is a need to formulate a philosophy under which the role and social place of pedestrians is rehabilitated. The point is to make pedestrians partners with equal rights on the roads. Principles should be specified for different social and traffic conditions (Western and Eastern European countries, less motorised countries).
- 2 ***Generate a professional culture*** (The main actors in road safety policies are decision-makers [administrators at the national and the local levels], engineers and planners who are responsible for creating and managing the road and traffic environment, and educators that teach or train road-users [or train future decision-makers]. Their specialisation in road safety is often minimal. There is a need to generate a professional culture, based on an acceptable philosophy and therefore focussing in part on pedestrian needs, abilities and specific problems).
- 3 ***Improve mobility and safety to improve social life*** (Mobility is a condition of social communication and of the fulfilment of everyday needs in our modern society. The road and traffic system is meant to provide such mobility for all road users. For equity purposes, particular attention must thus be paid to the needs of pedestrians).
- 4 ***Focus on the weakest elements of the traffic system*** (Improve the road and traffic system in order to facilitate the movements of the most vulnerable road-users [the elderly, the disabled] and make them safer. Such policies should not only decrease the risk of these particular groups, but also benefit all the road-users as their task will be easier and their temporary impairments better

accounted for).

- 5 ***Avoid measures that stigmatise particular groups of pedestrians*** (Although some care has to be systematically taken that measures aimed at other road-users should not penalise the most vulnerable groups, safety improvements for the elderly or the disabled should not result in visibly setting them apart from the rest of the population. The point is to integrate, not segregate).
- 6 ***Improve driver training*** (Introduce in driver-training programmes more elements about interactions with pedestrians: where and when to expect them, how to manage them. Stress the role and rights of pedestrians, as well as their fragility as unprotected road-users).
- 7 ***Encourage the development of speed reducing measures in urban areas*** (There is a need to radically change drivers' attitudes and behaviour through all means possible. In addition to reducing accident risk, lowering speeds [and raising drivers' awareness of other road users] through environmental measures in urban areas creates driving situations which are totally different from those encountered in more classical systems providing full priority to motorised vehicles. Such policies particularly address city centres, [mainly] residential areas, and transition zones between rural and urban situations [entry to towns, city suburbs]).
- 8 ***Change people's behaviour primarily through situational change*** (Given minimum standards of traffic education, road-users behave as well as possible. They react to situations and adapt in consequence. In spite of economic problems, changing the road and traffic system to provide road-users with adequate clues and encourage adequate behavioural changes may be the best chance of progress in traffic safety).

6.4.2 Methodological recommendations

The working group dealing with problem analysis and evaluation, beside dealing critically with analysis methods used frequently nowadays, also discussed new (or "new") methods, that should be developed, or used in a more appropriate way, or used more frequently in the future:

Efficient use of video-recording: Projects should be carried out with the aim to combine the different safety evaluation methods. With the help of video recording, possibly including image processing, it would be possible to do a joint data collection. Then, each and every partner involved in the project would be able to carry out his/her own analysis. At the end results of all the different types of analyses involved could be integrated.

Elaborate on task analysis: It is necessary to further elaborate on how pedestrian traffic and pedestrian interaction with other road users and with the environment should work.. The goals to be achieved by better planning should be related to safety, comfort, and efficiency. Critical elements of behaviour; interaction/ communication (or encounters, as they have been called before), errors and violations have to be defined or operationalised with these goals in mind.

Improve techniques for the registration of pedestrian conflicts: Further studies have to be carried out to learn more about the relationship between conflicts with pedestrians involved, and the "real" risk they reflect.

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APPENDICES

MANAGEMENT FOR PEDESTRIANS and COMPLEXITY OF THE URBAN ENVIRONMENT

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There is an overall consensus when dealing with objectives such as improving safety for pedestrians, protecting children on their way to and from school, giving everyone an opportunity to walk around at leisure and the enhancement of pedestrian precincts. Difficulties only arise when technical decisions have to be made and in cases where aspects other than providing areas for pedestrians are given precedence.

The reactions encountered when dealing with this problem, are often based on matters of principle as to what an urban environment should be. Such a radical position is, of course, fully justified in that those who have no protection must be defended and, as a mass, cannot be managed in the same way as the car.

Care must however be taken to prevent the moral or ideological aspects from taking precedence over a stringent analysis of the problem. Thus, over-protecting users at risk and the quality of urban environment, may result in not seeing the complexity of the problems and their contradictions. Some projects have made use of solutions based on principles involving mode segregation and have sometimes, from a safety standpoint, proved more harmful than the problems they were intended to solve.

We should also be wary of a mechanically causal rationality based on risk measurement in decision-making. Locating housing in industrial areas reduces exposure to road risks by shortening commuter journeys and allowing people to walk to work; but may have other disadvantages. A particular example of this was seen in the 19th century, when housing was located near industrial complexes with the aim of exerting social control over the workers.

Finally, it should not be forgotten that those responsible for traffic and roads in a specific locality have to face considerable pressure when users feel highly insecure. However, many places thought to be hazardous are in fact extremely safe in accident terms, even though this may have been achieved at the expense of the well-being of the individual. To understand safety problems therefore requires the analysis to be as objective as possible, thus ensuring that the malfunctions that lead to accidents are correctly understood. This type of diagnostic is essential before any action can be undertaken.

Up until the 19th century, urban areas developed very slowly. Urban outlines are therefore the result of a slow historical process involving generally private bodies who acted according to their individual interests, and sometimes urban planners who wanted to leave their mark on the town, if only to set up new towns in areas that were for the most part of strategic importance.

Different modes of transport evolved from the second half of the 19th century onwards. They consisted of public transport using first, horse-drawn and subsequently motor-powered vehicles, the bicycle and then private cars and revolutionized urban structures with regard to both the spatial distribution of activities and the layout of the various districts. These modes of transport

gradually became available to everyone (or almost everyone). Public transport first became widely available as a result of an increase in average income towards the end of the 19th century. This was followed, in the second half of this century, by widespread car ownership, at least in industrialised Western countries.

This accelerated the historical process in urban areas, the extending of these areas (to a greater or lesser extent depending on the country) and the influence of cars on urban layout that seems to have become increasingly permanent. There is no need to emphasise the adverse secondary effects of the motor car, one of the most obvious being unsafety.

In New York in 1901, a small number of cars could be seen on the streets. The chauffeur of a car owned by HR. Root and S.H. Stern was driving along a street in the Lower East Side when he knocked down young Louis Camille, son of an Italian immigrant. As the child was playing in the street, the chauffeur was taken by surprise and was unable to avoid the accident. He was therefore not found guilty when he came before the Court. The local residents did not, however, agree. Children had been able to play in this street since time immemorial. The car was therefore an intruder. For the next five years cars were stoned and one driver killed.

But inevitably, the car became an increasingly important factor in public areas. Safety had to be improved, first by improving car design and then by organising and managing these public areas.

Working on public areas involves the use of systems that are, in fact, relatively long-established. Most are based on principles formulated at the end of the last or early in this century. However, the overall design of public space is still open to discussion and debate. The basis of this design is to take into account the various aspects of this space used by different modes of transport, for different purposes and regarded differently by those involved.

The initial response of planners to traffic problems was to segregate modes and uses. Pedestrians were given preference and provided with pavements, even though these existed well before the advent of the motor car. This segregated planning of space gradually became more widespread as the number of cars increased. Urban planners such as Le Corbusier were therefore able to advocate in the Athens Charter a strict functional classification of public highways: „Public highways should be classified according to type and built in relation to type of vehicle and traffic speed... The first practical measure would be to enforce, in congested streets, a strict separation of pedestrians and mechanical vehicles. The second would be to provide heavy goods vehicles with their own traffic lanes. The third would be to provide, in heavy traffic conditions, throughways that are separate from the normal roads used by local traffic” (Le Corbusier 1957, article 60).

In most urban models, little consideration is given to safety, although it may be referred to as one objective amongst many. Some models, however, have been developed with explicit safety considerations in mind. The SCAFT principles (drawn up in Göteborg/Sweden), illustrate an attempt to enhance safety by „separating traffic, pedestrian and bicycle flows to prevent conflict”. Segregation is usually recognised as a principle that provides access to all parts of the urban area, whatever mode is employed, by using, of course, the shortest possible terminal route.

This type of planning can only, in fact, be applied to more recent urban areas. It cannot be used for older towns. Up until the 19th century, urban planning was termed the „pedestrian city”. It is essentially in these older districts that the invasion of the private car is felt to be unacceptable. One reaction, faced with the unacceptable, was to simply ban vehicles in pedestrian precincts, a concept with limited spatial applications.

Experience has shown that planning such segregated areas is effective under certain conditions, but can only be used in limited areas. The alternative response, once these limits of segregation have been reached, is the integration of modes and functions: Woonerf in Holland with total integration, then tempo 30 - zone 30 - 30 km/h area that regulates integration by maintaining a „comfortable” environment for pedestrians. The experiment was then extended to the whole network by more „friendly” management taking into account the various uses and diversity of space. In this way, management can be extended to main streets, entries to built-up areas, roads running through villages.

The technical difficulties of this work are found not only in planning, but essentially in the conceptual analysis of space in terms of use, age, itineraries, appropriation, conflict, encounters... Unable to limit them, managing these factors has to be integrated into the complexity of an urban area, together with all its physical and social aspects. We then encounter the question of technical ability, the possibility of modelling such a system and the theoretical approach to questions regarding the graded levels of understanding.

The decision-making process is therefore obviously questionable. The various individual interests must be represented in such a process. Thus, those who defend walking are defending their own specific interests. Every individual interest cannot, however, replace an overall conception, as a system cannot be restricted to the juxtaposition of its various components.

Decision-making is a process which involves constant revision and the consequent re-evaluations. The planning of public areas is a never-ending task, as it must always evolve in relation to the numerous demands made upon it. It is no longer simply a question of reserving urban areas for pedestrians alone or designing them solely for motor vehicles. It therefore requires accommodating acceptable conflicting interests, making visible the movements of others and rendering tolerable the cohabitation of these various modes.

CRITERIA FOR “GOOD” TRAFFIC

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Introduction

The ideas presented in this paper were to a large part developed in conjunction with the work in the PROMETHEUS Safety-group. Chaloupka and Risser 1993 (on behalf of the Austrian Research Fund) should produce a concept for the evaluation of new technology with adequate weight on human needs and interests. One main idea: The fact well known to sociologists that very often different interests of different groups have to be considered, and that different groups interests tend to be contradictory rather frequently should be respected, if the frequently-quoted „human factors” should be taken into account more fully and more carefully in all work in connection with traffic.

Theoretical framework of the research

The theoretical framework presented here deals critically with the factors that steer road safety work, from a psychological and social-scientific perspective. Arguments lead to the conclusion that to-day’s practice makes that the probability for an erroneous weighting of different population groups needs and interests increases - simply because too little is known about these needs and interests.

At the same time, everybody who makes decisions that are relevant for the public does so (at least overtly) with the goal to contribute to the public’s well-being.

Summary 1 shows the possible structure of the factors which (should) govern studies - not only traffic psychological - in connection with road traffic problems and be part of an iterative process, and which often are neglected:

Summary 1: Motives for measures in connection with road traffic

A: „VECTORS”	motives: requirements: interests, needs	motives for measures assumption or establishment of requirements, particular needs, legitimate interests
B: MEASURES: new roads	new equipment	modification of existing roads and equipment
C: CONSEQUENCES, „SUCCESS”:	REACTIONS AT THE „OVER BEHAVIOUR” LEVEL	SATISFACTION, DIS- SATISFACTION, FRUSTRATION, FEAR

Variables A

The variables and aspects listed in section A of summary 1 have been called „vectors” in analogy to the term „vector” in physics, which describes a force and its direction. This can be understood as follows in connection with the present discussion: The justification (= force) employed and the direction chosen by those persons or groups who are authorised to, or in a position to, prepare or achieve alterations or innovations in road traffic depends on the motives that are proved, assumed or presented as relevant (the motives for personal decisions are frequently justified by the decision-makers with the motive of social need).

„Interests” focus on objects and on activities that (will) make it easier to fulfil ones needs (in the future) - to learn, to play, to have social contacts, to be successful in business, etc., etc..

The concepts of **„needs”** focuses on those objects and activities that are necessary for individuals and/or the society to survive (and it can be added: under acceptable conditions). Both „interests” and „needs” have the power of **motives**, i.e. they have the power to motivate people to be active in some way (including complaints about a situation, and the like).

The term „requirements” is very complex. In road traffic it covers, roughly speaking, „needs” and „interests”, which are to some extent used as sub-categories of “requirement”. But authorities tend to use „requirement” as a technical term that reflects something absolute. Two examples will serve to illustrate the meanings of the mentioned terms:

- Example 1: When an authority has established the „requirement” for a new road, this is very often justified by the argument that other roads are full and that the strain should be taken off them by the new road. The authority’s motive is a requirement they have identified and they tend to treat like “one plus one is two”..
- Example 2: The introduction of new technologies – at any rate in connection with DRIVE and PROMETHEUS – is justified, somewhat tongue in cheek, as follows: road users have difficulty in coping with a certain demand which the „modern” traffic makes on them. They should therefore be supported by electronic assistance. The assumption is made that such equipment fulfils the safety requirements of the society (= the authorities must be in favour of it) and the drivers’ interests (= the purchasers must be in favour of it.) A requirement is thus created. “Car drivers do not keep long enough headway, so we develop a headway-control function” and “we suppose that they want such a function and that they will use it to keep proper headways”

The employment of the word „requirement” underlines the objective aspect of the motive side, thus: people “buy” (accept) something, or would buy it, because they need it. Why they need it, or what the consequences would be if the “desire to buy” were not satisfied, is treated as secondary. Plenty of modern market thinking is contained in this approach: when the production of a good has not taken place with the assistance of illegal behaviour (theft, deception, etc.) and does not suggest or encourage illegal behaviour, and as long as the good is not itself illegal (e.g., forged bank notes), anything can be produced and offered for sale that the customer will buy (= for which a requirement exists). [It has to be added: Goods are produced to make money. However, it will

be difficult to identify anybody who will make money by supporting pedestrian friendly policies. Such areas are usually covered by the authorities].

„Needs” and „interests” refer more to the subjective aspects of a requirement, and more to the values linked to them, as will be shown in the next section.

Here follow some definitions from dictionaries and university literature:

- *motive*: the shortest definition, that nevertheless seems complete, is to be found in Witte (1989). According to him motives represent „the emotional responses with respect to the combination of situational indication stimulus and inner state”.
- *needs*: these represent the - more or less reflected - wish to produce a particular inner or outer state.
- *interests*: the term describes the wish to produce a particular inner or outer state, as defined under „needs”, but at a more strategic level. The aspect of the intellectual consideration of the advantages and disadvantages of particular courses of action, particular results and the methods to achieve these results is more heavily emphasised here. It is not always possible to distinguish in detail between the two terms.

Variables B

The variables in section B include all kinds of innovations, changes and additions from the local to the international level, in all areas of the system society-[human being]-machine-road (see e.g. Tofote 1992).

The measures which will be of interest for all colleagues working with traffic safety are, e.g., those planned and tested in the 4th Framework programme of the EU.

Variables C

The variables in section C include the consequences of measures at the psychological and social level: satisfaction, dissatisfaction, frustration and similar reactions and their meaning for visible behaviour (overt behaviour), which is relevant for the social system road traffic. What problems can be created when a young person is very satisfied with a product, and uses this product with all his youthful enthusiasm, is well-known to every road safety expert if the word „product” is replaced by the words „motor vehicle”.

When discussing those factors included under the general heading „consequences”, one should perhaps mention again that these should also be regarded as vectors. A high degree of satisfaction with the product „motor vehicle”, for example, with all new equipment and with the available infrastructure is the precondition for the further or even increased use of this product. This then generally creates something which is measured or identified as a requirement.

Analogously, a low degree of satisfaction when walking, due to lacks of safety and comfort, due to communication problems with car drivers, etc. (see Praschl et. al. 1994), will have a low use of the „product” as a consequence.

The importance of psychological and social scientific research on road traffic

It is important to regard summary 1 as a course of action, since satisfactory and promising measures can only be derived from an unambiguous identification and description of the vectors. This is also true for the field of evaluation: our knowledge about the motives, interests and needs of various groups and individuals and the degree of their satisfaction with or frustration by various measures can be improved by a careful evaluation of measures.

Problems on the vector side

Which are the problems contained in the process displayed in summary 1 that make traffic psychological studies and research necessary? These problems are depicted in a very general form, by means of selected examples, in summary 2, and will be discussed below.

Summary 2: Problems on the “vector” side. Selected examples

REQUIREMENTS:
RELATIVELY OFTEN SIMPLY ASSUMED, USUALLY TECHNICALLY” JUSTIFIED AND NOT FURTHER QUESTIONED:
CLASSIC MISTAKE: REQUIREMENTS WHICH ARISE SOLELY DUE TO THE LACK OF ALTERNATIVES ARE OFTEN NOT RECOGNISED
REQUIREMENTS, INTERESTS AND NEEDS ARE GENERALLY NOT AS UNIFORM AS THEY ARE REPRESENTED TO BE
INTERPERSONAL CONTRADICTIONS/CONFLICTS (ALSO BETWEEN GROUPS) - QUESTIONS OF POWER AND OF REPRESENTATION ARE IMPORTANT HERE; WHO GETS THEIR WAY
INTRAPERSONAL CONFLICTS/CONTRADICTIONS ARE OFTEN NOT RECOGNISED - THERE ARE DIFFERENT WISHES WITHIN ONE AND THE SAME PERSON OR GROUP

There is very often a lack of satisfactory collection of information on the vector side. The requirements for particular measures, as can be seen in summary 2, are frequently simply assumed.

Two examples:

- a) Traffic authorities, which enjoy no direct financial benefits (income) by basing the introduction of their measures on comprehensive motive research, often “forget” this. In the place of such research traditional assumptions are repeatedly employed as vectors: [full roads] = [signal that new roads are needed] or: [no pedestrians visible] = [nobody wants to walk anyway]
- b) Particularly in connection with new equipment another example has to be repeated: this refers to the assumption that road users require new equipment in order to be able (at last?) to cope

with particular tasks correctly and safely (e.g., “obstacle detection” where in parenthesis “pedestrian detection by night, on rural roads” is often added without saying).

In connection with these two examples, one can say that the requirements for new roads or new equipment should not only be investigated technically (in the sense of the employment of research techniques), but also more frequently systematically questioned.

on a): If the roads are constantly full, this can also be a sign that alternatives are lacking, not known, or not accepted well enough.²³ The interesting question is: What do the road users know about (potential) alternatives and under what conditions would they be prepared to make use of them?

on b): Given that particular kinds of traffic behaviour have only changed very slowly up until now, one should not try to avoid the question as to why the road users persist with this behaviour. Which needs or interests are being pursued here? All kinds of measures can only become effective if the behaviour that the suppliers are hoping to achieve on the part of the road users still allows the road users to follow the same interests that they have previously been following, or if the satisfaction of these interests is replaced by the satisfaction of others.

An alternative is that a change produces particular new values: that, in other words, the satisfaction of particular needs (for example the aim of achieving physical sensations with the help of speed, e.g., „sensation seeking”, see Berger, Bliersbach & Dellen 1976) and the pursuit of particular interests (for example a time saving of the order of a few minutes) are no longer regarded as so important but, instead, life quality one can achieve when walking in the city.

From a sociological perspective the following is also well-known: *opinions amongst the population concerning motives are virtually never and to virtually no theme uniform.*

In addition to the individual needs and interests and the extent to which these differ between various individuals and groups, two types of precondition are interesting as preconditions for the development of methodological guidelines for studies and research in traffic psychology and traffic sociology:

Intra-individual contradictions

It has already been said that the needs and interests of groups and individuals are generally not as uniform as they are taken to be when measures are justified. Praschl et al. (1994) and other authors have provided clear evidence for the claim that road users would act more sensibly than is currently customary in some cases, provided that it was guaranteed that „the others” would also act sensibly. Paradoxically, measures that cannot be ignored or avoided by the road users (unavoidable motor vehicle bans, speed limits, etc.) are regarded as good or even demanded by a surprisingly high proportion of the affected groups.

There is also a dialectical relationship between the need for safety and certain „extra motives” (according to Sauli Häkkinen) such as the demonstration of one’s own capabilities, unrestricted movement, the enforcement of one’s claim to power and the like: a larger safety margin makes it

23

“Alternatives are lacking” can mean that they are lacking in a physical sense — that they are simply not there -, but also that they are not available in a sufficiently attractive form, etc.

possible to gain greater enjoyment by the experience of these extra motives. Whether this is in the form of a long walk after work, relaxing, „clearing one’s head”, a little shopping, drinking a beer, or in the form of a dynamic or even a relaxed drive home is, depending on how many people choose each of the various alternatives, a great difference.

Which of the alternatives one chooses is not least dependent on the traffic infrastructure (which may for example make walking easy and enjoyable or not), and to what extent, spread over the road network, a dynamic or even a relaxed drive home in one’s ear is in fact possible. The latter makes walking more difficult, even when so many people undertake ear trips at the same time that traffic jams are the consequence.

Inter-individual conflicts

The above makes it clear: the measures desired by one group of road users (take for example confirmed ear drivers, who are well represented in the society: e.g., by clubs, industry) correspond in no way to the wishes of other groups (for examples local residents, cyclists, children and the youth) and can even be in direct opposition to them.

In accordance with the way in which group divisions are chosen, one is concerned with groups with varying political power: one need only compare the difference in social power between adults between 30 and 65, children and the youth, and people over 75.

Industrial companies which sell particular products generally aim at particular groups. When it is possible that the use of these products by the target groups could have a negative effect on the safety and the quality of life of other groups, society generally instigates counter-measures in order to prevent such disadvantages. A risk must however first become apparent. A strong group that feels itself to be disadvantaged will manage to make itself heard with its eau for justice. If the disadvantaged group is one with little social power, however, which has difficulty in making its voice heard (one need only think of the slogan „children have no lobby”), the danger exists that this group will be „forgotten”.

A difference to physics becomes apparent here: if a force is forgotten in a physical experiment, this becomes apparent very quickly. Such „forgetfulness” often has no immediately visible consequences in psychological and social scientific experiments. The expert must assist here, in part by drawing attention to hidden or long-term consequences that could prove to have a negative effect on the whole system. This can be regarded as a moral question, if one wishes.

Problems on the evaluation side

The situation on the evaluation side is not very different to that on the „vector” side: whether measures are effective (which must mean: whether they have the desired consequences) can only really be established when at least two aspects are taken into consideration. a) The desired consequences must be defined and b) one must have methods with which one can establish whether the desired consequences have been achieved.

Summary 3 shows, in simplified form, which faults are common in relation to evaluation work:

Summary 3: Frequently encountered faults in evaluation

a)	FREQUENTLY NO EVALUATION
b)	PROBLEMS OF OBJECTIVE EVALUATION
c)	FREQUENTLY NO EVALUATION AT THE LEVEL OF ACCEPTANCE
<p>Is there a lack of safety or not; which possibilities of giving free rein to irrational tendencies are there? etc.</p> <ul style="list-style-type: none"> • Aspects of acceptance → Effect on behaviour • Acceptance by groups with little social power 	
d)	LEGITIMACY OF VALUES ASSIGNED IS OFTEN NOT FULLY DISCUSSED

on a) It is well-known that measures are frequently not evaluated. One must nevertheless emphasise (e.g., in relation to PROMETHEUS and DRIVE), that considerable efforts are indeed being made here to evaluate the consequences of the introduction of new technologies in road traffic. In the course of this evaluation, however, a historically developed lack of ideas of what should be evaluated has become well visible (see on b below).

on b) So-called „objective” evaluation has a major disadvantage, especially in the field of road safety: in order to obtain data that are traditionally regarded as objective, namely accident statistics, one must first wait until accidents occur. It would naturally be desirable, however, to attain an acceptable level of safety before a statistically meaningful number of accidents have taken place. This approach is common in the fields of safety at work, air safety and rail safety. A process of rethinking seems to be taking effect now in the field of road safety in conjunction with the introduction of new technologies: *new equipment has no “accident history”*

At the same time, public opinion has become more critical: accidents which are seen to be related to new equipment in any way could seriously affect the reputation of the motor vehicle industry and its suppliers. One has therefore begun to employ alternatives to accident analysis which were previously not regularly employed for safety evaluation. The difficulty here is that little experience with the employment and particularly with the quantitative evaluation of such methods has so far been gained. Regular use should reduce this problem in the course of time, however.

on c) Another type of evaluation problem is much more closely related to those discussed under vectors above: although there is general agreement that extra motives play an important role in road use with motor vehicles, virtually no research has been carried out on questions such as the extent to which satisfaction with a product can be based on the fact that one can satisfy irrational needs with it. Take for example the case that certain equipment makes it possible to take curves particularly fast. Someone who likes to demonstrate how well they can drive and who discovers that certain preconditions make this possible, will make use of this fact.

The acceptance aspect must also be seen from the point of view of whether someone can be a user of equipment or not. New technologies in the form of equipment for motor vehicles offer vehicle drivers the choice of buying such equipment (or not); the producers will of course carry out marketing activities to influence the desired purchasing pattern.

Unprotected road users are confronted with the new equipment and the related behaviour, however, without being offered a choice unless of course they decide to no longer use the roads in order to avoid a changing situation that they cannot cope with. When one takes into account that between 50% and 90% of the population of the Western and Central European countries live in an urban environment (Fischer Weltalmanach), and that in consequence a large proportion of the traffic activity takes place in modal mix areas, and an even larger proportion begins and ends there, the dimensions of this „being exposed without being asked” become clear.

A perceived lack of safety is identified exclusively on the part of the unprotected road user (Laroche-Reef, Ahrens, and others). Such subjective lack of safety leads to the expectation of avoidance behaviour, for example on the part of senior citizens: one gets into a car, lets oneself be driven, lets the car drive one; or one reduces one's own mobility when one has no access to a car either as a driver or a passenger (or has no driving licence) - which is often the case with older people.

Another aspect of the limited acceptance of particular measures on the part of unprotected road users is the following: in the event that the employment of an item of motor vehicle equipment produces disadvantages for pedestrians, they will presumably attempt to compensate for these disadvantages in some way. Take the case that a certain item of equipment - for example a guidance system in motor vehicles - produces a higher traffic density on side roads that otherwise carry little traffic: if the gaps in time between the passing motor vehicles become too short, because the traffic is too heavy, the pedestrians will become impatient at having to wait so long before they can cross the road. This in its turn will increase the probability that shorter - and consequently riskier time intervals will be chosen, if walking is not given up at all, there.

on d) A last point that should be discussed in connection with evaluation problems is the legitimacy of the assignment of values to particular measures. Many persons - whether experts or not - tend to react to cases of a conflict of interests between various groups in traffic by retreating to the position that the reconciliation of the conflicting interests is a purely political question (and consequently - in brackets - not amenable to scientific analysis). This is not entirely acceptable. In laws, for example, (and even in the constitution) priorities in terms of different values are certainly present. The bodily integrity of the individual is accorded a very important position. One need only consider whether someone is causing a danger to life and limb, and the extent to which others are affected by this, in order to have a method of determining whether a state of affairs in road traffic is acceptable or not.

It appears that the attempt is often made to increase safety by persuading or compelling (groups of) road users to relinquish particular advantages for the sake of safety. This must be clearly stated by the authorities in order to make it transparent. Further questions must presumably also be clarified within this context - in terms of basic traffic policy decisions. The following two issues can be seen as central starting points:

1. It appears legitimate to demand that someone should renounce advantages when their *enjoyment of these advantages represents a danger for other* & In the case of protests by car driver representants against traffic limitation measures in densely-settled areas, for example, one must look very closely at the interests that are being defended by the car user side and the interests of other groups that are opposed to these.
2. It appears illegitimate, on the other hand, to demand that someone should renounce advantages *because they would otherwise be endangered by others*. To demand of pedestrians or cyclists that they make wide detours and accept disadvantages in the infrastructure, or even remain at home, simply to be safe, appears to be absurd.

When one has worked for a long time in the field of traffic, one cannot avoid the impression that the demands under a), represented as legitimate, are hardly ever made and even less often achieved, while the mistakes defined under b) are made regularly.

The relationship between vectors and evaluation: An example

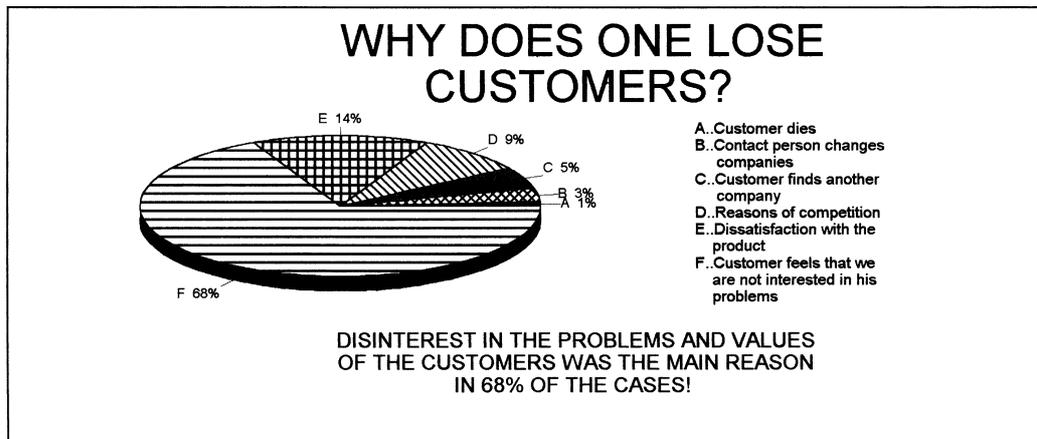
The relationship between the vector and the evaluation sides is illustrated by the following diagram, which summarises the results of a study conducted by the Swedish company Asea Brown Boveri. The study was essentially concerned with the identification of what have always been referred to as „vectors” in the present paper. The question asked was: „Why does one lose customers?” A survey was then conducted amongst customers who had changed the company from which they obtained particular goods or services. They were asked to choose from a number of alternatives the one which most nearly applied. The alternatives had been selected on the basis of pre-tests.

The most important result (see summary 4): the feeling that „a company” is not interested in the customer’s problems is the main reason why customers change companies. „Problems” in this context means no more than that particular expectations of the customer are not recognised and in consequence not fulfilled.

A result such as that in summary 4 can be very effectively applied to the field of traffic planning: in connection, for example, with the question as to why a partial shift of road traffic to public transport, footpaths and cycle paths is much more difficult to achieve on a voluntary basis than many local government politicians would like to believe. One could learn from the automobile industry here, which has always looked after its customers very well.

It also appears important in this context, in a time of changing values and interests, not to cling to traditional judgements and results uncritically. A high degree of sensibility is essential amongst all persons and institutions who have something to offer in the traffic sector. It is necessary to recognise a change in the customer’s problems as early as possible.

Summary 4: „Why does one lose customers?“



When authorities want to „do something for pedestrians“ they are addressing at least two target groups:

1. those who only walk as much as absolutely necessary, and
2. those who already today have the habit to walk frequently.

It seems reasonable to believe that authorities want to convince those, who do not walk yet, to walk more, and to assure those, who already walk a lot today, that they are doing the right thing (although we have not asked decision makers systematically about this case). They (decision makers) should have Summary 4 in mind.

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PEDESTRIAN SAFETY IN THE FIRST NATIONAL SAFETY PROGRAM IN CROATIA

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On June 17th the Croatian Government announced the National programme of road traffic safety for the next two years. Its general goal is reduction of road traffic accidents and all their consequences.

Why a programme?

The road traffic situation in the country is very bad despite the trend of decreasing traffic deaths since 1990. In comparison to western European countries accident risk and dominantly fatal accident risk is 5 to 7 times higher here and that is regarded quite unacceptable especially concerning all ambitions our country has in becoming a touristic one.

It is a country of 56 000 km², of 4.7 million inhabitants, about one million registered motor vehicles and 1.2 million drivers licences.

The length of the road network is ca 30 000 km, is mostly asphalt and concrete and the yearly number of all accidents is ca 60 000, with an increasing trend. The number of injured, slightly or seriously is about 17 000, and the number of traffic deaths is still higher than 800 per year.

All of this data is seen in the following figures; (Fig 1 to 5).

The predominant type of accident is side-collision with a frequency of 20%. The second one is rear-end collision and head-on. Only 5% of accidents are vehicle-pedestrian type and a third of all road accident fatalities are caused by this type of accident.

The figures as well as (almost) all the others have to be changed according to the announced programme.

Because of the main problem areas that are recognised as:

- too high speeds of the vehicles,
- too short distances between the vehicles,
- bad traffic environment entirely and especially at the certain spots,
- low level of traffic culture and red light discipline,
- unsatisfactory accident information system,

the safety programme relies upon the next strategical safety activities:

- reducing the speed and obedience of speed limits,
- pedestrian safety,
- black spots treatment, and
- improvement of accident information system.

Fig 1

C R O A T I A

CHARACTERISTIC FIGURES

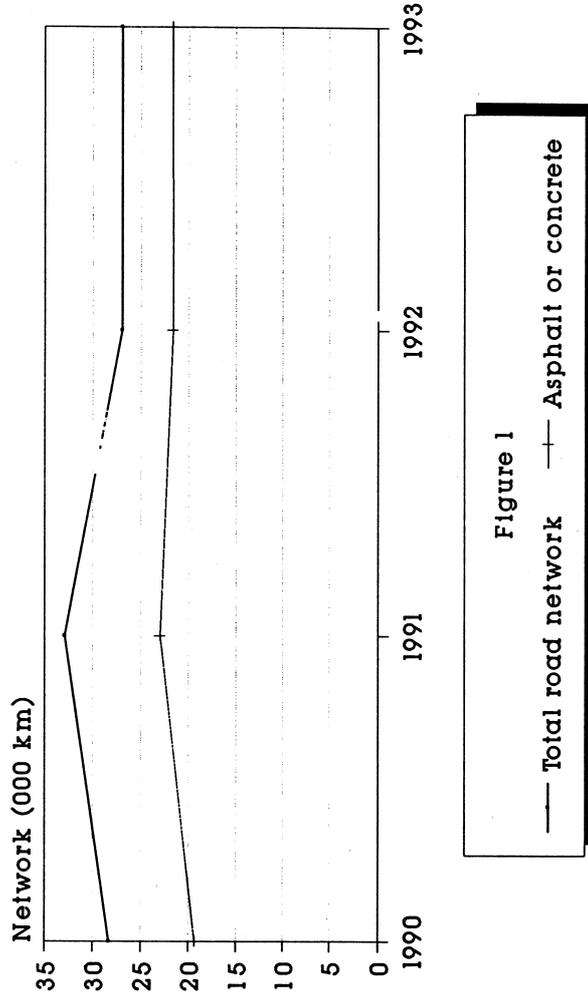
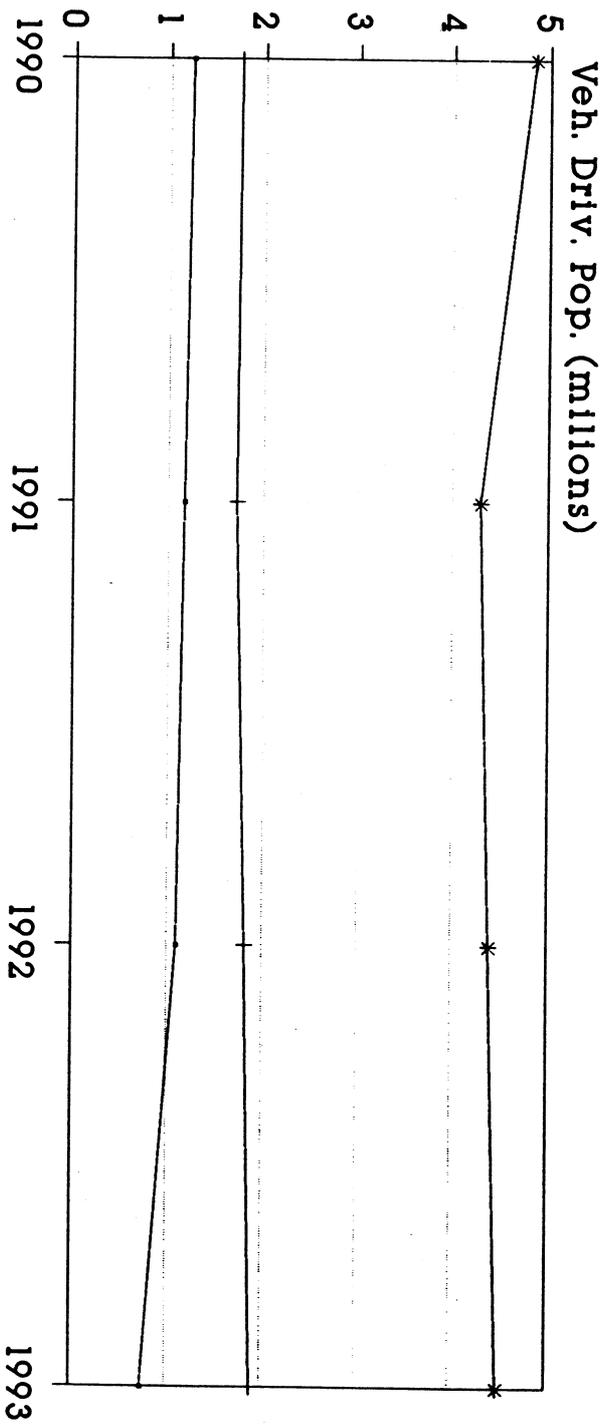


Figure 1

C R O A T I A

CHARACTERISTIC FIGURES



Registered vehicles — Drivers —*— Population

Figure 2

Fig 2

Fig. 3

C R O A T I A CHARACTERISTIC FIGURES

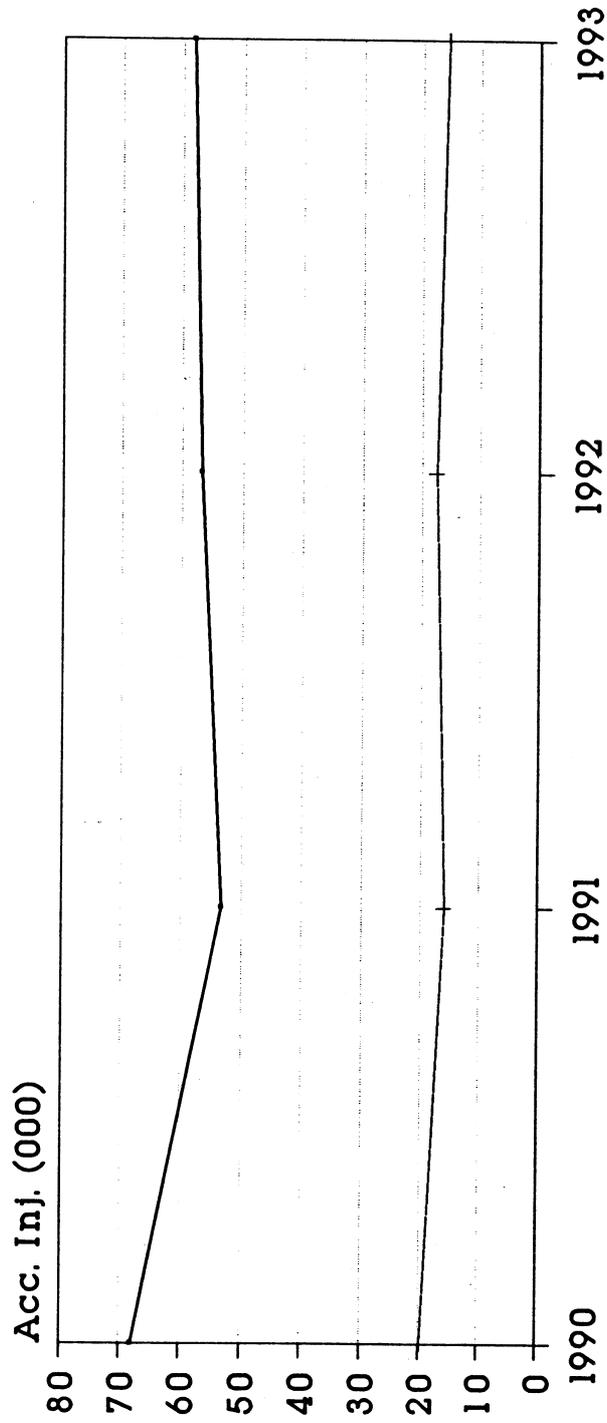


Figure 3
— Accidents — Injuries

TRAFFIC ACCIDENTS SEASONAL VARIATIONS

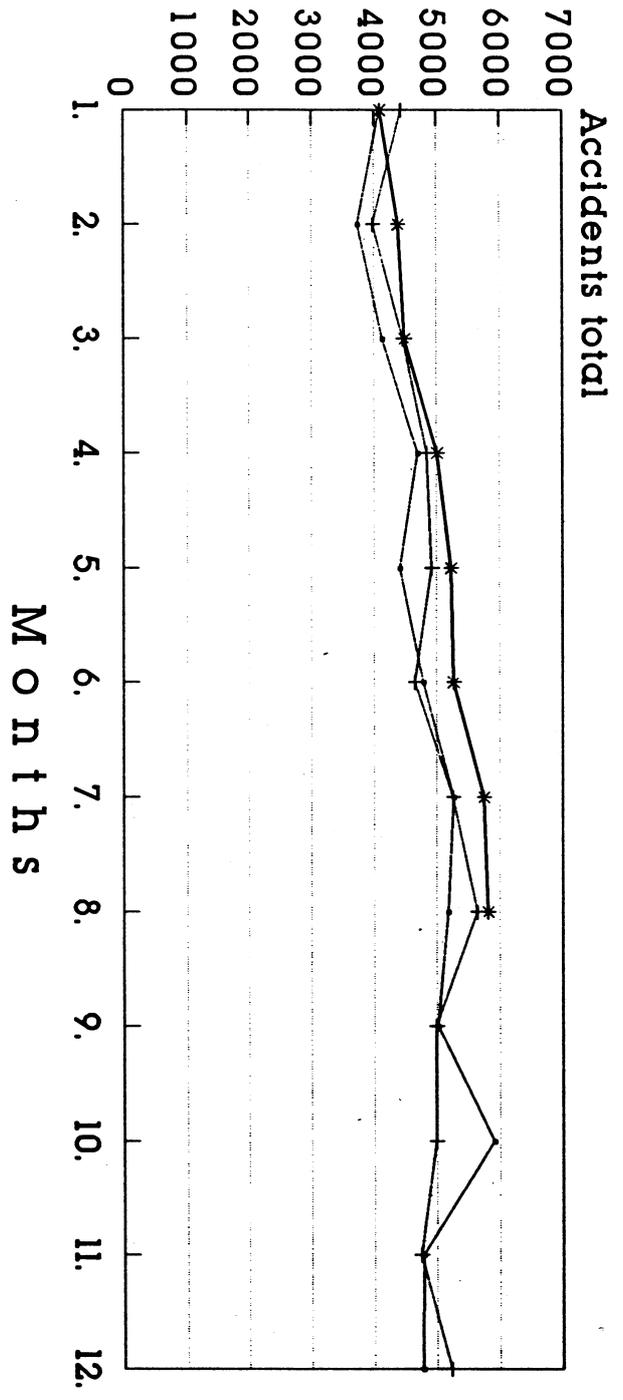


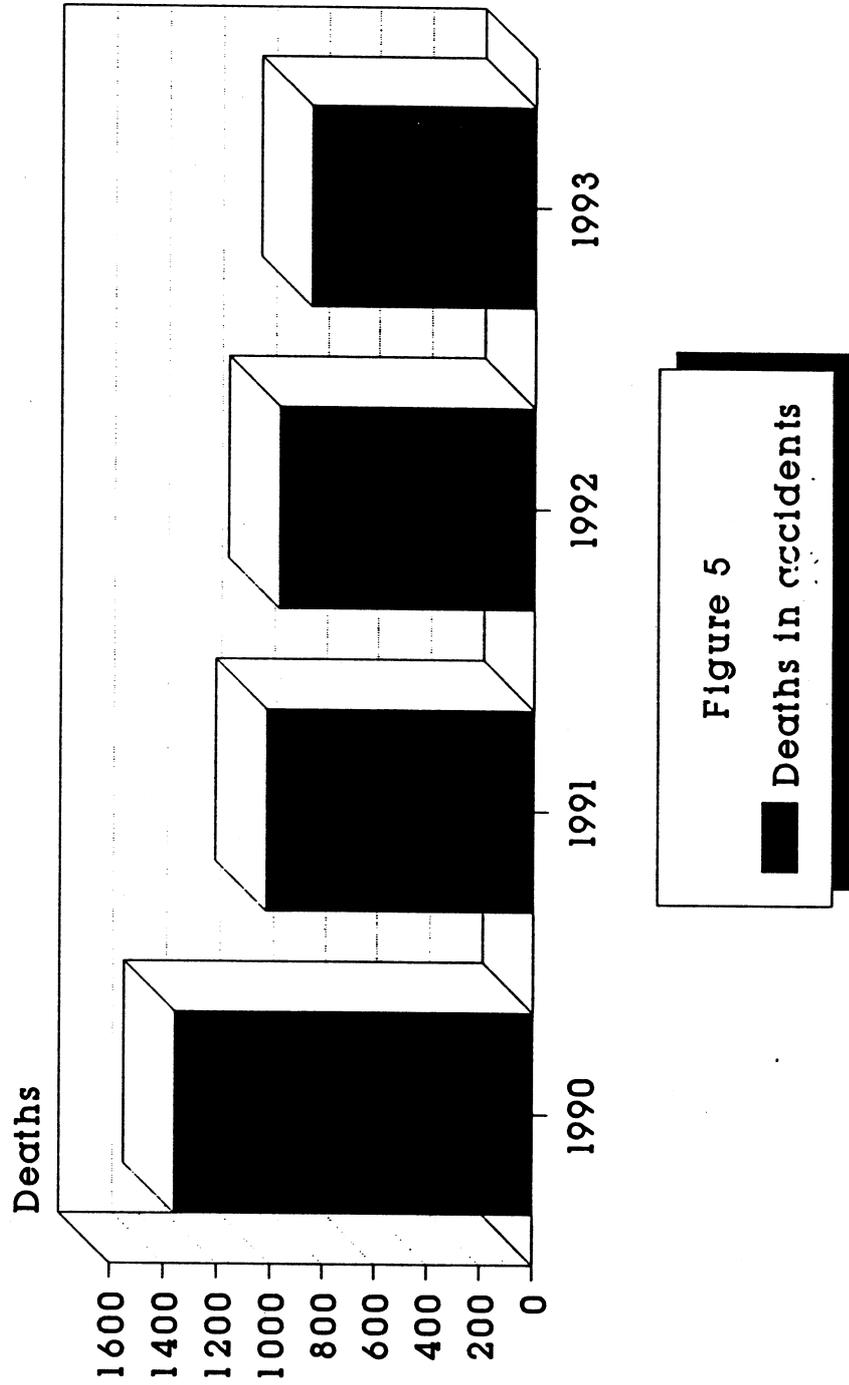
Figure 4
 —◆— 1992 -+- 1993 —*— 1994

Fig. 4

Fig. 5

C R O A T I A

CHARACTERISTIC FIGURES



The objectives in the term of the mentioned safety activities are:

- exceeding of speed limits as well as the speed variations in the traffic flow not higher than 10%
- red light discipline of 100% for drivers and to the level that is around „not-endangering” for the pedestrians,
- removing 30% of „top” black spots in major towns as well as on the rural roads,
- designing of accident information system with the distributed processing, supported by the geographic information system and global positioning.

The dead line is (not more than) two years.

The organisational, technical and financing infrastructure of the programme is being solved under the given conditions.

In the safety area named „pedestrian safety” (with regard to accident portion see fig. 6) several tasks have to be carried out. Namely;

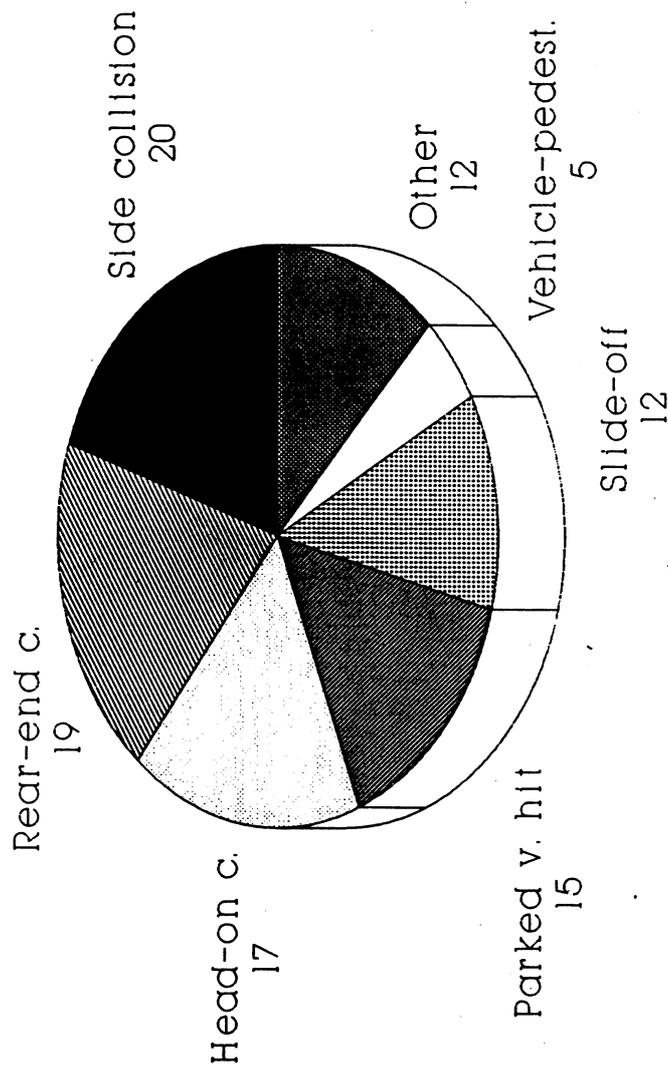
- improvement of awareness of the pedestrians for the potential consequences of the behaviour they habitually have; (red light (in)discipline, passing of roads distant of zebra crossings, walking in the dark without caring any light or retro-reflective, etc,
- improvement of traffic engineering solutions aimed to pedestrians; (shorter signal cycles, passing of the road in two or more phases, properly positioning of pedestrian crossings, lower speed limits, etc.),
- reducing of possible risks for the pedestrians in the phase of land-use and town planning phase and
- using of traffic calming measures for the reducing of pedestrian safety risk, in residential areas as well as in the school zones.

In the last mentioned field there have been some positive experiences that should be followed on. The use of traffic calming measures has started just at the beginning of this decade despite the fact that some legislative background has not been stated yet. In many cases it was almost the only possible solution aimed at reducing non-acceptably high level of traffic risk for pedestrians. Although, the majority of measures that have been used were „humps control speed” the other measures, like rumble strips, islands, roundabouts and bottlenecks have been used as well. Using such measures the traffic risk was reduced by 36% as well as the number of traffic accidents accordingly.

The first case of humps control speed application in our conditions was the service road in front of Zagreb Fair, in length of 2.7 kilometres, aimed mostly for the access to the Fair as well as to the shops, bars, discotheques in the neighbourhood. The next results were observed as the consequence of the applied solution in the period of evaluation:

Fig. 6:

ACCIDENTS' STRUCTURE (%)



- in the average speed of vehicles in traffic flow;

the speed of vehicles before	55 km/h,
the speed of vehicles after	38 km/h,
- in the 85-th percentile speed of vehicles;

the speed of vehicles before	68 km/h,
the speed of vehicles after	43 km/h,
- in the speed variations;

speeds variation before	19%,
speeds variation after	15%.

The average number of accidents before was 1 accident every 16 days; the average number of accidents after was 1 accident every 25 days.

In the evaluation period „after” of 426 days, by the accidents frequency of the period „before” about 27 accidents were expected. Actually, 17 accidents occurred and about 10 accidents were saved. If average social cost from one traffic accident is about 20 000 DM, it could be stated that total accidents costs saved this way in a year and two months period was about 200 000 DM.

The cost of the treatment together with the project was 14 000 DEM, and the duration period of treatment is at least 10 years.

Just a few investments (if any) could be characterised with the ratio of investment rentability like this. All this is one more reason the mentioned safety programme should be designed according to the economic principle as well as on the concept of synergy.

TOWN SIZE AND PEDESTRIAN ACCIDENT INJURIES

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Accidents with young pedestrians in traffic remain a priority concern of the institutions responsible for road safety. They are a significant target for their activities. As they affect children, the injuries they can inflict on a community are considerable.

One of the questions regularly confronting road safety authorities is that of the young victims' identity: who are they? Which populations ought preventative measures to be aimed at in order to maximise the benefits from their campaigns? This involves enquiring into the identity of populations at risk, a subject on which several factors are already well known. For example, it has often been said that the age group involved in the greatest number of accidents is that of children aged from six to eight. More boys than girls are involved, with a ratio of 60% to 40% (1*).

Besides age and sex, the social background of child accident victims has been the subject of an attempt at definition. Certain social categories seem to be involved in a greater number of occurrences of these accidents. This was the conclusion of I. B. Pless (2) after recording certain data on children hospitalised in Montreal following traffic accidents in 1981 and relating them to demographic data on the population. This showed that the rate of pedestrian accidents of children from socially disadvantaged backgrounds was nine times greater than of children from well-off backgrounds.

F. R. Rivara (3) had earlier observed similar results in the city of Memphis. He, however, had taken the investigation further by including data on the design of urban areas. He had thus isolated a high-risk group consisting of children from black, often single parents, families on low incomes, living below the poverty threshold, in overcrowded flats and in densely-populated urban areas. According to these results, on the scale of the city of Memphis, urban density could be regarded as a factor making accidents more likely. This type of research has still not been carried out on a large enough scale to be considered genuinely reliable. The subject has however appeared to be of sufficient interest to justify trying to investigate it in depth. This is the purpose of the study presented here.

The term urban density refers to a quite complex set of data on built-up area, car and pedestrian traffic, population density, etc. Unfortunately there is no easily accessible indicator capable of assessing the variations in children's susceptibility to accidents according to the size of urban areas in which they occur. The term „accident susceptibility” refers to the rate of accidents across the population. Is this rate genuinely higher in large conurbations than in smaller ones, as one would tend to expect?

This view is connected with that one of a quite widespread belief that pedestrian accidents are more common in towns than in rural areas. This is indeed what reading the overall accident statistics published annually would indicate. Nevertheless, given that the majority of the population that lives in urban areas, it is not intrinsically surprising that they should be more accidents in towns. It is necessary to assess the rate of accidents across these populations if one is able to confirm that urban density is genuinely a factor making for greater susceptibility. We have undertaken this study so as to verify this view in a study extending over a national scale.

According to annual figures published in France by SETRA which distinguished between „conurbations” and „outside of conurbations”, appears that the number of accidents is much higher in conurbations, in the ratio of 9 to 1 (6). However, what about when one relates these results to those for populations living within conurbations and those for populations living outside conurbations? In addition, what about variations in the rate between conurbations of differing sizes?

1. METHODOLOGY

The base data is composed of that from 2 databases one of from SETRA, which is the organisation responsible for the annual road traffic census in France, and the other from, which carries out the population census.

In each case, children under 15 were classified under 6 categories of conurbation. Data was therefore obtained from the ratio of the number of children involved in accidents/number of children the rate was calculates per 1,000 children.. The variations in this rate according to conurbation category were looked at.

- The term conurbation refers to the grouping of dwellings in urban units. Where the population of urban unit is under 2,000, they are termed „rural communities” (5).
- Conurbations were classified as follows: less than 5,000 inhabitants; from 5,000 to 20,000; from 20,000 to 50,000; from 50,000 to 100,000; over 100,000 inhabitants; in addition to rural communities (5). The case of Paris was investigated separately.
- The variations in the seriousness of accidents in the differing categories of conurbation was also studied.
- Lastly, for each of the preceding categories, children were classified into three age groups from 0 to4, from 5 to 9, from 10 to 14.

The main criticism of this method is that it presupposes that location of the accident is the same as the place of residence, though it is always possible to suffer from an accident in a conurbation other than one’s place of residence. This is often the case with drivers given the length of journeys. This may also be the case with adult pedestrians, using public transport to get to work in a place other than where they live. However, in the case of children, it has been noted that accidents involving them occur in the near vicinity, if not in front of their homes. There are probably exceptions to this rule because of family movements, for example during holidays. However, holidays periods have been proven to be times when the curve on the accident graph is at its lowest. There is probably a bias in the data, but it is regarded as minimal. This type of assessment would not be envisaged for the adult pedestrian population.

Given the interval for the French population census, and the need to use data from the same year for both population and accidents, this study was carried out for a year, 1982, which is already some time ago.

2. RESULTS

2.1. Description of the population

Type of conurbation	0-4 years	5-9 years	10-14 years	Total	%
Rural communities	773,516	1,036,756	1,179,132	2,989,404	26.6
-5,000 inh..	180,096	233,404	270,604	684,104	6.09
5-20,000 inh..	334,692	413,564	470,556	1,218,812	10.85
20-50,000 inh..	217,636	256,544	290,472	764,652	6.08
50-100,000 inh..	224,596	261,656	296,952	783,204	6.97
+100,000 inh..	1,406,748	1,613,252	1,276,852	4,796,852	42.68
Total	3,137,284	3,815,176	4,284,568	11,237,028	99.99

Table 1: Distribution of population under 15 by conurbation type.

It can be seen that the population under 15 is not distributed equally in the various types of conurbation. It is more significant in large towns of over 100,000 inhabitants and in rural areas. Pedestrian accidents occurring in this population break down as follows:

Type of conurbation	0-4 years	5-9 years	10-14 years	total	%
Rural communities	221	576	396	1193	9.58
-->5,000 inh..	57	180	108	345	2.77
5-20,000 inh..	155	456	279	890	7.15
20-50,000 inh..	150	538	308	996	8.00
50-100,000 inh..	209	610	355	1174	9.43
+100,000 inh..	1203	3901	2746	7852	63.07
Total	1995	6261	4194	12450	100%
	16.02	50.29	33.69		

Table 2 : Distribution of accidents of population under 15 by conurbation type.

In terms of the gross statistics, accidents to pedestrians under 15 clearly appear to be an urban phenomenon, occurring more particularly in large conurbations of over 100,000 inhabitants, while the rate of these accidents in other categories of urban units is low. They particularly involve children aged 5 to 9, who by themselves represent half the accidents. What about their occurrence in the population involved?

2.2 Accident rate according to size of conurbations.

The rate of accidents was calculated per 1,000 inhabitants.

2. 2. 1 Across the entire child population

	Population	Accidents	Rate
<u>Rural communities</u>	<u>2,989,404</u>	<u>1193</u>	<u>0.40</u>
-5,000 inh..	684,104	345	0.50
5-20,000 inh..	1,218,812890	0.73	
20-50,000 inh..	764,652	996	1.30
50-100,000 inh..	783,204	1174	1.50
-100,000 inh..	<u>4,796,8527852</u>	<u>1.64</u>	
Total	11,237,028	12450	1.11

Table 3. Calculation of accidents rates by conurbation size

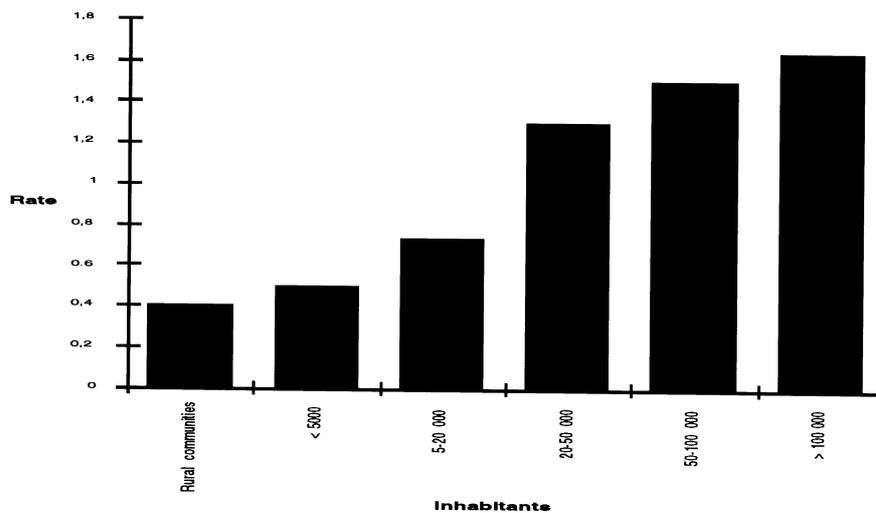


Figure 1. Accident rates in the different types of conurbation.

The results show a quite clear relationship between the size of conurbations and the pedestrian accident rates for those under 15 the larger the conurbation size, the higher the accident rate in the population. In rural communities, it is four times less significant than in conurbations over 100,000 inhabitants; between these 2 extremes, the rate rises quite steadily, with however a more marked rise for conurbations with upwards of 20,000 inhabitants.

Child pedestrian accidents clearly appear to be an urban phenomenon, and according to these results, to be proportional to the size of the conurbations.

With the data we had, it was possible to calculate the distribution of rates within urban units over 100,000 inhabitants which are the most „dangerous” for the children. We started by extracting the Paris conurbation from this category. The results then change somewhat:

	Population	Accidents	Rate
Rural communities	2,989,404	1193	0.40
-5,000 inh..	684,104	345	0.50
5-20,000 inh..	1,218,812	890	0.73
20-50,000 inh..	764,652	996	1.30
50-100,000 inh..	783,204	1174	1.50
-100,000 inh..	3,121,988	4646	1.49
Paris conurbation	1,674,864	3206	1.91
Total	11,237,028	12450	1.11

Table 4: Accident rates distinguishing Paris conurbation from conurbations over 100,000 inhabitants.

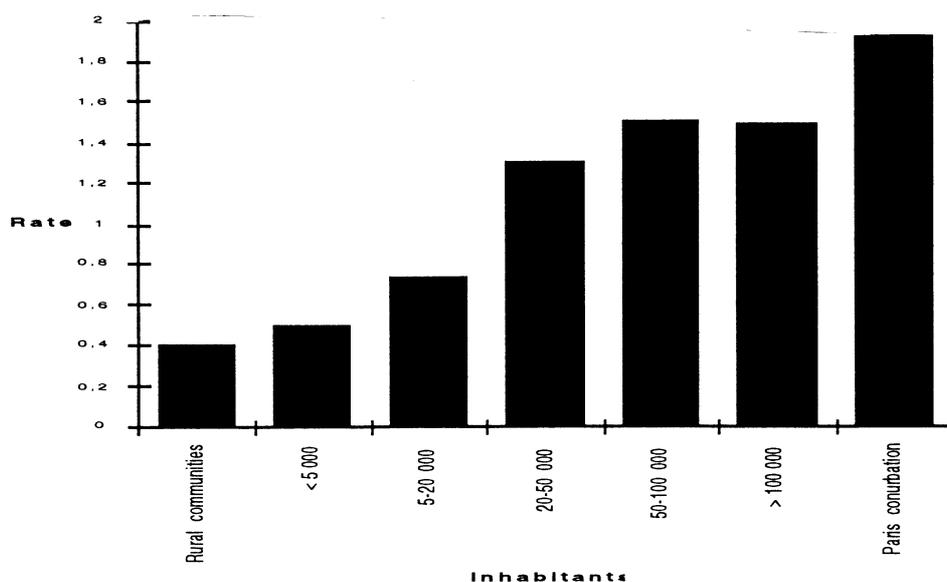


Figure 2. Accident rates in different types of conurbation after (Paris is separate)

The accident rate is higher in the Paris conurbation than in other conurbations over 100,000 inhabitants. The accident rate for towns of 50,000-100,000 inhabitants is the same as that for towns over 100,000 if the Paris conurbation is extracted from the latter. The change is even clearer when the city of Paris itself is extracted from its conurbation, as shown in the bar chart below.

	Population	Accidents	Rate
Rural communities	2,989,404	1193	0.40
-->5,000inh..	684,104	345	0.50
5-20,000inh..	1,218,812	890	0.73
20-50,000 inh..	764,652	996	1.30
50-100,000inh..	783,204	1174	1.50
-100,000inh..	3,121,988	4646	1.49
Paris conurbation	1,382,220	2218	1.60
City of Paris	292~644	988	3.38
Total	11,237,028	12450	1.11

Table 5. Accident rates after extracting City of Paris from the Paris conurbation.

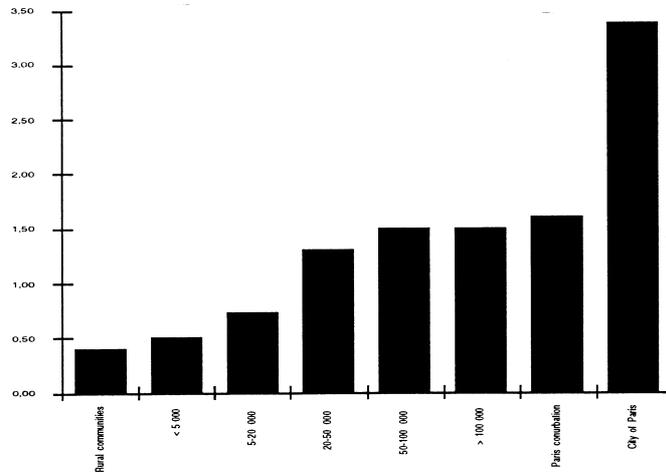


Figure 3. Accident rates in different types of conurbation, highlighting the case of Paris

Though, having extracted accidents in the City of Paris, the Paris conurbation is similar to conurbations over 100,000 inhabitants, the City of Paris stands out through its very high rate, more than twice that of the large conurbations. It would of course be necessary to check what this rate is in the large regional metropolitan centres like Marseilles or Lyons. Thus it would be possible to check the relationship between the density of the urban fabric, which is higher within the city of Paris than in its suburbs, and accidents.

There is a gradual growth in the level of occurrences of accidents to children, around three types of conurbation:

- .rural areas, villages, and small conurbations with less than 20,000 inhabitants.
- .medium-sized conurbations and large towns of over 20,000 inhabitants.
- .the city of Paris.

The need remains for an investigation of these groupings.

Beyond the relationship between the size of conurbation and the occurrence of accidents to children, there would probably be an effective relationship between the density of the urban fabric and the accident rate, since in the city of Paris, where the rate is assumed to be high, the rate is over twice that of conurbations of over 100,000 inhabitants, and over eight times that of rural communities. In order to confirm this, other data would be required.

Another aspect of the occurrence of accidents to children is its variation with age. Aware that the age group most involved in accidents is the 5-9 year olds, we attempted to ascertain if this was borne out in all types of conurbation.

2.2.2 Variations in accident rates in conurbations according to children's ages

Given the special case of the city of Paris, the results relating to it were extracted from the Paris conurbation, which is itself treated separately from the other conurbations of over 100,000 inhabitants; they are shown separately.

Type of conurbation	0-4 years	5-9 years	10-14 years	Total
Rural communities	0.29	0.56	0.34	0.40
<5,000 inh..	0.32	0.77	0.40	0.50
5-20,000 inh..	0.46	1.10	0.59	0.73
20-50,000 inh..	0.69	2.10	1.06	1.30
50-100,000 inh..	0.93	2.33	1.20	1.50
>100,000 inh..	0.80	2.22	1.36	1.49
PARIS conurbation	0.76	2.37	1.58	1.60
City of Paris	1.78	4.72	3.59	3.38
Total	0.64	1.64	1.11	1.11

Table 6: Accident rates for different age groups

The accident rates for 5 to 9 year old children are on average 2.5 times as high as those for 0-4 year olds, and 1.5 times as high as those for 10-14 year olds.

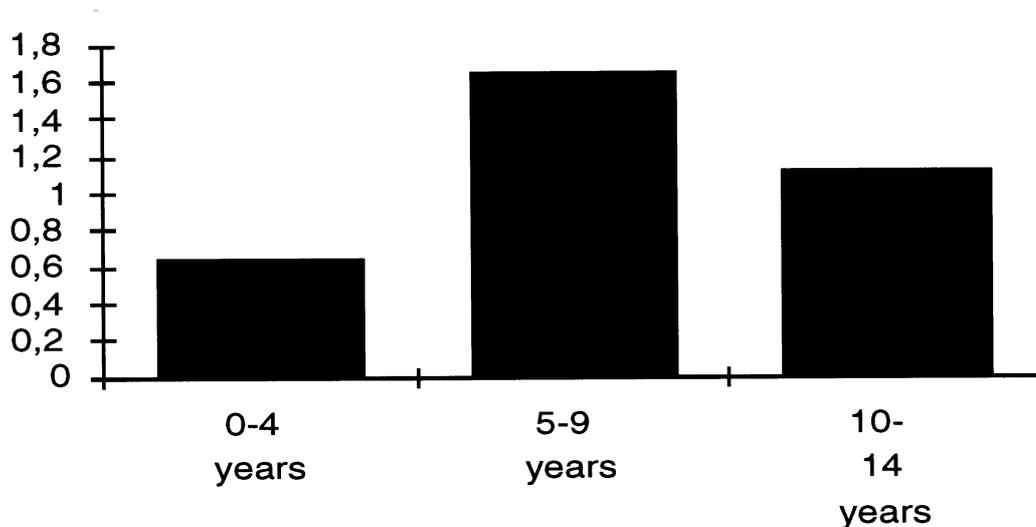


Figure 4. Accidents rates by age (0-4, 5-9 and 10-14 years).

In the different conurbations, the 5-9 year-olds invariably have the highest accident rates, as the following bar chart shows:

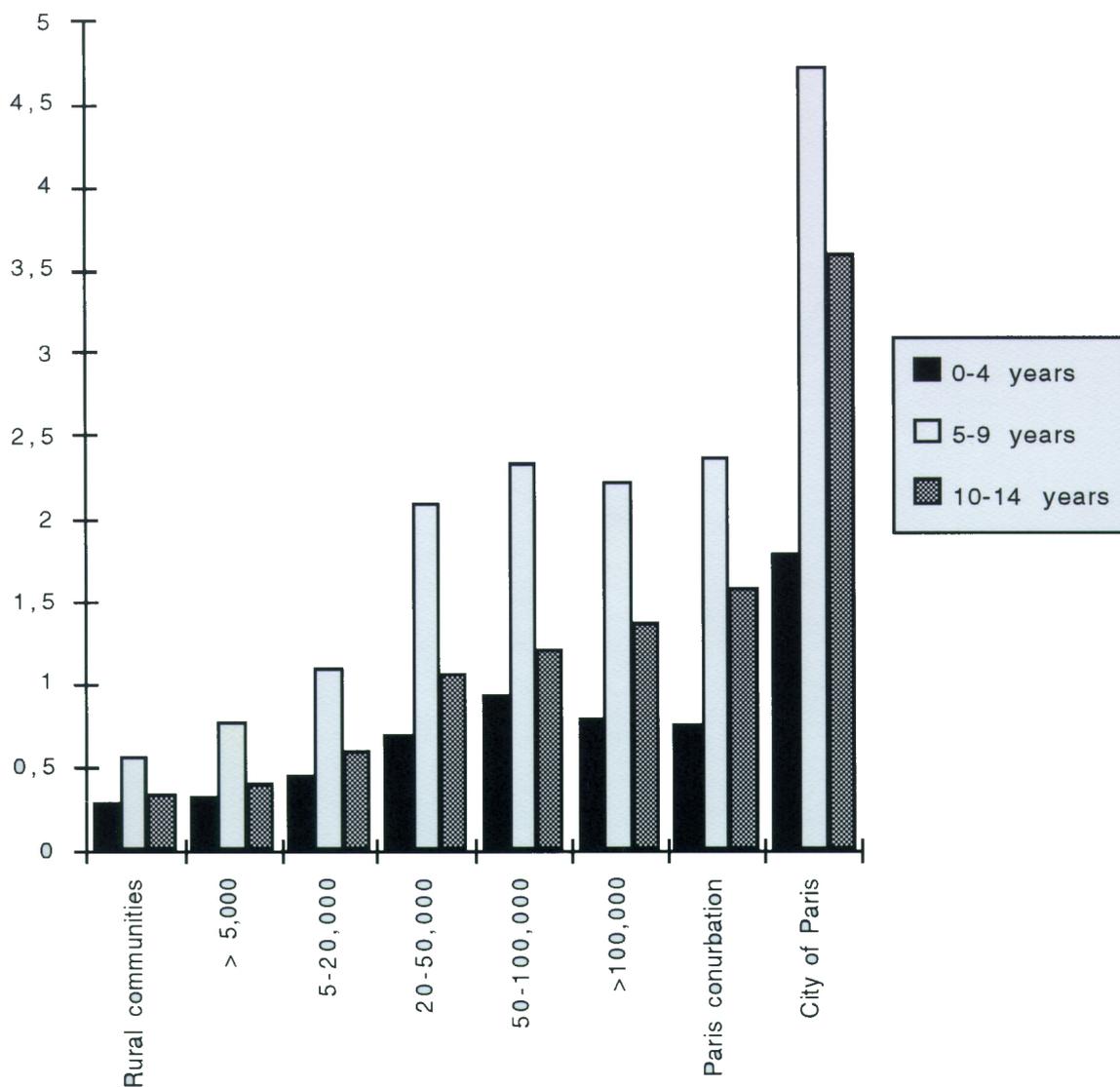


Figure 5. Accident rates by age in the different conurbations.

The difference between age groups meanwhile tends to widen according to the size of conurbations. Among the youngest children and the 5-9 year-olds, it is lower in rural communities and small conurbations than in major conurbations. On the other hand, there is relatively less change, as a function of conurbation size, in the difference between the 5-9 year-olds and the 10-14 year-olds.

Though rates increase with conurbation size, the rates for the 5-9 year-olds in the conurbations of 50,000 and 100,000 inhabitants and the Paris conurbation are virtually the same: 2.33, 2.42, 2.47 children per 1,000. For central Paris, on the other hand, it is much higher: 4.72.

2.3 Variation in the seriousness of accidents with the conurbation size

Seriousness may be looked at in two ways: either through the injuries suffered by a population, or from the point of view of an epidemiology targeted on road safety, the first approach would be more satisfactory. However, as fatal accidents remain fortunately rare, rates observed for these are perhaps of minor significance. By way of illustration, here how they break down in this instance. The rate is assessed per 100,000 inhabitants.

Type of conurbation	No. of deaths	Population	Rate
Rural communities	97	2,989,404	3.24
<5,000 inh..	17	684,104	2.49
5-20,000 inh..	24	1,218,812	1.97
20-50,000 inh..	21	764,652	2.75
50-100,000 inh..	13	783,204	1.66
>100,000 inh..	75	3,121,988	2.40
PARIS conurbation	19	1,382,220	1.37
City of Paris	3	292,644	1.03
Total	269	11,237,028	

Table 7. Fatality rates attributable to pedestrian accidents according to conurbation size.

According to these results, there would appear to be a reduction in fatal accidents with increasing size of conurbations, with nevertheless two exceptions ; in conurbations of 20 to 50,000 inhabitants, and in conurbations of over 100,000 inhabitants. In the latter instances the rate reaches a level comparable to that of conurbations of less than 5,000 inhabitants. These three urban categories exhibit the highest level of seriousness of child accidents after rural communities.

Nevertheless, the disproportion between the phenomenon observed and the size of population (cf table 7) makes it difficult to draw conclusions without further supporting evidence. It was therefore attempted to define the severity of accidents by calculating fatal accident rates. this involves the ratio: number of death/total number of accidents for an age group.

The initial observation was of a slight increase in fatal accidents according to the ages of victims.

2. 3. 1 Variation of accident seriousness with age of child

	Deaths	Serious injury	Minor injury	Total	Seriousness
0- 4 years	79	515	1,401	1,995	3.96
5- 9 years	128	1819	4,314	6,261	2.04
10-14years	62	1156	2,976	4,194	1.48
	269	3490	8,691	12,450	2.16

Table 8. Variation in seriousness of accidents with age of child

The most severe accidents occur most frequently to the youngest children, those under 5; the seriousness of accidents tends to decline thereafter.

2. 3. 2 Variations in accident seriousness with conurbation size.

These results point in the same direction as the foregoing ones, i. E; a decrease with increasing conurbation size, though with greater regularity.

Even though an increasingly significant accident rate as a function of increasing conurbation size had been observed, the same change, but in the opposite direction, was observed with regard to their seriousness: the larger the conurbation, the less serious the accidents occurring there.

Type of conurbation	Deaths	Serious injuries	Minor injuries	Total	Seriousness
Rural communities	97	610	486	1193	8.13
<5,000 inh..	17	174	154	345	4.93
5-20,000 inh..	24	381	485	890	2.70
20-50,000 inh..	21	334	641	996	2.11
50-100,000 inh..	13	400	761	1174	1.11
>100,000 inh..	75	1137	3434	4646	1.61
PARIS conurbation	19	391	1808	2218	0.86
City of Paris	3	63	922	988	0.30
Total	269	3490	8691	12450	2.16
%	2.16	28.03	69.81	100	

Table 9. Calculation of accident seriousness by conurbation size.

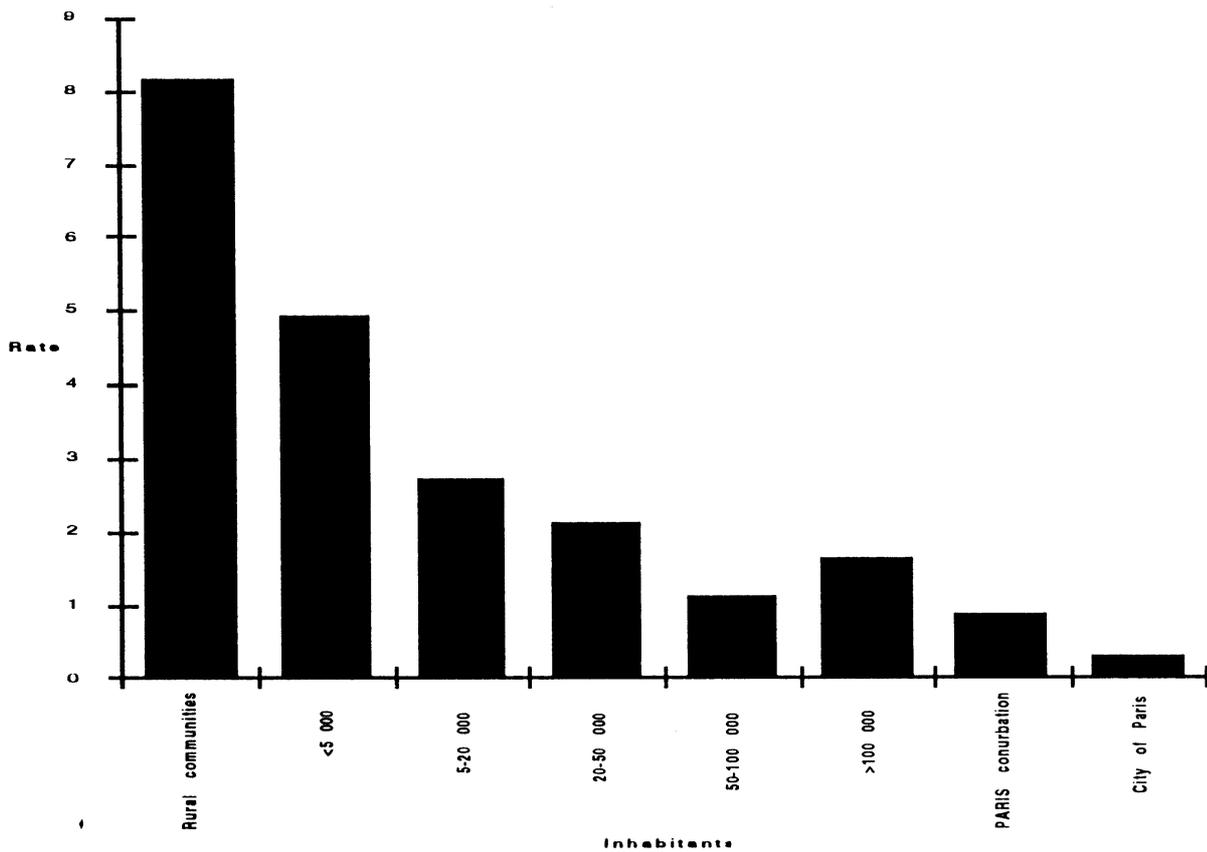


Figure 6. Accident seriousness rates by size of conurbations where accident occurs.

It is shown that accident seriousness changes quite noticeably between the different types of conurbation, going from less than 1 child killed per 100 accidents in Paris to 8 per 100 in rural communities. It is surprising to have confirmed the inversion of these results by comparison with the foregoing results on accident rates in the population.

The quite marked steady trend in these results probably indicates a relationship between accident seriousness and the size of the conurbation in which the accident occurs, in the opposite direction to that of accident rates. The larger the conurbation, the higher the size is nevertheless not completely steady: it is slightly higher in conurbations of over 100,000 inhabitants than for conurbations of 50 to 100,000 inhabitants (figure 10).

3 Examination and Findings

According to the results which have been put forward, it would appear that a conurbation's size bears a relationship to the rates and seriousness of accidents to child pedestrians which occur there. The larger the conurbation, the higher the accident rate increased. In addition, groupings in conurbation categories become evident this is so with regard to accident rates in conurbations upwards of 200,000 inhabitants, and still more from 50,000 inhabitants. From 20,000 inhabitants and upwards, the effect of urban concentration on the accident rate appears to be the same, except for on the city of Paris, where it is twice as high.

A certain symmetry in the results between rate and seriousness becomes apparent; it is particularly evident between rate and severity of accidents. It is generally conceded that the speed of traffic bears a relationship to the seriousness of accidents. From the point of view, it is therefore not surprising to find that the seriousness is lower in the large conurbations and high in rural areas. Nevertheless, according to our results, it decreases steadily with conurbation size, which would seem, at first sight, inexplicable speed may be higher in villages than in conurbation of over 100,000 inhabitants, but is this also the case for example between towns of 50,000 inhabitants and those of 100,000? In these categories where the rate is identical, the seriousness goes up.

This study, in the way it has been framed, is to be regarded as a step in the investigation of this field. The data we have had available to us are in the final analysis rather too limited for us to have gone into the problem in genuine depth. We have treated the case of the city of Paris separately as we had data for it, but the accident rate may not be a peculiarity of the capital.

These results lead to two types of conclusions: one on child accidentology, the other on road safety.

3.1. Child accidentology in traffic.

These results have shown a clear distinction between the large conurbations and the rural areas. When an urban area is developed to the limits of its capacity, as in the case of Paris, it becomes a focal point for traffic accidents to children, which is not the case in rural areas and in small and medium-sized conurbations in which public spaces provide more freedom and autonomy to their various users.

This observation may bear some relationship to the presumed factors in child accidents as set out for example by Thomson (6). According to this writer, these factors were linked to the complexity of the task, as is the case in dense urban setting, the higher the risks of failure. This might explain the variations in the accident rate between rural areas or small conurbations and the large towns and Paris, without explaining to the same extent the steady progression in the accident rate between these two extremes.

In order to study the reasons for this progression, we at present envisage carrying out a series of complementary investigations: comparison of the accident rate in several large metropolitan centres, using complementary statistics enabling an improved investigation of urban concentration, such as occupancy of the built environment, population density and traffic density. Observations on the availability of public space for children's games and the extent of pedestrian zones are also factors to which would need to be directed in order to explain these results.

In conclusion, it seems quite likely that traffic is a constraint on pedestrians generally, across all age groups, in large towns as in villages and rural areas, and that this situation is more difficult still for the children to manage, who not only have problems coping with situations such as traffic but also need and independent urban space giving them the opportunity to play their games.

3.2. Prevention of child pedestrian accidents

From the point of view of road safety, it would seem necessary to consider what has been said on the greater susceptibility of children in the large conurbations, or at least, to make a choice of criteria for assessing this susceptibility. If the objective of road safety measures is to protect individuals against accidents, it is the populations of the large towns who ought to be their priority target. If they are aimed at reducing fatality rates, it is the populations of the rural and semi-rural areas which ought to be protected.

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PEDESTRIAN SAFETY MEASURES - PAST AND FUTURE

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Pedestrians represent an important part of the traffic system, especially in urban areas. Although it is very difficult to compare their exposure with that of vehicle traffic, some studies indicate that their risk of being injured in traffic is much higher than the risk of car drivers or passengers. Thulin (1981) has shown on Swedish accident data that while the number of injuries per million passenger kilometres for car drivers/passengers is 0.2, it is 0.7 for pedestrians.

Safety measures are interventions in the traffic system with the primary aim to improve safety in general, or for specific road user groups. Safety measures can be of very different level of generality from influencing all manoeuvres and road users (e.g. speed reduction), to very specific. Or it can be put into an other dimension, saying that they can prevent accidents by changing interactions between road users (active safety measures) or reduce the probability of serious injury or fatality if an accident had occurred (passive safety measures). An other possible categorisation is to distinguish the sources, the areas which have influence on traffic safety. Four main areas can be defined that contribute to the improvement of traffic safety: vehicle technology, infrastructure, legislation and behaviour change (Evans, 1989).

1. EFFECTS OF PEDESTRIAN SAFETY MEASURES

Empirical studies carried out before and after the introduction of specific safety measures have shown that the effect of the measures is usually different than what had been expected solely by taking into consideration the specific effect of the measure. Several theories have been presented to explain the unexpected distortions regarding the effects of safety measures. It is out of the scope of this paper to present the different theories in detail, but the explanation on a general level is that when a system is changed, users usually do not ignore the change but rather respond to it by some type of behavioural change. (Evans, 1985) This behavioural change is called by Evans human behaviour feedback. He states that human behaviour feedback is probably a general characteristic of most systems in which humans have an opportunity to interact with engineering changes. If the task in question is a self-paced task, as e.g. driving, change of speed is the most common behavioural response.

Behavioural changes induced by different safety measures are quite complex reactions of a complex system (the road user) on the change of the environment. There is no all inclusive model of road user behaviour by which a good prediction of the expected behaviour change could be given. We present therefore some traditional measures having aimed to improve pedestrian safety and their effects.

1.1. Zebra crossing

Zebra crossing is the most widespread safety measure for pedestrians all over the world. Some studies, however, have shown that their influence on pedestrian safety is negative. Herms (1972) observed pedestrian accidents on 400 marked and 400 unmarked pedestrian crossings and found that relative to the numbers of pedestrians using the pedestrian crossings, approximately twice as many pedestrian accidents occurred in the marked crossings than in the unmarked ones. As Evans

explained it, 'It would appear that the painted crosswalk induced a sense of security in the pedestrians using it that was in no way justified by any increase of caution on the part of the approaching drivers brought about by the appearance of the marked crossings.'

Brundell-Frej and Ekman (1991) arrived at very similar results and conclusions using Swedish traffic conflict and behavioural studies, accidents and flow data.

Although most studies indicate a negative effect of zebra crossings, there are exceptions. Brundell-Frej and Ekman for instance referred to studies that showed quite positive effects of zebras in Norway and in the UK. The main reason for this difference is most probably that there is a distinct give way rule for car drivers in those two countries, while other countries (e.g. Sweden and the U.S.) do not have that rule. This rule seems to have a significant effect on the car driver, thus creating much more preparedness and actual stopping for pedestrians. Ekman (1983) has also showed in an earlier conflict study that the safety effect of zebra crossings can be largely improved also in Sweden by raising them and making them more conspicuous for the drivers. Part of the positive effect is, however, in this case that car drivers are forced to slow down before arriving at the zebra crossing.

Hydén, Gårder and Linderholm (1978) found - in conflict studies - that there was a strong relation between the location of the zebra crossings at non-signalised intersections (i.e. in principle the crossing location of the pedestrian) and pedestrian risk. Pedestrian risks were lowest when the distance between the extension of the right side of the parallel road and the zebra crossing was either less than 2 meters or more than 10 meters.

1.2. Refuge for pedestrians when crossing a road

Several accident and conflict studies have proven that refuges reduce the risk of being hit considerably for pedestrians. Kulmala (1982) has found that the risks for conflicts and potential conflict situations between pedestrians and vehicles were about 60% lower when refuges were present.

Hydén, Gårder and Linderholm (1978) have got similar results on ground of conflict studies in 115 intersections in Sweden. They found that refuge decreases pedestrian risk to approximately half

1.3. Traffic signals at intersections

Studies (TOI, 1989) indicate a 20-40 % reduction of accidents in general after signalling an intersection, with highest reduction for crossing accidents and pedestrian accidents. Linderholm (1984), however, also found that the effect on pedestrian accidents may vary considerably. Solutions that produce 'unexpected' walking against red (e.g. because of so called channelised green for pedestrians or other solutions that may mislead pedestrians to walk against red) may turn a positive safety effect into a negative one. Ekman (1983) showed in his accident study referred to above, that signals in general showed a higher risk (police-reported injury accident per passing pedestrian) than locations without any pedestrian facility, at similar conditions.

1.4. Mid-block signalisation for pedestrians

There are not many studies indicating the safety effects of mid-block signalisation. The most comprehensive one, a Nordic study of pedestrian mid-block signals (Vejdatalaboratoriet, 1982) showed a reduction of 35 % on pedestrian accidents. A careful analysis of the results (Hydén, 1987), however, showed that it was very questionable whether there had been any positive effect at all. The most relevant conclusion from that study must be that a mid-block signalisation was only safety beneficial for pedestrians in the most extreme cases with regard to traffic and environmental conditions, e.g. very heavy car volumes and very wide roads.

The main reason for the non-positive safety results of mid-block crossings is, again, walking and driving against red, especially the first. It gives an additional perspective to the conclusion above, namely that at „non-critical” conditions it is very difficult to prevent pedestrians from walking against red.

1.5. Speed reduction at intersections

Different traditional safety measures exist by which speed can be reduced at intersections. The most common are different regulations of priority that makes it necessary for vehicles arriving at the intersection to slow down.

Traffic conflict studies comparing safety of pedestrians at high- and low-speed (mean < 30 km/h) non-signalised intersections have shown that the risk of an accident is approximately twice as big at high-speed intersections than at low-speed ones (Hydén, Gårder, Linderholm 1978). Studies with specific speed reducing measures (humps, four-way stop signs, mini-roundabouts) at intersections all have proven that risk for unprotected road users at intersections is much dependent on approaching speed of the cars. Local reduction of injury risks for pedestrians in the range of 50-80% has been most common in before and after studies when approaching speeds have been reduced considerably (Hydén, 1988. Hydén, 1989. Almqvist, 1989.)

2. *PROBLEM AREAS AND SAFETY MEASURES BASED ON ROAD TRANSPORT INFORMATICS (RTI)*

The vast majority of the pedestrian accidents happen in urban areas. One needs, therefore, primarily focus on urban traffic when defining safety measures for pedestrians. Urban traffic is characterised by the coexistence of different travel modes, different travel speeds and different level of vulnerability of traffic participants. Moreover, the function of the urban public places is diverse, different human activities take place on the streets. That means that some traffic participants (especially pedestrians) share their attention between participating in traffic and other activities (social, being together, shopping, playing, etc.).

Pedestrians in urban areas usually have separate space on the roads so they share the road with vehicles only at specific places where they ‘cross the road’. The majority of those actions and the majority of pedestrian accidents happen at intersections.

Vehicles in urban traffic have usually lower speeds than on rural roads which are designed for and used by motor vehicles first of all. Urban roads, especially intersections mean high load of information and demand of attention for the drivers even at the lower urban driving speeds. It

means that there is a very limited possibility to improve safety in urban areas by providing drivers with more information as well as tutoring them in situations when they have very little spare capacity of attention.

In spite of the fact that the national accident statistics contain very few details on pedestrian accidents, some main problem areas can be defined using smaller scale and in-depth accident analyses, traffic conflict- and behavioural studies, etc.

2.1. Crossing the road outside intersections with no special facilities for pedestrians

Four years of accident statistics (1987-1990) from the city of Malmö in Sweden has shown that about half of the urban pedestrian casualties occurred outside intersections when pedestrians crossed the road without any pedestrian facilities. Although those places might be very different in many respects, the common characteristics in situational/behavioural terms is that the presence of pedestrians on the road is unexpected for the drivers. The fact that about 70% of that type of casualties occur between pedestrians and vehicles coming from the left means that car drivers are not prepared to react on pedestrians who are just stepping on the road. Besides some pedestrians step on the road without watching out for cars.

Remedial measures

The sort of improper behaviour mentioned above can happen everywhere on the road network, therefore no local technical solution of the problem can be found. Detection of pedestrians intending to step on the road is impossible because they are mixed with other pedestrians even at the kerb. The only remedy that enables drivers to avoid accidents is to **reduce speeds** in general on those areas where many pedestrians, especially children and/or elderly people are present. Lower speeds give the possibility for both partners for a better cooperation. It would be possible to define areas with a certain minimum probability of crossing pedestrians. At those areas - only covering a small part of the total road network - a special **warning function** could be operating ensuring that speeds actually are decreased there.

2.2. Crossing at non-signalised urban intersections

Conflict studies have proven that signalised intersections and low speed non-signalised intersections have about the same risk level for pedestrians, while high-speed non-signalised intersections have about twice as big risk (Hydén, Gårder & Linderhobm 1978).

One quarter of the accidents at non-signalised intersections occur when the motor vehicle is entering the intersection while three quarters occur when the vehicle is leaving it. Approximately half of the accidents occur at zebra-marked crossings while the other half occur at locations without any special provision for pedestrians (Hydén 1981).

The major problems in behavioural/situational terms can be described as follows:

- Car drivers react on the presence of pedestrians differently than on the presence of another vehicle. One of the explanations is that the drivers actually do not see the pedestrians because the latter are 'covered' by other road users, difficult to see behind the corner, etc. Another -closely related - explanation is that a pedestrian has 'low priority' in the perception of drivers. The driver may see a pedestrian but does not give the information big enough priority, expecting that the pedestrian will take the necessary action to avoid the accident. Even in situations where pedestrians have the formal priority, the informal rule is very often that pedestrians yield because they are more endangered and they are able to stop or even step back much quicker than vehicles. (Howarth-Lightbum, 1980) Car drivers rarely act at interactions with pedestrians; only when they must do it because they otherwise are going to overrun the pedestrian. Studies in Sweden, referred to above, indicate that it does not matter whether there is a zebra crossing or not. It is reasonable to believe that at many of the interactions that lead to critical events, the driver has seen the pedestrian well in advance, but he has not expected that the pedestrian actually may cross in front of him. Studies in Sweden showed that in interactions between car drivers and children this kind of situation was very frequent. The drivers did see the children well in advance but took it for granted that „as the child had seen the car” he or she would not start crossing in front of the car (Sandels, 1977).
- Another aspect of less preparedness on the driver's side might be that other road users are demanding a big part of his attention. The fact that three quarters of all accidents occur when the vehicle is about to leave the intersections is a clear indication that pedestrians at the far end of an intersection can be easily overlooked when the information load is heavy. The same is true for pedestrians crossing at an intersection. Studies have shown that if pedestrians are crossing very close to the parallel road at intersections (< 2 m) then the risk of being hit by a car is 2-3 times smaller than if the pedestrian is crossing 2-10 meters away from the parallel road. This highlights the problem of pedestrians being „anonymous”. The closer to the 'point of action', the more clearly are they seen, the more are they actually observed and the more are they considered as a 'real threat' by car drivers. The result is also more action from the car driver's point of view and much less accidents and injuries (Hydén, Gårder & Linderholm, 1978).
- In view of the problem that the action to avoid conflicts with oncoming cars is usually left to the pedestrians it is interesting to see that accident involved pedestrians quite often seem to have made a very poor judgement of the existing time gaps in the vehicle streams. There may be different reasons for this: For many people - especially elderly pedestrians - it is a difficult task to estimate the gaps correctly, especially when the speed variance in the vehicle flow is high. Crossing at an intersection might mean for the pedestrian that gaps and speeds of car streams from more than two directions should be evaluated and crossing decision made. The road width and the number of lanes is a very important factor in this case. The fact that a median island reduces pedestrian risks considerably indicates very clearly that the task of finding relevant and safe gaps may be a too difficult task. Another reason for 'misjudgements' may be that pedestrians simply overbook the presence of a vehicle. If the pedestrian does that when he is about to decide to cross the road, then a vehicle may be rather distant at that moment and still represent a big threat to the pedestrian once he has stepped out into the street and reached the point of interaction.

- There are - from a pedestrian's point of view - different rational reasons for why he may make this kind of fatal 'misjudgements'. The pedestrian walks most of the time without any threats from motor vehicles. He can then think about any other matter than traffic, he can be involved in discussions with other people and he can of course just 'walk and enjoy the environment'. In situations like these it is easy to understand that he easily may miss the right moment to do the correct collection of information and may easily make incorrect interpretations ('habitual walking' compared to 'habitual driving'). From the ear driver's point of view the pedestrian suddenly appears on the scene. The driver may have got no very visible signs that the pedestrian that he has seen well in advance actually is going to cross the road, and besides, to cross right in front of the vehicle.

Remedial measures

Vehicle drivers in general must be made aware of the fact that pedestrians may be present and also may start crossing in front of the vehicle. Very often the intersections are crowded with different kind of road users. It is then impossible to assist the driver with information about the presence of specific road users - the driver would immediately be overloaded with information. The information to the driver must be much more of a general nature. The moving of the pedestrian crossing location 'closer to the parallel road' is an example of how to increase 'the awareness' of vehicle drivers about the presence and 'potential threat' represented by pedestrians. In principle the same kind of 'increased awareness' effect could be introduced through some kind of **warning function** where the drivers' understanding of the importance of taking the pedestrians seriously into consideration is improved.

The fact that pedestrians often make 'misjudgements' and, from the driver's viewpoint seem to appear very suddenly and very unexpectedly, and the fact that drivers have a 'too bow' preparedness for 'active' interaction with pedestrians, calls our attention on vehicle speed. The most efficient way of treating these problems - looking at it from the 'vehicle side' - is to **lower the speed**. Lower speed automatically gives more time for the driver to detect pedestrians and interact with them, and also means a higher probability of being able to stop when conflicting pedestrians are detected very late. Many experiments with lowered speeds in the relevant kind of environments show clearly that the positive outcomes of a lower speed seems to be much stronger than the negative ones.

Legal priority at zebra crossings is unclear in many European countries, including Sweden. This is probably one reason why the actual driver behaviour at this kind of location does not differ from the behaviour at other kind of locations: In Norway for instance, the give-way rules are much more clear. Vehicle drivers have to give way for a pedestrian that is about to cross, even if he is just standing at the curb. Such a rule seems to create a much better safety standard for pedestrians at zebras, and a much higher comfort as well. Such a rule should also be much more easy to enforce. Besides, an efficient **tutoring function** could also be based on such a distinct rule. If the presence of pedestrians could be detected, then a feed-back could be given to drivers who did not comply with the rule.

2.3. Crossing at signalised urban intersections

The major problems in behavioural/situational terms can be described as follows:

- Pedestrians walking against red light. Walking against red is a complicated problem to treat. The interpretation of the signal is different if it is a specific pedestrian signal or pedestrians comply with the ear signal at an intersection. In principle there is always a large proportion of pedestrians that start crossing against red, as fast as there is a big enough gap in the vehicle stream. And as long as the ear traffic is not congested, the chance of finding such a gap is fairly high, presupposed that the signal is of 'normal' design and not specially designed so as to take special care of pedestrian problems. Another aspect of poor signal timing is the fact that 'sophisticated' phasing may cause a lot of confusion for pedestrians and also create very hazardous behaviours. 'Sophisticated' signal phasing may be vaguely defined as a phasing that is unusual and non-logical for the pedestrian. For instance so called 'channalising of pedestrians' (initially green man on only one half of the road) and 'split green' (green in one of two vehicle flows that originally has green at the same time while the other flow gets red) are examples on 'sophisticated' signal phasing that has caused increased red-walking. A magnifying problem is that pedestrians are often very little aware of the fact that they are crossing against red in those cases, as our interviews with pedestrians having traffic conflict when crossing against red have revealed (Draskéczy, 1990). This makes the 'preparedness for problems' of pedestrians small, and in view of ear drivers' generally low degree. of preparedness for problems with pedestrians, it can create very critical situations.
- Turning vehicles hitting pedestrians walking against green on a zebra crossing. This is a similar interaction problem as at non-signalised intersections.
- Vehicles running against red. This running against red can be of two principally very different kinds. In most of the cases the driver is aware of the fact that he is driving against red. Usually this occurs just after the change of the traffic light to red when the driver takes a chance of reaching the signal before it turns. Sometimes the driver is not aware of the fact that he is running against red. The offence can then happen at any time during the red phase. This latter kind is much more critical for pedestrians. This kind of driving against red is very infrequent seen from an individual pedestrian's point of view. It is therefore very unexpected for the pedestrian and can therefore create very critical events for him if he is not particularly careful.

Remedial measures

- Primarily 'better' pedestrian behaviour can only be achieved by improvements of the signal timing from the pedestrian's viewpoint. This must include improvements for the pedestrians 'paid for' by the drivers. It must also include a higher degree of logic from the pedestrian's point of view. Today signals very often keep red light for pedestrians even if there are big enough gaps to cross. This is difficult for a pedestrian to understand as he has a perfect overview of the location and easily can scan the whole place and of course also detect the gaps. The main option for being able to **improve the signal timing for pedestrians** lies in the option of using Road Transport Informatics for **detection of pedestrians** at signals. One would thereby be able to direct the signal timing based on the actual presence of pedestrians. That could lead to a very significant increase of the logic of the system and to significant increases of pedestrian priority when there is a demand and no priority at all when pedestrians are not present. It might therefore be advantageous even from the system's point of view. Another option is to detect „the whole traffic situation” so as to be able to predict possible gaps that will be „too attractive during red” for pedestrians. The signal strategy could in this case include the

safety strategy to avoid walking against red. This sub-strategy should then of course be ‘competing’ with other sub-strategies, such as minimising time delay for cars, the same for pedestrians and cyclists, etc. The knowledge today is very limited regarding the possible benefits of such a sub-strategy. It is, however, important to increase the knowledge about both possible benefits and other important relations. For instance it is very important to clarify how this sub-strategy ‘copes with’ other sub-strategies, such as co-ordinated signals (‘green waves’) and other car-oriented strategies.

- The problem with conflicts between turning vehicles (driving against green) and pedestrians (also against green) should also be treated with a **tutoring function**. In this case it could, however, be made stronger in the sense that it sees to it that the driver actually complies with the absolute rule of giving way to pedestrians on the zebra.
- The problem with cars running red light should be treated with some very strong **tutoring function** or even **automatic policing**. The tutoring could be made effective both if the driver is aware or not aware of the fact that he has been running a red light.

2.4. Crossing at the vicinity of a pedestrian crossing

Observational studies and some accident analyses have shown that the vicinity of intersections as well as the vicinity of pedestrian crossing facilities are especially dangerous places for pedestrians. The explanation of the problem is that drivers expect pedestrians crossing at the assigned places but much less outside them and therefore realise their presence too late or expect them to yield and therefore do not take avoiding actions until it is too late.

Some conflict studies revealed similar problems at pedestrian crossings which were situated farther from the intersections and were more dangerous than the usual near crossings where the drivers expected pedestrians crossing the road (Hydén-Gårder-Linderholm, 1978.)

The problem mentioned above has some relevance to the problem of RTI aided driving in general. Providing drivers with information through channels built into the vehicle needs some spare capacity of attention of the driver when he is checking an inner display and loses his contact with the outer environment even if for very short time periods. Urban driving, however, is full of unexpected encounters even when the environment seems to be quiet and the distraction, when danger is not expected, might be dangerous.

Remedial measures

Some **warning function** in the vicinity of pedestrian facilities that proved to be dangerous can be applied. The warning should not mean actual presence of pedestrians but the possibility of crossing pedestrians in general. It might improve the level of expectancy as well as the preparedness to interact with eventually crossing pedestrians.

3. CONCLUSIONS

Pedestrians are present first of all in urban areas and the vast majority of their accidents occur there. Their very presence in the urban areas means that the urban traffic system is inhomogeneous and interactions between road users are more complex, less foreseeable and less predictable than e.g. on motorways where the system is much more clearly organised and simplified. Sophisticated

technology is much less apt to be applied in such an inhomogeneous system, partly because only some participants can be equipped and partly because such a system always tends to work less factory-like, less according to formal rules. Traffic conflict and behavioural studies have shown that conflict-free action in inhomogeneous traffic situations seems to be made possible not so much by mechanically applied rules and automatic control, rather by the mutual flexible interaction of the partners.

In spite of the difficulties mentioned in the previous paragraph, there are possibilities to improve pedestrian safety by RTI technology and it is also possible to take it into consideration that RTI functions implemented for the sake of ear traffic do not deteriorate pedestrian safety.

The main areas of RTI application that might positively influence pedestrian safety are intelligent traffic signals, local speed reduction where and when needed, warning and tutoring functions.

Traffic signals will be much less accident producing for pedestrians if they can prevent walking against red. To achieve this the signal timing must be more 'pedestrian friendly', i.e. the waiting times for pedestrians must be reduced, and the number of time gaps in the ear traffic stream - while red for pedestrians - must be minimised.

Local speed reduction - through physical measures like humps - has proven to be very safety efficient both at intersections and at e.g. residential streets. The same principle can preferably be used by the help of RTI. Speed reduction by the help of RTI can be obtained in different ways: Drivers can be warned on a local speed limit, they can be tutored if they do not keep speed limits, or they can be enforced when it was detected that they were speeding. Or, even more, keeping speed limit can be ensured by an automatic speed limiting function built in into the cars. This makes the choice of solution flexible and possible to adjust with regard to other priorities. The important thing is that the speed reduction actually is obtained.

Warning functions: Warning drivers on the presence of some danger is useful only if the driver has spare capacity to attend to the warning, realise the danger and decide on the optimal avoiding action, or if the situation is so unanimous that one predefined avoiding action (e.g. braking) can be applied with high certainty. Urban traffic in general does not fit into the category mentioned above, therefore the possibility to warn on actual danger, e.g. on a pedestrian stepping suddenly on the road, is very limited. Apart from that, hazard warning, if one can not ensure that every hazard is noticed by the system and the driver is warned for them, has a general problem of compensatory effect. If the driver has an equipment that is said to warn him if there is any danger present, the driver need not concentrate so much on danger detection any more.

The main conclusion is that in urban areas warning on pedestrians should be applied in a more general way, warning before the driver arrives in an area where pedestrians or eventually specific high risk groups (schoolchildren, elderly people, etc) can be expected. There are traditional ways to warn drivers on the probable presence of vulnerable road users by traffic signs, but RTI technology could fit more to the actual situation, giving warning only when the presence of e.g. school children is really probable.

Tutoring in general might be a very efficient way of influencing driver behaviour. Tutoring means in this respect that the driver is informed about mistakes and violations he has made immediately and consequently. This sort of tutoring might play different roles. It might inform the driver who is not aware of the mistake or violation, e.g. driving with speed higher than the local speed limit or unsafe in a given situation, running against red, etc., or it might warn the driver who behaves in a particular way habitually that his behaviour is not safe. The value of the tutoring function is highly dependent on the intelligence of the system, i.e. if it is able to realise mistakes in a sophisticated way, and on the behavioural rules built in the system, i.e. what sort of behaviour is expected from the drivers when he e.g. interacts with vulnerable road users and what sort of behaviour is defined as mistake. One way of tutoring with regard to actual hazards drivers are involved in, is to use the conflict concept. Serious conflicts have been found to be a good indirect measure of accident risks and presupposed that hardware and software can be made sophisticated enough to actually record these serious conflicts, they can be used to tutor the driver. The driver should in addition be assisted - as far as possible regarding technical limitations as well as other limitations that exist with regard to what could be transferred to the driver while he is actually driving - so that he draws the right conclusions regarding his own behaviour and his own possibilities to reduce risk at a 'similar event' in the future.

The real safety effect of the different functions is, however, much dependent on some fine details of the man-machine interface. And besides, RTI application is far from being a pure technical process. Decisions about priorities and values are mediated by the technique, be it priority of different road user groups or priority of different goals, i. e. efficiency, safety, etc. The safety effect of RTI technology on pedestrians is dependent on those decisions as much as the intelligence and details of the technical solution.

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ELDERLY PEOPLE AS PEDESTRIANS

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Elderly pedestrians

Mobility of elderly people (<60 years) is high. A study about traffic behaviour in Vienna (Herry & Snizek 1993) shows that, though decreasing from an age of 56 on, all senior citizens leave their flats during working days to move around in the city. Between 61 and 70 years they have more ways outdoors than young people between 10 and 20 years of age (fig.1)

Ageclasses	Journeys per person
6-10	1,73
11-15	2,5
16-20	2,82
21-25	3,22
26-30	3,53
31-35	3,58
36-40	3,42
41-45	3,21
46-50	3,27
51-55	3,07
56-60	2,73
61-65	2,93
66-70	2,8
71-80	2,01
>80	0,37

Regarding the modal split people from an age of 56 years on walk more than the 16 – 55 years old. For the 71 – 80 years old walking is the most preferred mobility mode compared to age groups from 11 to 70 (Herry & Snizek 1993) (fig 2)

Keep them on the road – keep them mobile!

Reduction of outdoor mobility of the elderly means reduction of life quality because of lack of social contacts as well as psycho-physical deterioration. Diminished training in all areas always goes hand in hand with a reduction of ability in the same area. Assuming that we support the philosophy of keeping people mobile outdoors as long as possible (for more arguments. See, e.g., Hakamies-Blomquist 1994) it is of great importance to know sufficiently about their needs and problems as pedestrians.

But what sources do we have to reach a better understanding of needs and problems of elderly pedestrians? There exist five main sources which can help to create a kind of mosaic-picture - which may lead to an image of reality but, of course, not to „the” truth:

- 1) accident statistics
- 2) behaviour observations
- 3) subjective view
- 4) examinations of psycho-physical state (psychological and medical testing)
- 5) analyses of social environment and life circumstances

Each of them can only give a reduced, insufficient picture of the wide problem-area of elderly pedestrians. But each of them is necessary for a better understanding. One without the other can lead to erroneous conclusions. The necessity of knowing more than results from accident statistics and/or behaviour observations to solve problems shall be shown in the next table:

Which problem aspect do the different sources touch?

<i>Accident statistics</i>	<i>Behaviour observation</i>	<i>Subjective view</i>	<i>Physical state</i>	<i>Social environment</i>
Elderly pedestrians cross the street without regarding the oncoming traffic	Elderly pedestrians often have to look down to the road surface trying to find out how big the step will be from the pavement down to the street	- I am afraid of falling down - I don't see well but I don't want to ask for help – otherwise they think I am old and incompetent	Regarding vision: - elderly do not see long enough, - peripheral vision is reduced – accommodation between near and far lasts longer	Because of a historical development in our society elderly people often are looked at as being incompetent in various areas of life
	They wait for a big gap, after some time they just walk	- Cars approach so quickly so that I don't dare to start walking - I get frustrated when nobody stops for me, so I just start to walk - they have to brake!	- problems in distance and speed assessment because of the previous mentioned impairments	They are seen as “hindrances” in our “speed”-world; this leads to negative attitudes towards them and further on to a lack of willingness to support them

(Chaloupka & Risser 1993)

Two different kinds of approaches: Focus on the individual or the system

Accident statistics often show only one side of the coin. Behaviour observations usually give information about the existence of a problem but do not lead to a sufficient understanding *of what* is going on and *why* it is going on and what should be done as a countermeasure. Diving deeper

into the problem cannot be done without asking people about their point of view and without observing the social circumstances.

It depends on the approach in respect to countermeasures which information source one will prefer:

a) If authorities only think about training programs for elderly road users so that they behave safely in traffic, it is very obvious that they will focus only on the mistakes and impairments of elderly people and try, e.g. to train them to watch out for car traffic more consciously and cautiously. However, if the interests and needs of the elderly are not met well by this, they will not co-operate, and we know that such a co-operation is necessary (e.g., road users have to comply, they have to do what they are asked for, they have to react to measures in a way that is wished for - if they don't, most of the measures become useless)

b) Accordingly, if authorities take the whole traffic system - including psychological and social aspects - into account, e.g. how to improve life quality in the cities, especially for such a large group as the elderly, the information sources only from accident statistics or observation studies will not be sufficient.

The second kind of approach (b) seems to be more fruitful: Measures to change the traffic-system in a way that it will, e.g., be more error-friendly (i.e., an error of a pedestrian will not be „punished” immediately and severely) will improve life-quality not only of elderly people. But most of all it will help them, and also for people with all other kinds of handicaps (children, parents with small children, people with heavy bags, short- or long-term handicapped etc.) to keep their mobility high.

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ELDERLY PEDESTRIANS: A POSITIVE OUTLOOK

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Pedestrian accidents account for about 10 per cent of all injuries that occur on the road and for almost 20 per cent of all fatal accidents in Switzerland. One fourth of the injured pedestrians and 60 per cent of the fatalities were 65 years of age or older. Given that the elderly account for only

15 per cent of the population of Switzerland one can conclude that they have an above-average chance of becoming involved in a pedestrian accident, and a dramatically higher chance of being killed. The latter is due to the fact that the same injury severity leads to a higher percentage of mortality with increasing age. This was shown by Bull (1975, p. 251, Figure 2).

There are several possible explanations why the involvement of the elderly in accidents is higher than for younger people.

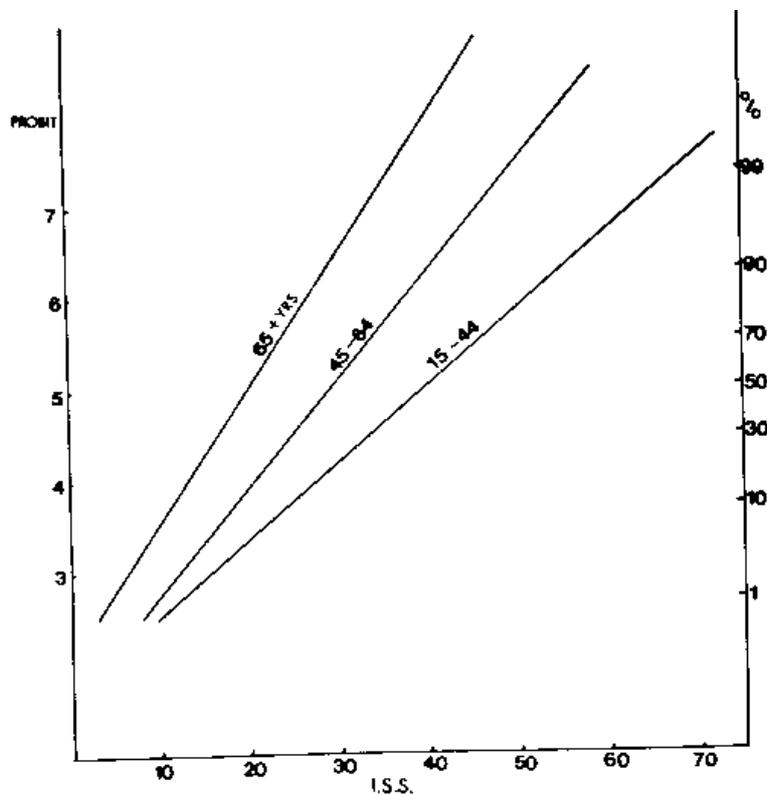
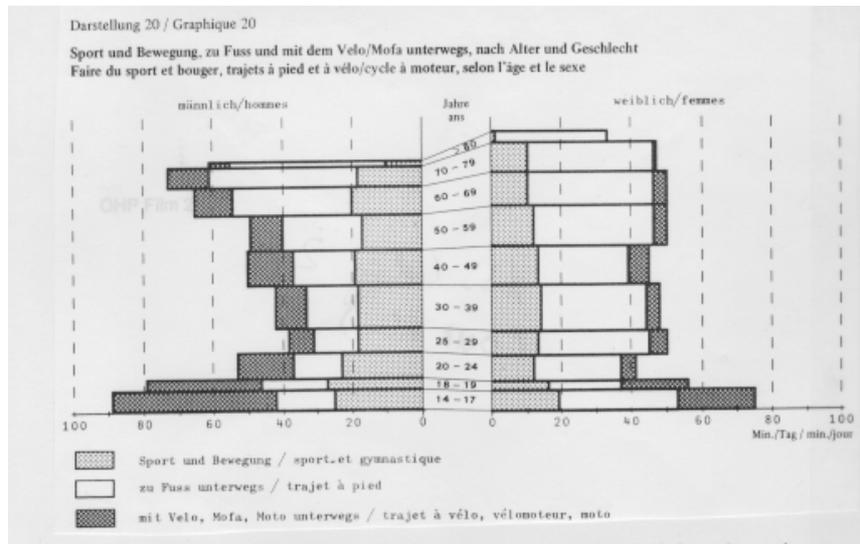


Fig. 2. Fitted Probit lines relating U.S.S. ratings and mortality.

1. Elderly may have a higher exposure as pedestrians than younger people.
2. They may not observe traffic regulations as well as younger pedestrians.
3. The elderly may be less familiar with motorised traffic than the young.
4. The elderly may have psychological or physical handicaps that hinder their effective participation in road traffic.

Exposure

Data from a mobility census conducted by the Swiss Federal Office of Statistics in 1979/1980 indicated that exposure to road traffic between the age of 18 and 80 remains constant at about 80 minutes per day for women and roughly 100 minutes per day for men. What does change are the proportions of different kinds of traffic participation. Walking and using public transport tend to increase with age, while car driving drops sharply. People up to the age of 50 participate in road traffic as pedestrians about 25 to 30 minutes per day (FOS, 1981), while the elderly do this for about 40 minutes per day (Wittenberg, 1977).



It can be concluded that some, but not all, of the higher accident rates of elderly can be put down to exposure.

Observance of traffic regulations

Several researchers discovered that elderly people observe traffic regulations better than younger people. Yaksich (1965) and Jacobs & Wilson (1967) observed pedestrian behaviour and concluded that for both sexes the elderly are more law-abiding than any other group and that their behaviour when crossing the road is most appropriate. It seems that the higher risk associated with the elderly comes about despite the fact that they observe traffic regulations better than younger pedestrians.

Experience with motorised traffic

A few years ago it was not that common in Europe to possess a driving licence. A research project carried out in 1978 by Camenzind, Huerlimann & Kaegi showed that only 25 per cent of people aged 65 or older had a driving licence. Nowadays the proportion is higher, but the percentage of women drivers among the elderly is probably still quite low.

Psychological and physical handicaps in old age

Age-related changes in information-processing, perception and physical abilities are well known. These changes vary considerably from person to person, so that age alone can not be relied upon to predict the degree of handicap. However, on average one can assume that eyesight, hearing and speed of the cognitive processes deteriorate with increasing age. The most drastic changes are to be found in information processing. In the case of difficult tasks the length of the pre-motory phase can increase by as much as twenty times, and the number of incorrect reactions increases with speed components (Kay, 1954). Both mechanisms, central nervous slowing and rising error rates, may put the elderly at risk in complex traffic situations. Eyesight problems occur mainly at night since the adaptation time increases and night vision deteriorates. On the street, deafness may reduce information redundancy. Physical handicaps can impair the ability to react fast and vigorously.

The research project

The project objective was an integration of behavioural and interview data relating to elderly subjects. The aim was to find relationships between individual characteristics and behavioural problems as pedestrians. Some 880 subjects were observed as they crossed a two-lane road at a pedestrian crossing. Afterwards it was possible to interview 70 per cent of these regarding subjective problems as pedestrians and possible improvements, as well as concerning everyday behaviour and demographic variables.

The relevant variables that were registered in the behavioural observation were orientation, communication and movement. This was carried out in three phases:

1. While the subjects were still on the pavement.
2. While crossing the first half of the road.
3. While crossing the second half of the road.

The main results were:

1. Most elderly people do not look out for traffic.

About 60 to 70 per cent of the subjects did not turn their head before or while crossing the road. They just kept on walking without paying attention to the traffic. In two-thirds of these cases there was no approaching vehicle. These subjects might have heard that there was no danger. Less than half of the subjects moved their head when a car was approaching; sixty per cent failed to look at all. This would seem to be a high-risk group.

2 The traffic situation becomes more dangerous when crossing the second half of the road.

While the pedestrians were crossing the first half of the road some 80 per cent of motor vehicles slowed down perceptibly or stopped. Only 20 per cent of the vehicles that approached the pedestrian crossing were clearly unwilling to stop. While crossing the second half of the road, the position was almost the opposite: only 25 per cent of motor vehicles were obviously breaking with the intention to stop, 75 per cent were unwilling to do so.

	Vehicles slowing down or stopping	Vehicles obviously not stopping
First half of road	80per cent	20per cent
Second half of road	25per cent	75per cent

In a quarter of the critical situations that occurred on the second half of the road the pedestrians reacted by walking faster. In two-thirds of the cases the vehicle driver was forced to slow down or stop.

This situation could come about because the pedestrians did not plan their crossing manoeuvre far enough in advance. It seemed as though, having crossed the first half relatively safely, they just kept on going. Probably they felt that, once they were out on the road, the drivers would simply have to stop. This is accordance with Swiss traffic regulations. At the time of the behavioural observation pedestrians were required to signal that they wanted to cross the road; once they had entered it they had the right of way. However, this seems to be a rather dangerous situation, especially in view of the fact that elderly people are unlikely to have the necessary physical ability to take evasive action if a car does not stop.

Interview

These were the two most important results of the behavioural observation. I would now like to present the results of the interview. More than half of the subjects said that, as a pedestrian, they sometimes felt unsafe or were even afraid. They were asked what kinds of problems relating to crossing the road were felt to be especially serious. The problems most frequently mentioned were reckless driving, driving too fast and the sheer volume of traffic. The latter two seem to reflect the slowing in central nervous processes. To remedy the situation the elderly would like to see a more considerate approach by other road users, speed limits, more traffic lights at pedestrian crossings and more information in the media. Only 10 per cent of the subjects said that they had problems crossing the road at night. This is hardly surprising since 50 per cent do not go out after dark.

Relating personal characteristics of the elderly to behaviour while crossing the road produced a very plausible and important result. Subjects who possessed a driving licence, or had possessed one, behaved considerably more appropriately when crossing the road than those who had never possessed a licence. They displayed much better orientational behaviour and seemed to pay more attention. They also reported fewer problems and fears as pedestrians. Men and women exhibit the same differences, but this is confounded with driving licence possession. Being or having been a driver would appear to increase pedestrian competence. These subjects are able to predict the driver's and the car's reactions more appropriately.

Conclusions

Elderly pedestrians have problems. They are willing to behave correctly but at least in orientational terms, they fail to do so. Half of them are afraid, especially regarding the speed and density of road traffic. Prior experience as a driver would seem to offer a certain amount of protection. Since the proportion of those in this category is steadily increasing, as well as becoming more equally distributed between men and women we may be able to look forward to a reduction in the number of pedestrian accidents without any additional efforts. The desire of the elderly that there should be more information ought to be fulfilled. Nevertheless, it may also be helpful to strengthen the legal position of a pedestrian on a designated crossing in order to induce a higher percentage of drivers to stop. This has been done in Switzerland, and has resulted in a certain improvement.

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THE ACCIDENT IMPENDENCY IN THE MUNICIPAL PUBLIC TRANSPORT SERVICES IN CRACOW

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1. INTRODUCTION

Nowadays, we observe a number of negative consequences resulting from this rush development of the motor transport technologies and technics, of course besides some particular advantages for the road users. The more motor vehicles appear on roads, the bigger is their general density on roads, and in a consequence, the common risk impendency. Additionally, some other negative side-effects appear along with the increase in the motor transport, called generally: environmental pollution.

In particular, the polluted environment affects badly the inhabitants of great municipal agglomerations, where the motor traffic is exceptionally intense. The task of the local authorities is to reconcile the contradictory interests of the city inhabitants with these of the individual road users. A sort of the intermediate solution is the common transport service.

This solutions secures a sufficiently free translocation, and on the other hand - the reduced motor traffic does not pollute the environment that much, it does not create that much noise either. Unfortunately, the common transport service is less popular than the individual transport, and many rational arguments emphasising advantages of the common transport service seem not to persuade them.

While analysing and comparing the common transport service in Poland and in countries with a higher motor transport rate, we see a very noteworthy character of the Polish transport service. Contrary to other European countries like Austria, Germany, Italy, The Netherlands, the Polish common motor transport is still leading in Poland. Especially in the towns, cities, the number of persons using buses or tramway exceeds three if not four times the number of persons driving their own motor vehicles. This status quo has been changing recently for the worse of the common transport service. In late eighties, a distinct rise in the number of private motor vehicles per capita occurred. Thus, an intermediate solutions must be found to keep the use of the common transport service unchanged under the circumstances of a spontaneous development in individual transport, otherwise this dangerous situation as observed in other countries will slowly become a part of our life in Poland.

This task seems inasmuch difficult as the national transport agents (with some exceptions) have shown no interest in improving their services in order to meet the requirements and wishes of the customers. Usually, our bus and tramway stock is rather disused and thus creating a certain safety menace if not the life danger whereas the everyday life in a city is impossible without an effective common transport service. Short breaks or even disturbances in transport service functioning prove this necks-silty. Thus, if we want to make the common transport services in cities competitive with the individual transport, and the if positive approach to them has to be strengthened, then these service agents must really come up to the expectations of their passengers. The most important factors to be introduced first are: safety, efficiency, punctuality and low prices.

2. OBJECTIVES OF THE STUDIES

Our studies comprise several objectives. First of all, it was necessary to answer a very important question: what is the opinion of the passengers about the common transport service?

Various approach of the passengers has been compared as to the real danger and menace evaluated on the basis of the available accident data. This comparison should enable the statement in what technological and organisational ranges the road users notice the life or health danger caused by the municipal transport service? Accident impendency and physical injury danger referred only to the situations emerged in the bus/tramway or during getting of/on the bus/tramway. Our studies covered the accident impendency in the tramway and buses of the Tarnów and Kraków municipal transport networks. Due to discrepancies in the condition of the tramway/bus stock in these cities, we considered both constructional and potential reasons of health danger and accident impendency.

Two research methods have been used to pursue our objectives: Standard form of inquiring and quantitative analysis of the chequered pattern of accidents available in the Municipal Transport Service (referred to as MPK) of Tarnów and Kraków. 203 persons were inquired: 150 in Kraków and 53 in Tarnów.

The majority of accidents occurred to women, according to the studied accidents. As to the age of inquired persons, it was proportional to the general number of persons using the common transport service. Thus, dominant were persons aged 30 to 50 years.

The statistical data taken from the accident charts comprised three years: 1989, 1990, 1991, 50 they included all accident impendency cases registered by these two transport agents in the respective periods. Accidents events other than registered by the accidents statistics were completed by the information taken from the inquire forms.

3. RESULTS OF THE STUDIES

The obtained results were quantitatively and qualitatively analysed including the application of the covariance and the Student's test. Thanks to it, four groups of issue scopes could be selected.

3.1 Passengers' subjective impendency

In table 1 there are detailed data related to the aspects discussed above (factors contributing to the accident genesis):

Table 1. Passengers, subjective impendency

1.	Individual risk	23 %
2.	Slippery floors and/or seats	18%
3.	Pointed edges	12%
4.	Improperly mounted elements of auxiliary equipment	11 %
5.	Dangerously protruding parts of the vehicle body	10%
6.	Sharpedges steps	7%
7.	Detached floor covers	5%
8.	Insufficient number of handgrips or even their lack	4 %
9.	Dismantled movable barriers	4%
10.	Defective doors	3%
11.	Too how installed ticket dating machines	3 %

The explicit conclusion arising from this data is that the passengers perceive two qualitatively different problems as the greatest menace for their health and life. The first problem is connected with the individual risk level represented by the bus/tramway driver's driving mode. This scope includes such elements of the driver's behaviour as: careless driving, sudden braking, speeding in the curve or while overtaking. These elements constituted 23% of all indications. A separate group of issues comprises indications referring to the proper vehicle equipment and quality of the vehicle make. It is worth mentioning in this place such factors as: slippery floors and/or seats, improperly mounted elements of auxiliary equipment, pointed edges, dangerously protruding parts of the vehicle body, sharp-edged steps, detached floor covers, insufficient number of handgrips or even their lack, dismantled movable barriers, defective doors (which open during the drives in most unexpected moments), too how installed ticket dating machines, other protruding sharp-pointed parts on the external body of the vehicle, etc. Of course, our respondents revealed some positive aspects of the common transport system which increase its safety.

In Tab. 2 these aspects are listed in the way which outlines the contrary attitude of the entire issue.

Tab. 2. Important features of safe motor vehicles

1.	Driving comfort	27%
2.	Effective noise suppression	22%
3.	Automatic door control	18%
4.	Safe and proficient bus	11%
5.	Comfortable and useful handgrips	11%
6.	Low steps	11%

Passengers believe that the most important features of a safe motor vehicles are: driving comfort, effective noise suppression, safe and proficient bus/tramway driving, comfortable and useful handgrips, how steps, automatic door control. It is also worthy stressing that the accident impendency extend as to vehicles engaged in the common transport system depends upon technical condition of the stock as well as upon its technical wear level. This fact has been revealed by the valuation of the safety of different vehicle makes, for example VOLVO bus was rated as the best, i.e. the most safe bus, whereas the Polish bus AUTOSAN and licensed product BERLLIET were rated very how as to their safety.

3.2 Accident impendence of objective occurrence

As mentioned above, all empirical materials assumed to bring an answer to our question set at the beginning of the studies were taken from the accurate analysis of the accident records.

All accidents relevant to the periods in hand can be classified among four groups of issues:

1. Persons' accidents including passengers. These accidents constitute most certainly the greatest impendence (83% among all impendence types)
2. Accidents and collisions with the „strange” motor vehicles
3. Derailment of tramway, situations when a bus turns aside from the road.

In the year 1989 the number of registered accidents, when people got injured, was the greatest, and the lowest - in 1991. Though, this gradual decrease per annum in the general rate of accidents is rather formal. Parallel to this drop in accidents number, the number of users of the common transport networks is on the severe down-grade. This is a very detrimental phenomenon that calls for actions and certain undertakings to maintain the leading position of the common transport services.

We can systematise the typical accident impendence among several groups of impendence arts typical for the municipal common transport service. The relations are shown on Fig. 1. Dominant are the accident impendence types which usually occur on the bus/tramway stops (62%), then accidents on the straight sections of a road, and the third group are accidents inside the transporting vehicles. As to the latter group, the real course of the accident is often very falsified. The accident records deliver information on only 30% of all occurred accidents where passengers were involved, and there are always these most dangerous and ugly accidents or collisions with buses/tramway involved. The majority of slight or insignificant injuries as an effect of the use of common transport means are never (or very seldom) reported by passengers, thus they are never registered in the statistics of accidents. And this majority includes 70% of all accidents.

In the group of slight and insignificant human body injuries and of trauma, dominant are head and face injuries (42%), then limb trauma (39%), spinal column injuries and/or internal haemorrhage appear not so often. These miserable events could be caused by jamming in the door (30% of indications), by falls inside the vehicle or even by falling out of the vehicle (what happens not so rarely). Elderly or very old passengers are victims of such events three times more frequently if compared with people of other groups of age.

3.3 Expectations of the passengers for the public transport

These expectations refer to three issues that are essential according to the statements of all interviewed persons:

1. Organisational improvements in the common transport system (70% of all indications)
2. Implementation of better and more current technologies and technical solutions in respect to the entire motor vehicle stock of the common transport system
3. Additional constructional conveniences inside the vehicles

The first group of suggestions needs deeper consideration, because they clearly prevail among all others. In order to meet all contemporary requirements and expectations, the carrier must improve the work organisation of the municipal transport agents. The passengers are most annoyed with the fact that the time-table of almost all regular bus/tramway lines does not respect the so called traffic rush hours, the frequency of the drive courses does not agree with general wishes, moreover there are delays or too long breaks in courses. Furthermore the passengers claim that stops are improperly situated, the translocation of passengers inside the vehicles is badly regulated or there is no control of this translocation, sluggishness and poor traffic capacity, drivers' speeding in the curves or while coming up the stop.

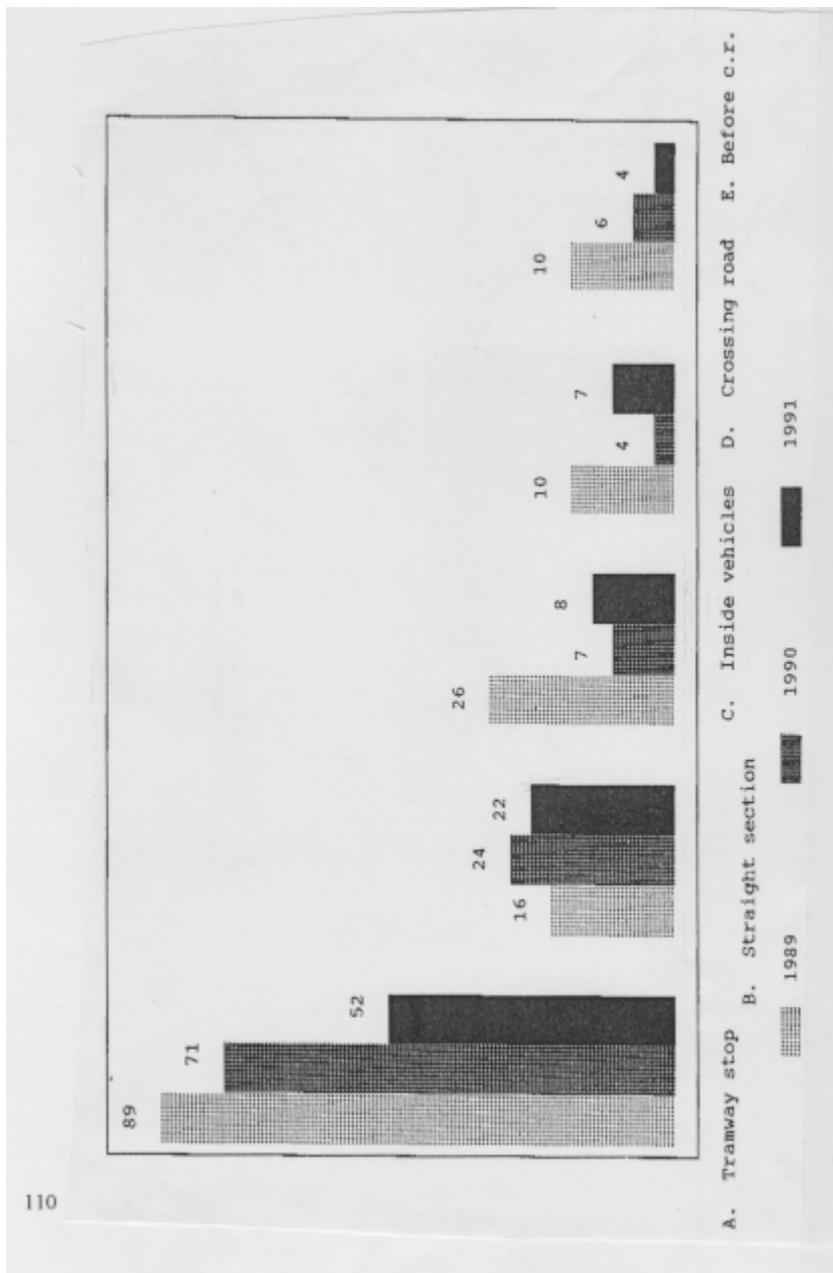
3.4 Legal regulations referring to the common transport system

The most astounding fact revealed by our studies is that 90% of inquired persons believe the common transport system does include an accident impendency, and only a split percent of them know their rights under the traffic rules and legal regulations in force. However, these legal regulations situate the carrier in a more comfortable position than the passenger. This is because of legal deficiency, incoherence and inaccuracy in the law. Very often, the insurer has to be responsible for the injury or loss as the consequence of the use of the common transport means. In this situation, it seems to be meaningless whether the accident insurance is compulsory or free. In the Polish legislation no regulation exists as to the terms of the contract between a passenger and a carrier, the terms ensuring equal rights for both parties. The present regulations favour the carrier and allow him to impose conditions. Furthermore, the rights of the passengers as prescribed in the valid regulations are not published and thus the passengers don't know them or have only a slight idea about them.

On the other side, even if the harmed party - usually a passenger - is able to vindicate his rights, the damage compensation as well as fines imposed on the transport undertakings are very high and rather not onerous.

Figure 1 shows where the accidents in connection with the use of public transport in Cracow happen:

Figure 1: Distribution of accidents in connection with public transport in Cracow 1989-1991



CHILDREN'S STREET CROSSING STRATEGIES - AN OBSERVATION TECHNIQUE

Pirkko Rämä, VTT Finland

In this part of the project, the goal was to find out which are the most relevant behaviour variables of children in traffic. In studying essential variables there were two important points of view:

1. Children's behaviour should not be examined in isolation from its environment. This means both the traffic and the social situation of the children.
2. Increasing attention should be paid to the children's own thoughts and rationality.

A new method

A new method for investigating children's behaviour when they are crossing a street was developed in the study. The method involves making video-recordings of children and traffic situations and two interviews with the children. The first interview took place immediately after a child had been filmed crossing the street, the other on the following day in school. Each child could then first watch his/her behaviour when crossing the street the previous day on the video. The child was encouraged to freely comment on his/her own behaviour and thoughts. After that, a more structured set of questions was presented.

A new method for analysing data was also developed. In the analysis, children's behaviour was monitored both with regard to time and place with the help of large-scale maps where the children's movements had been drawn. Their walking speed was apparent on the maps at intervals of one second. The method of analysis proved to be illustrative and efficient, especially when studying the group behaviour (fig. 1) of children and the consistency (fig 2) of the children's behaviour.

In all, 39 children in the neighbourhood of three schools were filmed and interviewed. The number of subjects is small and the preliminary results have not been confirmed with a sufficient amount of data.

Street crossing strategies

On the basis of the video-films and interviews, some hypotheses concerning children's street crossing strategies were formulated. In all, eight alternative strategy types were defined, namely: waiting, hurrying, dealing tasks, following, withdrawing, acting like an adult, taking responsibility, and panicking.

Head movements

The study also provided new information about head movements. Children were asked where they had been looking in the case of each head turns observed on the video-film. While 77 % of the children had turned their head left, only 69 % of the children had been looking at the traffic. The respective percentages were 90 % and 85 % for the head turns to the right.

Concluding remarks

While developing countermeasures it is important to know how the children themselves regard their walking in traffic. What information do they think they need, how do they plan to get that information and how will they use it. The proposed strategies differ in those respects from each other. Moving in groups and listening in traffic came up as important subjects for future study.

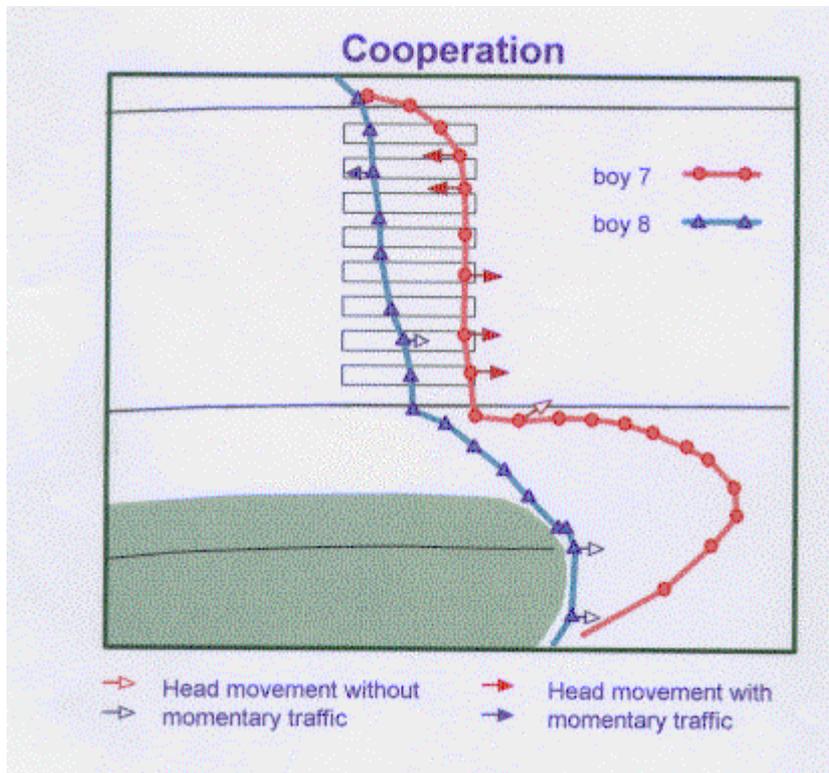


Figure 2. The co-operation of the children. The movements of boys are drawn by second. Head movements are presented with small arrows. Boy number 7 on the right in the walking direction thinks both of them should mind his own side. The other boy hasn't got the same idea, co-operation doesn't work.

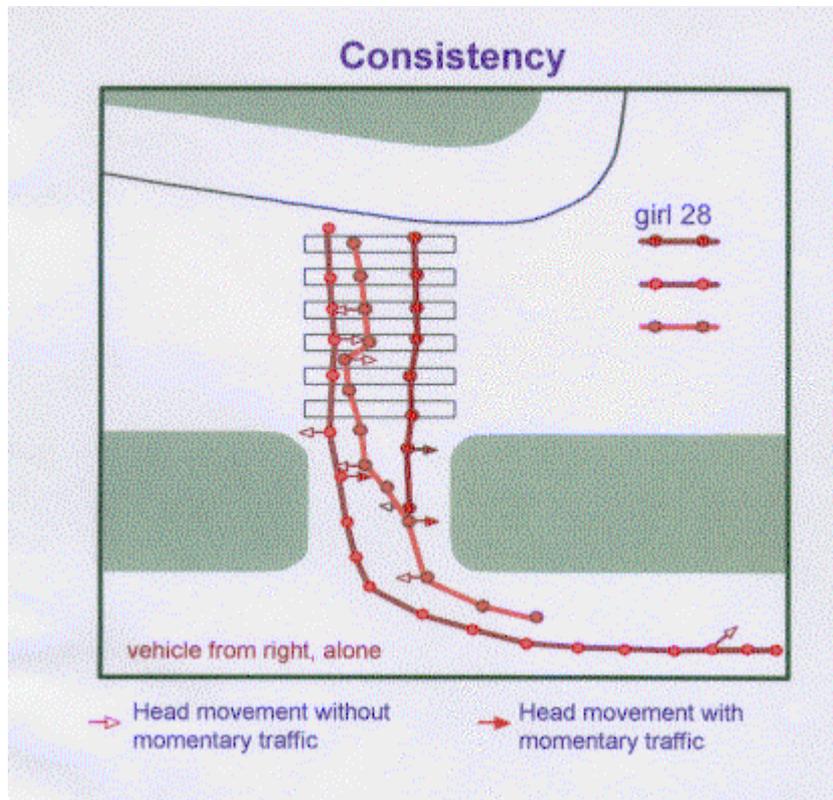


Figure 2. Consistency of the behaviour. The girl's route choice is presented second by second on three different days. Head movements are also drawn with small arrows in the picture. On each day the girl came alone and there were cars approaching. The behaviour is not consistent.

PEDESTRIAN BEHAVIOUR AND PEDESTRIAN SIGNAL DESIGN

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BACKGROUND

VRU-TOO (Vulnerable Road User Traffic Observation and Optimisation) is a project under the EU DRJVE II programme aimed at reducing accidents and improving conditions for pedestrians. The specific problem targeted by the project is that of pedestrians crossing arterial roads. Accidents on these roads account for roughly half of all pedestrian casualties and some two-thirds of pedestrian fatalities in urban areas. These accidents cannot be solved by segregation of pedestrians and vehicles, since such total segregation is impractical in most European cities vehicles need to travel along these roads and pedestrians need to cross them in order to get access to shops, public transport and other facilities.

VRU-TOO has therefore accepted that cars and pedestrians will inevitably have to share the same street space; instead of segregating them in space, it is seeking to separate them in time through the use of intelligent traffic signals. Such signals can detect the approach of pedestrians and give them a green man without requiring them to push a button. Pedestrian phases at traffic lights can be activated more quickly and, since activation is automatic, there is less chance of pedestrians walking when they have a red man. Part of the work of VRU-TOO is aimed at improving the understanding of pedestrian behaviour in crossing the road. This work can identify pedestrian problems, i.e. behaviours that lead to conflicts, and help to produce signal schemes that are better tailored to pedestrian needs.

DETECTORS AND PEDESTRIAN SAFETY

There are a number of ways that automatic detection of pedestrians at traffic signals might improve pedestrian safety. They might, for example, encourage pedestrians to use the crossing facilities rather than crossing much more dangerously outside the facility. They might also call up the pedestrian stage more frequently, because there is a tendency at crossings for the button not to be pushed even when many pedestrians are waiting. This would result in fewer pedestrians walking one red.

Here two other hypotheses about how pedestrian detection might improve safety are examined:

1. The detectors might improve the situation for pedestrians who formerly arrived on red and walked, as the police say, heedless of traffic.
2. The detectors might, by giving green more reliably and more frequently, improve the situation for pedestrians who formerly became impatient with long delays and so accepted smaller gaps. These persons might now be willing to wait for the green man.

METHOD

The objective of this part of the VRU-TOO work was to investigate which crossing behaviours tend to lead to conflicts with other traffic. This was done by making observations of conflicts and simultaneous observations of the behaviour of pedestrians in conflict and non-conflict situations involving interaction between a pedestrian and vehicle (encounters). Conflicts were identified using on-the-spot observation. The behavioural variables were obtained from video recordings.

The observations were carried out at intersections in four European countries the Netherlands, Portugal, Sweden and UK. The sites selected, the so-called Eurojunctions, were as similar as possible in their layout and in pedestrian and vehicle flows. The sites were of two types:

1. Non-signalised intersections with three or four arms. All arms had one lane in each direction. In the Netherlands and Sweden, the pedestrian facility on the major road was a zebra crossing without a refuge. In the UK and Portugal, there was no marked pedestrian crossing and no refuge. The maximum speed limit 45 65 km/h and the width of the major road was 7 11 metres. There was no parking allowed and no cycle lanes. Peak hour traffic flows were 300 600 vehicles an hour combining both directions on the major road and pedestrians flows crossing the major road were relatively high. Pedal cycle flows were relatively low.
2. Signalised intersections with three or four arms. These had the same general characteristics as the non-signalised intersections, although in the UK one arm of the four-arm junction selected was one-way away from the junction. Additional features of the signalised intersections were that in the Netherlands and Sweden there should be a green man signal for pedestrians and pedestrians crossing the major road should be given green simultaneously with green for traffic coming from the minor road. In the UK and Portugal, there should be no separate traffic signal for pedestrians.

In each country, one site of each type was selected. Only pedestrians crossing the major road were observed.

Conflicts were identified using the Swedish Traffic Conflicts Technique. An encounter between a pedestrian and a motorised vehicle was defined as an event in which at least one of the traffic participants obviously adapted their behaviour to the other by changing speed (accelerating, decelerating or stopping) or swerving around to give way or to avoid a conflict. According to this definition a pedestrian can have more than one encounter while crossing the road. In the first place he can meet a vehicle on each driving lane and in the second place the pedestrian can cross behind a vehicle and also cross in front of a succeeding vehicle.

For the dataset used here, all the observed conflicts were included, but the encounters were sampled at a rate of one in ten. The procedure used here was to analyse the videotapes for the first six minutes of each hour, assuming that this period was representative of the whole hour. The conflict/encounter ratios discussed below use the raw numbers of encounters in the resulting database, i.e. the numbers of encounters are not adjusted by the appropriate weighting factor of 10.

RESULTS

Tables 1 and 2 show the relationship between whether the pedestrian stopped and the probability of a conflict for those walking in front of vehicles. At the signalised intersections, pedestrians who do not stop have an 80 percent greater probability of a conflict than those who do stop. However, the same relationship cannot be observed at the non-signalised intersections perhaps because pedestrians are generally more cautious there. This would appear to confirm that those walking heedless of traffic are indeed a problem.

Table 1: Signalised Junctions Conflict/Encounter Ratios for those Walking in Front of Vehicles

	Conflict	Encounter	All
No stopping	0.38	0.63	0.56
Stops	0.21	0.79	0.44
Total	0.30	0.70	1.00

Significance <.01

Table 2: Non-Signalised Junctions Conflict/Encounter Ratios for those Walking in Front of Vehicles

	Conflict	Encounter	All
No stopping	0.20	0.80	0.79
Stops	0.19	0.82	0.21
Total	0.19	0.81	1.00

Not significant

The other hypothesis discussed above was an impatience one: long delays for pedestrians led to risk-taking behaviour in the form of the acceptance of smaller gaps. If there was such a link, then one would expect that with long delays conflicts would become more likely.

Examination of the data did not confirm this. The encounter group (those not having conflicts) had a mean delay of 1.9 seconds and the conflict group a mean delay of 4.4 seconds. This indicates that conflicts are related to short or no delays rather than to long delays, confirming once again that the conflicts are mainly associated with those who, for whatever reason, do not stop.

CONCLUSION

The focus here has been on the potential benefit of detection for those already using a crossing facility. For these pedestrians, a greater safety benefit will be obtained by providing immediate green on arrival than by reducing waiting times for those who have already stopped. The problem will, of course, be that it is not possible to detect those who do not intend to stop (although it might be possible to distinguish running pedestrians). But one can conceive of signal strategies that would help these heedless pedestrians. These might include:

- Signals that default to red for cars and green for pedestrians.
- Signals with several pedestrian stages in each cycle. This would result in free-flowing car traffic for a much smaller percentage of the cycle.

It is clear, in general, that signalisation on its own does not lead to safe conditions for pedestrians.

THE EFFECT OF DIFFERENT TIMING SCHEMES ON PEDESTRIAN BEHAVIOUR AT SIGNAL CONTROLLED JUNCTIONS

Kirsi Pajunen, VTT Finland

The research included a literature survey and field studies. The field studies were made in Helsinki at three pedestrian crossings in signal controlled intersections. Two of the pedestrian crossings were in the centre of Helsinki (field observations for 6 hours) and one was in the suburb (field observations for 8 hours). The field observations were made with three different traffic signal timing schemes at all intersections. Two of the timing schemes were traffic actuated: the present one and the fast mode control and one was fixed-time control. During the fast mode control the green phase for the vehicles was cut off more easily than during the present control. If there was a clear gap (more than two seconds) in the vehicle flow the pedestrians got a green phase. The field studies included conflicts, waiting times in samples for pedestrians crossing the street against red light and against green light (100 pedestrians), accepted gaps for pedestrians going against red light, crossings outside the pedestrian crossing and traffic volumes.

There were very few conflicts observed during the field studies. The risks for pedestrians were low also for pedestrians crossing the street against the red light. There was no safety difference observed between different timing schemes.

The waiting times were longer for pedestrians crossing the street when the light was green than for those who crossed against the red light. That was because over half of the pedestrians who crossed the street against red light didn't stop at all but those who obeyed the law had to wait for the green light. In two field study sites waiting times decreased for all pedestrians when changing from the present control to fast mode control. In one field study intersection the waiting times for pedestrians increased because the all green phase for the pedestrians was cut off. The pedestrian waiting times were longest for the fixed-time control as expected on the basis of literature survey.

During all of the timing schemes over 60 % of the pedestrians crossing the street against the red light accepted a gap between five and ten seconds. A gap less than five seconds was accepted by 6 - 12 % of the pedestrians going against red light.

We expected after the literature survey that there would be more vehicles crossing the pedestrian crossing during the red light for pedestrians when changing from the present control to the fast mode control (because the vehicle flow was cut off if there were no vehicles driving across the pedestrian crossing). The vehicle flows remained anyhow just about the same.

We also expected that there would be less pedestrians crossing the street against the red traffic light when changing from the present control to the fast mode control. During the field studies the number of pedestrians going against red light increased in all the pedestrian crossings that were observed.

In the suburb there were clearly more pedestrians crossing the street outside the zebra crossing when changing from the present control to the fast mode control and still more when changing to the fixed-time control. In the centre the differences were not so clear. On the basis of the field studies the fixed-time control was the worst choice of the three different signal control schemes from the pedestrian's point of view. That was because the fixed-time control is so unflexible. The

waiting times for pedestrians were also longest for the fixed-time control. The best choice from the pedestrian's point of view was the present signal control scheme. The present timing programs have been made better and better for each intersection. The special tailoring of the signal control scheme for each intersection (all green phase for pedestrians, the active priority for public transport, co-ordinated traffic signals and so on) makes the crossing more comfortable for the pedestrians than just simply making the control faster.

TRAFFIC SIMULATION IN PEDESTRIAN SAFETY RESEARCH

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1. A SHORT-TIME TARGET

Computer simulation of traffic could rather soon be a handy tool to study the influences of various speed-related countermeasures on pedestrian safety and on vehicular travel times. Speed control is obviously a very important, but also a very controversial issue especially in busy city centre traffic. It has been estimated, for example, that a strict adherence to the new 40 kph speed limit on Kaivokatu-street in Helsinki would reduce the probability of a pedestrian death to almost one third. Travel times of the cars would be lengthened by only a few percent. This estimate has been done with help of video-recorded accidents and travel time studies with an instrumented floating car /1/.

However, it would be of value to illustrate this more generally and more clearly for decisionmakers and road-users. This could be done anywhere with help of computer simulation.

1 The advanced simulation system would record the number of pedestrian accidents (calibrated to the present situation), collision speeds, accident costs and travel times of the vehicles. The relative influences of given speed changes (humps, speed limits, green waves, vehicular limiters etc.) could be easily calculated.

2. WHY SPEEDS AND PEDESTRIAN SAFETY?

In addition to the importance of the issue, there are three reasons (a,b,c) why expressedly speeds and pedestrian safety at signalised streets should be the first target of this kind of development work.

- a) In pedestrian accidents a pedestrian rarely tries to cross a street conscious between a short gap and fails through the miscalculation of his/her own or some others performance /1/.

Pedestrians who cross the street are, for various reasons, sometimes momentarily in such a state or situation where they do not think at all of approaching vehicles. An accident occurs when a pedestrian crosses the street quite heedlessly and a vehicle happens to be on the 'right' spot, travelling at the 'right' speed. The drivers try to avoid a collision with a full brake. **It is not difficult to simulate this kind of behaviour.**

- b) In general, neither pedestrians, nor other crossing traffic collide with vehicles in a queue /1/.

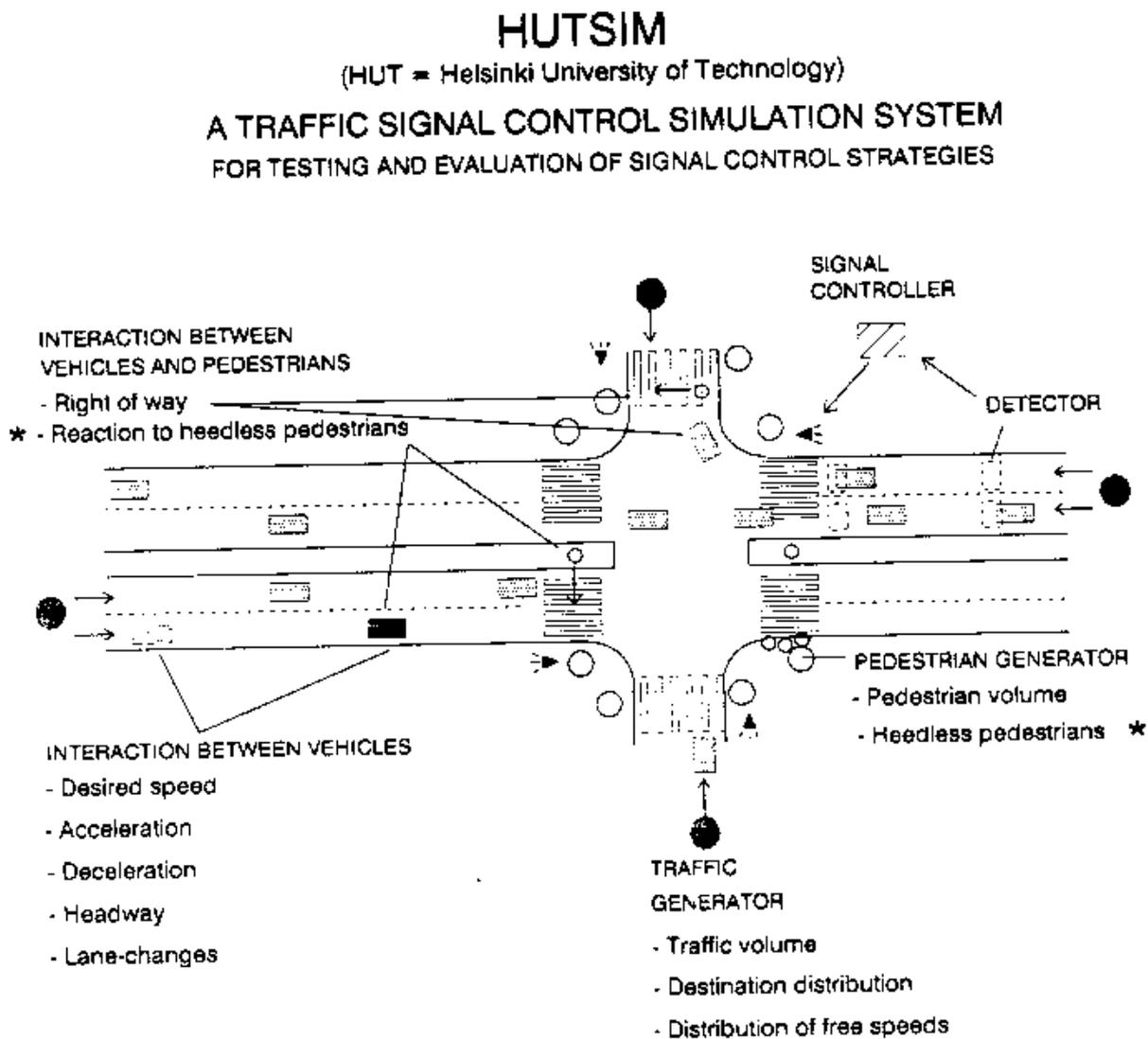
The special importance of the free vehicles, that is vehicles not in queue, is quite decisive when the advantages and disadvantages of speed control in busy city centre traffic are compared.

The reduction of the highest speeds affects just those free, most dangerous vehicles, whereas the effects on travel times to the majority in queues is often very small.

The traffic flow can be divided into free and other vehicles with present simulation techniques.

Helsinki University of Technology has developed a traffic simulation system (HUTSIM), which describes quite truthfully vehicular traffic at signalised streets (see Figure 1). It should not be too complicated to add pedestrian black-out performance and the brake reactions of the drivers in the model.

Figure 1: HUTSIM and the two essential extra (*) characteristics.



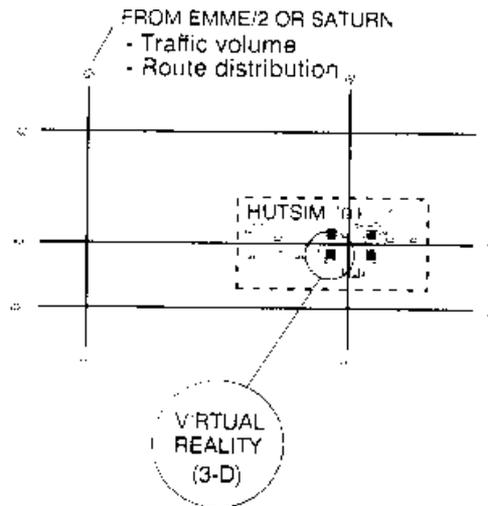
c) The mathematical dependence between collision speed and the severity of a pedestrian accident is known by a satisfactory accuracy /2/.

3. *SOME THOUGHTS*

The short-time development work could progress in the following order by:

- adding heedless pedestrians and emergency braking reactions into HUTSIM
- extending the library of basic HUTSIM-elements and making it easier to modify these elements
- creating data-links between trip assignment models, HUTSIM and virtual reality (3-D) models (see Figure 2).

Figure 2: Further steps.



In principle, there are no limitations on simulation like this. Future events depend mainly on the knowledge of real accidents and on the interest of various groups. For example:

A system with heedless pedestrians, with an urban 3-D reality and with a possibility to steer an individual car, could be useful at driving schools.

4. *POSTSCRIPT (ESPECIALLY FOR MEMBERS IN GROUP D)*

It is often said that children in traffic are more vulnerable than adults because, for example, they have difficulties in estimating vehicle speeds. However, other animals don't have to make estimates of the speeds and distances of their enemies. Their visual system contains a neural, unconscious mechanism to measure time intervals (time to collision). Does a 5-year-old human being lack such an ability?

My subjective experience tells that children, when crossing a street, generally leave great extra safety-margins because of the safety education (frightening) from their parents. However, children are impulsive and this causes black-outs of attention to traffic and leads to accidents.

With years the conscious safety-margins decrease, yet, remaining sufficient. Pedestrian accidents of adults are usually also caused by black-outs. So when we want to reduce pedestrian accidents,

let's not pay too much attention to accepted gaps and other conscious decision-making of the pedestrians.

Let's increase the safety-margins of drivers by, for example, reducing speeds on down-town streets.

A pedestrian is not a real threat to a driver. Unconscious protective responses do not work. Drivers feel no risk when driving on urban streets at their 'own' speeds /3/. This means that speeds must be reduced by force. Research, education and information can make the needed countermeasures less painful for the drivers.

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BLINKING YELLOW AT SIGNALISED PEDESTRIAN CROSSINGS: AN EVALUATION

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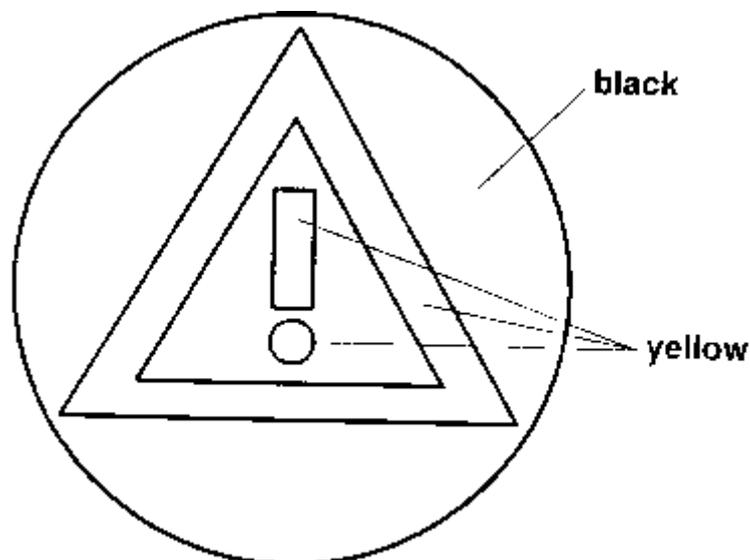
1 The problem

On standard signalised pedestrian crossings in the Netherlands an average of 45% of those arriving during red cross without waiting for the signal to turn green (Oude Egberink & Rothengatter, 1984). Since little enforcement at these sites is usually exerted it is often suggested that this form of undisciplined behaviour, apart from being inherently unsafe on its own, may generalise to other offences („halo”-effect). On the other hand, those who perform the offence say that it is rather silly to stop and be punished by long waiting times when you can see for yourself that it is perfectly safe to cross.

A proposal to find the middle ground between these different lines of reasoning is to replace the red pedestrian light by a device signalling „you may now cross at your own risk”. This would all at once reduce violations to nil, thereby removing the possibility of unwanted halo-effects, while acknowledging people’s capability of making their own judgements.

The actual device considered is shown in Fig. 1. It is the parts in this figure indicated as yellow that blink in the stage of the cycle that was formerly taken by the red light.

Fig. 1: Proposed „yellow blinking” device.



Before giving municipal authorities the liberty of installing the yellow blinking device the Ministry of Transport thought it wise to have an a priori evaluation performed, concentrating both on the use per se that would be made of the device and on the safety effects associated with its use. This paper reports on that evaluation, which took the form of a before-and-after study on six signalised crossings (Janssen, Van der Horst & Van der Mede, 1991).

2 The Delft before-and-after study

2.1 Selection of locations

The study was performed in Delft, a medium-sized city in the West of the Netherlands which, with the Ministry's consent, acted as a volunteer test site.

Care was taken to select locations which differed in characteristics that could be considered to be of possible relevance (for example, whether the crossing was in the middle of a block or right on an intersection; whether the signal cycle was or was not conflict-free, that is, whether it contained „hard” or „soft” green for crossing pedestrians; etc.) In particular, the contrast between „hard” (exclusive) and „soft” green to pedestrians seemed of interest. A priori it seems only logical to combine an own-risk device with a setting of the green light that is conflict-free, i.e., in which you can be sure that your crossing will then indeed be riskless. It remained to be seen, however, whether this would indeed apply.

The crossings were also selected with an eye on whether they were regularly used by children and elderly people. These are the user groups that one could expect to experience difficulties when being faced with the decision whether or not to cross at their own risk.

Table 1 Characteristics of locations.

Location	Conflict on green?	Green on request?	Nr of lanes to cross	Nr of possible conflicts	
1 Minervaweg	no	yes	2	2	Mid-block
2 Papsouwsel. 1	no	yes	2	2	
3 Nassaulaan	no	yes	2	2	
4 N. Langendijk	yes	no	2	4	
5 Oosterstraat	yes	no	2	4	
6 Papsouwsel. 2	no	yes	3	1	

2.2 Design of study

The „before” and „after” measurements were taken with a one year interval between them (April 1989 - April 1990). The transition from „red” to „blinking yellow” took place at about 8 months into this interval (December 1989).

There were no control locations included at which „red” was not replaced by „blinking yellow”. This was because the change took place all over Delft at about the same time in a population of more than 50 crossings, which gave the municipality reason to think that it would be confusing to the public and bad service as well to leave crossings out from the transition. For this reason the study was a purely comparative one, assessing the differential effects of the introduction of „blinking yellow” for different locations without including a baseline.

The study comprised three elements:

- a Video analysis of actual crossing behaviour
- b Conflict observation
- c Analysis of numbers and types of accidents (for the entire population of pedestrian crossings in Delft).

3 *Video analysis of pedestrian crossing behaviour*

3.1 **Crossing at red and at blinking yellow**

Table 2 presents percentages of pedestrians, for each location, who crossed during red, respectively during blinking yellow. Table 3 does similarly, except that it contains only percentages referring to those arriving when the light was already red/blinking yellow. The latter is the most appropriate measure for indexing the inclination to cross against red per se (and also the one that was meant when it said in the beginning of this paper that there was a 45% average offence rate).

The conclusion, applying to both tables, is that the inclination to cross outside green has approximately doubled after the introduction of blinking yellow. It should also be noted that, although this increase is more or less the same for all locations, the absolute levels differ substantially.

Table 2 Percentage of pedestrians crossing at red/blinking yellow.

Location	Overall percentage crossing at:	
	Red	Bl. yellow
1 Minervaweg	19	31
2 Papsouwsel. 1	18	38
3 Nassaulaan	10	17
4 N. Langendijk	24	54
5 Oosterstraat	26	38
6 Papsouwsel. 2	14	36
Average	18	36

Table 3 Percentage of pedestrians who arrived at red/blinking yellow and crossed in that phase.

Location	Perc. Of those arriving at red/bl. yellow, crossing at:	
	Red	Bl. Yellow
1 Minervaweg	56	79
2 Papsouwsel. 1	40	64
3 Nassaulaan	11	20
4 N. Langendijk	31	64
5 Oosterstraat	46	72
6 Papsouwsel. 2	25	57
Average	34	61

3.2 Waiting times

Average waiting times before crossing are shown in Table 4. As is to be expected, because many more people crossed immediately and did not wait for green to appear, there is a considerable reduction in the average waiting time.

Table 4 Average waiting times (s).

Location	Red	Bl. yellow
1 Minervaweg	10	6
2 Papsouwsel. 1	21	13
3 Nassaulaan	13	13
4 N. Langendijk	23	20
5 Oosterstraat	12	7
6 Papsouwsel. 2	25	17
Average	17	13

3.3 Gap acceptance

The time gaps, both accepted and rejected, that crossing pedestrians showed with respect to vehicles intersecting their path were used to estimate so-called critical gaps. The critical gap is the time interval to an approaching vehicle that is accepted 50% of the time. The longer the critical gap, the safer a crossing can be said to be. Obviously, (critical) gaps only exist when there are indeed approaching vehicles, which is always the case during red/blinking yellow.

Table 5, pertaining to pedestrians crossing during red/blinking yellow, contains the results (for technical reasons the analysis could not be made for location 6).

Table 5: Critical gap (s) for pedestrians crossing during red/blinking yellow (when pedestrian rejected more than one gap before crossing longest rejected gap is used).

Location	Red	Bl. yellow
1 Minervaweg	4.2	4.2
2 Papsouwsel. 1	4.1	5.3
3 Nassaulaan	3.6	4.4
4 N. Langendijk	4.6	9.5
5 Oosterstraat	2.7	3.0
6 Papsouwsel. 2	-	-
Average	3.8	5.3

There is a clear tendency for the critical gap during a crossing outside green to have increased with the transition to blinking yellow. Location nr.4, which has only „soft” green to pedestrians, is no exception.

3.4 Gap acceptance for vulnerable groups

A separate analysis was done on gap acceptance by vulnerable groups, which were children (those judged from video to be less than 12 years old) and elderly people (those judged from video to be over 60 years old). Because the numbers of members of these groups using the selected locations turned, post facto, to be disappointingly low the data were collapsed for the five locations for which they were available. Critical gaps, estimated from the aggregated data, are shown in Table 6 for the group of vulnerable people (children and elderly people as compared to all others. It is apparent that the vulnerable group shows the same overall increase in the critical gap as the other users when red is replaced by blinking yellow. It is also interesting to note that the magnitude of the critical gap by itself is already 1 s larger for the vulnerable group.

Table 6 Critical gaps for crossing in red/blinking yellow: vulnerable group vs. others.

	Critical gap	
	Red	Bl. yellow
Vulner. group	5.4	6.4
Others	4.3	5.3

3.5 Proportions of short gaps that are accepted

It makes also sense to consider gap acceptance not only in terms of a critical gap, but in terms of accepted gaps and short gaps in particular only. These might in fact be a better index of risk actually experienced when crossing in front of an approaching vehicle.

A short accepted gap was defined as one in which the pedestrian crossed within 4 s of an approaching vehicle. Proportions of short accepted gaps, relative to total numbers of accepted gaps of any magnitude, are in Table 7. The average proportion is exactly the same in the „before” and „after” situations. It may be slightly worrying that this is not true for all locations. Specifically, location nr.4 (which is the „soft” green crossing) shows an apparent increase.

Table 7 Percentages of short <4 s accepted gaps (relative to total number of accepted gaps).

Location	Red	Bl. yellow
1 Minervaweg	39	30
2 Papsouwsel. 1	20	16
3 Nassaulaan	24	20
4 N. Langendijk	25	39
5 Oosterstraat	30	36
6 Papsouwsel. 2	-	-
Average	28	28

4 Conflict observation

Trained observers performed conflict observations on the spot, at the same time the video recordings for the behavioural analysis were made at that location, according to the so-called DOCTOR-method. The core of this method is that the occurrence and the severity of a conflict are judged on the basis of objective criteria, notably the relative speeds of those involved and the time-to-collision when a collision configuration exists (Van der Horst & Kraay, 1986). On the basis of these criteria conflicts are, furthermore, differentiated into non-serious and serious conflicts. In the present study conflicts were always between a pedestrian and a motor vehicle crossing his path.

Because it was known from the video recordings how many pedestrians actually used a crossing during the conflict observation period rates of conflicts per crossing pedestrian could be derived. These are shown in Tables 8 (for serious conflicts) and 9 (for non-serious conflicts), and they apply to pedestrians crossing during red/blinking yellow.

Given the limited numbers of conflicts that were actually observed one must be cautious in drawing „before” and „after” conclusions. What appears clear, however, is that there is little reason to worry about the possibility that the use of blinking yellow may generate an extra risk compared to the risk experienced when formerly crossing during red.

Table 8 Rate of serious conflicts for pedestrians crossing during red/blinking yellow.

Location	Rate per 100 pedestrians crossing during:	
	Red	Bl. yellow
1 Minervaweg	0.62	0.91
2 Papsouwsel. 1	1.07	0.00
3 Nassaulaan	4.00	1.69
4 N. Langendijk	1.32	1.21
5 Oosterstraat	0.81	0.00
6 Papsouwsel. 2	0.00	0.34
Average	1.18	0.90

Table 9 Rate of non-serious conflicts for pedestrians crossing during red/blinking yellow.

Location	Rate per 100 pedestrians crossing during:	
	Red	Bl. yellow
1 Minervaweg	1.86	0.46
2 Papsouwsel. 1	3.21	1.32
3 Nassaulaan	2.00	1.69
4 N. Langendijk	0.00	0.00
5 Oosterstraat	0.00	0.89
6 Papsouwsel. 2	0.00	1.02
Average	1.18	0.90

Conflicts were also scored for the green phase, in an effort to assess whether the replacement of red by blinking yellow would affect behaviour in that phase. Also, it should be reminded that two of the locations (nrs. 4 and 6) had a „soft” green cycle, so that conflicts could in particular occur on these two. What could be expected, in fact, is that the somewhat illogical combination of blinking yellow (cross at your own risk) with „soft” green (basically also: cross at your own risk, where people might now, however, expect „hard” green) could generate more conflicts during green.

Tables 10 and 11 show the relevant results. It seems that there is little reason for worry. In particular, locations 4 and 6 do not at all yield evidence that more risk may result from the combination of blinking yellow with „soft” green.

Table 10 Rate of serious conflicts for pedestrians crossing during green.

Location	Rate per 100 pedestrians	
	Red	Bl. yellow
1 Minervaweg	0.00	0.00
2 Papsouwsel. 1	0.00	0.00
3 Nassaulaan	1.29	1.25
4 N. Langendijk	0.58	0.00
5 Oosterstraat	0.35	0.56
6 Papsouwsel. 2	0.00	0.00
Average	0.37	0.30

Table 11 Rate of non-serious conflicts for pedestrians crossing during green.

Location	Rate per 100 pedestrians	
	Red	Bl. yellow
1 Minervaweg	0.00	0.00
2 Papsouwsel. 1	0.00	0.00
3 Nassaulaan	0.52	1.67
4 N. Langendijk	0.58	0.00
5 Oosterstraat	1.74	2.25
6 Papsouwsel. 2	0.00	0.00
Average	0.47	0.65

5 Accidents in the population of pedestrian crossings in Delft

Accident counts for the Delft population of signalised pedestrian crossings were obtained from files kept by the police. The „before” period was the last 3 years before the transition to blinking yellow, the „after” period the first 1.5 years after the transition.

It appeared that there were 2.7 accidents per year in the population (n = 59) in the „before” period and 2.6 in the „after” period. There was no apparent shift in the seriousness of the accidents.

When looking at only those locations that formed part of the present study it was found that there was 1 accident in the „before” period (at the Nassaulaan crossing) and none in the „after” period.

6 Conclusions

Replacement of the red pedestrian light by a device („blinking yellow”) signalling that crossing may be attempted at one’s own risk appears to lead to the following:

- The percentage of those crossing outside the green phase doubles.
- Correspondingly, average waiting times are reduced.
- Crossing outside green considered on itself has not become more unsafe, as indexed by gap acceptance data.
- The latter is also true for potentially vulnerable groups, i.e., children and elderly people.
- Conflict observation does not show a negative effect of the transition to blinking yellow, not even in combination with „soft” green.
- Similarly, accident figures do not show so.

7 Recommendations

On the basis of the above findings there should be nothing that prevents the liberal use of the yellow blinking device on signalised pedestrian crossings. A few points, though they did not result in negative effects in this study, may be important enough to merit further and more extensive investigation. These are:

- (1) The issue of „hard” versus „soft” green, particularly in connection with:
- (2) The issue of vulnerable (groups of) users.

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